Cryptography for Intel® Integrated Performance Primitives Developer Reference

Contents

Developer Reference for Intel® Integrated Performance Primitives Cryptography

What's New

The Intel® Integrated Performance Primitives (Intel® IPP) is a software library that provides a comprehensive set of application domain-specific highly optimized functions for signal and image processing and cryptography.

NOTE
This publication, the *Developer Reference for Intel Integrated Performance Primitives Cryptography*, was previously known as the *Cryptography for Intel Integrated Performance Primitives Reference Manual*.

Intel IPP Cryptography is an add-on library that offers Intel IPP users a cross-platform and cross operating system application programming interface (API) for routines commonly used for cryptographic operations. Among other features, the library includes:

RSA Algorithm Functions

RSA Algorithm Functions implement the non-symmetric RSA algorithm. Subsections include reference for different encryption schemes and RSA system building functions.

Rijndael Functions

Rijndael Functions implement the symmetric iterated Rijndael block cipher with variable key and block sizes. The Rijndael cipher with 128 bit block size is also known as the Advanced Encryption Standard (AES) cipher.

Mask Generation Functions

A Mask Generation Function takes a string of arbitrary length and deterministically outputs a pseudorandom string of desired length. Mask Generation Functions are used in different cryptographic algorithms, including some RSA encryption schemes.

AES-CCM Functions

AES-CCM Functions are an implementation of the Counter with Cipher Block Chaining-Message Authentication Code (CCM) mode of operation of the AES cipher.

AES-GCM Functions

AES-GCM Functions implement the Galois/Counter Mode (GCM) of operation of the AES block cipher. GCM is an authenticated encryption algorithm, which allows you to verify the integrity of encrypted data.

Getting Help and Support

Getting Technical Support

If you did not register your Intel software product during installation, please do so now at the Intel® Software Development Products Registration Center. Registration entitles you to free technical support, product updates and upgrades for the duration of the support term.

For general information about Intel technical support, product updates, user forums, FAQs, tips and tricks and other support questions, please visit http://www.intel.com/software/products/support/ and the Intel IPP forum http://software.intel.com/en-us/forums/intel-integrated-performance-primitives/.

NOTE
If your distributor provides technical support for this product, please contact them rather than Intel.

What's New

The document has been updated with the following changes to the product:

- Added new sections to the Multi-buffer Functions chapter: Edwards Curve25519 Elliptic Curve Functions, SM2 Elliptic Curve Functions, SM4 Algorithm Functions, Modular Exponentiation.
- Added the `GFpECInitStd`, `GFpECPrivateKey`, `GFpECPublicKey`, `GFpECTstKeyPair`, `GFpECPSharedSecretDH`, `GFpECPSharedSecretDHC`, `GFpECPSignDSA`, `GFpECPSignNR`, `GFpECPSignSM2`, `GFpECPVerifyDSA`, `GFpECPVerifyNR`, `GFpECPVerifySM2` functions.
- Added the `AES_EncryptCFB16_MB` function.
- Added information on Security Validation of Library Functions.
- Expanded the description for the `GFpECSetPoint`, `GFpECSetPointHash`, and `GFpECGetPoint` functions.
- Added the section Multi-buffer Cryptography Functions. Added the `mbx_rsa_public`, `mbx_rsa_private`, `mbx_rsa_private_crt`, `mbx_RSA_Method_BufSize`, `mbx_nistp256/384/521_ecdsa_sign_setup`, `mbx_nistp256/384/521_ecdsa_sign_complete`, `mbx_nistp256/384/521_ecdsa_sign`, `mbx_nistp256/384/521_ecdsa_verify` , `mbx_nistp256/384/521_ecpublic_key`, `mbx_nistp256/384/521_ecdh`, `mbx_x25519_public_key`, `mbx_x25519` functions.
- Added HashMethodSet, HashMethodGetSize functions.
- Added SM3 Hash Functions.

Additionally, minor updates have been made to fix inaccuracies in the document.

Notational Conventions

The code and syntax used in this document for function and variable declarations are written in the ANSI C style. However, versions of Intel IPP for different processors or operating systems may, of necessity, vary slightly.

Product and Performance Information
Performance varies by use, configuration and other factors. Learn more at www.Intel.com/PerformanceIndex. Notice revision #20201201

In this document, notational conventions include:

- Fonts used for distinction between the text and the code
- Naming conventions for different items.

Font Conventions

The following font conventions are used throughout this document:

`This type style`	Mixed with the uppercase in function names, code examples, and call statements, for example, *`ippsAdd_BNU`*.
`This type style`	Parameters in function prototype parameters and parameters description, for example, *`pCtx`*, *`pSrcMesg`*.

Naming Conventions

The naming conventions for different items are the same as used by the Intel IPP software.

- All names of the functions used for cryptographic operations have the `ipps` prefix. In code examples, you can distinguish the Intel IPP interface functions from the application functions by this prefix.

  NOTE
  In this document, each function is introduced by its short name (without the `ipps` prefix and descriptors) and a brief description of its purpose.

  The `ipps` prefix in function names is always used in code examples and function prototypes. In the text, this prefix is omitted when referring to the function group.

- Each new part of a function name starts with an uppercase character, without underscore, for example, `ippsDESInit`.

Related Products

Intel® Integrated Performance Primitives (Intel® IPP)

Cryptography for Intel IPP is an add-on library for the main Intel IPP library, which provides a comprehensive set of application domain-specific highly optimized functions for signal processing, image and video processing, operations on small matrices, three-dimensional (3D) data processing and rendering. Search http://www.intel.com/software/products for more information.

Intel IPP Samples

An extensive library of code samples and codecs has been implemented using the Intel IPP functions to demonstrate the use of Intel IPP and to help accelerate the development of your applications, components, and codecs. The samples can be downloaded from www.intel.com/software/products/ipp/samples.htm.

Overview

This document describes the structure, operation, and functions of Intel® Integrated Performance Primitives (Intel® IPP) Cryptography. The document provides a background for cryptography concepts used in the Intel IPP Cryptography software as well as detailed description of the respective Intel IPP Cryptography functions. The Intel IPP Cryptography functions are combined in groups by their functionality. Each group of functions is described in a separate section.

For more information about cryptographic concepts and algorithms, refer to the books and materials listed in the Bibliography.

Basic Features

Like other members of Intel® Performance Libraries, Intel Integrated Performance Primitives is a collection of high-performance code that performs domain-specific operations. It is distinguished by providing a low-level, stateless interface.

Based on experience in developing and using Intel Performance Libraries, Intel IPP has the following major distinctive features:

- Intel IPP provides basic low-level functions for creating applications in several different domains, such as signal processing, image and video processing, operations on small matrices, and cryptography applications.
- Intel IPP functions follow the same interface conventions, including uniform naming conventions and similar composition of prototypes for primitives that refer to different application domains.
- Intel IPP functions use an abstraction level which is best suited to achieve superior performance figures by the application programs.

To speed up the performance, Intel IPP functions are optimized to use all benefits of Intel® architecture processors. Besides this, most of Intel IPP functions do not use complicated data structures, which helps reduce overall execution overhead.

Intel IPP is well-suited for cross-platform applications. For example, functions developed for the IA-32 architecture can be readily ported to the Intel® 64 architecture-based platform. In addition, each Intel IPP function has its reference code written in ANSI C, which clearly presents the algorithm used and provides for compatibility with different operating systems.

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Function Context Structures

Some Intel IPP Cryptography functions use special structures to store function-specific (context) information. For example, the `IppsRijndael128Spec` structure stores a set of round keys, a set of round inverse keys, and key management information for the Rijndael cipher scheme with the block size equal to 128.

Two different kinds of context structures are used:

- Specification structures, which are not modified during the function's operation. Their names include the Spec suffix.
- State structures, which are modified during operation. Their names include the `State` suffix.

Important
It is your application that defines the life cycle of the context: initialization, updating, and destruction.

Each type of context is initialized with the specific initialization function. For example, the `ippsAESInit` function initializes the user-supplied memory as the `IppsAESState` context.

Important
Your application must exclusively pass the address of the original (initialized by the suitable `Init` function) context to an Intel IPP function.

Simple copying of the context (for example, using `memcpy()`) and passing the address of this copy instead of the address of the original context to an Intel IPP call may lead to misinterpretation inside the library function.

See Also

Data Security Considerations

Data Security Considerations

IPP Cryptography functions use several types of buffers during operation, and some of them may contain sensitive information. These buffers may be reused multiple times, and there is no way for the underlying Intel IPP implementation to know when this data is no longer needed and sensitive information should be scrubbed from those buffers. Examples of sensitive information include but are not be limited to:

- Keys
- Initialization Vectors
- Context Structures

Important
If any such sensitive data is passed to Intel IPP, it is the responsibility of your application to scrub this information from the memory buffers.

See Also

Function Context Structures

Symmetric Cryptography Primitive Functions

In the context of secure data communication, symmetric cryptography primitive functions protect messages transferred over open communication media by offering adequate security strength to meet application security requirement, as well as algorithmic efficiency to enable secure communication in real time.

Intel® Integrated Performance Primitives (Intel® IPP) Cryptography offers operations using the following symmetric cryptography algorithms:

- Block ciphers: Rijndael [AES], including AES-CCM [NIST SP 800-38C] and AES-GCM [NIST SP 800-38D], Triple DES (TDES) [FIPS PUB 46-3], and SMS4 [SM4].
- Stream ciphers: ARCFour [AC], producing the same encryption/decryption as the RC4* proprietary cipher of RSA Security Inc.

Block Cipher Modes of Operation

Most of Symmetric Cryptography Algorithms implemented in Intel® IPP are Block Ciphers, which operate on data blocks of the fixed size. Block Ciphers encrypt a plaintext block into a ciphertext block or decrypts a ciphertext block into a plaintext block. The size of the data blocks depends on the specific algorithm. The table below shows the correspondence between Block Ciphers applied and their data block size.

Block Sizes in Symmetric Algorithms

Block Cipher Name	Data Block Size (bits)
Rijndael128 (AES)	128
TDES	64
SMS4	128

Block Cipher modes of executing the operation of encryption/decryption are applied in practice more frequently than “pure” Block Ciphers. On one hand, the modes enable you to process arbitrary length data stream. On the other hand, they provide additional security strength.

Intel IPP for cryptography supports five widely used modes, as specified in [NIST SP 800-38A]:

- Electronic Code Book (ECB) mode
- Cipher Block Chain (CBC) mode
- Cipher Feedback (CFB) mode

- Output Feedback (OFB) mode.
- Counter (CTR) mode.

Using the OFB mode

Intel IPP function APIs of the OFB mode contain the *ofbBlkSize* parameter, which represents size of the feedback. Possible size values vary between 8 and *B**8 bits, where *B* is the data block size of the underlying cipher. For cryptographic strength reasons, avoid using *ofbBlkSize* smaller than *B**8 bits.

Using the CTR mode

IPP calls performing encryption and decryption treat the processed message *msg* of length *msgLen* as an integral data unit. So the `ippsAESEncryptCTR` or `ippsAESDencryptCTR` function processes the whole message in a single call.

If an application cannot encrypt or decrypt the message in a single call, the input data *M* can be treated as a set of blocks

$M = M_0| |M_1| |\ldots M_{n-1}| |M_n$

where:

- *n* is the largest integer so that *B***n* is not bigger than the *M* size;
- lengths of the first *n* blocks M_0, ..., M_{n-1} are multiple to the data block size *B* of the underlying cipher;
- size of the last block M_n is between 0 and *B*-1 bytes.

In this case, the application processes the message *M* using a sequence of IPP encryption or decryption calls.

The cryptographic functions described in this section require the application to specify both the plaintext message and the ciphertext message lengths as multiples of block size of the respective algorithm (see Table "Block Sizes in Symmetric Algorithms"). To meet this requirement in ciphering the message, the application may use any padding scheme, for example, the scheme defined in [PKCS7]. In case padding is used, the application is responsible for correct interpretation and processing of the last deciphered message block. So of the three padding schemes available for earlier releases,

```
typedef enum {
    NONE  = 0, IppsCPPaddingNONE = 0,
    PKCS7 = 1, IppsCPPaddingPKCS7 = 1,
    ZEROS = 2, IppsCPPaddingZEROS = 2
} IppsCPPadding;
```

only `IppsCPPaddingNONE` remains acceptable.

Rijndael Functions

Rijndael cipher scheme is an iterated block cipher with a variable block size and a variable key length.

Rijndael functions with the 128-bit key length are, in fact, Advanced Encryption Standard (AES) cipher functions implemented in the way to comply with the American Standard FIPS 197.

The AES* functions use the `IppsAESSpec` context. This context serves as an operational vehicle to carry not only a set of round keys and a set of round inverse keys at the same time, but also the key management information.

Once the respective initialization function generates the round keys, the functions for ECB, CBC, CFB, and other modes are ready for either encrypting or decrypting the streaming data.

The application code for conducting a typical encryption under CBC mode using the AES scheme, that is, the Rijndael128 with a 128-bit key, should follow the sequence of operations as outlined below:

1. Get the size required to configure the context `IppsAESSpec` by calling the function `AESGetSize`.
2. Call the operating system memory-allocation service function to allocate a buffer whose size is no less than the one specified by the function `AESGetSize`.

3. Initialize the context `IppsAESSpec*pCtx` by calling the function `AESInit` with the allocated buffer and the respective 128-bit AES key.
4. Specify the initialization vector and call the function `AESEncryptCBC` to encrypt the input data stream using the AES encryption function with CBC mode.
5. Clean up secret data stored in the context.
6. Call the operating system memory free service function to release the buffer allocated for the context `IppsAESSpec`, if needed.

The `IppsAESSpec` context is position-dependent. The `AESPack/AESUnpack` function transforms the respective position-dependent context to a position-independent form and vice versa.

See Also

AES-CCM Functions
AES-GCM Functions
Data Security Considerations

AESGetSize

Gets the size of the `IppsAESSpec` *context.*

Syntax

```
IppStatus ippsAESGetSize(int* pSize);
```

Include Files

`ippcp.h`

Parameters

pSize	Pointer to the `IppsAESSpec` context size value.

Description

The function gets the `IppsAESSpec` context size in bytes and stores it in `*pSize`.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.

AESInit

Initializes user-supplied memory as `IppsAESSpec` *context for future use.*

Syntax

```
IppStatus ippsAESInit(const Ipp8u* pKey, int keylen, IppsAESSpec* pCtx, int ctxSize);
```

Include Files

`ippcp.h`

Parameters

pKey	Pointer to the AES key.

keylen	Key byte stream length in bytes defined by the `IppsRijndaelKeyLength` enumerator.
pCtx	Pointer to the buffer being initialized as `IppsAESSpec` context.
ctxSize	Available size of the buffer being initialized.

Description

This function initializes the memory pointed by *pCtx* as `IppsAESSpec`. The key is used to provide all necessary key material for both encryption and decryption operations.

NOTE
If the *pKey* pointer is `NULL`, the function initializes the context with the zero key, which can help you to clean up the actual secret before releasing the context.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if the *pCtx* pointer is `NULL`.
`ippStsLengthErr`	Returns an error condition if *keyLen* is not equal to 16, 24, or 32.
`ippStsMemAllocErr`	Indicates an error condition if the allocated memory is insufficient for the operation.

See Also

Data Security Considerations

AESSetKey

Resets the AES secret key in the initialized `IppsAESSpec` *context.*

Syntax

```
IppStatus ippsAESSetKey(const Ipp8u* pKey, int keylen, IppsAESSpec* pCtx);
```

Include Files

`ippcp.h`

Parameters

pKey	Pointer to the AES key.
keylen	Length of the secret key.
pCtx	Pointer to the initialized `IppsAESSpec` context.

Description

This function resets the AES secret key in the initialized `IppsAESSpec` context with the user-supplied secret key.

NOTE
If the *pKey* pointer is `NULL`, the function resets the context with the zero key, which can help you to clean up the actual secret before releasing the context.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if the *pCtx* pointer is `NULL`.
`ippStsLengthErr`	Returns an error condition if *keyLen* is not equal to 16, 24, or 32.

See Also

Data Security Considerations

AESPack, AESUnpack

Packs/unpacks the `IppsAESSpec` *context into/from a user-defined buffer.*

Syntax

```
IppStatus ippsAESPack (const IppsAESSpec* pCtx, Ipp8u* pBuffer, int bufSize);
IppStatus ippsAESUnpack (const Ipp8u* pBuffer, IppsAESSpec* pCtx, int ctxSize);
```

Include Files

`ippcp.h`

Parameters

pCtx	Pointer to the `IppsAESSpec` context.
pBuffer	Pointer to the user-defined buffer.
bufSize	Available size of the buffer.
ctxSize	Available size of the context.

Description

The AESPack function transforms the **pCtx* context to a position-independent form and stores it in the **pBuffer* buffer. The AESUnpack function performs the inverse operation, that is, transforms the contents of the **pBuffer* buffer into a normal `IppsAESSpec` context. The AESPack and AESUnpack functions enable replacing the position-dependent `IppsAESSpec` context in the memory.

Call the `AESGetSize` function prior to AESPack/AESUnpack to determine the size of the buffer.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if *bufSize* or *ctxSize* is less than the real size of the `IppsAESSpec` context.

`ippStsContextMatchErr`	Indicates an error condition if the *pCtx* parameter does not match the operation.

AESEncryptECB

Encrypts plaintext message by using ECB encryption mode (deprecated).

Syntax

```
IppStatus ippsAESEncryptECB(const Ipp8u *pSrc, Ipp8u *pDst, int srclen, const
IppsAESSpec* pCtx);
```

Include Files

`ippcp.h`

Parameters

pSrc	Pointer to the input plaintext data stream of variable length.
pDst	Pointer to the resulting ciphertext data stream.
srclen	Length of the input plaintext data in bytes.
pCtx	Pointer to the `IppsAESSpec` context.

Description

NOTE The ECB functionality remains in the library, but it is not safe when used as is. Use any other mode, for example CBC.

The function encrypts the input data stream of a variable length according to the cipher scheme specified in [NIST SP 800-38A].

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if the input data stream length is less than or equal to zero.
`ippStsUnderRunErr`	Indicates an error condition if *srclen* is not divisible by cipher block size.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

AESDecryptECB

Decrypts byte data stream by using the AES algorithm in the ECB mode (deprecated).

Syntax

```
IppStatus ippsAESDecryptECB(const Ipp8u* pSrc, Ipp8u* pDst, int srclen, const
IppsAESSpec* pCtx);
```

Include Files

`ippcp.h`

Parameters

pSrc	Pointer to the input ciphertext data stream of variable length.
pDst	Pointer to the resulting plaintext data stream of variable length.
srclen	Length of the ciphertext data stream in bytes.
pCtx	Pointer to the `IppsAESSpec` context.

Description

NOTE The ECB functionality remains in the library, but it is not safe when used as is. Use any other mode, for example CBC.

The function decrypts the input data stream of a variable length according to the ECB mode as specified in [NIST SP 800-38A].

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if the output data stream length is less than or equal to zero.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsUnderRunErr`	Indicates an error condition if *srclen* is not divisible by cipher block size.

AESEncryptCBC

Encrypts byte data stream according to AES in the CBC mode.

Syntax

```
IppStatus ippsAESEncryptCBC(const Ipp8u* pSrc, Ipp8u* pDst, int len, const IppsAESSpec*
pCtx, const Ipp8u* pIV);
```

Include Files

`ippcp.h`

Parameters

pSrc	Pointer to the input plaintext data stream of variable length.
pDst	Pointer to the resulting ciphertext data stream.
len	Length of the plaintext data stream length in bytes.

pCtx	Pointer to the `IppsAESSpec` context.
pIV	Pointer to the initialization vector for the CBC mode operation.

Description

The function encrypts the input data stream of a variable length according to the CBC mode as specified in [NIST SP 800-38A].

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if the input data stream length is less than or equal to zero.
`ippStsUnderRunErr`	Indicates an error condition if *len* is not divisible by data block size.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

AESDecryptCBC

Decrypts byte data stream according to AES in the CBC mode.

Syntax

```
IppStatus ippsAESDecryptCBC(const Ipp8u* pSrc, Ipp8u* pDst, int len, const IppsAESSpec*
pCtx, const Ipp8u* pIV);
```

Include Files

`ippcp.h`

Parameters

pSrc	Pointer to the input ciphertext data stream.
pDst	Pointer to the resulting plaintext data stream of the variable length.
len	Length of the ciphertext data stream length in bytes.
pCtx	Pointer to the `IppsAESSpec` context.
pIV	Pointer to the initialization vector for CBC mode operation.

Description

The function decrypts the input data stream of a variable length according to the CBC mode as specified in [NIST SP 800-38A].

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.

`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if the output data stream length is less than or equal to zero.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsUnderRunErr`	Indicates an error condition if *`len`* is not divisible by cipher block size.

AESEncryptCBC_CS

Encrypts plaintext in the CBC ciphertext stealing mode of the AES block cipher.

Syntax

```
IppStatus ippsAESEncryptCBC_CS1(const Ipp8u* pSrc, Ipp8u* pDst, int len, const
IppsAESSpec* pCtx, const Ipp8u* pIV);
```

```
IppStatus ippsAESEncryptCBC_CS2(const Ipp8u* pSrc, Ipp8u* pDst, int len, const
IppsAESSpec* pCtx, const Ipp8u* pIV);
```

```
IppStatus ippsAESEncryptCBC_CS3(const Ipp8u* pSrc, Ipp8u* pDst, int len, const
IppsAESSpec* pCtx, const Ipp8u* pIV);
```

Include Files

`ippcp.h`

Parameters

`pSrc`	Pointer to the input plaintext data of variable length.
`pDst`	Pointer to the resulting ciphertext data.
`len`	Length of the input data stream in bytes.
`pCtx`	Pointer to the `IppsAESSpec` context.
`pIV`	Pointer to the initialization vector for the CBC mode operation.

Description

These functions encrypt the input data stream according to the three variants of the Cipher Block Chaining (CBC) mode with Ciphertext Stealing (CS), as specified in [NIST SP 800-38A A.]. An important difference of these variants from the CBC mode without CS is that the number of bits in the input plaintext does not have to be a multiple of the block size.

The block size is 128 bits in accordance with [FIPS PUB 197].

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.

`ippStsLengthErr`	• For AESEncryptCBC_CS1 and AESEncryptCBC_CS2, indicates an error condition if the input data length is less than the cipher block size. • For AESEncryptCBC_CS3, indicates an error condition if the input data length is less than or equal to the cipher block size.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

AESDecryptCBC_CS

Decrypts plaintext in the CBC ciphertext stealing mode of the AES block cipher.

Syntax

IppStatus ippsAESDecryptCBC_CS1(const Ipp8u* *pSrc*, Ipp8u* *pDst*, int *len*, const IppsAESSpec* *pCtx*, const Ipp8u* *pIV*);

IppStatus ippsAESDecryptCBC_CS2(const Ipp8u* *pSrc*, Ipp8u* *pDst*, int *len*, const IppsAESSpec* *pCtx*, const Ipp8u* *pIV*);

IppStatus ippsAESDecryptCBC_CS3(const Ipp8u* *pSrc*, Ipp8u* *pDst*, int *len*, const IppsAESSpec* *pCtx*, const Ipp8u* *pIV*);

Include Files

`ippcp.h`

Parameters

pSrc	Pointer to the input ciphertext data of variable length.
pDst	Pointer to the resulting plaintext data.
len	Length of the input data stream in bytes.
pCtx	Pointer to the `IppsAESSpec` context.
pIV	Pointer to the initialization vector for the CBC mode operation.

Description

These functions decrypt the input data stream according to the three variants of the Cipher Block Chaining (CBC) mode with Ciphertext Stealing (CS), as specified in [NIST SP 800-38A A.].

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	• For AESDecryptCBC_CS1 and AESDecryptCBC_CS2, indicates an error condition if the input data length is less than the cipher block size. • For AESDecryptCBC_CS3, indicates an error condition if the input data length is less than or equal to the cipher block size.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

AESEncryptCFB

Encrypts byte data stream according to AES in the CFB mode.

Syntax

IppStatus ippsAESEncryptCFB(const Ipp8u* *pSrc*, Ipp8u* *pDst*, int *srcLen*, int *cfbBlkSize*, const IppsAESSpec* *pCtx*, const Ipp8u **pIV*);

Include Files

ippcp.h

Parameters

pSrc	Pointer to the input plaintext data stream of variable length.
pDst	Pointer to the resulting ciphertext data stream.
srcLen	Length of the plaintext data stream in bytes.
cfbBlkSize	Size of the CFB block in bytes.
pCtx	Pointer to the IppsAESSpec context.
pIV	Pointer to the initialization vector for the CFB mode operation.

Description

The function encrypts the input data stream of variable length according to the CFB mode as specified in [NIST SP 800-38A].

Return Values

ippStsNoErr	Indicates no error. Any other value indicates an error or warning.
ippStsNullPtrErr	Indicates an error condition if any of the specified pointers is NULL.
ippStsLengthErr	Indicates an error condition if the input data stream length is less than or equal to zero.
ippStsUnderRunErr	Indicates an error condition if *srcLen*is not divisible by *cfbBlkSize* parameter value.
ippStsCFBSizeErr	Indicates an error condition if the value for *cfbBlkSize* is illegal.
ippStsContextMatchErr	Indicates an error condition if the context parameter does not match the operation.

AES_EncryptCFB16_MB

Encrypts multiple independent buffers of byte data according to AES in the CFB mode with 16-byte CFB block size.

Syntax

IppStatus ippsAES_EncryptCFB16_MB(const Ipp8u* *pSrc[]*, Ipp8u* *pDst[]*, int len[], const IppsAESSpec* *pCtx[]*, const Ipp8u **pIV[]*, IppStatus status[] , int numBuffers);

Include Files

`ippcp.h`

Parameters

pSrc[]	Pointer to the array of the input plaintext data streams of variable length.
pDst[]	Pointer to the array of the resulting ciphertext data streams.
len[]	Pointer to the array of the lengths of the plaintext data streams, in bytes.
pCtx[]	Pointer to the array of the `IppsAESSpec` contexts.
pIV[]	Pointer to the array of initialization vectors for the CFB mode operation.
status[]	Pointer to the `IppStatus` array thar contains status for each processed buffer in an encryption operation.
numBuffers	Number of buffers to be processed.

Description

The function performs the AES multi-buffer encryption operation, which consists of several AES operations performed simultaneously with a variable-length input data stream in accordance with the CFB mode, as specified in [NIST SP 800-38A].

The function can perform a variable number of independent AES CFB encryption operations at the same time. This number is specified in the *numBuffers* parameter.

Each AES CFB encryption operation requires valid parameters that follow the `AESEncryptCFB` syntax.

After execution, the statuses array contains statuses for each single AES CFB encryption operation returned by `AESEncryptCFB`.

Important
All *IppAESSpecs* in operation must be initialized with the same size of key (see `ippsAESInit` and `ippsAESSetKey`).

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if the input *numBuffers* parameter is less than or equal to zero.
`ippStsContextMatchErr`	Indicates an error condition if input buffers have different key sizes.
`ippStsErr`	Indicates an error when one or more processed operations are executed with errors. For details, check the statuses array.

AESDecryptCFB

Decrypts byte data stream according to AES in CFB mode.

Syntax

```
IppStatus ippsAESDecryptCFB(const Ipp8u* pSrc, Ipp8u* pDst, int srclen, int cfbBlkSize,
const IppsAESSpec* pCtx, const Ipp8u* pIV);
```

Include Files

`ippcp.h`

Parameters

pSrc	Pointer to the input ciphertext data stream.
pDst	Pointer to the resulting plaintext data stream of variable length.
srclen	Length of the ciphertext data stream in bytes.
cfbBlkSize	Size of the CFB block in bytes.
pCtx	Pointer to the `IppsAESSpec` context.
pIV	Pointer to the initialization vector for the CFB mode operation.

Description

The function decrypts the input data stream of variable length according to the CFB mode as specified in [NIST SP 800-38A].

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if the output data stream length is less than or equal to zero.
`ippStsCFBSizeErr`	Indicates an error condition if the value for *cfbBlkSize* is illegal.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsUnderRunErr`	Indicates an error condition if *srcLen* is not divisible by cipher block size.

AESEncryptOFB

Encrypts a variable length data stream according to AES in the OFB mode.

Syntax

```
IppStatus ippsAESEncryptOFB (const Ipp8u* pSrc, Ipp8u* pDst, int srclen, int
ofbBlkSize, const IppsAESSpec* pCtx, Ipp8u* pIV);
```

Include Files

ippcp.h

Parameters

pSrc	Pointer to the input plaintext data stream of variable length.
pDst	Pointer to the resulting ciphertext data stream.
srclen	Length of the plaintext data stream in bytes.
ofbBlkSize	Size of the OFB block in bytes.
pCtx	Pointer to the IppsAESSpec context.
pIV	Pointer to the initialization vector for the OFB mode operation.

Description

The function encrypts the input data stream of a variable length in the OFB mode as specified in [NIST SP 800-38A].

Return Values

ippStsNoErr	Indicates no error. Any other value indicates an error or warning.
ippStsNullPtrErr	Indicates an error condition if any of the specified pointers is NULL.
ippStsLengthErr	Indicates an error condition if the input data stream length is less than or equal to zero.
ippStsUnderRunErr	Indicates an error condition if *srclen* is not divisible by the *ofbBlkSize* parameter value.
ippStsOFBSizeErr	Indicates an error condition if the value of *ofbBlkSize* is illegal.
ippStsContextMatchErr	Indicates an error condition if the context parameter does not match the operation.

AESDecryptOFB

Decrypts a variable length data stream according to AES in the OFB mode.

Syntax

IppStatus ippsAESDecryptOFB (const Ipp8u* *pSrc*, Ipp8u* *pDst*, int *srclen*, int *ofbBlkSize*, const IppsAESSpec* *pCtx*, Ipp8u* *pIV*);

Include Files

ippcp.h

Parameters

pSrc	Pointer to the input ciphertext data stream of variable length.
pDst	Pointer to the resulting plaintext data stream.
srclen	Length of the ciphertext data stream in bytes.

ofbBlkSize	Size of the OFB block in bytes.
pCtx	Pointer to the `IppsAESSpec` context.
pIV	Pointer to the initialization vector for the OFB mode operation.

Description

The function decrypts the input data stream of a variable length in the OFB mode as specified in [NIST SP 800-38A].

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if the input data stream length is less than or equal to zero.
`ippStsUnderRunErr`	Indicates an error condition if *srclen*is not divisible by the *ofbBlkSize* parameter value.
`ippStsOFBSizeErr`	Indicates an error condition if the value of *ofbBlkSize* is illegal.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

AESEncryptCTR

Encrypts a variable length data stream in the CTR mode.

Syntax

```
IppStatus ippsAESEncryptCTR(const Ipp8u* pSrc, Ipp8u* pDst, int srcLen,const
IppsAESSpec* pCtx, Ipp8u* pCtrValue , int ctrNumBitSize);
```

Include Files

`ippcp.h`

Parameters

pSrc	Pointer to the input plaintext data stream of a variable length.
pDst	Pointer to the resulting ciphertext data stream.
srcLen	Length of the plaintext data stream in bytes.
pCtx	Pointer to the `IppsAESSpec` context.
pCtrValue	Pointer to the counter data block.
ctrNumBitSize	Number of bits in the specific part of the counter to be incremented.

Description

The function encrypts the input data stream of a variable length according to the CTR mode as specified in [NIST SP 800-38A].

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if the input data stream length is less than or equal to zero.
`ippStsCTRSizeErr`	Indicates an error condition if the value of the *`ctrNumBitSize`* is illegal.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

AESDecryptCTR

Decrypts a variable length data stream in the CTR mode.

Syntax

```
IppStatus ippsAESDecryptCTR(const Ipp8u* pSrc, Ipp8u* pDst, int srcLen,const
IppsAESSpec* pCtx, Ipp8u* pCtrValue, int ctrNumBitSize);
```

Include Files

`ippcp.h`

Parameters

`pSrc`	Pointer to the input ciphertext data stream.
`pDst`	Pointer to the resulting plaintext data stream of a variable length.
`srcLen`	Length of the plaintext data stream in bytes.
`pCtx`	Pointer to the `IppsAESSpec` context.
`pCtrValue`	Pointer to the counter data block.
`ctrNumBitSize`	Number of bits in the specific part of the counter to be incremented.

Description

The function decrypts the input data stream of a variable length according to the CTR mode as specified in the [NIST SP 800-38A].

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if the output data stream length is less than or equal to zero.
`ippStsCTRSizeErr`	Indicates an error condition if the value of the *`ctrNumBitSize`* is illegal.

`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

AESEncryptXTS_Direct, AESDecryptXTS_Direct

Encrypts/decrypts a data buffer in the XTS mode.

Syntax

```
IppStatus ippsAESEncryptXTS_Direct(const Ipp8u* pSrc, Ipp8u* pDst, int encBitSize, int
aesBlkNo, const Ipp8u* pTweakPT, const Ipp8u* pKey, int keyBitSize, int
dataUnitBitSize);
```

```
IppStatus ippsAESDecryptXTS_Direct(const Ipp8u* pSrc, Ipp8u* pDst, int encBitSize, int
aesBlkNo, const Ipp8u* pTweakPT, const Ipp8u* pKey, int keyBitSize, int
dataUnitBitSize);
```

Include Files

`ippcp.h`

Parameters

pSrc	Pointer to the input (plain- or cipher-text) data buffer.
pDst	Pointer to the output (cipher- or plain-text) data buffer.
encBitSize	Length of the input data being encrypted or decrypted, in bits. The output data length is equal to the input data length.
aesBlkNo	The sequential number of the first plain- or cipher-text block for operation inside the data unit.
pTweakPT	Pointer to the little-endian 16-byte array that contains the tweak value assigned to the data unit being encrypted/ decrypted.
pKey	Pointer to the XTS-AES key.
keyBitSize	Size of the XTS-AES key, in bits.
dataUnitBitSize	Size of the data unit, in bits.

Description

These functions encrypt or decrypt the input data according to the XTS-AES mode [IEEE P1619] of the AES block cipher. The XTS-AES tweakable block cipher can be used for encryption/decryption of sector-based storage. The XTS-AES algorithm acts on a single **data unit** or a section within the data unit and uses AES as the internal cipher. The length of the data unit must be 128 bits or more. The data unit is considered as partitioned into `m+1` blocks:

`T = T[0] | T[1] | … |T[m-2] | T[m-1] | T[m]`

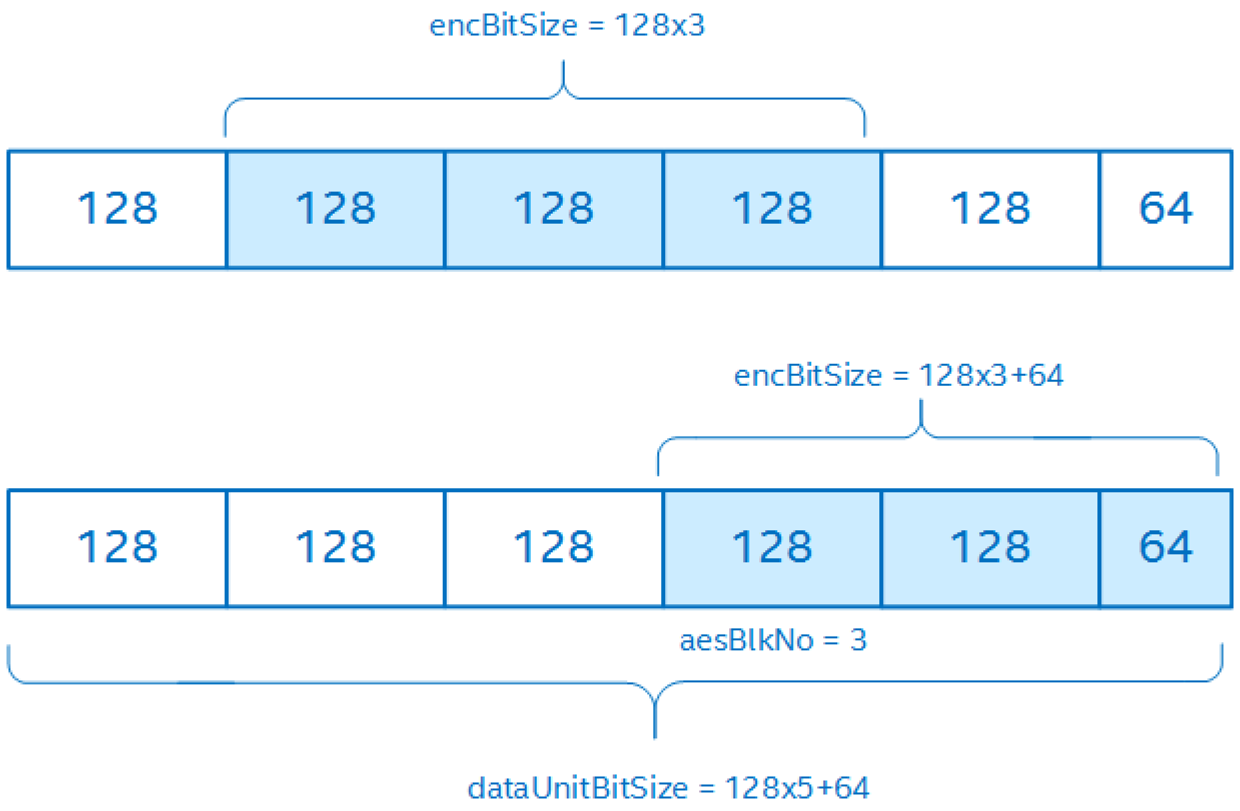
where

- `m = ceil(`*dataUnitBitLen*`/128)`
- the first `m` blocks `T[0], T[1], …,T[m-1]` are exactly 128 bits long
- the last block `T[m]` is between 0 and 127 bits long (it could be empty, for example, 0 bits long)

The cipher processes the first `(m-1)` blocks `T[0], T[1], …, T[m-2]` independently of each other. If the last block `T[m]`*is empty*, then the block `T[m-1]` is processed independently too. However, if the last block `T[m]`*is not empty,* the cipher processes the blocks `T[m-1]` and `T[m]` together using a *ciphertext stealing* mechanism. See [IEEE P1619] for details.

With the Intel IPP implementation of XTS-AES, you can select a sequence of adjacent data blocks (section) within the data unit for processing. The section you select is specified by the *aesBlkNo* and *encBitSize* parameters.

The ciphertext stealing mechanism constrains possible section selections. If the last block `T[m]` of the data unit is not empty, the section you select must contain either both `T[m-1]` and `T[m]` or neither of them. Therefore, consider *encBitSize*, *aesBlkNo*, and *dataUnitBitSize* all together when making a function call. The following figure shows valid selections of a section within the data unit:



The XTS-AES block cipher uses tweak values to ensure that each data unit is processed differently. A tweak value is a 128-bit integer that represents the logical position of the data unit. The tweak values are assigned to the data units consecutively, starting from an arbitrary non-negative integer. Before calling the function, convert the tweak value into a 16-byte little-endian array. For example, the tweak value 0x123456789A corresponds to the byte array

```
Ipp8u twkArray[16] = {0x9A, 0x78, 0x56, 0x34, 0x12, 0x00, 0x00, 0x00,
                      0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00}.
```

The key for XTS-AES is parsed as a concatenation of two fields of equal size, called `data key` and `tweak key`, so that `key = data key|tweak key`.

where

- `data key` is used for data encryption/decryption
- `tweak key` is used for encryption of the tweak value

The standard allows only AES128 and AES256 keys.

Refer to [IEEE P1619] for more details.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error when any of the specified pointers is `NULL`.
`ippsStsLengthErr`	Indicates an error condition when: • *`encBitSize`* `< 128` • *`keyBitSize`* `!= 256` and *`keyBitSize`* `!= 512` • *`dataUnitBitSize`* `< 128`
`ippsStsBadArgErr`	Indicates an error when: • *`aesBlkNo`* `< 0` • *`aesBlkNo`* `>=` *`dataUnitBitSize`*`/128` • There is any other inconsistency with the assumed data unit partition

Example of Using AES Functions

AES Encryption and Decryption

```
    // use of the CTR mode
int AES_sample(void)
{
   // secret key
   Ipp8u key[] = "\x00\x01\x02\x03\x04\x05\x06\x07"
                 "\x08\x09\x10\x11\x12\x13\x14\x15";
   // define and setup AES cipher
   int ctxSize;
   ippsAESGetSize(&ctxSize);
   IppsAESSpec* pAES = (IppsAESSpec*)( new Ipp8u [ctxSize] );
   ippsAESInit(key, sizeof(key)-1, pAES, ctxSize);

   // message to be encrypted
   Ipp8u msg[] = "the quick brown fox jumps over the lazy dog";
   // and initial counter
   Ipp8u ctr0[] = "\xff\xee\xdd\xcc\xbb\xaa\x99\x88"
                  "\x77\x66\x55\x44\x33\x22\x11\x00";

   // counter
   Ipp8u ctr[16];

   // init counter before encryption
   memcpy(ctr, ctr0, sizeof(ctr));
   // encrypted message
   Ipp8u  ctext[sizeof(msg)];
   // encryption
   ippsAESEncryptCTR(msg, ctext, sizeof(msg), pAES, ctr, 64);

   // init counter before decryption
   memcpy(ctr, ctr0, sizeof(ctr));
   // decrypted message
   Ipp8u  rtext[sizeof(ctext)];
   // decryption
   ippsAESDecryptCTR(ctext, rtext, sizeof(ctext), pAES, ctr, 64);
   // remove secret and release resource
   ippsAESInit(0, sizeof(key)-1, pAES, ctxSize);
   delete [] (Ipp8u*)pAES;

   int error = memcmp(rtext, msg, sizeof(msg));
   return 0==error;
}
```

AES-CCM Functions

This section describes functions for authenticated encryption/decryption using the Counter with Cipher Block Chaining-Message Authentication Code (CCM) mode [NIST SP 800-38C] of the AES (Rijndael128) block cipher.

The AES-CCM functions enable authenticated encryption/decryption of several messages using one key that the AES_CCMInit function sets. Processing of each new message starts with a call to the AES_CCMStart function. The application code for conducting a typical AES-CCM authenticated encryption should follow the sequence of operations as outlined below:

1. Get the size required to configure the context IppsAES_CCMState by calling the function AES_CCMGetSize.
2. Call the system memory-allocation service function to allocate a buffer whose size is not less than the function AES_CCMGetSize specifies.
3. Initialize the context IppsAES_CCMState*pCtx by calling the function AES_CCMInit with the allocated buffer and respective AES key.
4. Optionally call AES_CCMMessageLen and/or AES_CCMTagLen to set up message and tag parameters.
5. Call AES_CCMStart to start authenticated encryption of the first/next message.
6. Keep calling AES_CCMEncrypt until the entire message is processed.
7. Request the authentication tag by calling AES_CCMGetTag.
8. Proceed to the next message, if any, that is, go to step 5.
9. Clean up secret data stored in the context.
10. Call the system memory free service function to release the buffer allocated for the context IppsAES_CCMState, if needed.

See Also

Data Security Considerations

AES_CCMGetSize

Gets the size of the IppsAES_CCMState *context.*

Syntax

```
IppStatus ippsAES_CCMGetSize(int* pSize);
```

Include Files

ippcp.h

Parameters

pSize	Pointer to the size of the IppsAES_CCMState context.

Description

The function gets the size of the IppsAES_CCMState context in bytes and stores it in **pSize*.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if the specified pointer is `NULL`.

AES_CCMInit

Initializes user-supplied memory as the `IppsAES_CCMState` *context for future use.*

Syntax

`IppStatus ippsAES_CCMInit(const Ipp8u*` *`pKey`*`, int` *`keyLen`*`, IppsAES_CCMState*` *`pState`*`, int` *`ctxSize`*`);`

Include Files

`ippcp.h`

Parameters

pKey Pointer to the secret key.

keyLen Length of the secret key.

pState Pointer to the buffer being initialized as `IppsAES_CCMState` context.

ctxSize Size of the buffer being initialized.

Description

The function initializes the memory pointed by *pState* as the `IppsAES_CCMState` context. In addition, the function uses the initialization variable and additional authenticated data to provide all necessary key material for both encryption and decryption.

NOTE
If the *pKey* pointer is `NULL`, the function initializes the context with the zero key, which can help you to clean up the actual secret before releasing the context.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if the *pState* pointer is `NULL`.
`ippStsLengthErr`	Indicates an error condition an error condition if *keyLen* is not equal to 16, 24, or 32.
`ippStsMemAllocErr`	Indicates an error condition if the allocated memory is insufficient for the operation.

See Also

Data Security Considerations

AES_CCMStart

Starts the process of authenticated encryption/ decryption for a new message.

Syntax

IppStatus ippsAES_CCMStart(const Ipp8u* *pIV*, int *ivLen*, const Ipp8u* *pAD*, int *adLen*, IppsAES_CCMState* *pCtx*);

Include Files

ippcp.h

Parameters

pIV	Pointer to the initialization vector.
ivLen	Length of the initialization vector **pIV* (in bytes).
pAD	Pointer to the additional authenticated data.
adLen	Length of additional authenticated data **pAAD* (in bytes).
pCtx	Pointer to the IppsAES_CCMState context.

Description

The function resets internal counters and buffers of the **pCtx* context.

Return Values

ippStsNoErr	Indicates no error. Any other value indicates an error or warning.
pState	Indicates an error condition if any of the specified pointers is NULL.
pState	Indicates an error condition if the context parameter does not match the operation.
pState	Indicates an error condition if *ivLen* < 7 or *ivLen* > 13 .

AES_CCMEncrypt

Encrypts a data buffer in the CCM mode.

Syntax

IppStatus ippsAES_CCMEncrypt(const Ipp8u* *pSrc*, Ipp8u* *pDst*, int *len*, IppsAES_CCMState* *pState*);

Include Files

ippcp.h

Parameters

pSrc	Pointer to the input plaintext data stream of a variable length.
pDst	Pointer to the resulting ciphertext data stream.
len	Length of the plaintext and ciphertext data stream in bytes.

pState	Pointer to the `IppsAES_CCMState` context.

Description

The function encrypts the input data stream of a variable length in the CCM mode as specified in [NIST SP 800-38C].

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsLengthErr`	Indicates an error condition if *len* is less than zero or the value that accumulates *len* parameters from previous calls to `AES_CCMEncrypt` with the current value of *len* exceeds the tag length specified in the previous call to AES_CCMMessageLen.

AES_CCMDecrypt

Decrypts a data buffer in the CCM mode.

Syntax

```
IppStatus ippsAES_CCMDecrypt(const Ipp8u* pSrc, Ipp8u* pDst, int len, IppsAES_CCMState*
pState);
```

Include Files

`ippcp.h`

Parameters

pSrc	Pointer to the input ciphertext data stream of variable length.
pDst	Pointer to the resulting plaintext data stream.
len	Length of the plaintext and ciphertext data stream in bytes.
pState	Pointer to the `IppsAES_CCMState` context.

Description

The function decrypts the input ciphered data stream of a variable length in the CCM mode as specified in [NIST SP 800-38C].

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

`ippStsLengthErr`	Indicates an error condition if *len* is less than zero or the value that accumulates *len* parameters from previous calls to `AES_CCMDecrypt` with the current value of *len* exceeds the tag length specified in the previous call to AES_CCMMessageLen.

AES_CCMGetTag

Generates the message authentication tag in the CCM mode.

Syntax

```
IppStatus ippsAES_CCMGetTag (Ipp8u* pTag, int tagLen, const IppsAES_CCMState* pState);
```

Include Files

`ippcp.h`

Parameters

pTag	Pointer to the authentication tag.
tagLen	Length of the authentication tag **pTag* (in bytes).
pState	Pointer to the `IppsAES_CCMState` context.

Description

The function generates and computes the authentication tag of length *tagLen* bytes in the CCM mode as specified in [NIST SP 800-38C]. The `ippsRijndael128GCMGetTag` function does not stop the encryption/decryption and authentication process.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsLengthErr`	Indicates an error condition if *tagLen* is less than one or *tagLen* exceeds the tag length specified in the previous call to AES_CCMTagLen.

AES_CCMMessageLen

Sets up the length of the message to be processed.

Syntax

```
IppStatus ippsAES_CCMMessageLen(Ipp64u msgLen, IppsAES_CCMState* pState);
```

Include Files

`ippcp.h`

Parameters

msgLen	Length of the message to be processed (in bytes).

pState	Pointer to the `IppsAES_CCMState` context.

Description

The function assigns the value of *msgLen* to the length of the message to be processed in the **pState* context.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsLengthErr`	Indicates an error condition if *msgLen*=0.

AES_CCMTagLen

Sets up the length of the required authentication tag.

Syntax

```
IppStatus ippsAES_CCMTagLen(int tagLen, IppsAES_CCMState* pState);
```

Include Files

`ippcp.h`

Parameters

tagLen	Length of the required authentication tag (in bytes).
pState	Pointer to the `IppsAES_CCMState` context.

Description

The function assigns the value of *tagLen* to the length of the required authentication tag in the **pState* context.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsLengthErr`	Indicates an error condition if *tagLen* < 4 or *tagLen* > 16 or *taglen* is odd.

AES-GCM Functions

The Galois/Counter Mode (GCM) is a mode of operation of the AES algorithm. GCM [NIST SP 800-38D] uses a variation of the Counter mode of operation for encryption. GCM assures authenticity of the confidential data (of up to about 64 GB per invocation) using a universal hash function defined over a binary finite field (the Galois field).

GCM can also provide authentication assurance for additional data (of practically unlimited length per invocation) that is not encrypted. If the GCM input contains only data that is not to be encrypted, the resulting specialization of GCM, called GMAC, is simply an authentication mode for the input data.

GCM provides stronger authentication assurance than a (non-cryptographic) checksum or error detecting code. In particular, GCM can detect both accidental modifications of the data and intentional, unauthorized modifications.

The AES-GCM function set includes incremental functions, which enable authenticated encryption/decryption of several messages using one key. The application code for conducting a typical AES-GCM authenticated encryption should follow the sequence of operations as outlined below:

1. Get the size required to configure the context `IppsAES_GCMState` by calling the function `AES_GCMGetSize`.
2. Call the system memory-allocation service function to allocate a buffer whose size is not less than the function `AES_GCMGetSize` specifies.
3. Initialize the context `IppsAES_GCMState*`*`pCtx`* by calling the function `AES_GCMInit` with the allocated buffer and the respective AES key.
4. Call `AES_GCMStart` to start authenticated encryption of the first/next message.
5. Keep calling `AES_GCMEncrypt` until the entire message is processed.
6. Request the authentication tag by calling `AES_GCMGetTag`.
7. Proceed to the next message, if any, that is, go to step 4.
8. Clean up secret data stored in the context.
9. Call the system memory free service function to release the buffer allocated for the context `IppsAES_GCMState`, if needed.

If the size of the initial vector and/or additional authenticated data (*IV* and *AAD* parameters of the `AES_GCMStart` function, respectively) is large or any of these parameters is placed in a disconnected memory buffer, replace step 4 above with the following sequence:

1. Call `AES_GCMReset` to prepare the `IppsAES_GCMState` context for authenticated encryption of the first/new message.
2. Keep calling `AES_GCMProcessIV` for successive parts of *IV* until the entire *IV* is processed.
3. Keep calling `AES_GCMProcessAAD` for successive parts of *AAD* until the entire *AAD* is processed.

See Also

Data Security Considerations

AES_GCMGetSize

Gets the size of the `IppsAES_GCMState` *context for use of the AES-GCM implementation with the specified characteristics.*

Syntax

```
IppStatus ippsAES_GCMGetSize(int* pSize);
```

Include Files

```
ippcp.h
```

Parameters

pSize	Pointer to the size of the `IppsAES_GCMState` context.

Description

The function gets the size of the `IppsAES_GCMState` context (in bytes) and stores the size in `*`*pSize*.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if the specified pointer is `NULL`.

AES_GCMInit

Initializes user-supplied memory as the `IppsAES_GCMState` *context for future use.*

Syntax

`IppStatus ippsAES_GCMInit(const Ipp8u*` *pKey*`, int` *keyLen*`, IppsAES_GCMState*` *pState*`, int` *ctxSize*`);`

Include Files

`ippcp.h`

Parameters

pKey	Pointer to the secret key.
keyLen	Length of the secret key.
pState	Pointer to the buffer being initialized as `IppsAES_GCMState` context.
ctxSize	Available size of the buffer.

Description

The function initializes the memory pointed by *pState* as the `IppsAES_GCMState` context. In addition, the function uses the initialization variable and additional authenticated data to provide all necessary key material for both encryption and decryption.

Call the `AES_GCMGetSize` function prior to `AES_GCMInit` to determine the size of the buffer.

NOTE
If the *pKey* pointer is `NULL`, the function initializes the context with the zero key, which can help you to clean up the actual secret before releasing the context.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if the *pState* pointer is `NULL`.

`ippStsLengthErr`	Indicates an error condition if *keyLen* is not equal to 16, 24, or 32.
`ippStsMemAllocErr`	Indicates an error condition if the allocated memory is insufficient for the operation.

See Also

Data Security Considerations

AES_GCMStart

Starts the process of authenticated encryption/ decryption for new message.

Syntax

```
IppStatus ippsAES_GCMStart(const Ipp8u* pIV, int ivLen, const Ipp8u* pAAD, int aadLen,
IppsAES_GCMState* pState);
```

Include Files

`ippcp.h`

Parameters

pIV	Pointer to the initialization vector.
ivLen	Length of the initialization vector **pIV* (in bytes).
pAAD	Pointer to the additional authenticated data.
aadLen	Length of additional authenticated data **pAAD* (in bytes).
pState	Pointer to the `IppsAES_GCMState` context.

Description

The function resets internal counters and buffers of the **pState* context.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is NULL.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsLengthErr`	Indicates an error condition if the length of the initialization vector is zero.

AES_GCMReset

Resets the `IppsAES_GCMState` *context for authenticated encryption/decryption of a new message.*

Syntax

```
IppStatus ippsAES_GCMReset(IppsAES_GCMState* pState);
```

Include Files

`ippcp.h`

Parameters

`pState`	Pointer to the `IppsAES_GCMState` context.

Description

The function resets the *`*pState`* context to prepare it for either of the following operations with a new message:

- encryption and tag generation
- decryption and tag authentication

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is NULL.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

AES_GCMProcessIV

Processes an initial vector of a given length according to the GCM specification.

Syntax

```
IppStatus ippsAES_GCMProcessIV(const Ipp8u* pIV, int ivLen, IppsAES_GCMState* pState);
```

Include Files

`ippcp.h`

Parameters

`pIV`	Pointer to the initialization vector.
`ivLen`	Length of the initialization vector *`*pIV`* (in bytes).
`pState`	Pointer to the `IppsAES_GCMState` context.

Description

The function processes *`ivLen`* bytes of the initial vector *`*pIV`* as specified in [NIST SP 800-38D].

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is NULL.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

`ippStsLengthErr`	Indicates an error condition if the length of the initialization vector is zero.
`ippStsBadArgErr`	Indicates an error condition if the *`pState`* parameter value is not `GcmInit` or `GcmIVProcessing`. This means that the function call sequence is illegal.

AES_GCMProcessAAD

Processes additional authenticated data of a given length according to the GCM specification.

Syntax

```
IppStatus ippsAES_GCMProcessAAD(const Ipp8u* pAAD, int ivAAD, IppsAES_GCMState*
pState);
```

Include Files

`ippcp.h`

Parameters

`pAAD`	Pointer to the additional authenticated data.
`ivAAD`	Length of additional authenticated data *`*pAAD`* (in bytes).
`pState`	Pointer to the `IppsAES_GCMState` context.

Description

The function processes *`ivAAD`* bytes of additional authenticated data *`*pAAD`* as specified in [NIST SP 800-38D].

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is NULL.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsLengthErr`	Indicates an error condition if *`ivAAD`* is less than zero.
`ippStsBadArgErr`	Indicates an error condition if *`ivAAD`* is zero and *`pState`* is not `GcmInit` or `GcmIVProcessing`. This means that the function call sequence is illegal.

AES_GCMEncrypt

Encrypts a data buffer in the GCM mode.

Syntax

```
IppStatus ippsAES_GCMEncrypt(const Ipp8u* pSrc, Ipp8u* pDst, int len, IppsAES_GCMState*
pState);
```

Include Files

`ippcp.h`

Parameters

pSrc	Pointer to the input plaintext data stream of a variable length.
pDst	Pointer to the resulting ciphertext data stream.
len	Length of the plaintext and ciphertext data stream in bytes.
pState	Pointer to the `IppsAES_GCMState` context.

Description

The function encrypts the input data stream of a variable length according to GCM as specified in [NIST SP 800-38D].

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsLengthErr`	Indicates an error condition if *len* is less than zero.

AES_GCMDecrypt

Decrypts a data buffer in the GCM mode.

Syntax

```
IppStatus ippsAES_GCMDecrypt(const Ipp8u* pSrc, Ipp8u* pDst, int len, IppsAES_GCMState*
pState);
```

Include Files

`ippcp.h`

Parameters

pSrc	Pointer to the input ciphertext data stream of a variable length.
pDst	Pointer to the resulting plaintext data stream.
len	Length of the plaintext and ciphertext data stream in bytes.
pState	Pointer to the `IppsAES_GCMState` context.

Description

The function decrypts the input cipher data stream of a variable length according to GCM as specified in [NIST SP 800-38D].

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.

`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsLengthErr`	Indicates an error condition if *`len`* is less than zero.

AES_GCMGetTag

Generates the authentication tag in the GCM mode.

Syntax

`IppStatus ippsAES_GCMGetTag (Ipp8u* pTag, int tagLen, const IppsAES_GCMState* pState);`

Include Files

`ippcp.h`

Parameters

`pTag`	Pointer to the authentication tag.
`tagLen`	Length of the authentication tag *pTag (in bytes).
`pState`	Pointer to the `IppsAES_GCMState` context.

Description

The function generates and computes the authentication tag of length *`tagLen`* according to GCM as specified in [NIST SP 800-38D]. A call to `ippsAES_GCMGetTag` does not stop the process of authenticated encryption/ decryption.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsLengthErr`	Indicates an error condition if *`tagLen`* <1 or *`taglen`* >16.

AES-SIV Functions

This section describes functions for the Synthetic Initialization Vector (SIV) authenticated encryption using the AES cipher [RFC5297].

AES_S2V_CMAC

Produces the synthetic initialization vector.

Syntax

`IppStatus ippsAES_S2V_CMAC(const Ipp8u* pKey, int keyLen, const Ipp8u* AD[], const int ADlen[], int numAD, Ipp8u* pSIV);`

Include Files

`ippcp.h`

Parameters

pKey	Pointer to the key.
keyLen	Length of the key in bytes.
AD	Array of pointers to individual input strings.
ADlen	Array of length (in bytes) of the individual input strings.
numAD	The number of the strings.
pSIV	Pointer to the output 16-byte vector.

Description

The AES_S2V_CMAC function takes a key and maps the vector of individual strings *AD*[0], *AD*[1], ..., *AD*[*numAD*-1] to the 16-byte output vector.

The function uses pseudorandom AES_CMAC functions to process each input string, as well as doubling and xoring operations to map the output to a single output vector.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL` or a pointer *AD*[*i*] to any individual string is `NULL` while the length *ADlen*[*i*] is non-zero.
`ippStsLengthErr`	Indicates an error condition that occurs because of one of the following: • The *keyLen* parameter is different from 16, 24, and 32 • The number of the strings *numAD* in the *AD* array is negative • The length *ADlen*[*i*] of any individual input string is negative

AES_SIVEncrypt

Performs the SIV authenticated encryption using the AES cipher.

Syntax

IppStatus ippsAES_SIVEncrypt(const Ipp8u* *pSrc*, Ipp8u* *pDst*, int *len*, Ipp8u* *pSIV*, const Ipp8u* *pAuthKey*, const Ipp8u* *pConfKey*, int *keyLen*, const Ipp8u* *AD*[], const int *ADlen*[], int *numAD*);

Include Files

`ippcp.h`

Parameters

pSrc	Pointer to the input data to encrypt (plaintext).
pDst	Pointer to the output encrypted data (ciphertext).
len	Length in bytes of the plaintext and ciphertext.
pSIV	Pointer to the output synthetic initialization vector.

pAuthKey	Pointer to the authentication key.
pConfKey	Pointer to the confidentiality key.
keyLen	Length of keys in bytes.
AD	Array of pointers to the associated input strings.
ADlen	Array of length (in bytes) of the associated input strings.
numAD	The number of the associated strings.

Description

The AES_SIVEncrypt function accepts authentication and confidentiality keys of length *keyLen* each, plaintext (**pSrc*) of an arbitrary length *len*, and a vector *AD*[] of associated data (strings). The output of the function is the 16-byte synthetic initialization vector (**pSIV*) and encrypted data (**pDst*) of the same length as the plaintext.

The computation includes the following steps:

1. Compute a synthetic initialization vector by passing the plaintext, *pAuthKey* key, and *AD*[] to AES_S2V_CMAC.
2. Encrypt the plaintext using the AES cipher in the CTR mode with the initial counter value (*CTR0*) equal to the synthetic initialization vector xored with a fixed mask.

Return Values

ippStsNoErr	Indicates no error. Any other value indicates an error or warning.
ippStsNullPtrErr	Indicates an error condition if any of the specified pointers is NULL or a pointer *AD*[*i*] to any individual string is NULL while the length *ADlen*[*i*] is non-zero.
ippStsLengthErr	Indicates an error condition that occurs because of one of the following: • The *keyLen* parameter is different from 16, 24, and 32 • The number of the strings *numAD* in the *AD* array is negative or greater than 127 • The length *ADlen*[*i*] of any individual input string is negative • The *len* parameter is negative

AES_SIVDecrypt

Performs the SIV authenticated decryption using the AES cipher.

Syntax

```
IppStatus ippsAES_SIVDecrypt(const Ipp8u* pSrc, Ipp8u* pDst, int len, int* pAuthPassed,
const Ipp8u* pAuthKey, const Ipp8u* pConfKey, int keyLen, const Ipp8u* AD[], const int
ADlen[], int numAD, const Ipp8u* pSIV);
```

Include Files

ippcp.h

Parameters

pSrc	Pointer to the input data to decrypt (ciphertext).

pDst	Pointer to the output decrypted data (plaintext).
len	Length in bytes of the plaintext and ciphertext.
pAuthPassed	Pointer to the result flag.
pAuthKey	Pointer to the authentication key.
pConfKey	Pointer to the confidentiality key.
keyLen	Length of keys in bytes.
AD	Array of pointers to the associated input strings.
ADlen	Array of length (in bytes) of the associated input strings.
numAD	The number of the associated strings.
pSIV	Pointer to the synthetic initialization vector.

Description

The AES_SIVDecrypt function accepts authentication and confidentiality keys of length *keyLen* each, a vector *AD*[] of associated data (strings), 16-byte synthetic initialization vector (**pSIV*), and ciphertext (**pSrc*) of an arbitrary length *len*. The output of the function is the decrypted plaintext (**pDst*) of the same length as the ciphertext and the result of plaintext authentication (**pAuthPassed*).

The computation includes the following steps:

1. Decrypt the input ciphertext using the AES cipher in the CTR mode with the initial counter value (*CTR0*) equal to the synthetic initialization vector (**pSIV*) xored with a fixed mask.
2. Re-compute the synthetic initialization vector using the input data *AD*[] and the computed plaintext.

If the input and re-computed values of SIV are the same, the plaintext authentication is considered passed (**pAuthPassed* = 1), otherwise, the plaintext authentication is considered failed (**pAuthPassed* = 0).

Return Values

ippStsNoErr	Indicates no error. Any other value indicates an error or warning.
ippStsNullPtrErr	Indicates an error condition if any of the specified pointers is NULL or a pointer *AD*[*i*] to any individual string is NULL while the length *ADlen*[*i*] is non-zero.
ippStsLengthErr	Indicates an error condition that occurs because of one of the following: • The *keyLen* parameter is different from 16, 24, and 32 • The number of the strings *numAD* in the *AD* array is negative or greater than 127 • The length *ADlen*[*i*] of any individual input string is negative • The *len* parameter is negative

Usage Example

```
////////////////////////// Usage example for AES-SIV primitives /////////////////////
   // key:
   Ipp8u key[] =
      "\x7f\x7e\x7d\x7c\x7b\x7a\x79\x78\x77\x76\x75\x74\x73\x72\x71\x70"
      "\x40\x41\x42\x43\x44\x45\x46\x47\x48\x49\x4a\x4b\x4c\x4d\x4e\x4f";
   // ADs:
```

```
  Ipp8u ad1[] =
     "\x00\x11\x22\x33\x44\x55\x66\x77\x88\x99\xaa\xbb\xcc\xdd\xee\xff"
     "\xde\xad\xda\xda\xde\xad\xda\xda\xff\xee\xdd\xcc\xbb\xaa\x99\x88"
     "\x77\x66\x55\x44\x33\x22\x11\x00";
  Ipp8u ad2[] =
     "\x10\x20\x30\x40\x50\x60\x70\x80\x90\xa0";
  Ipp8u nonce[] =
     "\x09\xf9\x11\x02\x9d\x74\xe3\x5b\xd8\x41\x56\xc5\x63\x56\x88\xc0";

  // PT
  Ipp8u pt[] =
     "\x74\x68\x69\x73\x20\x69\x73\x20\x73\x6f\x6d\x65\x20\x70\x6c\x61"
     "\x69\x6e\x74\x65\x78\x74\x20\x74\x6f\x20\x65\x6e\x63\x72\x79\x70"
     "\x74\x20\x75\x73\x69\x6e\x67\x20\x53\x49\x56\x2d\x41\x45\x53";
  Ipp8u  rt[sizeof(pt)];
  int authRes = 0xaa;

  Ipp8u  auth_ct[16+sizeof(pt)-1];

  Ipp8u* adSlist[] = {ad1,
                      ad2,
                      nonce,
                      pt};
  int    adLlist[] = {(int)(sizeof(ad1)-1),
                      (int)(sizeof(ad2)-1),
                      (int)(sizeof(nonce)-1),
                      sizeof(pt)-1};
  Ipp8u v[16];

  // compute ISV
  ippsAES_S2V_CMAC(key, 16, (const Ipp8u**)adSlist, adLlist, sizeof(adSlist)/sizeof(void*), v);

  // encode
  ippsAES_SIVEncrypt(pt, auth_ct+16, sizeof(pt)-1, auth_ct,
 key, key+16, 16,
                    (const  Ipp8u**)adSlist,  adLlist,  sizeof(adSlist)/sizeof(void*)-1);

  // decode
  ippsAES_SIVDecrypt(auth_ct+16, rt, sizeof(pt)-1, &authRes,
 key, key+16, 16,
                    (const  Ipp8u**)adSlist,  adLlist,  sizeof(adSlist)/sizeof(void*)-1,
                    auth_ct);


  if((1==authRes) && (0==memcmp(pt, rt, sizeof(pt)-1)))
     printf("authenticated  decryption  passed\n");
  else
     printf("authenticated  decryption  failed\n");
////////////////////////////////////////////////////////////////////////
```

AES-XTS Functions

This section describes functions for the **X**EX **T**weakable Block Cipher with Ciphertext **S**tealing (XTS) encryption using the AES cipher [IEEE P1619] [NIST SP 800-38E].

AES_XTSGetSize

Gets the size of the IppsAES_XTSSpec *context.*

Syntax

```
IppStatus ippsAES_XTSGetSize(int* pSize);
```

Include Files

`ippcp.h`

Parameters

pSize	Pointer to the `IppsAES_XTSSpec` context size value.

Description

The function gets the size of the `IppsAES_XTSSpec` context in bytes and stores it in `*`*pSize*.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if the *pSize* pointer is `NULL`.

AES_XTSInit

Initializes user-supplied memory as `IppsAES_XTSSpec` *context for future use.*

Syntax

```
IppStatus ippsAES_XTSInit(const Ipp8u* pKey, int keyLen, int duBitSize,
IppsAES_XTSSpec* pCtx, int ctxSize);
```

Include Files

`ippcp.h`

Parameters

pKey	Pointer to the secret key.
keyLen	Length of the secret key in bits.
duBitSize	Length of the Data Unit in bits.
pCtx	Pointer to the buffer being initialized as `IppsAES_XTSSpec` context.
ctxSize	Available size of the buffer being initialized.

Description

This function initializes the memory pointed by *pCtx* as `IppsAES_XTSSpec`. In addition, the function uses the initialization variable and additional authenticated data to provide all necessary key material for both encryption and decryption operations.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if the *pCtx* pointer is `NULL`.

`ippStsLengthErr`	Indicates an error condition if *keyLen* is not equal to 16×8×2 or 32×8×2.
`ippStsMemAllocError`	Indicates an error condition if the allocated memory is insufficient for the operation.

AES_XTSEncrypt

Encrypts a data buffer in the XTS mode.

Syntax

```
IppStatus ippsAES_XTSEncrypt(const Ipp8u* pSrc, Ipp8u* pDst, int bitSizeLen, const
IppsAES_XTSSpec* pCtx, const Ipp8u* pTweak, int startCipherBlkNo);
```

Include Files

`ippcp.h`

Parameters

pSrc	Pointer to the input plaintext data stream of variable length.
pDst	Pointer to the resulting ciphertext data stream.
bitSizeLen	Length of the input buffer in bits.
pCtx	Pointer to the `IppsAES_XTSSpec` context.
pTweak	Pointer to the tweak vector assigned to the data unit being encrypted.
startCipherBlkNo	Number of the first block of the data unit.

Description

The function encrypts the input data stream of a variable length in the XTS mode as specified in [IEEE P1619] and [NIST SP 800-38E].

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if the *bitSizeLen* parameter value is less than 128.
`ippStsBadArgErr`	Indicates an error condition in the following cases: • *startCipherBlkNo* value is less than zero. • *startCipherBlkNo* value is greater than or equal to the number of the data unit blocks. • *startCipherBlkNo*×128+*bitSizeLen* value is greater than size of the data unit in bits. • size of the data unit in bits modulo 128 is zero and the *bitSizeLen* value modulo 128 is not zero. • *bitSizeLen* value modulo 128 is zero and *startCipherBlkNo*×128+*bitSizeLen* value is not equal to size of the data unit in bits.

`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

AES_XTSDecrypt

Decrypts a data buffer in the XTS mode.

Syntax

`IppStatus ippsAES_XTSDecrypt(const Ipp8u* pSrc, Ipp8u* pDst, int bitSizeLen, const IppsAES_XTSSpec* pCtx, const Ipp8u* pTweak, int startCipherBlkNo);`

Include Files

`ippcp.h`

Parameters

pSrc	Pointer to the input ciphertext data stream of variable length.
pDst	Pointer to the resulting plaintext data stream.
bitSizeLen	Length of the input buffer in bits.
pCtx	Pointer to the `IppsAES_XTSSpec` context.
pTweak	Pointer to the tweak vector assigned to the data unit being decrypted.
startCipherBlkNo	Number of the first block of the data unit.

Description

The function decrypts the input ciphered data stream of a variable length in the XTS mode as specified in [IEEE P1619] and [NIST SP 800-38E].

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if the *bitSizeLen* parameter value is less than 128.
`ippStsBadArgErr`	Indicates an error condition in the following cases: • *startCipherBlkNo* value is less than zero. • *startCipherBlkNo* value is greater than or equal to the number of the data unit blocks. • *startCipherBlkNo*×128+*bitSizeLen* value is greater than size of the data unit in bits. • size of the data unit in bits modulo 128 is zero and the *bitSizeLen* value modulo 128 is not zero. • *bitSizeLen* value modulo 128 is zero and *startCipherBlkNo*×128+*bitSizeLen* value is not equal to size of the data unit in bits.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

TDES Functions

NOTE
The TDES algorithm is considered weak due to known attacks on it. The functionality remains in the library, but the implementation will no longer be optimized and no security patches will be applied. A more secure alternative is available: AES. For more information, see *Transitioning the Use of Cryptographic Algorithms and Key Lengths* (https://csrc.nist.gov/CSRC/media/Publications/sp/800-131a/rev-2/draft/documents/sp800-131Ar2-draft.pdf), *Update to Current Use and Deprecation of TDEA* (https://csrc.nist.gov/News/2017/Update-to-Current-Use-and-Deprecation-of-TDEA), *Sweet32: Birthday attacks on 64-bit block ciphers in TLS and OpenVPN* (https://sweet32.info/).

The Triple Data Encryption Algorithm (TDEA) is a revised symmetric algorithm scheme built on the Data Encryption Standard (DES) system. The Triple DES (TDES) encryption process includes three consecutive DES operations in the encryption, decryption, and encryption (E-D-E) sequence again in accordance with the American standard FIPS 46-3. While AES (Rijndael) is preferred, TDEA is an approved cipher. Use implementations of AES where possible. In cases where using AES is impossible or inconvenient, use TDES functions.

Although the functions that support TDES operations require three sets of round keys, the functions can operate under TDES cipher system with a two-set round keys by simply setting the third set of round keys to be the same as the first set.

You can use the functions described in this section for performing various operational modes under the TDES cipher systems.

NOTE
Intel IPP functions for cryptography do not allocate memory internally. The `GetSize` function does not require allocated memory. You need to call the `GetSize` function to find out how much available memory you need to have to work with the selected algorithm and after that you call the initialization function to create a memory buffer and initialize it.

Intel IPP for cryptography supports ECB, CBC, CFB, and CTR modes. You can tell which algorithm a given function supports from the function base name, for example, the `TDESEncryptECB` function operates under the ECB mode.

The encryption function `TDESEncryptCBC` operates under the CBC mode using its cipher scheme and requires to have an initialization vector *`iv`*. Since there are a number of ways to initialize the initialization vector *`iv`*, you should remember which of them you used to be able to decrypt the message when needed.

The encryption function `TDESEncryptCFB` operates under the CFB mode using its cipher scheme and requires having the initialization vector *`pIV`* and CFB block size *`cfbBlkSize`*.

All functions described in this section use the context `IppsDESSpec` to serve as an operational vehicle that carries a set of round keys.

Application code for conducting a typical encryption under CBC mode using the TDES scheme must perform the following sequence of operations:

1. Get the size required to configure the context `IppsDESSpec` by calling the function `DESGetSize`.
2. Call operating system memory allocation service function to allocate three buffers whose sizes are not less than the one specified by the function `DESGetSize`. Initialize pointers to contexts *`pCtx1`*, *`pCtx2`*, and *`pCtx3`* by calling the function `DESInit` three times, each with the allocated buffer and the respective DES key.
3. Specify the initialization vector and then call the function `TDESEncryptCBC` to encrypt the input data stream under CBC mode using TDES scheme.
4. Clean up secret data stored in the contexts.
5. Free the memory allocated to the buffer once TDES encryption under the CBC mode has been completed and the data structures allocated for set of round keys are no longer required.

NOTE
Similar procedure can be applied for ECB, CFB, and CTR mode operation.

The `IppsDESSpec` context is position-dependent. The `DESPack/DESUnpack` functions transform the position-dependent context to a position-independent form and vice versa.

See Also

Data Security Considerations

DESGetSize

Gets the size of the `IppsDESSpec` *context (deprecated).*

Syntax

`IppStatus ippsDESGetSize(int* pSize);`

Include Files

`ippcp.h`

Parameters

pSize	Pointer to the `IppsDESSpec` context size value.

Description

NOTE
This algorithm is considered weak due to known attacks on it. The functionality remains in the library, but the implementation will no longer be optimized and no security patches will be applied. A more secure alternative is available: AES.

This function gets the `IppsDESSpec` context size in bytes and stores it in **pSize*.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.

DESInit

Initializes user-supplied memory as the `IppsDESSpec` *context for future use (deprecated).*

Syntax

`IppStatus ippsDESInit(const Ipp8u* pKey, IppsDESSpec* pCtx);`

Include Files

`ippcp.h`

Parameters

pKey	Pointer to the DES key.
pCtx	Pointer to the `IppsDESSpec` context being initialized.

Description

NOTE
This algorithm is considered weak due to known attacks on it. The functionality remains in the library, but the implementation will no longer be optimized and no security patches will be applied. A more secure alternative is available: AES.

This function initializes the memory pointed by *pCtx* as `IppsDESSpec` context. In addition, the function uses the key to provide all necessary key material for both encryption and decryption operations.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.

See Also

Data Security Considerations

DESPack, DESUnpack

Packs/unpacks the `IppsDESSpec` *context into/from a user-defined buffer (deprecated).*

Syntax

```
IppStatus ippsDESPack (const IppsDESSpec* pCtx, Ipp8u* pBuffer);
IppStatus ippsDESUnpack (const Ipp8u* pBuffer, IppsDESSpec* pCtx);
```

Include Files

`ippcp.h`

Parameters

pCtx	Pointer to the `IppsDESSpec` context.
pBuffer	Pointer to the user-defined buffer.

Description

NOTE
This algorithm is considered weak due to known attacks on it. The functionality remains in the library, but the implementation will no longer be optimized and no security patches will be applied. A more secure alternative is available: AES.

The DESPack function transforms the `*pCtx` context to a position-independent form and stores it in the `*pBuffer` buffer. The DESUnpack function performs the inverse operation, that is, transforms the contents of the `*pBuffer` buffer into a normal `IppsDESSpec` context. The DESPack and DESUnpack functions enable replacing the position-dependent `IppsDESSpec` context in the memory.

Call the `DESGetSize` function prior to DESPack/DESUnpack to determine the size of the buffer.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the *pCtx* pointer does not contain the `IppsDESSpec` context.

TDESEncryptECB

Encrypts variable length data stream in ECB mode (deprecated).

Syntax

```
IppStatus ippsTDESEncryptECB(const Ipp8u *pSrc, Ipp8u *pDst, int length, const
IppsDESSpec *pCtx1, const IppsDESSpec *pCtx2, const IppsDESSpec * pCtx3, IppsCPPadding
padding);
```

Include Files

`ippcp.h`

Parameters

pSrc	Input plaintext data stream of a variable length.
pDst	Resulting ciphertext data stream.
length	Input data stream length in bytes.
pCtx1	First set of round keys scheduled for TDES internal operations.
pCtx2	Second set of round keys scheduled for TDES internal operations.
pCtx3	Third set of round keys scheduled for TDES internal operations.
padding	`IppsPaddingNONE` padding scheme.

Description

NOTE
This algorithm is considered weak due to known attacks on it. The functionality remains in the library, but the implementation will no longer be optimized and no security patches will be applied. A more secure alternative is available: AES.

This function encrypts the input data stream of a variable length according to the cipher scheme specified in [NIST SP 800-38A]. The function uses three sets of supplied round keys in the ECB mode. The function returns the ciphertext result.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if the input data stream length is less than or equal to zero.
`ippStsUnderRunErr`	Indicates an error condition if the input data stream length is not divisible by cipher block size.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

TDESDecryptECB

Decrypts variable length data stream in the ECB mode (deprecated).

Syntax

```
IppStatus ippsTDESDecryptECB(const Ipp8u *pSrc, Ipp8u *pDst, int length, const
IppsDESSpec *pCtx1, const IppsDESSpec *pCtx2, const IppsDESSpec * pCtx3, IppsCPPadding
padding);
```

Include Files

`ippcp.h`

Parameters

pSrc	Input ciphertext data stream of variable length.
pDst	Resulting plaintext data stream.
length	Input data stream length in bytes.
pCtx1	First set of round keys scheduled for TDES internal operations.
pCtx2	Second set of round keys scheduled for TDES internal operations.
pCtx3	Third set of round keys scheduled for TDES internal operations.
padding	`IppsPaddingNONE` padding scheme.

Description

NOTE
This algorithm is considered weak due to known attacks on it. The functionality remains in the library, but the implementation will no longer be optimized and no security patches will be applied. A more secure alternative is available: AES.

This function decrypts the input data stream of a variable length according to the cipher scheme specified in [NIST SP 800-38A]. The function uses three sets of supplied round keys in the ECB mode. The function returns the ciphertext result and validates the final plaintext block.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if the decrypted plaintext data stream length is less than or equal to zero.
`ippStsUnderRunErr`	Indicates an error condition if *`length`* is not divisible by cipher block size.
`ippStsContextMatchErr`	Indicates an error condition if the *`pCtx1`*, *`pCtx2`*, or *`pCtx3`* parameter does not match the operation.

TDESEncryptCBC

Encrypts variable length data stream in the CBC mode (deprecated).

Syntax

```
IppStatus ippsTDESEncryptCBC(const Ipp8u *pSrc, Ipp8u *pDst, int length, const
IppsDESSpec *pCtx1, const IppsDESSpec *pCtx2, const IppsDESSpec * pCtx3, const Ipp8u
*pIV, IppsCPPadding padding);
```

Include Files

`ippcp.h`

Parameters

`pSrc`	Input plaintext data stream of a variable length.
`pDst`	Resulting ciphertext data stream.
`pIV`	Initialization vector for TDES CBC mode operation.
`length`	Input data stream length in bytes.
`pCtx1`	First set of round keys scheduled for TDES internal operations.
`pCtx2`	Second set of round keys scheduled for TDES internal operations.
`pCtx3`	Third set of round keys scheduled for TDES internal operations.
`padding`	`IppsCPPaddingNONE` padding scheme.

Description

NOTE
This algorithm is considered weak due to known attacks on it. The functionality remains in the library, but the implementation will no longer be optimized and no security patches will be applied. A more secure alternative is available: AES.

This function encrypts the input data stream of a variable length according to the cipher scheme specified in [NIST SP 800-38A]. The function uses three sets of the supplied round keys in the Cipher Block Chaining (CBC) mode with the initialization vector. The function returns the ciphertext result.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if the input data stream length is less than or equal to zero.
`ippStsUnderRunErr`	Indicates an error condition if the input data stream length is not divisible by cipher block size.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

TDESDecryptCBC

Decrypts variable length data stream in the CBC mode (deprecated).

Syntax

```
IppStatus ippsTDESDecryptCBC(const Ipp8u *pSrc, Ipp8u *pDst, int length, const
IppsDESSpec *pCtx1, const IppsDESSpec *pCtx2, const IppsDESSpec * pCtx3, const Ipp8u
*pIV, IppsCPPadding padding);
```

Include Files

`ippcp.h`

Parameters

pSrc	Input ciphertext data stream of a variable length.
pDst	Resulting plaintext data stream.
pIV	Initialization vector for TDES CBC mode operation.
length	Input data stream length in bytes.
pCtx1	First set of round keys scheduled for TDES internal operations.
pCtx2	Second set of round keys scheduled for TDES internal operations.
pCtx3	Third set of round keys scheduled for TDES internal operations.
padding	`IppsCPPaddingNONE` padding scheme.

Description

NOTE
This algorithm is considered weak due to known attacks on it. The functionality remains in the library, but the implementation will no longer be optimized and no security patches will be applied. A more secure alternative is available: AES.

This function decrypts the input data stream of a variable length according to the cipher scheme specified in [NIST SP 800-38A]. The function uses three sets of the supplied round keys in the Cipher Block Chaining (CBC) mode with the initialization vector. The function returns the ciphertext result and validates the final plaintext block.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if the decrypted plaintext data stream length is less than or equal to zero.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsUnderRunErr`	Indicates an error condition if *`length`* is not divisible by cipher block size.

TDESEncryptCFB

Encrypts variable length data stream in the CFB mode (deprecated).

Syntax

```
IppStatus ippsTDESEncryptCFB(const Ipp8u *pSrc, Ipp8u *pDst, int length, int
cfbBlkSize, const IppsDESSpec *pCtx1, const IppsDESSpec * pCtx2, const IppsDESSpec
*pCtx3, const Ipp8u *pIV, IppsCPPadding padding);
```

Include Files

`ippcp.h`

Parameters

`pSrc`	Input plaintext data stream of variable length.
`pDst`	Resulting ciphertext data stream.
`pIV`	Initialization vector for TDES CFB mode operation.
`length`	Input data stream length in bytes.
`pCtx1`	First set of round keys scheduled for TDES internal operations.
`pCtx2`	Second set of round keys scheduled for TDES internal operations.
`pCtx3`	Third set of round keys scheduled for TDES internal operations.
`cfbBlkSize`	CFB block size in bytes.
`padding`	`IppsCPPaddingNONE` padding scheme.

Description

NOTE
This algorithm is considered weak due to known attacks on it. The functionality remains in the library, but the implementation will no longer be optimized and no security patches will be applied. A more secure alternative is available: AES.

This function encrypts the input data stream of a variable length according to the cipher scheme specified in [NIST SP 800-38A]. The function uses three sets of the supplied round keys in the Cipher Feedback (CFB) mode with the initialization vector. The function returns the ciphertext result.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if the input data stream length is less than or equal to zero.
`ippStsUnderRunErr`	Indicates an error condition if *`length`* is not divisible by *`cfbBlkSize`* parameter value.
`ippStsCFBSizeErr`	Indicates an error condition if the value for *`cfbBlkSize`* is illegal.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

TDESDecryptCFB

Decrypts variable length data stream in the CFB mode (deprecated).

Syntax

```
IppStatus ippsTDESDecryptCFB(const Ipp8u *pSrc, Ipp8u *pDst, int length, int
cfbBlkSize, const IppsDESSpec *pCtx1, const IppsDESSpec * pCtx2, const IppsDESSpec
*pCtx3, const Ipp8u *pIV, IppsCPPadding padding);
```

Include Files

`ippcp.h`

Parameters

`pSrc`	Input ciphertext data stream of variable length.
`pDst`	Resulting plaintext data stream.
`pIV`	Initialization vector for TDES CFB mode operation.
`length`	Ciphertext data stream length in bytes.
`pCtx1`	First set of round keys scheduled for TDES internal operations.
`pCtx2`	Second set of round keys scheduled for TDES internal operations.
`pCtx3`	Third set of round keys scheduled for TDES internal operations.
`cfbBlkSize`	CFB block size in bytes.
`padding`	`IppsCPPaddingNONE` padding scheme.

Description

NOTE

This algorithm is considered weak due to known attacks on it. The functionality remains in the library, but the implementation will no longer be optimized and no security patches will be applied. A more secure alternative is available: AES.

This function decrypts the input data stream of a variable length according to the cipher scheme specified in [NIST SP 800-38A]. The function uses three sets of the supplied round keys in the Cipher Feedback (CFB) mode with the initialization vector. The function returns the ciphertext result and validates the final plaintext block.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if the decrypted plaintext data stream length is less than or equal to zero.
`ippStsCFBSizeErr`	Indicates an error condition if the value for *`cfbBlkSize`* is illegal.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsUnderRunErr`	Indicates an error condition if *`length`* is not divisible by cipher block size.

TDESEncryptOFB

Encrypts a variable length data stream according to the TDES algorithm in the OFB mode (deprecated).

Syntax

```
IppStatus ippsTDESEncryptOFB (const Ipp8u* pSrc, Ipp8u* pDst, int len, int ofbBlkSize,
const IppsDESSpec *pCtx1, const IppsDESSpec * pCtx2, const IppsDESSpec *pCtx3, Ipp8u*
pIV);
```

Include Files

`ippcp.h`

Parameters

`pSrc`	Pointer to the input plaintext data stream of variable length.
`pDst`	Pointer to the resulting ciphertext data stream.
`len`	Length of the plaintext data stream in bytes.
`ofbBlkSize`	Size of the OFB block in bytes.
`pCtx1`	First set of round keys scheduled for TDES internal operations.
`pCtx2`	Second set of round keys scheduled for TDES internal operations.
`pCtx3`	Third set of round keys scheduled for TDES internal operations.
`pIV`	Pointer to the initialization vector for the OFB mode operation.

Description

NOTE
This algorithm is considered weak due to known attacks on it. The functionality remains in the library, but the implementation will no longer be optimized and no security patches will be applied. A more secure alternative is available: AES.

This function encrypts the input data stream of a variable length in the OFB mode as specified in [NIST SP 800-38A].

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if the input data stream length is less than or equal to zero.
`ippStsUnderRunErr`	Indicates an error condition if *`len`*is not divisible by the *`ofbBlkSize`* parameter value.
`ippStsOFBSizeErr`	Indicates an error condition if the value of *`ofbBlkSize`* is illegal.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

TDESDecryptOFB

Decrypts a variable length data stream according to the TDES algorithm in the OFB mode (deprecated).

Syntax

```
IppStatus ippsTDESDecryptOFB (const Ipp8u* pSrc, Ipp8u* pDst, int len, int ofbBlkSize,
const IppsDESSpec *pCtx1, const IppsDESSpec * pCtx2, const IppsDESSpec *pCtx3, Ipp8u*
pIV);
```

Include Files

`ippcp.h`

Parameters

`pSrc`	Pointer to the input ciphertext data stream of variable length.
`pDst`	Pointer to the resulting plaintext data stream.
`len`	Length of the ciphertext data stream in bytes.
`ofbBlkSize`	Size of the OFB block in bytes.
`pCtx1`	First set of round keys scheduled for TDES internal operations.
`pCtx2`	Second set of round keys scheduled for TDES internal operations.
`pCtx3`	Third set of round keys scheduled for TDES internal operations.
`pIV`	Pointer to the initialization vector for the OFB mode operation.

Description

NOTE
This algorithm is considered weak due to known attacks on it. The functionality remains in the library, but the implementation will no longer be optimized and no security patches will be applied. A more secure alternative is available: AES.

This function decrypts the input data stream of a variable length in the OFB mode as specified in [NIST SP 800-38A].

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if the input data stream length is less than or equal to zero.
`ippStsUnderRunErr`	Indicates an error condition if *`len`*is not divisible by the *`ofbBlkSize`* parameter value.
`ippStsOFBSizeErr`	Indicates an error condition if the value of *`ofbBlkSize`* is illegal.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

TDESEncryptCTR

Encrypts a variable length data stream in the CTR mode (deprecated).

Syntax

```
IppStatus ippsTDESEncryptCTR(const Ipp8u *pSrc, Ipp8u *pDst, int len, const IppsDESSpec
*pCtx1, const IppsDESSpec *pCtx2, const IppsDESSpec *pCtx3,Ipp8u *pCtrValue, int
ctrNumBitSize);
```

Include Files

`ippcp.h`

Parameters

`pSrc`	Input plaintext data stream of a variable length.
`pDst`	Resulting ciphertext data stream.
`len`	Input data stream length in bytes.
`pCtx1`	First set of round keys scheduled for TDES internal operations.
`pCtx2`	Second set of round keys scheduled for TDES internal operations.
`pCtx3`	Third set of round keys scheduled for TDES internal operations.
`pCtrValue`	Counter.

ctrNumBitSize	Number of bits in the specific part of the counter to be incremented.

Description

NOTE
This algorithm is considered weak due to known attacks on it. The functionality remains in the library, but the implementation will no longer be optimized and no security patches will be applied. A more secure alternative is available: AES.

This function encrypts the input data stream of a variable length according to the cipher scheme specified in the [NIST SP 800-38A] recommendation. The function uses three sets of the supplied round keys. The standard incrementing function is applied to increment counter value. The function returns the ciphertext result.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if the input data stream length is less that or equal to zero.
`ippStsCTRSizeErr`	Indicates an error condition if the value of the *ctrNumBitSize* is illegal.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

TDESDecryptCTR

Decrypts a variable length data stream in the CTR mode (deprecated).

Syntax

```
IppStatus ippsTDESDecryptCTR(const Ipp8u *pSrc, Ipp8u *pDst, int дen,const IppsDESSpec
*pCtx1, const IppsDESSpec *pCtx2, const IppsDESSpec *pCtx3, Ipp8u *pCtrValue, int
ctrNumBitSize);
```

Include Files

`ippcp.h`

Parameters

pSrc	Input ciphertext data stream of a variable length.
pDst	Resulting plaintext data stream.
дen	Length of the plaintext data stream in bytes.
pCtx1	First set of round keys scheduled for TDES internal operations.
pCtx2	Second set of round keys scheduled for TDES internal operations.
pCtx3	Third set of round keys scheduled for TDES internal operations.

pCtrValue	Counter.
ctrNumBitSize	Number of bits in the specific part of the counter to be incremented.

Description

NOTE
This algorithm is considered weak due to known attacks on it. The functionality remains in the library, but the implementation will no longer be optimized and no security patches will be applied. A more secure alternative is available: AES.

This function decrypts the input data stream of a variable length according to the cipher scheme specified in the [NIST SP 800-38A] recommendation. The function uses three sets of the supplied round keys. The standard incrementing function is applied to increment value of counter. The function returns the ciphertext result.

Return Values

ippStsNoErr	Indicates no error. Any other value indicates an error or warning.
ippStsNullPtrErr	Indicates an error condition if any of the specified pointers is NULL.
ippStsLengthErr	Indicates an error condition if the descrypted plaintext data stream length is less that or equal to zero.
ippStsCTRSizeErr	Indicates an error condition if the value of the *ctrNumBitSize* is illegal.
ippStsContextMatchErr	Indicates an error condition if the context parameter does not match the operation.

Example of Using TDES Functions

TDES Encryption and Decryption

```
// Use of the ECB mode
void  TDES_sample(void){
      // size of the TDES algorithm block is equal to 8
      const int tdesBlkSize = 8;

      // get size of the context needed for the encryption/decryption operation
      int ctxSize;
      ippsDESGetSize(&ctxSize);
      // and allocate one
      IppsDESSpec* pCtx1 = (IppsDESSpec*)( new Ipp8u [ctxSize] );
      IppsDESSpec* pCtx2 = (IppsDESSpec*)( new Ipp8u [ctxSize] );
      IppsDESSpec* pCtx3 = (IppsDESSpec*)( new Ipp8u [ctxSize] );

      // define the key
      Ipp8u key1[] = {0x01,0x02,0x03,0x04,0x05,0x06,0x07,0x08};
      Ipp8u key2[] = {0x11,0x12,0x13,0x14,0x15,0x16,0x17,0x18};
      Ipp8u key3[] = {0x21,0x22,0x23,0x24,0x25,0x26,0x27,0x28};
      Ipp8u keyX[] = {0x00,0x00,0x00,0x00,0x00,0x00,0x00,0x00};

      // and prepare the context for the TDES usage
      ippsDESInit(key1,  pCtx1);
```

```
   ippsDESInit(key2,  pCtx2);
   ippsDESInit(key3,  pCtx3);

   // define the message to be encrypted
   Ipp8u ptext[] = {"the quick brown fox jumps over the lazy dog"};
   // allocate enough memory for the ciphertext
   // note that
   // the size of ciphertext is always a multiple of the cipher block size
   Ipp8u  ctext[(sizeof(ptext)+desBlkSize-1)  &~(desBlkSize-1)];
   // encrypt (ECB mode) ptext message
   // pay attention to the 'length' parameter
   // it defines the number of bytes to be encrypted
   ippsTDESEncryptECB(ptext, ctext, sizeof(ctext), pCtx1, pCtx2, pCtx3, IppsCPPaddingNONE);

   // allocate memory for the decrypted message
   Ipp8u  rtext[sizeof(ctext)];
   // decrypt (ECB mode) ctext message
   // pay attention to the 'length' parameter
   // it defines the number of bytes to be decrypted
   ippsTDESDecryptECB(ctext, rtext, sizeof(ctext), pCtx1, pCtx2, pCtx3, IppsCPPaddingNONE);

   // remove actual secret from contexts
   ippsDESInit(keyX,  pCtx1);
   ippsDESInit(keyX,  pCtx2);
   ippsDESInit(keyX,  pCtx3);
   // release resources
   delete  (Ipp8u*)pCtx1;
   delete  (Ipp8u*)pCtx2;
   delete  (Ipp8u*)pCtx3;
}
```

SMS4 Functions

You can use the functions described in this section for various operational modes of SMS4 cipher systems [SM4].

Intel IPP for cryptography supports ECB, CBC, CFB, CTR, and OFB modes. You can tell which algorithm a given function supports from the function base name, for example, the `SMS4EncryptECB` function operates under the ECB mode.

All functions for the SMS4 block cipher use the context `IppsSMS4Spec`, which serves as an operational vehicle to carry the material required for various modes of operation.

Application code for conducting a typical encryption under the CBC mode using the SMS4 scheme must perform the following sequence of operations:

1. Get the size required to configure the context `IppsSMS4Spec` by calling the function `SMS4GetSize`.
2. Call an operating system memory allocation service function to allocate a buffer of size not less than the one specified by the function SMS4GetSize.
3. Initialize the pointer to the context by calling the function `SMS4Init`.
4. Specify the initialization vector and then call the function `SMS4EncryptCBC` to encrypt the input data stream under CBC mode using SMS4 scheme.
5. Clean up secret data stored in the context.
6. Free the memory allocated to the buffer once SMS4 encryption under the CBC mode has been completed.

NOTE
You can apply a similar procedure to ECB, CFB, CTR, and OFB modes of operation.

A similar scheme also holds for decryption.

See Also

Data Security Considerations

SMS4GetSize

Gets the size of the `IppsSMS4Spec` *context.*

Syntax

`IppStatus ippsSMS4GetSize(int* *pSize*);`

Include Files

`ippcp.h`

Parameters

pSize	Pointer to the `IppsSMS4Spec` context size value.

Description

The function gets the `IppsSMS4Spec` context size in bytes and stores it in `*`*pSize*.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.

SMS4Init

Initializes user-supplied memory as `IppsSMS4Spec` *context for future use.*

Syntax

`IppStatus ippsSMS4Init(const Ipp8u* *pKey*, int *keyLen*, IppsSMS4Spec* *pCtx*, int *ctxSize*);`

Include Files

`ippcp.h`

Parameters

pKey	Pointer to the SMS4 key.
keyLen	Key byte stream length. Must equal 16.
pCtx	Pointer to the buffer being initialized as `IppsSMS4Spec` context.
ctxSize	Available size of the buffer being initialized.

Description

This function initializes the memory pointed by *pCtx* as `IppsSMS4Spec`. The key is used to provide all necessary key material for both encryption and decryption operations.

> **NOTE**
> If the *pKey* pointer is `NULL`, the function initializes the context with the zero key, which can help you to clean up the actual secret before releasing the context.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if the *pCtx* pointer is `NULL`.
`ippStsLengthErr`	Returns an error condition if *keyLen* is not equal to 16.
`ippStsMemAllocErr`	Indicates an error condition if the allocated memory is insufficient for the operation.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

See Also

Data Security Considerations

SMS4SetKey

Resets the SMS4 secret key in the initialized `IppsSMS4Spec` *context.*

Syntax

```
IppStatus ippsSMS4SetKey(const Ipp8u* pKey, int keyLen, IppsSMS4Spec* pCtx);
```

Include Files

`ippcp.h`

Parameters

pKey	Pointer to the SMS4 key.
keyLen	Length of the secret key.
pCtx	Pointer to the initialized `IppsSMS4Spec` context.

Description

This function resets the SMS4 secret key in the initialized `IppsSMS4Spec` context with the user-supplied secret key.

> **NOTE**
> If the *pKey* pointer is `NULL`, the function resets the context with the zero key, which can help you to clean up the actual secret before releasing the context.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if the *`pCtx`* pointer is `NULL`.
`ippStsLengthErr`	Returns an error condition if *`keyLen`* is not equal to 16.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

See Also

Data Security Considerations

SMS4EncryptECB

Encrypts plaintext message by using ECB encryption mode (deprecated).

Syntax

```
IppStatus ippsSMS4EncryptECB(const Ipp8u *pSrc, Ipp8u *pDst, int len, const
IppsSMS4Spec* pCtx);
```

Include Files

`ippcp.h`

Parameters

`pSrc`	Pointer to the input plaintext data stream of variable length.
`pDst`	Pointer to the resulting ciphertext data stream.
`len`	Length of the input plaintext data in bytes.
`pCtx`	Pointer to the `IppsSMS4Spec` context.

Description

NOTE The ECB functionality remains in the library, but it is not safe when used as is. Use any other mode, for example CBC.

The function encrypts the input data stream of a variable length according to the cipher scheme specified in [NIST SP 800-38A].

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if the input data stream length is less than or equal to zero.
`ippStsUnderRunErr`	Indicates an error condition if *`len`* is not divisible by cipher block size.

`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

SMS4DecryptECB

Decrypts byte data stream by using the SMS4 algorithm in the ECB mode (deprecated).

Syntax

```
IppStatus ippsSMS4DecryptECB(const Ipp8u* pSrc, Ipp8u* pDst, int len, const
IppsSMS4Spec* pCtx);
```

Include Files

`ippcp.h`

Parameters

pSrc	Pointer to the input ciphertext data stream of variable length.
pDst	Pointer to the resulting plaintext data stream of variable length.
len	Length of the ciphertext data stream in bytes.
pCtx	Pointer to the `IppsSMS4Spec` context.

Description

NOTE The ECB functionality remains in the library, but it is not safe when used as is. Use any other mode, for example CBC.

The function decrypts the input data stream of a variable length according to the ECB mode as specified in [NIST SP 800-38A].

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if the output data stream length is less than or equal to zero.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsUnderRunErr`	Indicates an error condition if *len* is not divisible by cipher block size.

SMS4EncryptCBC

Encrypts byte data stream according to SMS4 in the CBC mode.

Syntax

```
IppStatus ippsSMS4EncryptCBC(const Ipp8u* pSrc, Ipp8u* pDst, int len, const
IppsSMS4Spec* pCtx, const Ipp8u* pIV);
```

Include Files

`ippcp.h`

Parameters

pSrc	Pointer to the input plaintext data stream of variable length.
pDst	Pointer to the resulting ciphertext data stream.
len	Length of the plaintext data stream length in bytes.
pCtx	Pointer to the `IppsSMS4Spec` context.
pIV	Pointer to the initialization vector for the CBC mode operation.

Description

The function encrypts the input data stream of a variable length according to the CBC mode as specified in [NIST SP 800-38A].

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if the input data stream length is less than or equal to zero.
`ippStsUnderRunErr`	Indicates an error condition if `len` is not divisible by data block size.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

SMS4DecryptCBC

Decrypts byte data stream according to SMS4 in the CBC mode.

Syntax

```
IppStatus ippsSMS4DecryptCBC(const Ipp8u* pSrc, Ipp8u* pDst, int len, const
IppsSMS4Spec* pCtx, const Ipp8u* pIV);
```

Include Files

`ippcp.h`

Parameters

pSrc	Pointer to the input ciphertext data stream.
pDst	Pointer to the resulting plaintext data stream of the variable length.
len	Length of the ciphertext data stream length in bytes.
pCtx	Pointer to the `IppsSMS4Spec` context.
pIV	Pointer to the initialization vector for CBC mode operation.

Description

The function decrypts the input data stream of a variable length according to the CBC mode as specified in [NIST SP 800-38A].

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if the output data stream length is less than or equal to zero.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsUnderRunErr`	Indicates an error condition if *len* is not divisible by cipher block size.

SMS4EncryptCBC_CS

Encrypts plaintext in the CBC ciphertext stealing mode of the SMS4 block cipher.

Syntax

```
IppStatus ippsSMS4EncryptCBC_CS1(const Ipp8u* pSrc, Ipp8u* pDst, int len, const
IppsSMS4Spec* pCtx, const Ipp8u* pIV);
```

```
IppStatus ippsSMS4EncryptCBC_CS2(const Ipp8u* pSrc, Ipp8u* pDst, int len, const
IppsSMS4Spec* pCtx, const Ipp8u* pIV);
```

```
IppStatus ippsSMS4EncryptCBC_CS3(const Ipp8u* pSrc, Ipp8u* pDst, int len, const
IppsSMS4Spec* pCtx, const Ipp8u* pIV);
```

Include Files

`ippcp.h`

Parameters

pSrc	Pointer to the input plaintext data of variable length.
pDst	Pointer to the resulting ciphertext data.
len	Length of the input data stream in bytes.
pCtx	Pointer to the `IppsSMS4Spec` context.
pIV	Pointer to the initialization vector for the CBC mode operation.

Description

These functions encrypt the input data stream according to the three variants of the Cipher Block Chaining (CBC) mode with Ciphertext Stealing (CS), as specified in [NIST SP 800-38A A.]. An important difference of these variants from the CBC mode without CS is that the number of bits in the input plaintext does not have to be a multiple of the block size.

The block size is 128 bits in accordance with [SMS4].

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	• For `SMS4EncryptCBC_CS1` and `SMS4EncryptCBC_CS2`, indicates an error condition if the input data length is less than the cipher block size. • For `SMS4EncryptCBC_CS3`, indicates an error condition if the input data length is less than or equal to the cipher block size.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

SMS4DecryptCBC_CS

Decrypts plaintext in the CBC ciphertext stealing mode of the SMS4 block cipher.

Syntax

```
IppStatus ippsSMS4DecryptCBC_CS1(const Ipp8u* pSrc, Ipp8u* pDst, int len, const
IppsSMS4Spec* pCtx, const Ipp8u* pIV);
```

```
IppStatus ippsSMS4DecryptCBC_CS2(const Ipp8u* pSrc, Ipp8u* pDst, int len, const
IppsSMS4Spec* pCtx, const Ipp8u* pIV);
```

```
IppStatus ippsSMS4DecryptCBC_CS3(const Ipp8u* pSrc, Ipp8u* pDst, int len, const
IppsSMS4Spec* pCtx, const Ipp8u* pIV);
```

Include Files

`ippcp.h`

Parameters

pSrc	Pointer to the input ciphertext data of variable length.
pDst	Pointer to the resulting plaintext data.
len	Length of the input data length in bytes.
pCtx	Pointer to the `IppsSMS4Spec` context.
pIV	Pointer to the initialization vector for the CBC mode operation.

Description

These functions decrypt the input data stream according to the three variants of the Cipher Block Chaining (CBC) mode with Ciphertext Stealing (CS), as specified in [NIST SP 800-38A A.].

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.

`ippStsLengthErr`	• For `SMS4DecryptCBC_CS1` and `SMS4DecryptCBC_CS2`, indicates an error condition if the input data length is less than the cipher block size. • For `SMS4DecryptCBC_CS3`, indicates an error condition if the input data length is less than or equal to the cipher block size.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

SMS4EncryptCFB

Encrypts byte data stream using SMS4 block cipher in the CFB mode.

Syntax

```
IppStatus ippsSMS4EncryptCFB(const Ipp8u* pSrc, Ipp8u* pDst, int len, int cfbBlkSize,
const IppsSMS4Spec* pCtx, const Ipp8u *pIV);
```

Include Files

`ippcp.h`

Parameters

pSrc	Pointer to the input plaintext data stream of variable length.
pDst	Pointer to the resulting ciphertext data stream.
len	Length of the plaintext data stream in bytes.
cfbBlkSize	Size of the CFB block in bytes.
pCtx	Pointer to the `IppsSMS4Spec` context.
pIV	Pointer to the initialization vector for the CFB mode operation.

Description

The function encrypts the input data stream of variable length according to the CFB mode as specified in [NIST SP 800-38A].

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if the input data stream length is less than or equal to zero.
`ippStsUnderRunErr`	Indicates an error condition if *len*is not divisible by *cfbBlkSize* parameter value.
`ippStsCFBSizeErr`	Indicates an error condition if the value for *cfbBlkSize* is illegal.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

SMS4DecryptCFB

Decrypts byte data stream using SMS4 block cipher in CFB mode.

Syntax

```
IppStatus ippsSMS4DecryptCFB(const Ipp8u* pSrc, Ipp8u* pDst, int len, int cfbBlkSize,
const IppsSMS4Spec* pCtx, const Ipp8u* pIV);
```

Include Files

`ippcp.h`

Parameters

pSrc	Pointer to the input ciphertext data stream.
pDst	Pointer to the resulting plaintext data stream of variable length.
len	Length of the ciphertext data stream in bytes.
cfbBlkSize	Size of the CFB block in bytes.
pCtx	Pointer to the `IppsSMS4Spec` context.
pIV	Pointer to the initialization vector for the CFB mode operation.

Description

The function decrypts the input data stream of variable length according to the CFB mode as specified in [NIST SP 800-38A].

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if the output data stream length is less than or equal to zero.
`ippStsCFBSizeErr`	Indicates an error condition if the value for *cfbBlkSize* is illegal.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsUnderRunErr`	Indicates an error condition if *len* is not divisible by cipher block size.

SMS4EncryptOFB

Encrypts a variable length data stream using SMS4 block cipher in the OFB mode.

Syntax

```
IppStatus ippsSMS4EncryptOFB (const Ipp8u* pSrc, Ipp8u* pDst, int len, int ofbBlkSize,
const IppsSMS4Spec* pCtx, Ipp8u* pIV);
```

Include Files

`ippcp.h`

Parameters

pSrc	Pointer to the input plaintext data stream of variable length.
pDst	Pointer to the resulting ciphertext data stream.
len	Length of the plaintext data stream in bytes.
ofbBlkSize	Size of the OFB block in bytes.
pCtx	Pointer to the `IppsSMS4Spec` context.
pIV	Pointer to the initialization vector for the OFB mode operation.

Description

The function encrypts the input data stream of a variable length in the OFB mode as specified in [NIST SP 800-38A].

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if the input data stream length is less than or equal to zero.
`ippStsUnderRunErr`	Indicates an error condition if *len* is not divisible by the *ofbBlkSize* parameter value.
`ippStsOFBSizeErr`	Indicates an error condition if the value of *ofbBlkSize* is illegal.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

SMS4DecryptOFB

Decrypts a variable length data stream using SMS4 block cipher in the OFB mode.

Syntax

```
IppStatus ippsSMS4DecryptOFB (const Ipp8u* pSrc, Ipp8u* pDst, int len, int ofbBlkSize,
const IppsSMS4Spec* pCtx, Ipp8u* pIV);
```

Include Files

`ippcp.h`

Parameters

pSrc	Pointer to the input ciphertext data stream of variable length.
pDst	Pointer to the resulting plaintext data stream.
len	Length of the ciphertext data stream in bytes.

ofbBlkSize	Size of the OFB block in bytes.
pCtx	Pointer to the `IppsSMS4Spec` context.
pIV	Pointer to the initialization vector for the OFB mode operation.

Description

The function decrypts the input data stream of a variable length in the OFB mode as specified in [NIST SP 800-38A].

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if the input data stream length is less than or equal to zero.
`ippStsUnderRunErr`	Indicates an error condition if *len*is not divisible by the *ofbBlkSize* parameter value.
`ippStsOFBSizeErr`	Indicates an error condition if the value of *ofbBlkSize* is illegal.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

SMS4EncryptCTR

Encrypts a variable length data stream using SMS4 block cipher in the CTR mode.

Syntax

```
IppStatus ippsSMS4EncryptCTR(const Ipp8u* pSrc, Ipp8u* pDst, int len,const
IppsSMS4Spec* pCtx, Ipp8u* pCtrValue , int ctrNumBitSize);
```

Include Files

`ippcp.h`

Parameters

pSrc	Pointer to the input plaintext data stream of a variable length.
pDst	Pointer to the resulting ciphertext data stream.
len	Length of the plaintext data stream in bytes.
pCtx	Pointer to the `IppsSMS4Spec` context.
pCtrValue	Pointer to the counter data block.
ctrNumBitSize	Number of bits in the specific part of the counter to be incremented.

Description

The function encrypts the input data stream of a variable length according to the CTR mode as specified in [NIST SP 800-38A].

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if the input data stream length is less than or equal to zero.
`ippStsCTRSizeErr`	Indicates an error condition if the value of the *`ctrNumBitSize`* is illegal.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

SMS4DecryptCTR

Decrypts a variable length data stream using SMS4 block cipher in the CTR mode.

Syntax

```
IppStatus ippsSMS4DecryptCTR(const Ipp8u* pSrc, Ipp8u* pDst, int len,const IppsAESSpec*
pCtx, Ipp8u* pCtrValue, int ctrNumBitSize);
```

Include Files

`ippcp.h`

Parameters

`pSrc`	Pointer to the input ciphertext data stream.
`pDst`	Pointer to the resulting plaintext data stream of a variable length.
`len`	Length of the plaintext data stream in bytes.
`pCtx`	Pointer to the `IppsAESSpec` context.
`pCtrValue`	Pointer to the counter data block.
`ctrNumBitSize`	Number of bits in the specific part of the counter to be incremented.

Description

The function decrypts the input data stream of a variable length according to the CTR mode as specified in the [NIST SP 800-38A].

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if the output data stream length is less than or equal to zero.
`ippStsCTRSizeErr`	Indicates an error condition if the value of the *`ctrNumBitSize`* is illegal.

`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

ARCFour Functions

NOTE
ARCFour algorithm functions are deprecated and will be removed in a future Intel® IPP release.

As the RC4* stream cipher, widely used for file encryption and secure communications, is the property of RSA Security Inc., a cipher discussed in this section and resulting in the same encryption/decryption as RC4* is called ARCFour.

The ARCFour stream cipher ([AC]) uses a variable length key of up to 256 octets (bytes). ARCFour operates in the Output Feedback mode (OFB), defined in [NIST SP 800-38A], which creates the keystream independently of both the plaintext and the ciphertext.

The ARCFour algorithm functions, described in this section, use the context `IppsARCFourState` as an operational vehicle to carry variables needed to execute the algorithm: S-Boxes and a current pair of indices.

The typical application code for conducting an encryption or decryption using ARCFour should follow the sequence of operations listed below:

1. Get the buffer size required to configure the context `IppsARCFourState` by calling the function `ARCFourGetSize`.
2. Call the operating system memory allocation service function to allocate a buffer whose size is not less than the one specified by the function `ARCFourGetSize`.
3. Initialize the pointer *pCtx* to the `IppsARCFourState` context by calling the function `ARCFourInit` with the allocated buffer and the respective ARCFour cipher key of the specified size.
4. Call the `ARCFourEncrypt` or `ARCFourDecrypt` function to encrypt or decrypt the input data stream, respectively.
5. Clean up secret data stored in the context.
6. Call the operating system memory free service function to release the buffer allocated for the `IppsARCFourState` context, if needed.

The ARCFourSpec context is position-dependent. The `ARCFourPack/ARCFourUnpack` functions transform the position-dependent context to a position-independent form and vice versa.

See Also

Data Security Considerations

ARCFourGetSize

Gets the size of the `IppsARCFourState` *context (deprecated).*

Syntax

```
IppStatus ippsARCFourGetSize(int* pSize);
```

Include Files

`ippcp.h`

Parameters

pSize	Pointer to the size value of the `IppsARCFourState` context.

Description

NOTE
This function is deprecated.

The function gets the size of the `IppsARCFourState` context in bytes and stores it in `*`*`pSize`*.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if the specified pointer is `NULL`.

ARCFourCheckKey

Checks weakness of a user-defined key (deprecated).

Syntax

```
IppStatus ippsARCFourCheckKey(const Ipp8u* pKey, int keyLen, IppBool* pIsWeak);
```

Include Files

`ippcp.h`

Parameters

`pKey`	Pointer to the user-defined key.
`keyLen`	Length of the user-defined key in octets.
`pIsWeak`	Pointer to the result of checking.

Description

NOTE
This function is deprecated.

The function checks weakness of user-defined key. The function allows to make sure that the supplied key provides sufficient security.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if *`keyLen`* <1 or *`keyLen`* >256.

ARCFourInit

Initializes user-supplied memory as the `IppsARCFourState` *context for future use (deprecated).*

Syntax

`IppStatus ippsARCFourInit(const Ipp8u* pKey, int keyLen, IppsARCFourState* pCtx);`

Include Files

`ippcp.h`

Parameters

pKey	Pointer to the user-defined key.
keyLen	Length of the user-defined key in octets.
pCtx	Pointer to the `IppsARCFourState` context being initialized.

Description

NOTE
This function is deprecated.

The function initializes the memory pointed by *pCtx* as `IppsARCFourState` context. In addition, the function uses the key to provide all necessary key material for both encryption and decryption operations.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if *keyLen* <1 or *keyLen* >256.

See Also

Data Security Considerations

ARCFourPack, ARCFourUnpack

Packs/unpacks the `IppsARCFourSpec` *context into/ from a user-defined buffer (deprecated).*

Syntax

`IppStatus ippsARCFourPack (const IppsARCFourState* pCtx, Ipp8u* pBuffer);`

`IppStatus ippsARCFourUnpack (const Ipp8u* pBuffer, IppsARCFourState* pCtx);`

Include Files

`ippcp.h`

Parameters

pCtx	Pointer to the `IppsARCFourState` context.
pBuffer	Pointer to the user-defined buffer.

Description

NOTE
These functions are deprecated.

The ARCFourPack function transforms the **pCtx* context to a position-independent form and stores it in the **pBuffer* buffer. The ARCFourUnpack function performs the inverse operation, that is, transforms the contents of the **pBuffer* buffer into a normal IppsARCFourState context. The ARCFourPack and ARCFourUnpack functions enable replacing the position-dependent IppsARCFourState context in the memory.

Call the ARCFourGetSize function prior to ARCFourPack/ARCFourUnpack to determine the size of the buffer.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is NULL.

ARCFourEncrypt

Encrypts a variable length data stream according to ARCFour (deprecated).

Syntax

```
IppStatus ippsARCFourEncrypt(const Ipp8u* pSrc, Ipp8u* pDst, int srclen,
IppsARCFourState* pCtx);
```

Include Files

ippcp.h

Parameters

pSrc	Pointer to the input plaintext data stream of variable length.
pDst	Pointer to the resulting ciphertext data stream.
srclen	Length of the plaintext data stream in octets.
pCtx	Pointer to the ARCFourState context.

Description

NOTE
This function is deprecated.

The function encrypts the input data stream of a variable length using the ARCFour algorithm.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.

`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if length of the input data stream is less than one octet.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

ARCFourDecrypt

Decrypts a variable length data stream according to ARCFour (deprecated).

Syntax

```
IppStatus ippsARCFourDecrypt(const Ipp8u* pSrc, Ipp8u* pDst, int srclen,
IppsARCFourState* pCtx);
```

Include Files

`ippcp.h`

Parameters

pSrc	Pointer to the input ciphertext data stream of variable length.
pDst	Pointer to the resulting plaintext data stream.
srclen	Length of the ciphertext data stream in octets.
pCtx	Pointer to the `ARCFourState` context.

Description

NOTE
This function is deprecated.

The function decrypts the input data stream of a variable length according to the ARCFour algorithm.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if length of the input data stream is less than one octet.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

ARCFourReset

Resets the `IppsARCFourState` *context to the initial state (deprecated).*

Syntax

```
IppStatus ippsARCFourReset(IppsARCFourState* pCtx);
```

Include Files

`ippcp.h`

Parameters

pCtx	Pointer to the `IppsARCFourState` context being reset.

Description

NOTE
This function is deprecated.

The function resets the `IppsARCFourState` context to the state it had immediately after the `ARCFourInit` function call. Contrary to `ARCFourInit`, `ARCFourReset` requires no secret key to initialize the S-Box.

Return Values

`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

One-Way Hash Primitives

Hash functions are used in cryptography with digital signatures and for ensuring data integrity.

When used with digital signatures, a publicly available hash function hashes the message and signs the resulting hash value. The party who receives the message can then hash the message and check if the block size is authentic for the given hash value.

Hash functions are also referred to as “message digests” and “one-way encryption functions”. Both terms are appropriate since hash algorithms do not have a key like symmetric and asymmetric algorithms and you can recover neither the length nor the contents of the plaintext message from the ciphertext.

To ensure data integrity, hash functions are used to compute the hash value that corresponds to a particular input. Then, if necessary, you can check if the input data has remained unmodified; you can re-compute the hash value again using the available input and compare it to the original hash value.

The Hash Functions section describes functions that implement the following hash algorithms for streaming messages: MD5 [RFC 1321], SHA-1, SHA-224, SHA-256, SHA-384, SHA-512 [FIPS PUB 180-2], and SM3 [SM3]. These algorithms are widely used in enterprise applications nowadays.

Subsequent sections describe Hash Functions for Non-Streaming Messages, which apply hash algorithms to entire (non-streaming) messages, and Mask Generation Functions, whose algorithms are often based on hash computations.

Additionally, Intel® Integrated Performance Primitives (Intel® IPP) Cryptography supports two relatively new variants of SHA-512, the so called SHA-512/224 and SHA-512/256 algorithms. Both employ much of the basic SHA-512 algorithm but have some specifics. Intel IPP Cryptography does not provide a separate API exactly targeting SHA-512/224 and SHA-512/256. To enable SHA-512/224 and SHA-512/256, Intel IPP Cryptography declares extensions of the Hash Functions, Hash Functions for Non-Streaming Messages, Mask Generation Functions, and Keyed Hash Functions. These extensions use the `IppHashAlgId` enumerator associated with a particular hash algorithm as shown in the table below.

Supported Hash Algorithms

Value of IppHashAlgId	Associated Hash Algorithm
ippHashAlg_SHA1	SHA-1
ippHashAlg_SHA224	SHA-224
ippHashAlg_SHA256	SHA-256
ippHashAlg_SHA384	SHA-384
ippHashAlg_SHA512	SHA-512
ippHashAlg_SHA512_224	SHA-512/224
ippHashAlg_SHA512_256	SHA-512/256
ippHashAlg_MD5	MD5
ippHashAlg_SM3	SM3

Reduced Memory Footprint Functions

When your application uses the `IppHashAlgId` enumerator, it gets linked to all available hashing algorithm implementations. This results in unnecessary memory overhead if the application does not need all the algorithms. Intel IPP Cryptography includes a number of *reduced memory footprint* functions that allow you to select the exact hashing methods for your application's needs. These functions have the `_rmf` suffix in their names and use pointers to `IppsHashMethod` structure variables instead of `IppHashAlgId` values. To get a pointer to a `IppsHashMethod` structure variable, call an appropriate function from the table below. See `HashMethod` for the syntax.

NOTE
Functions that have the _TT suffix in their names return pointers to dynamically dispatched `IppsHashMethod` structures. These structures check for support of the SHA-NI instruction set at run time and choose the implementation of an algorithm depending on the outcome of the check. Using such `IppsHashMethod` structures leads to a slightly larger memory footprint compared to applications that use non-dynamically dispatched `IppsHashMethod` structures.

HashMethod Functions

Function name	Returns pointer to implementation of
ippsHashMethod_SHA1	SHA1 (without the SHA-NI instruction set)
ippsHashMethod_SHA1_NI	SHA1 (using the SHA-NI instruction set)
ippsHashMethod_SHA1_TT	SHA1 (using the SHA-NI instructions set if it is available at run time)
ippsHashMethod_SHA256	SHA256 (without the SHA-NI instruction set)
ippsHashMethod_SHA256_NI	SHA256 (using the SHA-NI instruction set)
ippsHashMethod_SHA256_TT	SHA256 (using the SHA-NI instructions set if it is available at run time)
ippsHashMethod_SHA224	SHA224 (without the SHA-NI instruction set)

Function name	Returns pointer to implementation of
`ippsHashMethod_SHA224_NI`	SHA224 (using the SHA-NI instruction set)
`ippsHashMethod_SHA224_TT`	SHA224 (using the SHA-NI instructions set if it is available at run time)
`ippsHashMethod_SHA384`	SHA384
`ippsHashMethod_SHA512`	SHA512
`ippsHashMethod_SHA512_256`	SHA512-256
`ippsHashMethod_SHA512_224`	SHA512-224
`ippsHashMethod_MD5`	MD5
`ippsHashMethod_SM3`	SM3

Important
The crypto community does not consider SHA-1 or MD5 algorithms secure anymore.

Recommendation: use a more secure hash algorithm (for example, any algorithm from the SHA-2 family) instead of SHA-1 or MD5.

Hash Functions

NOTE The MD5 algorithm is considered weak due to known attacks on it. The functionality remains in the library, but the implementation will no longer be optimized and no security patches will be applied. A more secure alternative is available: SHA-2. For more information, see *Fast Collision Attack on MD5* (https://eprint.iacr.org/2013/170.pdf) and *How to Break MD5 and Other Hash Functions* (http://merlot.usc.edu/csac-f06/papers/Wang05a.pdf).

Functions described in this section apply hash algorithms to digesting streaming messages.

Usage model of the generalized hash functions is similar to the model explained below.

A primitive implementing a hash algorithm uses the state context `IppsHashState` as an operational vehicle to carry all necessary variables to manage the computation of the chaining digest value.

The following example illustrates how the application code can apply the implemented SHA-1 hash standard to digest the input message stream.

1. Call the function HashGetSize to get the size required to configure the `IppsHashState` context.
2. Ensure that the required memory space is properly allocated. With the allocated memory, call the HashInit function with the value of *hashAlg* equal to `ippHashAlg_SHA1` to set up the initial context state with the SHA-1 specified initialization vectors.
3. Keep calling the function HashUpdate to digest incoming message stream in the queue till its completion. To determine the current value of the digest, call HashGetTag between the two calls to `HashUpdate`.
4. Call the function HashFinal to pad the partial block into a final SHA-1 message block and transform it into a 160-bit message digest value.
5. Clean up secret data stored in the context.
6. Call the operating system memory free service function to release the `IppsSHA1StateIppsHashState` context.

The `IppsHashState` context is position-dependent. The `HashPack, HashUnpack` functions transform this context to a position-independent form and vice versa.

NOTE
For memory-critical applications, consider using Reduced Memory Footprint Functions.

Important
The crypto community does not consider SHA-1 or MD5 algorithms secure anymore.

Recommendation: use a more secure hash algorithm (for example, any algorithm from the SHA-2 family) instead of SHA-1 or MD5.

See Also

Data Security Considerations

HashGetSize

Gets the size of the `IppsHashState` *or* `IppsHashState_rmf` *context in bytes.*

Syntax

```
IppStatus ippsHashGetSize(int *pSize);
IppStatus ippsHashGetSize_rmf(int *pSize);
```

Include Files

`ippcp.h`

Parameters

pSize	Pointer to the value of the `IppsHashState` or `IppsHashState_rmf` context size.

Description

The function gets the size of the `IppsHashState` or `IppsHashState_rmf` context in bytes and stores it in `*pSize`.

NOTE
This function has a *reduced memory footprint* version. To learn more, see Reduced Memory Footprint Functions.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is NULL.

HashInit

Initializes user-supplied memory as `IppsHashState` *or* `IppsHashState_rmf` *context for future use.*

Syntax

```
IppStatus ippsHashInit(IppsHashState* pCtx, IppHashAlgId hashAlg);
IppStatus ippsHashInit_rmf(IppsHashState_rmf* pCtx, IppsHashMethod* pMethod);
```

Include Files

`ippcp.h`

Parameters

pCtx	Pointer to the `IppsHashState` or `IppsHashState_rmf` context being intialized.
hashAlg	Identifier of the hash algorithm.
pMethod	Pointer to the hash method.

Description

The function initializes the memory pointed by *pCtx* as `IppsHashState` or `IppsHashState_rmf` context. The *hashAlg* and *pMethod* parameters define the hash algorithm to be used in subsequent calls to `HashUpdate` , `HashFinal`, or `HashGetTag` functions. The *hashAlg* parameter can take one of the values listed in table Supported Hash Algorithms. To get a value for the *pMethod* parameter, call one of the HashMethod functions.

NOTE
This function has a *reduced memory footprint* version. To learn more, see Reduced Memory Footprint Functions.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsNotSupportedModeErr`	Indicates an error condition if the *hashAlg* parameter does not match any value of `IppHashAlg` listed in table Supported Hash Algorithms.

See Also

Data Security Considerations

HashPack, HashUnpack

Packs/unpacks the `IppsHashState` *or* `IppsHashState_rmf` *context into/from a user-defined buffer.*

Syntax

```
IppStatus ippsHashPack (const IppsHashState* pCtx, Ipp8u* pBuffer, int bufSize);
IppStatus ippsHashPack_rmf(const IppsHashState_rmf* pCtx, Ipp8u* pBuffer, int
bufferSize);
IppStatus ippsHashUnpack (const Ipp8u* pBuffer, IppsHashState* pCtx);
IppStatus ippsHashUnpack_rmf(const Ipp8u* pBuffer, IppsHashState_rmf* pCtx);
```

Include Files

`ippcp.h`

Parameters

pCtx	Pointer to the IppsHashState or IppsHashState_rmf context.
pBuffer	Pointer to the user-defined buffer.
bufSize, *bufferSize*	The size of the user-defined buffer in bytes.

Description

The HashPack function transforms the **pCtx* context to a position-independent form and stores it in the the **pBuffer* buffer. The HashUnpack function performs the inverse operation, that is, transforms the contents of the **pBuffer* buffer into a normal IppsHashState or IppsHashState_rmf context. The HashPack and HashUnpack functions enable replacing the position-dependent IppsHashState or IppsHashState_rmf context in the memory.

The value of the *bufSize* parameter must be not less than the size of IppsHashState or IppsHashState_rmf context. Call the HashGetSize function prior to HashPack to determine the size of the buffer.

NOTE
This function has a *reduced memory footprint* version. To learn more, see Reduced Memory Footprint Functions.

Return Values

ippStsNoErr	Indicates no error. Any other value indicates an error or warning.
ippStsNullPtrErr	Indicates an error condition if any of the specified pointers is NULL.
ippStsMemErr	Indicates an error condition if the value of *bufSize* is less than the size of the IppsHashState context.
ippStsContextMatchErr	Indicates an error condition in a ippsHashPack_rmf call if the context parameter does not match the operation.
ippStsNoMem	Indicates an error condition if the value of *bufferSize* is less than the size of the IppsHashState_rmf context.

HashDuplicate

Copies one IppsHashState *or* IppsHashState_rmf *context to another.*

Syntax

IppStatus ippsHashDuplicate(const IppsHashState* *pSrcCtx*, IppsHashState* *pDstCtx*);

IppStatus ippsHashDuplicate_rmf(const ippsHashState_rmf* *pSrcCtx*, ippsHashState_rmf* *pDstCtx*);

Include Files

ippcp.h

Parameters

pSrcCtx	Pointer to the input `IppsHashState` or `IppsHashState_rmf` context to be cloned.
pDstCtx	Pointer to the output `IppsHashState` or `IppsHashState_rmf` context.

Description

The function copies one `IppsHashState` or `IppsHashState_rmf` context to another.

NOTE
This function has a *reduced memory footprint* version. To learn more, see Reduced Memory Footprint Functions.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if any of the context parameters does not match the operation.

HashUpdate

Digests the current input message stream of the specified length.

Syntax

```
IppStatus ippsHashUpdate(const Ipp8u *pSrc, int len, IppsHashState *pCtx);
IppStatus ippsHashUpdate_rmf(const Ipp8u *pSrc, int len, ippsHashState_rmf *pCtx);
```

Include Files

`ippcp.h`

Parameters

pSrc	Pointer to the buffer containing a part of or the whole message.
len	Length of the actual part of the message in bytes.
pCtx	Pointer to the `IppsHashState` or `IppsHashState_rmf` context.

Description

The function digests the current input message stream of the specified length.

The function first integrates the previous partial block with the input message stream and then partitions them into multiple message blocks (as specified by the applied hash algorithm) with a possible additional partial block. For each message block, the function uses the selected hash algorithm to transform the block into a new chaining digest value.

NOTE
This function has a *reduced memory footprint* version. To learn more, see Reduced Memory Footprint Functions.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is NULL.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsLengthErr`	Indicates an error condition in any of the following cases: • The length of the input data stream is less than zero • The length of the totally processed stream (including the current update request) exceeds the limit defined by the particular hash algorithm.

HashFinal

Completes computation of the digest value.

Syntax

`IppStatus ippsHashFinal(Ipp8u *pMD, IppsHashState *pCtx);`

`IppStatus ippsHashFinal_rmf(Ipp8u *pHash, ippsHashState_rmf *pCtx);`

Include Files

`ippcp.h`

Parameters

pMD, *pHash*	Pointer to the resultant digest value.
pCtx	Pointer to the `IppsHashState` or `IppsHashState_rmf` context.

Description

The function completes calculation of the digest value and stores the result at the specified memory location, then re-initializes the *pCtx* context.

NOTE
This function has a *reduced memory footprint* version. To learn more, see Reduced Memory Footprint Functions.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is NULL.

`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

HashGetTag

Computes the current digest value of the processed part of the message.

Syntax

`IppStatus ippsHashGetTag(Ipp8u* pTag, int tagLen, const IppsHashState* pCtx);`

`IppStatus ippsHashGetTag_rmf(Ipp8u* pTag, int tagLen, ippsHashState_rmf* pCtx);`

Include Files

`ippcp.h`

Parameters

pTag	Pointer to the authentication tag.
tagLen	The length of the tag (in bytes).
pCtx	Pointer to the `IppsHashState` or `IppsHashState_rmf` context.

Description

The function computes the message digest based on the current context as specified in [FIPS PUB 180-2], [FIPS PUB 180-4] and [RFC 1321]. A call to this function retains the possibility to update the digest.

NOTE
This function has a *reduced memory footprint* version. To learn more, see Reduced Memory Footprint Functions.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if *tagLen* < 1 or *tagLen* exceeds the maximal length of a particular digest.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

HashMethod

Returns a pointer to a pre-defined hash algorithm.

Syntax

`const IppsHashMethod* ippsHashMethod_SHA1(void);`

`const IppsHashMethod* ippsHashMethod_SHA1_NI(void);`

`const IppsHashMethod* ippsHashMethod_SHA1_TT(void);`

```
const IppsHashMethod* ippsHashMethod_SHA256(void);
const IppsHashMethod* ippsHashMethod_SHA256_NI(void);
const IppsHashMethod* ippsHashMethod_SHA256_TT(void);
const IppsHashMethod* ippsHashMethod_SHA224(void);
const IppsHashMethod* ippsHashMethod_SHA224_NI(void);
const IppsHashMethod* ippsHashMethod_SHA224_TT(void);
const IppsHashMethod* ippsHashMethod_SHA512(void);
const IppsHashMethod* ippsHashMethod_SHA384(void);
const IppsHashMethod* ippsHashMethod_SHA512_224(void);
const IppsHashMethod* ippsHashMethod_SHA512_256(void);
const IppsHashMethod* ippsHashMethod_MD5(void);
const IppsHashMethod* ippsHashMethod_SM3(void);
```

Include Files

`ippcp.h`

Description

NOTE
The `ippsHashMethod_MD5` function is deprecated. The MD5 algorithm is considered weak due to known attacks on it. The functionality remains in the library, but the implementation will no longer be optimized and no security patches will be applied.

Each of these functions returns a pointer to a method-defined implementation of a particular hash algorithm. Use these functions in calls to HashInit and HashMessage. See table HashMethod Functions for an explanation of the values returned by the HashMethod functions.

Return Values

`const ippsHashMethod*`	Pointer to the particular hash method.

HashMethodSet

Initializes IppsHashMethod structure by pre-defined hash algorithm parameters.

Syntax

```
const IppStatus ippsHashMethodSet_SHA1(IppsHashMethod* pMethod);
const IppStatus ippsHashMethodSet_SHA1_NI(IppsHashMethod* pMethod);
const IppStatus ippsHashMethodSet_SHA1_TT(IppsHashMethod* pMethod);
const IppStatus ippsHashMethodSet_SHA256(IppsHashMethod* pMethod);
const IppStatus ippsHashMethodSet_SHA256_NI(IppsHashMethod* pMethod);
const IppStatus ippsHashMethodSet_SHA256_TT(IppsHashMethod* pMethod);
const IppStatus ippsHashMethodSet_SHA224(IppsHashMethod* pMethod);
const IppStatus ippsHashMethodSet_SHA224_NI(IppsHashMethod* pMethod);
```

```
~~const IppStatus ippsHashMethodSet_SHA224_TT(IppsHashMethod* pMethod);~~
const IppStatus ippsHashMethodSet_SHA512(IppsHashMethod* pMethod);
const IppStatus ippsHashMethodSet_SHA384(IppsHashMethod* pMethod);
const IppStatus ippsHashMethodSet_SHA512_224(IppsHashMethod* pMethod);
const IppStatus ippsHashMethodSet_SHA512_256(IppsHashMethod* pMethod);
const IppStatus ippsHashMethodSet_MD5(IppsHashMethod* pMethod);
const IppStatus ippsHashMethodSet_SM3(IppsHashMethod* pMethod);
```

Include Files

`ippcp.h`

Parameters

*IppsHashMethod**	Pointer to the uninitialized hash method.

Description

NOTE The `ippsHashMethodSet_MD5` function is deprecated. The MD5 algorithm is considered weak due to known attacks on it. The functionality remains in the library, but the implementation will no longer be optimized and no security patches will be applied.

Each of these functions accepts a pointer to uninitialized memory of the size obtained using HashMethodGetSize, and initializes this memory to method-defined implementation of a particular hash algorithm. Use these functions in calls to HashInit and HashMessage.

Return Values

ippStsNoErr	Indicates no errors. Any other value indicates an error or warning.
ippStsNullPtrErr	Indicates an error condition if any of the specified pointers is NULL.

HashMethodGetSize

Gets the size of the IppsHashMethod context in bytes.

Syntax

```
IppStatus ippsHashMethodGetSize(int *pSize);
```

Include Files

`ippcp.h`

Parameters

pSize	Pointer to the value of the `IppsHashMethod` context size.

Description

The function gets the size of the `IppsHashMethod` context in bytes and stores it in **pSize*.

Return Values

ippStsNoErr	Indicates no errors. Any other value indicates an error or warning.
ippStsNullPtrErr	Indicates an error condition if any of the specified pointers is NULL.

SM3GetSize

Gets the size of the `IppsSM3State` *context in bytes.*

Syntax

```
IppStatus ippsSM3GetSize(int *pSize);
```

Include Files

`ippcp.h`

Parameters

pSize	Pointer to the `IppsSM3State` context size value.

Description

The function gets the `IppsSM3State` context size in bytes and stores it in **pSize*.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.

SM3Init

Initializes user-supplied memory as `IppsSM3State` *context for future use.*

Syntax

```
IppStatus ippsSM3Init(IppsSM3State* pCtx);
```

Include Files

`ippcp.h`

Parameters

pCtx	Pointer to the `IppsSM3State` context being intialized.

Description

The function initializes the memory pointed by *pCtx* as `IppsSM3State` context.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.

`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.

See Also

Data Security Considerations

SM3Pack, SM3Unpack

Packs/unpacks the `IppsSM3State` *context into/from a user-defined buffer.*

Syntax

`IppStatus ippsSM3Pack (const IppsSM3State* pCtx, Ipp8u* pBuffer);`

`IppStatus ippsSM3Unpack (const Ipp8u* pBuffer, IppsSM3State* pCtx);`

Include Files

`ippcp.h`

Parameters

pCtx	Pointer to the `IppsSM3State` context.
pBuffer	Pointer to the user-defined buffer.

Description

The SM3Pack function transforms the `*pCtx` context to a position-independent form and stores it in the `*pBuffer` buffer. The SM3Unpack function performs the inverse operation, that is, transforms the contents of the `*pBuffer` buffer into a normal `IppsSM3State` context. The SM3Pack and SM3Unpack functions enable replacing the position-dependent `IppsSM3State` context in the memory.

Call the `SM3GetSize` function prior to SM3Pack/SM3Unpack to determine the size of the buffer.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

SM3Duplicate

Copies one `IppsSM3State` *context to another.*

Syntax

`IppStatus ippsSM3Duplicate(const IppsSM3State* pSrcCtx, IppsSM3State* pDstCtx);`

Include Files

`ippcp.h`

Parameters

pSrcCtx	Pointer to the source `IppsSM3State` context to be cloned.

pDstCtx	Pointer to the destination `IppsSM3State` context.

Description

The function copies one `IppsSM3State` context to another.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

SM3Update

Digests the current input message stream of the specified length.

Syntax

`IppStatus ippsSM3Update(const Ipp8u *`*`pSrc`*`, int `*`len`*`, IppsSM3State *`*`pCtx`*`);`

Include Files

`ippcp.h`

Parameters

pSrc	Pointer to the buffer containing a part of or the whole message.
len	Length of the actual part of the message in bytes.
pCtx	Pointer to the `IppsSM3State` context.

Description

The function digests the current input message stream of the specified length.

The function first integrates the previous partial block with the input message stream and then partitions them into multiple message blocks (as specified by the applied hash algorithm) with a possible additional partial block. For each message block, the function uses the selected hash algorithm to transform the block into a new chaining digest value.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsLengthErr`	Indicates an error condition if the input data stream length is less than zero.

SM3Final

Completes computation of the SM3 digest value.

Syntax

```
IppStatus ippsSM3Final(Ipp8u *pMD, IppsSM3State *pCtx);
```

Include Files

`ippcp.h`

Parameters

pMD	Pointer to the resultant digest value.
pCtx	Pointer to the `IppsSM3State` context.

Description

The function completes calculation of the digest value and stores the result into the specified memory.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

SM3GetTag

Computes the current SM3 digest value of the processed part of the message.

Syntax

```
IppStatus ippsSM3GetTag(Ipp8u* pTag, Ipp32u tagLen, const IppsSM3State* pCtx);
```

Include Files

`ippcp.h`

Parameters

pTag	Pointer to the authentication tag.
tagLen	Length of the tag (in bytes).
pCtx	Pointer to the `IppsSM3State` context.

Description

The function computes the message digest based on the current context as specified in [SM3]. A call to this function retains the possibility to update the digest.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.

`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if *`tagLen`* < 1 or *`tagLen`* exceeds the maximal length of a particular digest.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

MD5GetSize

Gets the size of the `IppsMD5State` *context in bytes (deprecated).*

Syntax

```
IppStatus ippsMD5GetSize(int *pSize);
```

Include Files

`ippcp.h`

Parameters

`pSize`	Pointer to the `IppsMD5State` context size value.

Description

NOTE

This algorithm is considered weak due to known attacks on it. The functionality remains in the library, but the implementation will no longer be optimized and no security patches will be applied.

The function gets the `IppsMD5State` context size in bytes and stores it in *`*pSize`*.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.

MD5Init

Initializes user-supplied memory as `IppsMD5State` *context for future use (deprecated).*

Syntax

```
IppStatus ippsMD5Init(IppsMD5State* pCtx);
```

Include Files

`ippcp.h`

Parameters

`pCtx`	Pointer to the `IppsMD5State` context being intialized.

Description

NOTE
This algorithm is considered weak due to known attacks on it. The functionality remains in the library, but the implementation will no longer be optimized and no security patches will be applied.

The function initializes the memory pointed by *pCtx* as `IppsMD5State` context.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.

See Also

Data Security Considerations

MD5Pack, MD5Unpack

Packs/unpacks the `IppsMD5State` *context into/from a user-defined buffer (deprecated).*

Syntax

```
IppStatus ippsMD5Pack (const IppsMD5State* pCtx, Ipp8u* pBuffer);
IppStatus ippsMD5Unpack (const Ipp8u* pBuffer, IppsMD5State* pCtx);
```

Include Files

`ippcp.h`

Parameters

pCtx	Pointer to the `IppsMD5State` context.
pBuffer	Pointer to the user-defined buffer.

Description

NOTE
This algorithm is considered weak due to known attacks on it. The functionality remains in the library, but the implementation will no longer be optimized and no security patches will be applied.

The `MD5Pack` function transforms the **pCtx* context to a position-independent form and stores it in the **pBuffer* buffer. The `MD5Unpack` function performs the inverse operation, that is, transforms the contents of the **pBuffer* buffer into a normal `IppsMD5State` context. The `MD5Pack` and `MD5Unpack` functions enable replacing the position-dependent `IppsMD5State` context in the memory.

Call the `MD5GetSize` function prior to `MD5Pack`/`MD5Unpack` to determine the size of the buffer.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

MD5Duplicate

Copies one `IppsMD5State` *context to another (deprecated).*

Syntax

`IppStatus ippsMD5Duplicate(const IppsMD5State* `*`pSrcCtx`*`, IppsMD5State* `*`pDstCtx`*`);`

Include Files

`ippcp.h`

Parameters

`pSrcCtx`	Pointer to the source `IppsMD5State` context to be cloned.
`pDstCtx`	Pointer to the destination `IppsMD5State` context.

Description

NOTE
This algorithm is considered weak due to known attacks on it. The functionality remains in the library, but the implementation will no longer be optimized and no security patches will be applied.

The function copies one `IppsMD5State` context to another.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

MD5Update

Digests the current input message stream of the specified length (deprecated).

Syntax

`IppStatus ippsMD5Update(const Ipp8u *`*`pSrc`*`, int `*`len`*`, IppsMD5State *`*`pCtx`*`);`

Include Files

`ippcp.h`

Parameters

pSrc	Pointer to the buffer containing a part of or the whole message.
len	Length of the actual part of the message in bytes.
pCtx	Pointer to the `IppsMD5State` context.

Description

NOTE
This algorithm is considered weak due to known attacks on it. The functionality remains in the library, but the implementation will no longer be optimized and no security patches will be applied.

The function digests the current input message stream of the specified length.

The function first integrates the previous partial block with the input message stream and then partitions them into multiple message blocks (as specified by the applied hash algorithm) with a possible additional partial block. For each message block, the function uses the selected hash algorithm to transform the block into a new chaining digest value.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsLengthErr`	Indicates an error condition if the input data stream length is less than zero.

MD5Final

Completes computation of the MD5 digest value (deprecated).

Syntax

```
IppStatus ippsMD5Final(Ipp8u *pMD, IppsMD5State *pCtx);
```

Include Files

`ippcp.h`

Parameters

pMD	Pointer to the resultant digest value.
pCtx	Pointer to the `IppsMD5State` context.

Description

NOTE
This algorithm is considered weak due to known attacks on it. The functionality remains in the library, but the implementation will no longer be optimized and no security patches will be applied.

The function completes calculation of the digest value and stores the result into the specified memory.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

MD5GetTag

Computes the current MD5 digest value of the processed part of the message (deprecated).

Syntax

`IppStatus ippsMD5GetTag(Ipp8u* pTag, Ipp32u tagLen, const IppsMD5State* pCtx);`

Include Files

`ippcp.h`

Parameters

pTag	Pointer to the authentication tag.
tagLen	Length of the tag (in bytes).
pCtx	Pointer to the `IppsMD5State` context.

Description

NOTE
This algorithm is considered weak due to known attacks on it. The functionality remains in the library, but the implementation will no longer be optimized and no security patches will be applied.

The function computes the message digest based on the current context as specified in [FIPS PUB 180-2] and [RFC 1321]. A call to this function retains the possibility to update the digest.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.

`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if *`tagLen`* < 1 or *`tagLen`* exceeds the maximal length of a particular digest.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

SHA1GetSize

Gets the size of the `IppsSHA1State` *context in bytes.*

Syntax

`IppStatus ippsSHA1GetSize(int *`*`pSize`*`);`

Include Files

`ippcp.h`

Parameters

`pSize`	Pointer to the `IppsSHA1State` context size value.

Description

The function gets the `IppsSHA1State` context size in bytes and stores it in `*`*`pSize`*.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.

SHA1Init

Initializes user-supplied memory as `IppsSHA1State` *context for future use.*

Syntax

`IppStatus ippsSHA1Init(IppsSHA1State* `*`pCtx`*`);`

Include Files

`ippcp.h`

Parameters

`pCtx`	Pointer to the `IppsSHA1State` context being intialized.

Description

The function initializes the memory pointed by *`pCtx`* as `IppsSHA1State` context.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.

`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.

See Also

Data Security Considerations

SHA1Pack, SHA1Unpack

Packs/unpacks the `IppsSHA1State` *context into/from a user-defined buffer.*

Syntax

```
IppStatus ippsSHA1Pack (const IppsSHA1State* pCtx, Ipp8u* pBuffer);
IppStatus ippsSHA1Unpack (const Ipp8u* pBuffer, IppsSHA1State* pCtx);
```

Include Files

`ippcp.h`

Parameters

`pCtx`	Pointer to the `IppsSHA1State` context.
`pBuffer`	Pointer to the user-defined buffer.

Description

The SHA1Pack function transforms the *`*pCtx`* context to a position-independent form and stores it in the *`*pBuffer`* buffer. The SHA1Unpack function performs the inverse operation, that is, transforms the contents of the *`*pBuffer`* buffer into a normal `IppsSHA1State` context. The SHA1Pack and SHA1Unpack functions enable replacing the position-dependent `IppsSHA1State` context in the memory.

Call the `SHA1GetSize` function prior to SHA1Pack/SHA1Unpack to determine the size of the buffer.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

SHA1Duplicate

Copies one `IppsSHA1State` *context to another.*

Syntax

```
IppStatus ippsSHA1Duplicate(const IppsSHA1State* pSrcCtx, IppsSHA1State* pDstCtx);
```

Include Files

`ippcp.h`

Parameters

`pSrcCtx`	Pointer to the source `IppsSHA1State` context to be cloned.

pDstCtx	Pointer to the destination `IppsSHA1State` context.

Description

The function copies one `IppsSHA1State` context to another.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

SHA1Update

Digests the current input message stream of the specified length.

Syntax

`IppStatus ippsSHA1Update(const Ipp8u *pSrc, int len, IppsSHA1State *pCtx);`

Include Files

`ippcp.h`

Parameters

pSrc	Pointer to the buffer containing a part of or the whole message.
len	Length of the actual part of the message in bytes.
pCtx	Pointer to the `IppsSHA1State` context.

Description

The function digests the current input message stream of the specified length.

The function first integrates the previous partial block with the input message stream and then partitions them into multiple message blocks (as specified by the applied hash algorithm) with a possible additional partial block. For each message block, the function uses the selected hash algorithm to transform the block into a new chaining digest value.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsLengthErr`	Indicates an error condition if the input data stream length is less than zero.

SHA1Final

Completes computation of the SHA-1 digest value.

Syntax

`IppStatus ippsSHA1Final(Ipp8u *pMD, IppsSHA1State *pCtx);`

Include Files

`ippcp.h`

Parameters

pMD	Pointer to the resultant digest value.
pCtx	Pointer to the `IppsSHA1State` context.

Description

The function completes calculation of the digest value and stores the result into the specified memory.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

SHA1GetTag

Computes the current SHA-1 digest value of the processed part of the message.

Syntax

`IppStatus ippsSHA1GetTag(Ipp8u* pTag, Ipp32u tagLen, const IppsSHA1State* pCtx);`

Include Files

`ippcp.h`

Parameters

pTag	Pointer to the authentication tag.
tagLen	Length of the tag (in bytes).
pCtx	Pointer to the `IppsSHA1State` context.

Description

The function computes the message digest based on the current context as specified in [FIPS PUB 180-2] and [RFC 1321]. A call to this function retains the possibility to update the digest.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.

`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if *`tagLen`* < 1 or *`tagLen`* exceeds the maximal length of a particular digest.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

SHA224GetSize

Gets the size of the `IppsSHA224State` *context in bytes.*

Syntax

`IppStatus ippsSHA224GetSize(int *pSize);`

Include Files

`ippcp.h`

Parameters

`pSize`	Pointer to the `IppsSHA224State` context size value.

Description

The function gets the `IppsSHA224State` context size in bytes and stores it in *`*pSize`*.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.

SHA224Init

Initializes user-supplied memory as `IppsSHA224State` *context for future use.*

Syntax

`IppStatus ippsSHA224Init(IppsSHA224State* pCtx);`

Include Files

`ippcp.h`

Parameters

`pCtx`	Pointer to the `IppsSHA224State` context being intialized.

Description

The function initializes the memory pointed by *`pCtx`* as `IppsSHA224State` context.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.

See Also

Data Security Considerations

SHA224Pack, SHA224Unpack

Packs/unpacks the `IppsSHA224State` *context into/ from a user-defined buffer.*

Syntax

```
IppStatus ippsSHA224Pack (const IppsSHA224State* pCtx, Ipp8u* pBuffer);
IppStatus ippsSHA224Unpack (const Ipp8u* pBuffer, IppsSHA224State* pCtx);
```

Include Files

`ippcp.h`

Parameters

`pCtx`	Pointer to the `IppsSHA224State` context.
`pBuffer`	Pointer to the user-defined buffer.

Description

The SHA224Pack function transforms the *`*pCtx`* context to a position-independent form and stores it in the *`*pBuffer`* buffer. The SHA224Unpack function performs the inverse operation, that is, transforms the contents of the *`*pBuffer`* buffer into a normal `IppsSHA224State` context. The SHA224Pack and SHA224Unpack functions enable replacing the position-dependent `IppsSHA224State` context in the memory.

Call the `SHA224GetSize` function prior to SHA224Pack/SHA224Unpack to determine the size of the buffer.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.

SHA224Duplicate

Copies one `IppsSHA224State` *context to another.*

Syntax

```
IppStatus ippsSHA224Duplicate(const IppsSHA224State* pSrcCtx, IppsSHA224State*
pDstCtx);
```

Include Files

`ippcp.h`

Parameters

pSrcCtx	Pointer to the source `SHA224State` context to be cloned.
pDstCtx	Pointer to the destination `IppsSHA224State` context.

Description

The function copies one `IppsSHA224State` context to another.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

SHA224Update

Digests the current input message stream of the specified length.

Syntax

```
IppStatus ippsSHA224Update(const Ipp8u *pSrc, int len, IppsSHA224State *pCtx);
```

Include Files

`ippcp.h`

Parameters

pSrc	Pointer to the buffer containing a part of or the whole message.
len	Length of the actual part of the message in bytes.
pCtx	Pointer to the `IppsSHA224State` context.

Description

The function digests the current input message stream of the specified length.

The function first integrates the previous partial block with the input message stream and then partitions them into multiple message blocks (as specified by the applied hash algorithm) with a possible additional partial block. For each message block, the function uses the selected hash algorithm to transform the block into a new chaining digest value.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

`ippStsLengthErr`	Indicates an error condition if the input data stream length is less than zero.

SHA224Final

Completes computation of the SHA-224 digest value.

Syntax

`IppStatus ippsSHA224Final(Ipp8u *pMD, IppsSHA224State *pCtx);`

Include Files

`ippcp.h`

Parameters

pMD	Pointer to the resultant digest value.
pCtx	Pointer to the `IppsSHA224State` context.

Description

The function completes calculation of the digest value and stores the result into the specified memory.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

SHA224GetTag

Computes the current SHA-224 digest value of the processed part of the message.

Syntax

`IppStatus ippsSHA224GetTag(Ipp8u* pTag, Ipp32u tagLen, const IppsSHA224State* pCtx);`

Include Files

`ippcp.h`

Parameters

pTag	Pointer to the authentication tag.
tagLen	Length of the tag (in bytes).
pCtx	Pointer to the `IppsSHA224State` context.

Description

The function computes the message digest based on the current context as specified in [FIPS PUB 180-2] and [RFC 1321]. A call to this function retains the possibility to update the digest.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if *`tagLen`* < 1 or *`tagLen`* exceeds the maximal length of a particular digest.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

SHA256GetSize

Gets the size of the `IppsSHA256State` *context in bytes.*

Syntax

```
IppStatus ippsSHA256GetSize(int *pSize);
```

Include Files

`ippcp.h`

Parameters

`pSize`	Pointer to the `IppsSHA256State` context size value.

Description

The function gets the `IppsSHA256State` context size in bytes and stores it in *`*pSize`*.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.

SHA256Init

Initializes user-supplied memory as `IppsSHA256State` *context for future use.*

Syntax

```
IppStatus ippsSHA256Init(IppsSHA256State *pCtx);
```

Include Files

`ippcp.h`

Parameters

`pCtx`	Pointer to the `IppsSHA256State` context being intialized.

Description

The function initializes the memory pointed by *`pCtx`* as `IppsSHA256State` context.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.

See Also

Data Security Considerations

SHA256Pack, SHA256Unpack

Packs/unpacks the `IppsSHA256State` *context into/from a user-defined buffer.*

Syntax

`IppStatus ippsSHA256Pack (const IppsSHA256State* pCtx, Ipp8u* pBuffer);`

`IppStatus ippsSHA256Unpack (const Ipp8u* pBuffer, IppsSHA256State* pCtx);`

Include Files

`ippcp.h`

Parameters

`pCtx`	Pointer to the `IppsSHA256State` context.
`pBuffer`	Pointer to the user-defined buffer.

Description

The SHA256Pack function transforms the *`*pCtx`* context to a position-independent form and stores it in the *`*pBuffer`* buffer. The SHA256Unpack function performs the inverse operation, that is, transforms the contents of the *`*pBuffer`* buffer into a normal `IppsSHA256State` context. The SHA256Pack and SHA256Unpack functions enable replacing the position-dependent `IppsSHA256State` context in the memory.

Call the `SHA256GetSize` function prior to SHA256Pack/SHA256Unpack to determine the size of the buffer.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.

SHA256Duplicate

Copies one `IppsSHA256State` *context to another.*

Syntax

`IppStatus ippsSHA256Duplicate(const IppsSHA256State* pSrcCtx, IppsSHA256State* pDstCtx);`

Include Files

`ippcp.h`

Parameters

pSrcCtx	Pointer to the source `IppsSHA256State` context to be cloned.
pDstCtx	Pointer to the destination `IppsSHA256State` context.

Description

The function copies one `IppsSHA256State` context to another.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

SHA256Update

Digests the current input message stream of the specified length.

Syntax

```
IppStatus ippsSHA256Update(const Ipp8u *pSrc, int len, IppsSHA256State *pCtx);
```

Include Files

`ippcp.h`

Parameters

pSrc	Pointer to the buffer containing a part of or the whole message.
len	Length of the actual part of the message in bytes.
pCtx	Pointer to the `IppsSHA256State` context.

Description

The function digests the current input message stream of the specified length.

The function first integrates the previous partial block with the input message stream and then partitions them into multiple message blocks (as specified by the applied hash algorithm) with a possible additional partial block. For each message block, the function uses the selected hash algorithm to transform the block into a new chaining digest value.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

`ippStsLengthErr`	Indicates an error condition if the input data stream length is less than zero.

SHA256Final

Completes computation of the SHA-256 digest value.

Syntax

`IppStatus ippsSHA256Final(Ipp8u *pMD, IppsSHA256State *pCtx);`

Include Files

`ippcp.h`

Parameters

pMD	Pointer to the resultant digest value.
pCtx	Pointer to the `IppsSHA256State` context.

Description

The function completes calculation of the digest value and stores the result into the specified memory.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

SHA256GetTag

Computes the current SHA-256 digest value of the processed part of the message.

Syntax

`IppStatus ippsSHA256GetTag(Ipp8u* pTag, Ipp32u tagLen, const IppsSHA256State* pCtx);`

Include Files

`ippcp.h`

Parameters

pTag	Pointer to the authentication tag.
tagLen	Length of the tag (in bytes).
pCtx	Pointer to the `IppsSHA265State` context.

Description

The function computes the message digest based on the current context as specified in [FIPS PUB 180-2] and [RFC 1321]. A call to this function retains the possibility to update the digest.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if *`tagLen`* < 1 or *`tagLen`* exceeds the maximal length of a particular digest.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

SHA384GetSize

Gets the size of the `IppsSHA384State` *context in bytes.*

Syntax

```
IppStatus ippsSHA384GetSize(int *pSize);
```

Include Files

`ippcp.h`

Parameters

`pSize`	Pointer to the `IppsSHA384State` context size value.

Description

The function gets the `IppsSHA384State` context size in bytes and stores it in *`*pSize`*.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.

SHA384Init

Initializes user-supplied memory as `IppsSHA384State` *context for future use.*

Syntax

```
IppStatus ippsSHA384Init(IppsSHA384State* pCtx);
```

Include Files

`ippcp.h`

Parameters

`pCtx`	Pointer to the `IppsSHA384State` context being intialized.

Description

The function initializes the memory pointed by *`pCtx`* as `IppsSHA384State` context.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.

See Also

Data Security Considerations

SHA384Pack, SHA384Unpack

Packs/unpacks the `IppsSHA384State` *context into/ from a user-defined buffer.*

Syntax

```
IppStatus ippsSHA384Pack (const IppsSHA384State* pCtx, Ipp8u* pBuffer);
IppStatus ippsSHA384Unpack (const Ipp8u* pBuffer, IppsSHA384State* pCtx);
```

Include Files

`ippcp.h`

Parameters

`pCtx`	Pointer to the `IppsSHA384State` context.
`pBuffer`	Pointer to the user-defined buffer.

Description

The SHA384Pack function transforms the *`*pCtx`* context to a position-independent form and stores it in the *`*pBuffer`* buffer. The SHA384Unpack function performs the inverse operation, that is, transforms the contents of the *`*pBuffer`* buffer into a normal `IppsSHA384State` context. The SHA384Pack and SHA384Unpack functions enable replacing the position-dependent `IppsSHA384State` context in the memory.

Call the `SHA384GetSize` function prior to SHA384Pack/SHA384Unpack to determine the size of the buffer.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

SHA384Duplicate

Copies one `IppsSHA384State` *context to another.*

Syntax

```
IppStatus ippsSHA384Duplicate(const IppsSHA384State* pSrcCtx, IppsSHA384State*
pDstCtx);
```

Include Files

`ippcp.h`

Parameters

pSrcCtx	Pointer to the source `IppsSHA384State` context to be cloned.
pDstCtx	Pointer to the destination `IppsSHA384State` context.

Description

The function copies one `IppsSHA384State` context to another.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

SHA384Update

Digests the current input message stream of the specified length.

Syntax

```
IppStatus ippsSHA384Update(const Ipp8u *pSrc, int len, IppsSHA384State *pCtx);
```

Include Files

`ippcp.h`

Parameters

pSrc	Pointer to the buffer containing a part of or the whole message.
len	Length of the actual part of the message in bytes.
pCtx	Pointer to the `IppsSHA384State` context.

Description

The function digests the current input message stream of the specified length.

The function first integrates the previous partial block with the input message stream and then partitions them into multiple message blocks (as specified by the applied hash algorithm) with a possible additional partial block. For each message block, the function uses the selected hash algorithm to transform the block into a new chaining digest value.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.

`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsLengthErr`	Indicates an error condition if the input data stream length is less than zero.

SHA384Final

Completes computing of the SHA-384 digest value.

Syntax

```
IppStatus ippsSHA384Final( Ipp8u *pMD, IppsSHA384State *pCtx);
```

Include Files

`ippcp.h`

Parameters

pMD	Pointer to the resultant digest value.
pCtx	Pointer to the `IppsSHA384State` context.

Description

The function completes calculation of the digest value and stores the result into the specified memory.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

SHA384GetTag

Computes the current SHA-384 digest value of the processed part of the message.

Syntax

```
IppStatus ippsSHA384GetTag(Ipp8u* pTag, Ipp32u tagLen, const IppsSHA384State* pCtx);
```

Include Files

`ippcp.h`

Parameters

pTag	Pointer to the authentication tag.
tagLen	Length of the tag (in bytes).
pCtx	Pointer to the `IppsSHA384State` context.

Description

The function computes the message digest based on the current context as specified in [FIPS PUB 180-2] and [RFC 1321]. A call to this function retains the possibility to update the digest.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if *`tagLen`* < 1 or *`tagLen`* exceeds the maximal length of a particular digest.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

SHA512GetSize

Gets the size of the `IppsSHA512State` *context in bytes.*

Syntax

```
IppStatus ippsSHA512GetSize(int *pSize);
```

Include Files

`ippcp.h`

Parameters

`pSize`	Pointer to the `IppsSHA512State` context size value.

Description

The function gets the `IppsSHA512State` context size in bytes and stores it in *`*pSize`*.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.

SHA512Init

Initializes user-supplied memory as `IppsSHA512State` *context for future use.*

Syntax

```
IppStatus ippsSHA512Init(IppsSHA512State* pCtx);
```

Include Files

`ippcp.h`

Parameters

`pCtx`	Pointer to the `IppsSHA512State` context being intialized.

Description

The function initializes the memory pointed by *`pCtx`* as `IppsSHA512State` context.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.

See Also

Data Security Considerations

SHA512Pack, SHA512Unpack

Packs/unpacks the `IppsSHA512State` *context into/ from a user-defined buffer.*

Syntax

`IppStatus ippsSHA512Pack (const IppsSHA512State* *pCtx*, Ipp8u* *pBuffer*);`

`IppStatus ippsSHA512Unpack (const Ipp8u* *pBuffer*, IppsSHA512State* *pCtx*);`

Include Files

`ippcp.h`

Parameters

`pCtx`	Pointer to the `IppsSHA512State` context.
`pBuffer`	Pointer to the user-defined buffer.

Description

The SHA512Pack function transforms the *`*pCtx`* context to a position-independent form and stores it in the *`*pBuffer`* buffer. The SHA512Unpack function performs the inverse operation, that is, transforms the contents of the *`*pBuffer`* buffer into a normal `IppsSHA512State` context. The SHA512Pack and SHA512Unpack functions enable replacing the position-dependent `IppsSHA512State` context in the memory.

Call the `SHA512GetSize` function prior to SHA512Pack/SHA512Unpack to determine the size of the buffer.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

SHA512Duplicate

Copies one `IppsSHA512State` *context to another.*

Syntax

`IppStatus ippsSHA512Duplicate(const IppsSHA512State* *pSrcCtx*, IppsSHA512State* *pDstCtx*);`

Include Files

`ippcp.h`

Parameters

pSrcCtx	Pointer to the source `IppsSHA512State` context to be cloned.
pDstCtx	Pointer to the destination `IppsSHA512State` context.

Description

The function copies one `IppsSHA512State` context to another.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

SHA512Update

Digests the current input message stream of the specified length.

Syntax

```
IppStatus ippsSHA512Update(const Ipp8u *pSrc, int len, IppsSHA512State *pCtx);
```

Include Files

`ippcp.h`

Parameters

pSrc	Pointer to the buffer containing a part of or the whole message.
len	Length of the actual part of the message in bytes.
pCtx	Pointer to the `IppsSHA512State` context.

Description

The function digests the current input message stream of the specified length.

The function first integrates the previous partial block with the input message stream and then partitions them into multiple message blocks (as specified by the applied hash algorithm) with a possible additional partial block. For each message block, the function uses the selected hash algorithm to transform the block into a new chaining digest value.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.

`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsLengthErr`	Indicates an error condition if the input data stream length is less than zero.

SHA512Final

Completes computation of the SHA-512 digest value.

Syntax

`IppStatus ippsSHA512Final(Ipp8u *pMD, IppsSHA512State *pCtx);`

Include Files

`ippcp.h`

Parameters

pMD	Pointer to the resultant digest value.
pCtx	Pointer to the `IppsSHA512State` context.

Description

The function completes calculation of the digest value and stores the result into the specified memory.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

SHA512GetTag

Computes the current SHA-512 digest value of the processed part of the message.

Syntax

`IppStatus ippsSHA512GetTag(Ipp8u* pTag, Ipp32u tagLen, const IppsSHA512State* pCtx);`

Include Files

`ippcp.h`

Parameters

pTag	Pointer to the authentication tag.
tagLen	Length of the tag (in bytes).
pCtx	Pointer to the `IppsSHA512State` context.

Description

The function computes the message digest based on the current context as specified in [FIPS PUB 180-2] and [RFC 1321]. A call to this function retains the possibility to update the digest.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if *`tagLen`* < 1 or *`tagLen`* exceeds the maximal length of a particular digest.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

Hash Functions for Non-Streaming Messages

This section describes functions that calculate a digest of an entire (non-streaming) input message by applying a selected hash algorithm, as well as a possibility to use a different implementation of a hash algorithm.

Important
The crypto community does not consider SHA-1 or MD5 algorithms secure anymore.

Recommendation: use a more secure hash algorithm (for example, any algorithm from the SHA-2 family) instead of SHA-1 or MD5.

General Definition of a Hash Function

Syntax

typedef IppStatus(_STDCALL *IppHASH)(const Ipp8u* *pMsg*, int *msgLen*, Ipp8u* *pMD*);

Parameters

pMsg	Pointer to the input octet string.
msgLen	Length of the input string in octers.
pMD	Pointer to the output message digest.

Description

This declaration is included in the `ippcp.h` file. The function calculates the digest of a non-streaming message using the implemented hash algorithm.

NOTE
Definition of a hash function used in Intel IPP limits length (in octets) of an input message for any specific hash function by the range of the `int` data type, with the upper bound of 2^{32}-1.

HashMessage

Computes the digest value of an input message.

Syntax

IppStatus ippsHashMessage(const Ipp8u **pMsg*, int *len*, Ipp8u **pMD*, IppHashAlgId *hashAlg*);

`IppStatus ippsHashMessage_rmf(const Ipp8u *pMsg, int msgLen, Ipp8u *pHash, const ippsHashMethod *pMethod);`

Include Files

`ippcp.h`

Parameters

pMsg	Pointer to the input message.
len, *msgLen*	Message length in octets.
pMD, *pHash*	Pointer to the resultant digest.
hashAlg	Identifier of the hash algorithm.
pMethod	Pointer to the hash method.

Description

The function uses the selected hash algorithm to compute the digest value of the entire (non-streaming) input message. The *hashAlg* and *pMethod* parameters define the hash algorithm used. The *hashAlg* parameter can take one of the values listed in table Supported Hash Algorithms. To get a value for the *pMethod* parameter, call one of the HashMethod functions.

NOTE
This function has a *reduced memory footprint* version. To learn more, see Reduced Memory Footprint Functions.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is NULL.
`ippStsLengthErr`	Indicates an error condition if the length of the input data stream is less than zero.
`ippStsNotSupportedModeErr`	Indicates an error condition if the *hashAlg* parameter does not match any value of `IppHashAlg` listed in table Supported Hash Algorithms.

Example

The code below computes MD5 digest of a message.

```
void  MD5_sample(void)
{
      // define message
      Ipp8u msg[] = "abcdefghijklmnopqrstuvwxyz";

      // once the whole message is placed into memory,
      // you can use the integrated primitive
      Ipp8u digest[16];
      ippsHashMessage(msg,  strlen((char*)msg),  digest,  IPP_ALG_HASH_MD5);
}
```

SM3MessageDigest

Computes SM3 digest value of the input message.

Syntax

```
IppStatus ippsSM3MessageDigest(const Ipp8u *pMsg, int len, Ipp8u *pMD);
```

Include Files

`ippcp.h`

Parameters

pMsg	Pointer to the input message.
len	Message length in octets.
pMD	Pointer to the resultant digest.

Description

The function uses the selected hash algorithm to compute digest value of the entire (non-streaming) input message.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if the input data stream length is less than zero.

MD5MessageDigest

Computes MD5 digest value of the input message (deprecated).

Syntax

```
IppStatus ippsMD5MessageDigest(const Ipp8u *pMsg, int len, Ipp8u *pMD);
```

Include Files

`ippcp.h`

Parameters

pMsg	Pointer to the input message.
len	Message length in octets.
pMD	Pointer to the resultant digest.

Description

NOTE
This algorithm is considered weak due to known attacks on it. The functionality remains in the library, but the implementation will no longer be optimized and no security patches will be applied.

The function uses the selected hash algorithm to compute digest value of the entire (non-streaming) input message.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if the input data stream length is less than zero.

Example

The code example below shows MD5 digest of a message.

```
void  MD5_sample(void){
   // define message

   Ipp8u msg[] = "abcdefghijklmnopqrstuvwxyz";

   // once the whole message is placed into memory,
   // one can use the integrated primitive
   Ipp8u digest[16];
   ippsMD5MessageDigest(msg,  strlen((char*)msg),  digest);
}
```

SHA1MessageDigest

Computes SHA-1 digest value of the input message.

Syntax

`IppStatus ippsSHA1MessageDigest(const Ipp8u *pMsg, int len, Ipp8u *pMD);`

Include Files

`ippcp.h`

Parameters

pMsg	Pointer to the input message.
len	Message length in octets.
pMD	Pointer to the resultant digest.

Description

The function uses the selected hash algorithm to compute the digest value of the entire (non-streaming) input message.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if the input data stream length is less than zero.

Example

The code example below shows SHA1 digest of a message.

```
   //    Compute two SHA1 digests of a message:
   //    1-st will correspond of 1/2 message
   //    2-nd will correspond of whole message
void  SHA1_sample(void){
   // get size of the SHA1 context
   int ctxSize;
   ippsSHA1GetSize(&ctxSize);

   // allocate the SHA1 context
   IppsSHA1State* pCtx = (IppsSHA1State*)( new Ipp8u [ctxSize] );
   // and initialize the context
   ippsSHA1Init(pCtx);
   // define a message
   Ipp8u  msg[]  =  "abcdbcdecdefdefgefghfghighijhijkijkljklmklmnlmnomnopnopq";
   int n;
   // update digest using a piece of message
   for(n=0; n<(sizeof(msg)-1)/2; n++)
      ippsSHA1Update(msg+n, 1, pCtx);
// clone the SHA1 context
   IppsSHA1State* pCtx2 = (IppsSHA1State*)( new Ipp8u [ctxSize] );
   ippsSHA1Init(pCtx2);
   ippsSHA1Duplicate(pCtx,  pCtx2);
 // finalize and extract digest of a half message
   Ipp8u digest[20];
   ippsSHA1Final(digest,  pCtx);
   // update digest using the SHA1 clone context
   ippsSHA1Update(msg+n,  sizeof(msg)-1-n,  pCtx2);

   // finalize and extract digest of a whole message
   Ipp8u digest2[20];
   ippsSHA1Final(digest2,  pCtx2);

   delete [] (Ipp8u*)pCtx;
   delete [] (Ipp8u*)pCtx2;
}
```

SHA224MessageDigest

Computes SHA-224 digest value of the input message.

Syntax

IppStatus ippsSHA224MessageDigest(const Ipp8u **pMsg*, int *len*, Ipp8u **pMD*);

Include Files

ippcp.h

Parameters

pMsg	Pointer to the input message.
len	Message length in octets.
pMD	Pointer to the resultant digest.

Description

The function uses the selected hash algorithm to compute the digest value of the entire (non-streaming) input message.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if the input data stream length is less than zero.

SHA256MessageDigest

Computes SHA-256 digest value of the input message.

Syntax

```
IppStatus ippsSHA256MessageDigest(const Ipp8u *pMsg, int len, Ipp8u *pMD);
```

Include Files

`ippcp.h`

Parameters

pMsg	Pointer to the input message.
len	Message length in octets.
pMD	Pointer to the resultant digest.

Description

The function uses the selected hash algorithm to compute the digest value of the entire (non-streaming) input message.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if the input data stream length is less than zero.

SHA384MessageDigest

Computes SHA-384 digest value of the input message.

Syntax

```
IppStatus ippsSHA384MessageDigest(const Ipp8u *pMsg, int len, Ipp8u *pMD);
```

Include Files

`ippcp.h`

Parameters

pMsg	Pointer to the input message.
len	Message length in octets.
pMD	Pointer to the resultant digest.

Description

The function uses the selected hash algorithm to compute the digest value of the entire (non-streaming) input message.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if the input data stream length is less than zero.

SHA512MessageDigest

Computes SHA-512 digest value of the input message.

Syntax

```
IppStatus ippsSHA512MessageDigest(const Ipp8u *pMsg, int len, Ipp8u *pMD);
```

Include Files

`ippcp.h`

Parameters

pMsg	Pointer to the input message.
len	Message length in octets.
pMD	Pointer to the resultant digest.

Description

The function uses the selected hash algorithm to compute the digest value of the entire (non-streaming) input message.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.

`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if the input data stream length is less than zero.

Mask Generation Functions

Public Key Cryptography frequently uses mask generation functions (MGFs) to achieve a particular security goal. For example, MGFs are used both in RSA-OAEP encryption and RSA-SSA signature schemes.

MGF function takes an octet string of a variable length and generates an octet string of a desired length. MGFs are deterministic, which means that the input octet string completely determines the output one. The output of an MGF should be pseudorandom, that is, infeasible to predict. The provable security of such cryptography schemes as RSA-OAEP or RSA-SSA relies on the random nature of the MGF output. That is why one-way hash functions is one of the well-known ways to implement an MGF. The exact definition of an MGF based on a one-way hash function may be found in [PKCS 1.2.1].

This section describes MGFs based on widely-used hash algorithms, as well as a possibility to use a different implementation of MGF.

Intel IPP implementation of MGFs limits the length (in octets) of an input message for any specific MGF by the range of the `int` data type, with the upper bound of 2^{32}-1.

Important
The crypto community does not consider SHA-1 or MD5 algorithms secure anymore.

Recommendation: use a more secure hash algorithm (for example, any algorithm from the SHA-2 family) instead of SHA-1 or MD5.

User's Implementation of a Mask Generation Function

In case you prefer or have to use a different implementation of an MGF you can still use IPPCP. To do this, use the definition of MGF introduced in the IPPCP library and described in this section. The declaration provided below also defines an MGF when it is used as a parameter in some Public Key Cryptography operations.

Syntax

```
typedef IppStatus(_STDCALL *IppMGF)(const Ipp8u* pSeed, int seedLen, Ipp8u* pMask, int
maskLen);
```

Parameters

`pSeed`	Pointer to the input octet string.
`seedLen`	Length of the input string.
`pMask`	Pointer to the output pseodorandom mask.
`maskLen`	Desired length of the output.

Description

This declaration is included in the `ippcp.h` file. The function generates an octet string of length *`maskLen`* according to the implemented algorithm, providing pseudorandom output.

MGF

Generates a pseudorandom mask of the specified length using a selected hash algorithm.

Syntax

`IppStatus ippsMGF(const Ipp8u *pSeed, int seedLen, Ipp8u* pMask, int maskLen, IppHashAlgId hashAlg);`

Include Files

`ippcp.h`

Parameters

pSeed	Pointer to the input octet string.
seedLen	Length of the input string.
pMask	Pointer to the output pseodorandom mask.
maskLen	Desired length of the output.
hashAlg	Identifier of the hash algorithm.

Description

The function generates a pseudorandom mask of the specified length using the hash algorithm defined by *algID*. The *hashAlg* parameter can take one of the values listed in table Supported Hash Algorithms.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if *pMask* pointer is `NULL`.
`ippStsLengthErr`	Indicates an error condition if any of the specified lengths is negative or zero.
`ippStsNotSupportedModeErr`	Indicates an error condition if the *hashAlg* parameter does not match any value of `IppHashAlg` listed in table Supported Hash Algorithms.

MGF1_rmf, MGF2_rmf

Generates a pseudorandom mask of the specified length using a selected hash lagorithm based on MGF1 or MGF2 specifications.

Syntax

`IppStatus ippsMGF1_rmf(const Ipp8u* pSeed, int seedLen, Ipp8u* pMask, int maskLen, const IppsHashMethod* pMethod);`

`IppStatus ippsMGF2_rmf(const Ipp8u* pSeed, int seedLen, Ipp8u* pMask, int maskLen, const IppsHashMethod* pMethod);`

Include Files

`ippcp.h`

Parameters

pSeed	Pointer to the input octet string.
seedLen	Length of the input string in bytes.
pMask	Pointer to the output pseodorandom mask.
maskLen	Desired length of the output.
pMethod	Pointer to the hash method.

Description

The function generates a pseudorandom mask of the specified length using the hash algorithm defined by *pMethod*, as defined in the MGF1 and MGF2 specifications. To get a value for the *pMethod* parameter, call one of the HashMethod functions.

NOTE
These are *reduced memory footprint* functions. To learn more, see Reduced Memory Footprint Functions.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`
`ippStsLengthErr`	Indicates an error condition if any of the specified lengths is negative or zero.

Data Authentication Primitive Functions

Intel® IPP Cryptography implements functions for generating message authentication code (MAC), that is, Message Authentication Functions.

Message Authentication Functions

Hash function-based MAC (HMAC) is widely used in the applications requiring message authentication and data integrity check. HMAC was initially put forward in [RFC 2401] and adopted by ANSI X9.71 and [FIPS PUB 198]. See Keyed Hash Functions for a description of the Intel® Integrated Performance Primitives (Intel® IPP) HMAC primitives.

A MAC algorithm based on a symmetric key block cipher, in other words, a cipher-based MAC (CMAC), is standardized in [NIST SP 800-38B]. CMAC may be appropriate for information systems where an approved block cipher is available rather than an approved hash function. See CMAC Functions for a description of the Intel IPP CMAC primitives.

Keyed Hash Functions

The Intel IPP HMAC primitive functions, described in this section, use various HMAC schemes based on one-way hash functions described in One-Way Hash Primitives.

Usage model of the generalized HMAC functions is similar to the model explained below.

Each HMAC scheme is implemented as a set of the primitive functions. Each primitive implementing HMAC uses the `HashState` context as an operational vehicle to carry all necessary variables to manage computation of the chaining digest value.

The following example illustrates how the application code can apply the implemented HMAC-SHA1 hash standard to digest the input message stream:

1. Call the function HMAC_GetSize to get the size required to configure the `HashState` context.
2. Ensure that the required memory space is properly allocated. With the allocated memory, call the function HMAC_Init with the value of *`hashAlg`* equal to `ippHashAlg_SHA1` to set up key material and the initial context state with the SHA-1 specified initialization vectors.
3. Keep calling the function HMAC_Update to digest incoming message stream in the queue till its completion. To determine the current value of the message digest, call HMAC_GetTag between the two calls to `HMACUpdate`.
4. Call the function HMAC_Final to pad the partial block into a final SHA-1 message block and transform it into a resulting HMAC value.
5. Clean up secret data stored in the context.
6. Call the operating system memory free service function to release the `HashState` context.

The `HashState` context is position-dependent. The `HMACPack, HMACUnpack` functions transform it to a position-independent form and vice versa:

Important
The crypto community does not consider HMACSHA1 or HMACMD5 secure anymore.

Recommendation: use a more secure hash algorithm (for example, any algorithm from the SHA-2 family) instead of HMACSHA1 or HMACMD5.

See Also

Data Security Considerations

HMAC_GetSize

Gets the size of the `IppsHMACState` *or* `IppsHMACState_rmf` *context.*

Syntax

```
IppStatus ippsHMAC_GetSize(int *pSize);
```

```
IppStatus ippsHMACGetSize_rmf(int *pSize);
```

Include Files

`ippcp.h`

Parameters

pSize	Pointer to the value of the `IppsHMACState` or `IppsHMACState_rmf` context size.

Description

The function gets the size of the `IppsHMACState` or `IppsHMACState_rmf` context in bytes and stores it in *`pSize`*.

NOTE
This function has a *reduced memory footprint* version. To learn more, see Reduced Memory Footprint Functions.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.

HMAC_Init

Initializes user-supplied memory as `IppsHMACState` *or* `IppsHMACState_rmf` *context for future use.*

Syntax

`IppStatus ippsHMAC_Init(const Ipp8u *`*`pKey`*`, int `*`keyLen`*`, IppsHMACState *`*`pCtx`*`, IppHashAlgId `*`hashAlg`*`);`

`IppStatus ippsHMACInit_rmf(const Ipp8u* `*`pKey`*`, int `*`keyLen`*`, IppsHMACState_rmf* `*`pCtx`*`, const IppsHashMethod* `*`pMethod`*`);`

Include Files

`ippcp.h`

Parameters

`pKey`	Pointer to the user-supplied key.
`keyLen`	Key length in bytes.
`pCtx`	Pointer to the `IppsHMACState` or `IppsHMACState_rmf` context being initialized.
`hashAlg`	Identifier of the hash algorithm.
`pMethod`	Pointer to the hash method.

Description

The function initializes the memory pointed to by *`pCtx`* as the `IppsHMACState` or `IppsHMACState_rmf` context. The function also sets up the initial chaining digest value according to the hash algorithm specified by the *`hashAlg`* or *`pMethod`*parameter and computes necessary key material from the supplied key *`pKey`*. The *`hashAlg`* parameter can take one of the values listed in table Supported Hash Algorithms. To get a value for the *`pMethod`* parameter, call one of the HashMethod functions.

NOTE
This function has a *reduced memory footprint* version. To learn more, see Reduced Memory Footprint Functions.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if *`keyLen`* is less than one.
`ippStsNotSupportedModeErr`	Indicates an error condition if the *`hashAlg`* parameter does not match any value of `IppHashAlg` listed in table Supported Hash Algorithms.

See Also

Data Security Considerations

HMAC_Pack, HMAC_Unpack

Packs/unpacks the IppsHMACState *or* IppsHMACState_rmf *context into/from a user-defined buffer.*

Syntax

IppStatus ippsHMAC_Pack (const IppsHMACState* *pCtx*, Ipp8u* *pBuffer*, int *bufSize*);

IppStatus ippsHMACPack_rmf (const IppsHMACState_rmf* *pCtx*, Ipp8u* *pBuffer*, int *bufSize*);

IppStatus ippsHMAC_Unpack (const Ipp8u* *pBuffer*, IppsHMACState* *pCtx*);

IppStatus ippsHMACUnpack_rmf (const Ipp8u* *pBuffer*, IppsHMACState_rmf* *pCtx*);

Include Files

ippcp.h

Parameters

pCtx	Pointer to the IppsHMACState or IppsHMACState_rmf context.
pBuffer	Pointer to the user-defined buffer.
bufSize	The size of the user-defined buffer in bytes.

Description

The HMAC_Pack function transforms the **pCtx* context to a position-independent form and stores it in the **pBuffer* buffer. The HMAC_Unpack function performs the inverse operation, that is, transforms the contents of the **pBuffer* buffer into a normal IppsHMACState or IppsHMACState_rmf context. The HMAC_Pack and HMAC_Unpack functions enable replacing the position-dependent IppsHMACState or IppsHMACState_rmf context in the memory. Call the HMAC_GetSize function prior to HMAC_Pack to determine the size of the buffer.

NOTE
This function has a *reduced memory footprint* version. To learn more, see Reduced Memory Footprint Functions.

Return Values

ippStsNoErr	Indicates no error. Any other value indicates an error or warning.
ippStsNullPtrErr	Indicates an error condition if any of the specified pointers is NULL.
ippStsMemErr	Indicates an error condition if the value of *bufSize* is less than the size of the IppsHMACState or IppsHMACState_rmf context.

HMAC_Duplicate

Copies one IppsHMACState *or* IppsHMACState_rmf *context to another.*

Syntax

`IppStatus ippsHMAC_Duplicate(const IppsHMACState* pSrcCtx, IppsHMACState* pDstCtx);`

`IppStatus ippsHMACDuplicate_rmf(const IppsHMACState_rmf* pSrcCtx, IppsHMACState_rmf* pDstCtx);`

Include Files

`ippcp.h`

Parameters

pSrcCtx	Pointer to the input `IppsHMACState` or `IppsHMACState_rmf` context to be cloned.
pDstCtx	Pointer to the output `IppsHMACState` or `IppsHMACState_rmf` context.

Description

The function copies one `IppsHMACState` or `IppsHMACState_rmf` context to another.

NOTE
This function has a *reduced memory footprint* version. To learn more, see Reduced Memory Footprint Functions.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if any of the context parameters does not match the operation.

HMAC_Update

Digests the current input message stream of the specified length.

Syntax

`IppStatus ippsHMAC_Update(const Ipp8u *pSrc, int len, IppsHMACState *pCtx);`

`IppStatus ippsHMACUpdate_rmf(const Ipp8u *pSrc, int len, IppsHMACState_rmf *pCtx);`

Include Files

`ippcp.h`

Parameters

pSrc	Pointer to the buffer containing a part of the whole message.
len	The length of the actual part of the message in bytes.
pCtx	Pointer to the `IppsHMACState` or `IppsHMACState_rmf` context.

Description

The function digests the current input message stream of the specified length.

The function first integrates the previous partial block with the input message stream and then partitions them into multiple message blocks (as specified by the applied hash algorithm) with a possible additional partial block. For each message block, the function uses the selected hash algorithm to transform the block into a new chaining digest value.

NOTE
This function has a *reduced memory footprint* version. To learn more, see Reduced Memory Footprint Functions.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsLengthErr`	Indicates an error condition if the length of the input data stream is less than zero.

HMAC_Final

Completes computation of the HMAC value.

Syntax

`IppStatus ippsHMAC_Final(Ipp8u *pMD, int mdLen, IppsHMACState *pCtx);`

`IppStatus ippsHMACFinal_rmf(Ipp8u *pMD, int mdLen, IppsHMACState_rmf *pCtx);`

Include Files

`ippcp.h`

Parameters

pMD	Pointer to the resultant HMAC value.
mdLen	Specified HMAC length.
pCtx	Pointer to the `IppsHMACState` or `IppsHMACState_rmf` context.

Description

The function completes calculation of the digest value and stores the result at the memory location specified by *pMD*.

NOTE
This function has a *reduced memory footprint* version. To learn more, see Reduced Memory Footprint Functions.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsLengthErr`	Indicates an error condition if *mdLen* is less than one or greater than the length of the hash value.

HMAC_GetTag

Computes the current HMAC value of the processed part of the message.

Syntax

```
IppStatus ippsHMAC_GetTag(Ipp8u* pMD, int mdLen, const IppsHMACState* pCtx);
IppStatus ippsHMACGetTag_rmf(Ipp8u* pMD, int mdLen, const IppsHMACState_rmf* pCtx);
```

Include Files

`ippcp.h`

Parameters

pMD	Pointer to the authentication tag.
mdLen	The length of the tag (in bytes).
pCtx	Pointer to the `IppsHMACState` or `IppsHMACState_rmf` context.

Description

The function computes the message digest based on the current context as specified in [FIPS PUB 198]. A call to this function retains the possibility to update the digest.

NOTE
This function has a *reduced memory footprint* version. To learn more, see Reduced Memory Footprint Functions.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if *mdLen* <1 or *mdLen* exceeds the maximal length of a particular digest.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

~~HMAC_Message~~

Computes the HMAC value of an entire message.

Syntax

IppStatus ippsHMAC_Message(const Ipp8u **pMsg*, int *msgLen*, const Ipp8u **pKey*, int *keyLen*, Ipp8u **pMD*, int *mdLen*, IppHashAlgId *hashAlg*);

IppStatus ippsHMACMessage_rmf(const Ipp8u **pMsg*, int *msgLen*, const Ipp8u **pKey*, int *keyLen*, Ipp8u **pMAC*, int *macLen*, const ippsHashMethod **pMethod*);

Include Files

ippcp.h

Parameters

pMsg	Pointer to the input message.
msgLen	Message length in bytes.
pKey	Pointer to the user-supplied key.
keyLen	Key length in bytes.
pMD, *pMAC*	Pointer to the resultant HMAC value.
mdLen, *macLen*	Specified HMAC length.
hashAlg	Identifier of the hash algorithm.
pMethod	Pointer to the hash method.

Description

The function takes the input secret key *pKey* of the specified key length *keyLen* and applies the keyed hash-based message authentication code scheme to transform the input message into the respective message authentication code *pMD* or *pMAC* of the specified length *mdLen* or *macLen*. The *hashAlg* and *pMethod* parameters define the hash algorithm applied. The *hashAlg* parameter can take one of the values listed in table Supported Hash Algorithms. To get a value for the *pMethod* parameter, call one of the HashMethod functions.

NOTE
This function has a *reduced memory footprint* version. To learn more, see Reduced Memory Footprint Functions.

Return Values

ippStsNoErr	Indicates no error. Any other value indicates an error or warning.
ippStsNullPtrErr	Indicates an error condition if any of the specified pointers is NULL.
ippStsLengthErr	Indicates an error condition if: • *msgLen* is less than zero • *mdLen* is less than one or greater than the length of the hash value • *macLen* is less than one or greater than the length of the hash value

`ippsStsNotSupportedModeErr`	Indicates an error condition if the *hashAlg* parameter does not match any value of `IppHashAlg` listed in table Supported Hash Algorithms.

CMAC Functions

The Intel IPP CMAC primitive functions use CMAC schemes based on block ciphers described in the Symmetric Cryptography Primitive Functions.

A CMAC scheme is implemented as a set of primitive functions.

Typical application code for computing CMAC of an input message stream should follow the sequence of operations as outlined below:

1. Call the function `AES_CMACGetSize` to get the size required to configure the `IppsAES_CMACState` context.
2. Ensure that the required memory space is properly allocated. With the allocated memory, call the function `AES_CMACInit` to initialize the context.
3. Keep calling the function `AES_CMACUpdate` to update the MAC value of the incoming message stream in the queue till its completion. To determine the current MAC value, call `AES_CMACGetTag` between each two calls to `AES_CMACUpdate`.
4. Call the function `AES_CMACFinal` to complete computation of the MAC value of the streaming message and prepare the context for computation of MAC of another message.
5. Clean up secret data stored in the context.
6. Call the operating system memory free service function to release the `IppsAES_CMACState` context.

AES_CMACGetSize

Gets the size of the `IppsAES_CMACState` *context.*

Syntax

`IppStatus ippsAES_CMACGetSize(int *pSize);`

Include Files

`ippcp.h`

Parameters

pSize	Pointer to the `IppsAES_CMACState` context.

Description

This function gets the size of the `IppsAES_CMACState` context.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.

AES_CMACInit

Initializes user-supplied memory as `IppsAES_CMACState` *context for future use.*

Syntax

`IppStatus ippsAES_CMACInit(const Ipp8u* pKey, int keyLen, IppsAES_CMACState* pState, int ctxSize);`

Include Files

`ippcp.h`

Parameters

pKey	Pointer to the AES key.
keyLen	Key bytestream length (in bytes) defined by the `IppsAESKeyLength` enumerator.
pState	Pointer to the memory buffer being initialized as `IppsAES_CMACState` context.
ctxSize	Available size of the buffer.

Description

This function initializes the memory at the address of *pState* as the `IppsAES_CMACState` context. In addition, the function uses the key to provide all necessary key material for both encryption and decryption operations.

NOTE
If the *pKey* pointer is `NULL`, the function initializes the context with the zero key, which can help you to clean up the actual secret before releasing the context.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if the *pState* pointer is `NULL`.
`ippStsLengthErr`	Indicates an error condition if *keyLen* is not equal to 16, 24, or 32.
`ippStsMemAllocErr`	Indicates an error condition if the allocated memory is insufficient for the operation.

See Also

Data Security Considerations

AES_CMACUpdate

Updates the MAC value depending on the current input message stream of the specified length.

Syntax

```
IppStatus ippsAES_CMACUpdate(const Ipp8u *pSrc, int len, IppsAES_CMACState* pState);
```

Include Files

`ippcp.h`

Parameters

pSrc	Pointer to the buffer containing a part or the entire message.
len	Length of the actual part of the message in bytes.

pState	Pointer to the `IppsAES_CMACState` context.

Description

The function updates the MAC value depending on the current input message stream of the specified length. The function first integrates the previous partial message block with the input message stream and then partitions the obtained message into multiple message blocks with a possible additional partial block. For each message block, the function uses the AES cipher to transform the input block into a new chaining MAC value.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if the input data stream length is less than zero.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

AES_CMACFinal

Completes computation of the MAC value.

Syntax

`IppStatus ippsAES_CMACFinal(Ipp8u *pMD, int mdLen, IppsAES_CMACState *pState);`

Include Files

`ippcp.h`

Parameters

pMD	Pointer to the MAC value.
mdLen	Specified length of the MAC.
pState	Pointer to the `IppsAES_CMACState` context.

Description

The function completes calculation of the MAC of a message, stores the result in the memory at the address of *pMD*, and prepares the context for computation of the MAC of another message.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if *mdLen* is less than 1 or greater than cipher's data block length.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

AES_CMACGetTag

Computes the MAC value of the processed part of the message.

Syntax

```
IppStatus ippsAES_CMACGetTag(Ipp8u* pMD, int mdLen, const IppsAES_CMACState *pState);
```

Include Files

`ippcp.h`

Parameters

pMD	Pointer to the MAC value.
mdLen	Specified length of the MAC.
pState	Pointer to the `IppsAES_CMACState` context.

Description

The function computes the MAC value based on the current context. A call to this function retains the possibility to update the MAC value.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if *mdLen* is less than 1 or greater than cipher's data block length.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

Public Key Cryptography Functions

Big Number Arithmetic

This section describes primitives for performing arithmetic operations with integer big numbers of variable length.

The magnitude of an integer big number is specified by an array of unsigned integer data type `Ipp32u` `rp[length]` and corresponds to the mathematical value

$$r = \sum_{0 \le i < length} rp[i] \times 2^{32i} .$$

This section uses the following definition for the sign of an integer big number:

```
typedef enum {
    IppsBigNumNEG=0,
    IppsBigNumPOS=1
} IppsBigNumSGN;
```

The functions described in this section use the context `IppsBigNumState` to serve as an operational vehicle that carries not only the sign and value of the data, but also a sufficient working buffer reserved for various arithmetic operations. The length of the context `IppsBigNumState` is defined as the length of the data carried by the structure and the size of the context `IppsBigNumState` is therefore defined as the maximal length of the data that this operational vehicle can carry.

NOTE
In all unsigned big number arithmetic functions, integers pointed to by *a*, *b*, and *r* are all of (*n**32) bits.

BigNumGetSize

Gets the size of the `IppsBigNumState` *context in bytes.*

Syntax

```
IppStatus ippsBigNumGetSize(int length, int* psize);
```

Include Files

`ippcp.h`

Parameters

`length`	The length of the integer big number in `Ipp32u`.
`pSize`	Pointer to the size, in bytes, of the buffer required for initialization.

Description

The function specifies the buffer size required to define a structured working buffer of the context `IppsBigNumState` for the storage and operations on an integer big number in bytes.

NOTE
For security reasons, the length of the big number is restricted to 16 kilobits.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if *`length`* is less than or equal to 0 or greater than 512.

BigNumInit

Initializes context and partitions allocated buffer.

Syntax

```
IppStatus ippsBigNumInit(int length, IppsBigNumState* pBN);
```

Include Files

`ippcp.h`

Parameters

`length`	Size of the big number for the context initialization.
`pBN`	Pointer to the supplied buffer used to store the initialized context `IppsBigNumState`.

Description

The function initializes the context `IppsBigNumState` using the specified buffer space and partitions the given buffer to store and execute arithmetic operations on an integer big number of the *`length`* size.

NOTE
For security reasons, the length of the big number is restricted to 16 kilobits.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if *`length`* is less than or equal to 0 or greater than 512.

See Also

Data Security Considerations

Set_BN

Defines the sign and value of the context.

Syntax

```
IppStatus ippsSet_BN(IppsBigNumSGN sgn, int length, const Ipp32u* pData,
IppsBigNumState* pBN);
```

Include Files

`ippcp.h`

Parameters

`sgn`	Sign of `IppsBigNumState` *`*x`*.
`length`	Array length of the input data.
`pData`	Pointer to the data array.
`pBN`	On output, the context `IppsBigNumState` updated with the input data.

Description

The function defines the sign and value for `IppsBigNumState` *`*x`* with the specified inputs `IppsBigNumSGN` *`sgn`* and `const Ipp32u` *`*pData`*.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if *`length`* is less than or equal to 0.
`ippStsOutOfRangeErr`	Indicates an error condition if *`length`* is more than the size of `IppsBigNumState *`*`pBN`*.
`ippStsBadArgErr`	Indicates an error condition if the big number is set to zero with the negative sign.

Example

The code example below shows how to create a big number.

```
IppsBigNumState* New_BN(int size, const Ipp32u* pData=0){
   // get the size of the Big Number context
   int ctxSize;
   ippsBigNumGetSize(size,  &ctxSize);
   // allocate the Big Number context
   IppsBigNumState* pBN = (IppsBigNumState*) (new Ipp8u [ctxSize] );
   // and initialize one
   ippsBigNumInit(size,  pBN);
   // if any data was supplied, then set up the Big Number value
   if(pData)
      ippsSet_BN(IppsBigNumPOS, size, pData, pBN);
   // return pointer to the Big Number context for future use
   return pBN;
}
```

SetOctString_BN

Converts octet string into a positive Big Number.

Syntax

`IppStatus ippsSetOctString_BN(const Ipp8u*` *`pStr`*`, int` *`strLen`*`, IppsBigNumState*` *`pBN`*`);`

Include Files

`ippcp.h`

Parameters

`pStr`	Pointer to the input octet string.
`strLen`	Octet string length in bytes.
`pBN`	Pointer to the context of the output Big Number.

Description

This function converts an octet string into a positive Big Number.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.

`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsLengthErr`	Indicates an error condition if specified *`strLen`* is less than 1.
`ippStsSizeErr`	Indicates an error condition if insufficient space has been reserved for Big Number.

Example

The code example below shows how to create a big number from a string.

```
void  Set_BN_sample(void){
   // desired value of Big Number is 0x123456789abcdef0fedcba9876543210
   Ipp8u desiredBNvalue[] = "\x12\x34\x56\x78\x9a\xbc\xde\xf0"
                            "\xfe\xdc\xba\x98\x76\x54\x32\x10";
   // estimate required size of Big Number
   //int size = (sizeof(desiredBNvalue)+3)/4;
   //int size = (sizeof(desiredBNvalue)+3)/4;
   int size = (sizeof(desiredBNvalue)-1+3)/4;
   // and create new (and empty) one
   IppsBigNumState* pBN = New_BN(size);
   // set up the value from the srting
   ippsSetOctString_BN(desiredBNvalue,  sizeof(desiredBNvalue)-1,  pBN);
   Type_BN("Big Number value is:\n", pBN);
}
```

GetSize_BN

Returns the maximum length of the integer big number the structure can store.

Syntax

`IppStatus ippsGetSize_BN(const IppsBigNumState *`*`pBN`*`, int *`*`pSize`*`);`

Include Files

`ippcp.h`

Parameters

`pBN`	Integer big number of the data type `IppsBigNumState`.
`pSize`	Pointer to the maximum length of the integer big number.

Description

The function evaluates the working buffer assigned to the context `IppsBigNumState` and returns the size of the structure to indicate the maximum length of the integer big number that the structure can store.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.

`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

Get_BN

Extracts the sign and value of the integer big number from the input structure.

Syntax

`IppStatus ippsGet_BN(IppsBigNumSGN *sgn, int* pLength, Ipp32u* pData, const IppsBigNumState* pBN);`

Include Files

`ippcp.h`

Parameters

sgn	Sign of `IppsBigNumState *x`.
pLength	Pointer to the array length of the input data.
pData	Pointer to the data array.
pBN	Integer big number of the context `IppsBigNumState`.

Description

The function extracts the sign and value of the integer big number from the input structure.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

ExtGet_BN

Extracts the specified combination of the sign, data length, and value characteristics of the integer big number from the input structure.

Syntax

`IppStatus ippsExtGet_BN(IppsBigNumSGN* pSgn, int* pBitSize, Ipp32u* pData, const IppsBigNumState* pBN);`

Include Files

`ippcp.h`

Parameters

pSgn	Pointer to the sign of `IppsBigNumState` *pBN*.
pBitSize	Pointer to the length of *pData* in bits.

pData	Pointer to the data array.
pBN	Pointer to the integer big number context `IppsBigNumState`.

Description

For the integer big number from the input structure, the function extracts the specified combination of the following characteristics: sign, data length, and value. The function is similar to the `Get_BN` function but more flexible, because any target pointer (*pSgn*, *pBitSize*, and/or *pData*) may be `NULL`, in which case the appropriate big number characteristic will not be extracted. For example,

`ippsExtGet_BN(&sgn, 0,0, pBN);` extracts only the sign

`ippsExtGet_BN(0, &dataLen, 0, pBN);` extracts only the data length

`ippsExtGet_BN(&sgn, &dataLen, 0, pBN);` extracts the sign and data length

`ippsExtGet_BN(0,0,0, pBN);` does nothing

`ippsExtGet_BN(&sgn, &dataLen, pData, pBN);` does exactly what `Get_BN` does.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if the pointer to the integer big number of the context is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

Ref_BN

Extracts the main characteristics of the integer big number from the input structure.

Syntax

```
IppStatus ippsRef_BN(IppsBigNumSGN* pSgn, int* bitSize, Ipp32u** const ppData, const
IppsBigNumState* pBN);
```

Include Files

`ippcp.h`

Parameters

pSgn	Pointer to the sign of `IppsBigNumState *x`.
bitSize	Length of the integer big number in bits.
ppData	Double pointer to the data array.
pBN	Integer big number of the context `IppsBigNumState`.

Description

The function extracts from the input structure the main characteristics of the integer big number: sign, length, and pointer to the data array. You can extract either the entire set or any subset of these characteristics. To turn off extraction of a particular characteristic, set the appropriate function parameter to NULL.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

GetOctString_BN

Converts a positive Big Number into octet String.

Syntax

`IppStatus ippsGetOctString_BN(Ipp8u* pStr, int strLen, const IppsBigNumState* pBN);`

Include Files

`ippcp.h`

Parameters

pStr	Pointer to the input octet string.
strLen	Octet string length in bytes.
pBN	Pointer to the context of the input Big Number.

Description

This function converts a positive Big Number into the octet string.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsLengthErr`	Indicates an error condition if specified *pStr* is insufficient in length.
`ippStsRangeErr`	Indicates an error condition if Big Number is negative.

Example

The code example below types a big number.

```
void Type_BN(const char* pMsg, const IppsBigNumState* pBN){
   // size of Big Number
   int size;
   ippsGetSize_BN(pBN,  &size);

  // extract Big Number value and convert it to the string presentation
  Ipp8u* bnValue = new Ipp8u [size*4];
  ippsGetOctString_BN(bnValue,  size*4,  pBN);

  // type header
```

```
   if(pMsg)
      cout<<pMsg;

   // type value
   for(int n=0; n<size*4; n++)
      cout<<hex<<setfill('0')<<setw(2)<<(int)bnValue[n];
   cout<<endl;

   delete [] bnValue;
}
```

Cmp_BN

Compares two Big Numbers.

Syntax

`IppStatus ippsCmp_BN(const IppsBigNumState* pA, const IppsBigNumState* pB, Ipp32u* pResult);`

Include Files

`ippcp.h`

Parameters

pA	Pointer to the context of the Big Number A.
pB	Pointer to the context of the Big Number B.
pResult	Pointer to the result of the comparison.

Description

This function compares Big Numbers A and B and sets up the result according to the following conditions:

- if A==B, then *pResult* = IS_ZERO
- if A > B, then *pResult* = GREATER_THAN_ZERO
- if A < B, then *pResult* = LESS_THAN_ZERO

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

CmpZero_BN

Checks the value of the input data field.

Syntax

`IppStatus ippsCmpZero_BN(const IppsBigNumState* pBN, Ipp32u* pResult);`

Include Files

`ippcp.h`

Parameters

pBN	Integer big number of the data type `IppsBigNumState`.
pResult	Indicates whether the input integer big number is positive, negative, or zero.

Description

The function scans the data field of the input `const IppsBigNumState *pBN` and returns

- IS_ZERO if the value held by `IppsBigNumState *pBN` is zero
- GREATER_THAN_ZERO if the input is more than zero
- LESS_THAN_ZERO if the input is less than zero.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

Add_BN

Adds two integer big numbers.

Syntax

`IppStatus ippsAdd_BN(IppsBigNumState *pA, IppsBigNumState *pB, IppsBigNumState * pR);`

Include Files

`ippcp.h`

Parameters

pA	Pointer to the first integer big number of the data type `IppsBigNumState`.
pB	Pointer to the second integer big number of the data type `IppsBigNumState`.
pR	Pointer to the addition result.

Description

The function adds two integer big numbers regardless of their signs and sizes and returns the result of the operation.

The following pseudocode represents this function:

(**pR*) ← (**pA*) + (**pB*).

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.

`ippStsOutOfRangeErr`	Indicates an error condition if the size of pR is smaller than the resulting data length.
`ippStsContextMatchErr`	Indicates an error condition if any of the context parameters does not match the operation.

NOTE
The function executes only under the condition that size of `IppsBigNumState` **pR* is not less than either the length of `IppsBigNumState` **pA* or that of `IppsBigNumState` **pB*.

Example

The code example below adds big numbers.

```
void  Add_BN_sample(void){
   // define and set up Big Number A
   const Ipp32u bnuA[] = {0x01234567,0x9abcdeff,0x11223344};
   IppsBigNumState* bnA = New_BN(sizeof(bnuA)/sizeof(Ipp32u));
   // define and set up Big Number B
   const Ipp32u bnuB[] = {0x76543210,0xfedcabee,0x44332211};
   IppsBigNumState* bnB = New_BN(sizeof(bnuB)/sizeof(Ipp32u), bnuB);
   // define Big Number R
   int sizeR = max(sizeof(bnuA), sizeof(bnuB));
   IppsBigNumState* bnR = New_BN(1+sizeR/sizeof(Ipp32u));
   // R = A+B
   ippsAdd_BN(bnA, bnB, bnR);
   // type R
   Type_BN("R=A+B:\n",  bnR);
   delete [] (Ipp8u*)bnA;
   delete [] (Ipp8u*)bnB;
   delete [] (Ipp8u*)bnR;
}
```

Sub_BN

Subtracts one integer big number from another.

Syntax

`IppStatus ippsSub_BN(IppsBigNumState* pA, IppsBigNumState* pB, IppsBigNumState* pR);`

Include Files

`ippcp.h`

Parameters

pA	Pointer to the first integer big number of the data type `IppsBigNumState`.
pB	Pointer to the second integer big number of the data type `IppsBigNumState`.
pR	Pointer to the subtraction result.

Description

The function subtracts one integer big number from another regardless of their signs and sizes and returns the result of the operation.

The following pseudocode represents this function:

(**pR*) ← (**pA*) - (**pB*).

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsOutOfRangeErr`	Indicates an error condition if `IppsBigNumState` **pR* is smaller than the result data length.
`ippStsContextMatchErr`	Indicates an error condition if any of the context parameters does not match the operation.

NOTE
The function executes only under the condition that size of `IppsBigNumState` **pR* is not less than either the length of `IppsBigNumState` **pA* or that of `IppsBigNumState` **pB*.

Mul_BN

Multiplies two integer big numbers.

Syntax

```
IppStatus ippsMul_BN(IppsBigNumState* pA, IppsBigNumState* pB, IppsBigNumState* pR);
```

Include Files

`ippcp.h`

Parameters

pA	Pointer to the multiplicand of `IppsBigNumState`.
pB	Pointer to the multiplier of `IppsBigNumState`.
pR	Pointer to the multiplication result.

Description

The function multiplies an integer big number by another integer big number regardless of their signs and sizes and returns the result of the operation.

The following pseudocode represents this function:

pR←*pA* **pB*.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsOutOfRangeErr`	Indicates an error condition if `IppsBigNumState` **r* is smaller than the result data length.

`IppStsContextMatchErr`	Indicates an error condition if any of the context parameters does not match the operation

---

NOTE

The function executes only under the condition that the size `IppsBigNumState` **pR* is not less than the sum of the lengths of `IppsBigNumState` **pA* or that of `IppsBigNumState` **pB* minus one.

MAC_BN_I

Multiplies two integer big numbers and accumulates the result with the third integer big number.

Syntax

`IppStatus ippsMAC_BN_I(IppsBigNumState* pA, IppsBigNumState* pB, IppsBigNumState* pR);`

Include Files

`ippcp.h`

Parameters

pA	Pointer to the multiplicand of `IppsBigNumState`.
pB	Pointer to the multiplier of `IppsBigNumState`.
pR	Pointer to the multiplication result.

Description

The function multiplies one integer big number by another and accumulates the result with the third input integer big number regardless of their signs and sizes. The function subsequently returns the result of the operation.

The following pseudocode represents this function:

pR←*pR* + *pA* * *pB*.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsOutOfRangeErr`	Indicates an error condition if `IppsBigNumState` **pR* is smaller than the result data length.
`ippStsContextMatchErr`	Indicates an error condition if any of the context parameters does not match the operation.

NOTE

The function executes only under the condition that the size `IppsBigNumState` **pR* is not less than the sum of the lengths of `IppsBigNumState` **pA* or that of `IppsBigNumState` **pB* minus one.

Div_BN

Divides one integer big number by another.

Syntax

`IppStatus ippsDiv_BN(IppsBigNumState *pA, IppsBigNumState *pB, IppsBigNumState *pQ, IppsBigNumState *pR);`

Include Files

`ippcp.h`

Parameters

pA	Pointer to the dividend of `IppsBigNumState`.
pB	Pointer to the divisor of `IppsBigNumState`.
pQ	Pointer to the quotient of `IppsBigNumState`.
pR	Pointer to the remainder of `IppsBigNumState`.

Description

The function divides an integer big number dividend by another integer big number regardless of their signs and sizes and returns the quotient of the division and the respective remainder.

The following pseudocode represents this function:

```
pQ←pA/pB
pR←pA - pB*pQ .
```

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsOutOfRangeErr`	Indicates an error condition if `IppsBigNumState *pR` is smaller than the length of `IppsBigNumState *pB` or when the size of `IppsBigNumState *pQ` is smaller than the quotient result data length.
`ippStsDivByZeroErr`	Indicates an error condition if the zero divisor is attempted.
`ippStsContextMatchErr`	Indicates an error condition if any of the context parameters does not match the operation.

NOTE
The size of `IppsBigNumState *pQ` should not be less than `(lengthof *pA) - (length of *pB) + 1`, and the size of `IppsBigNumState *pR` should be not less than the length of `IppsBigNumState *pB`.

Mod_BN

Computes modular reduction for input integer big number with respect to specified modulus.

Syntax

`IppStatus ippsMod_BN(IppsBigNumState *pA, IppsBigNumState *pM, IppsBigNumState *pR);`

Include Files

`ippcp.h`

Parameters

pA	Pointer to the integer big number of `IppsBigNumState`.
pM	Pointer to the modulus integer of `IppsBigNumState`.
pR	Pointer to the modular reduction result.

Description

The function computes the modular reduction for an input integer big number with respect to the modulus specified by a positive integer big number and returns the modular reduction result in the range of `[0, (`*m*`-1)]`.

The following pseudocode represents this function:

pR←*pAmod pM*.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsOutOfRangeErr`	Indicates an error condition if `IppsBigNumState *`*pR* is smaller than the length of `IppsBigNumState *`*m*.
`ippStsBadModulusErr`	Indicates an error condition if the modulus `IppsBigNumState *`*pM* is not a positive integer.
`ippStsContextMatchErr`	Indicates an error condition if any of the context parameters does not match the operation.

NOTE
The size of `IppsBigNumState *`*pR* should not be less than the length of `IppsBigNumState *`*pM*.

Gcd_BN

Computes greatest common divisor.

Syntax

`IppStatus ippsGcd_BN(IppsBigNumState* pA, IppsBigNumState* pB, IppsBigNumState* pGCD);`

Include Files

`ippcp.h`

Parameters

pA	Pointer to the first integer big number of `IppsBigNumState`.
pB	Pointer to the second integer big number of `IppsBigNumState`.
pCGD	Pointer to the greatest common divisor to *pA* and *pB*.

Description

The function computes the greatest common divisor (GCD) for two positive integer big numbers.

The following pseudocode represents this function:

pCGD←*gcd* (*pA* , *pB*).

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsOutOfRangeErr`	Indicates an error condition if `IppsBigNumState`**pCGD* is smaller than the length of `IppsBigNumState`**pA* or `IppsBigNumState`**pB*.
`ippStsContextMatchErr`	Indicates an error condition if any of the context parameters does not match the operation.

NOTE
The size of `IppsBigNumState` **pCGD* should not be less than either the length of `IppsBigNumState` **pA* and `IppsBigNumState` **pB*.

ModInv_BN

Computes multiplicative inverse of a positive integer big number with respect to specified modulus.

Syntax

```
IppStatus ippsModInv_BN(IppsBigNumState* pA, IppsBigNumState* pM, IppsBigNumState*
pInv);
```

Include Files

`ippcp.h`

Parameters

pA	Pointer to the integer big number of `IppsBigNumState`.
pM	Pointer to the modulus integer of `IppsBigNumState`.
pInv	Pointer to the multiplicative inverse.

Description

The function uses the extended Euclidean algorithm to compute the multiplicative inverse of a given positive integer big number *pA* with respect to the modulus specified by another positive integer big number *pM*, where *gcd* `(`*pA*`,` *pM*`) = 1`.

The following pseudocode represents this function:

compute *pInv* such that `pInv*pA = 1 modpM`.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsBadArgErr`	Indicates an error condition if *pA* is less than or equal to 0.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsBadModulusErr`	Indicates an error condition if the modulus *pA* is greater than *pM*, or *gcd (pA,pM)* is greater than 1, or *pM* is less than or equal to 0.
`ippStsOutOfRangeErr`	Indicates an error condition if `IppsBigNumState` **pInv* is smaller than the length of `IppsBigNumState` **pM*.
`ippStsContextMatchErr`	Indicates an error condition if any of the context parameters does not match the operation.
`ippStsScaleRangeErr`	Indicates an error condition if *pA* is greater than or equal to *pM*

NOTE
The size of `IppsBigNumState` **pInv* should not be less than the length of `IppsBigNumState` **pM*.

Montgomery Reduction Scheme Functions

This section describes Montgomery reduction scheme functions.

Montgomery reduction is a technique for efficient implementation of modular multiplication without explicitly carrying out the classical modular reduction step.

This section describes functions for Montgomery modular reduction, Montgomery modular multiplication, and Montgomery modular exponentiation.

Let *n* be a positive integer, and let *R* and *T* be integers such that $R > n$, $\gcd(n, R) = 1$, and $0 < T < nR$. The Montgomery reduction of T modulo n with respect to R is defined as $TR^{-1} \bmod n$.

For better results, functions included in the cryptography package use $R = b^k$ where $b = 2^{32}$ and k is the Montgomery index integer computed by the ceiling function of the bit length of the integer *n* over 32.

All functions use employ the context `IppsMontState` to serve as an operational vehicle to carry the Montgomery reduction index *k*, the integer big number modulus *n*, the least significant word n0 of the multiplicative inverse of the modulus *n* with respect to the Montgomery reduction factor *R*, and a sufficient working buffer reserved for various Montgomery modular operations.

Furthermore, two new terms are introduced in this section:

- length of the context `IppsMontState` is defined as the data length of the modulus *n* carried by the structure
- size of the context `IppsMontState` is therefore defined as the maximum data length of such an integer modulus *n* that could be carried by this operational vehicle.

The following example can briefly illustrate the procedure of using the primitives described in this section to compute a classical modular exponentiation $T = x^e \bmod n$. Consider computing $T = x^4 \bmod n$, for some integer *x* with $0 < x < n$.

First get the buffer size required to configure the context `IppsMontState` by calling `MontGetSize` and then allocate the working buffer using OS service function, with allocated buffer to call `MontInit` to initialize the context `IppsMontState`.

Set the modulus *n* by calling`MontSet` and then convert *x* into its respective Montgomery form by calling `MontForm`, that is, computing

$$\underline{x} = xR \bmod n\,.$$

Then compute the Montgomery reduction of

$$\underline{x}\underline{x}$$

using the function `MontMul` to generate

$$T = \underline{x}\underline{x}R^{-1} \bmod n\,.$$

The Montgomery reduction of T*T*mod n* with respect to *R* is

$$T^2R^{-1} \bmod n = (\underline{x}^2R^{-1})^2R^{-1} \bmod n = x^4R \bmod n\,.$$

Further applying `MontMul` with this value and the value of 1 yields the desired result $T = x^4 \bmod n$.

The classical modular exponentiation should be computed by performing the following sequence of operations:

1. Get the buffer size required to configure the context `IppsMontState` by calling the function `MontGetSize`. For limited memory system, choose binary method, and otherwise, choose sliding window method. Using the binary method reduces the buffer size significantly while using sliding window method enhances the performance.
2. Allocate working buffer through an operating system memory allocation function and configure the structure `IppsMontState` by calling the function `MontInit` with the allocated buffer and the choice made on the modular exponential method at time invoking `MontGetSize`.
3. Call the function `MontSet` to set the integer big number module for `IppsMontState`.
4. Call the function `MontForm` to convert the integer *x* to be its Montgomery form.
5. Call the function`MontExp` to compute the Montgomery modular exponentiation.
6. Call the function `MontMul` to compute the Montgomery modular multiplication of the above result with the integer 1 as to convert the above result back to the desired classical modular exponential result.
7. Clean up secret data stored in the context.
8. Free the memory using an operating system memory free function, if needed.

See Also

Data Security Considerations

MontGetSize

Gets the size of the `IppsMontState` *context.*

Syntax

```
IppStatus ippsMontGetSize(IppsExpMethod method, int length, int * pSize);
```

Include Files

`ippcp.h`

Parameters

method	Selected exponential method.
length	Data field length for the modulus in `Ipp32u` chunks.

pSize	Pointer to the size of the buffer required for initialization.

Description

The function specifies the buffer size required to define the structured working buffer of the context `IppsMontState` to store the modulus and perform operations using various Montgomery modulus schemes.

> **NOTE**
> For security reasons, the length of the modulus is restricted to 16 kilobits.

The function returns the required buffer size based on the selected exponential method. The binary method helps to significantly reduce the buffer size, while the sliding windows method results in enhanced performance.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if *`length`* is less than or equal to 0 or greater than 512.

MontInit

Initializes the context and partitions the specified buffer space.

Syntax

`IppStatus ippsMontInit(IppsExpMethod` *`method`*`, int` *`length`*`, IppsMontState *`*`pCtx`*`);`

Include Files

`ippcp.h`

Parameters

method	Selected exponential method.
length	Data field length for the modulus in `Ipp32u` chunks.
pCtx	Pointer to the context `IppsMontState`.

Description

The function initializes the *`*pCtx`* buffer as the `IppsMontState` context. The function then partitions the buffer using the selected modular exponential method in such a way as to carry up to *`length`*`*`*`sizeof`*`(Ipp32u)`-bit big number modulus and execute various Montgomery modulus operations.

> **NOTE**
> For security reasons, the length of the modulus is restricted to 16 kilobits.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if *`length`* is less than or equal to 0 or greater than 512.

See Also

Data Security Considerations

MontSet

Sets the input integer big number to a value and computes the Montgomery reduction index.

Syntax

```
IppStatus ippsMontSet(const Ipp32u *pModulo, int size, IppsMontState *pCtx);
```

Include Files

`ippcp.h`

Parameters

`pModulo`	Pointer to the input big number modulus.
`size`	The size of the modulus in `Ipp32u` chunks.
`pCtx`	Pointer to the context `IppsMontState` capturing the modulus and the least significant word of the multiplicative inverse *Ni*.

Description

The function sets the input positive integer big number *`pModulo`* to be the modulus for the context `IppsMontState *`*`pCtx`*, computes the Montgomery reduction index *k* with respect to the input big number modulus *`pModulo`* and the least significant 32-bit word of the multiplicative inverse *Ni* with respect to the modulus *R*, that satisfies $R*R^{-1} - pModulo *Ni = 1$.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsBadModulusErr`	Indicates an error condition if the modulus is not a positive odd integer.
`ippStsLengthErr`	Indicates an error condition if *`size`* is less than or equal to 0.
`ippStsOutOfRangeErr`	Indicates an error condition if *`size`* is larger than `IppsMontState*`*`pCtx`*.
`ippStsContextMatchErr`	Indicates an error condition if *`pCtx`* does not match the operation.

MontGet

Extracts the big number modulus.

Syntax

`IppStatus ippsMontGet(Ipp32u *pModulo, int *pSize, const IppsMontState *pCtx);`

Include Files

`ippcp.h`

Parameters

pCtx	Pointer to the context `IppsMontState`.
pModulo	Pointer to the modulus data field.
pSize	Pointer to the modulus data size in `Ipp32u` chunks.

Description

The function extracts the big number modulus from the input `IppsMontState *pCtx`.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if *pCtx* does not match the operation.

MontForm

Converts input positive integer big number into Montgomery form.

Syntax

`IppStatus ippsMontForm(const IppsBigNumState* pA, IppsMontState* pCtx, IppsBigNumState* pR);`

Include Files

`ippcp.h`

Parameters

pA	Pointer to the input integer big number within the range [0, *pCtx*- 1].
pCtx	Pointer to the input big number modulus of `IppsBigNumState`.
pR	Pointer to the resulting Montgomery form *pR* = *pA***RmodpCtx*.

Description

The function converts an input positive integer big number into the Montgomery form with respect to the big number modulus and stores the conversion result.

The following pseudocode represents this function:

pR←*pA***RmodpCtx*.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsBadArgErr`	Indicates an error condition if *pA* is a negative integer.
`ippStsScaleRangeErr`	Indicates an error condition if *pA* is more than *pCtx*.
`ippStsOutOfRangeErr`	Indicates an error condition if `IppsBigNumState` **pR* is larger than `IppsMontState` **m*.
`ippStsContextMatchErr`	Indicates an error condition if any of the context parameters does not match the operation.

NOTE
The size of `IppsBigNumState` **pR* should not be less than the data length of the modulus *pCtx*.

MontMul

Computes Montgomery modular multiplication for positive integer big numbers of Montgomery form.

Syntax

```
IppStatus ippsMontMul(const IppsBigNumState *pA, const IppsBigNumState *pB,
IppsMontState *m, IppsBigNumState *pR);
```

Include Files

`ippcp.h`

Parameters

pA	Pointer to the multiplicand within the range `[0, m- 1]`.
pB	Pointer to the multiplier within the range `[0, m- 1]`.
m	Modulus.
pR	Pointer to the montgomery multiplication result.

Description

The function computes the Montgomery modular multiplication for positive integer big numbers of Montgomery form with respect to the modulus `IppsMontState` **m*. As a result, `IppsBigNumState` **pR* holds the product.

The following pseudocode represents this function:

pR←*pA***pB**R^{-1}*mod m*.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsBadArgErr`	Indicates an error condition if *pA* or *pB* is a negative integer.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsScaleRangeErr`	Indicates an error condition if *pA* or *pB* is more than *m*.
`ippStsOutOfRangeErr`	Indicates an error condition if `IppsBigNumState` **pR*is larger than `IppsMontState` **m*.
`ippStsContextMatchErr`	Indicates an error condition if any of the context parameters does not match the operation.

NOTE
The size of `IppsBigNumState` **pR* should not be less than the data length of the modulus *m*.

Example of Using Montgomery Reduction Scheme Functions

Montgomery Multiplication

```
void  MontMul_sample(void){</codeblock>
   int size;

   // define and initialize Montgomery Engine over Modulus N
   Ipp32u bnuN = 19;
   ippsMontGetSize(IppsBinaryMethod, 1, &amp;size);
   IppsMontState* pMont = (IppsMontState*)( new Ipp8u [size] );
   ippsMontInit(IppsBinaryMethod, 1, pMont);
   ippsMontSet(&amp;bnuN, 1, pMont);

   // define and init Big Number multiplicant A
   Ipp32u bnuA = 12;
   IppsBigNumState* bnA = New_BN(1, &amp;bnuA);
   // encode A into Montfomery form
   ippsMontForm(bnA, pMont, bnA);

   // define and init Big Number multiplicant A
   Ipp32u bnuB = 15;
   IppsBigNumState* bnB = New_BN(1, &amp;bnuB);


   // compute R = A*B mod N
   IppsBigNumState* bnR = New_BN(1);
   ippsMontMul(bnA, bnB, pMont, bnR);

   Type_BN("R = A*B mod N:\n", bnR);
   delete [] (Ipp8u*)pMont;
   delete [] (Ipp8u*)bnA;
   delete [] (Ipp8u*)bnB;
   delete [] (Ipp8u*)bnR;
}
```

MontExp

Computes Montgomery exponentiation.

Syntax

```
IppStatus ippsMontExp(const IppsBigNumState *pA, const IppsBigNumState *pE,
IppsMontState *m, IppsBigNumState *pR);
```

Include Files

`ippcp.h`

Parameters

pA	Pointer to the big number Montgomery integer within the range of [0, *m*- 1].
pE	Pointer to the big number exponent.
m	Modulus.
pR	Pointer to the montgomery exponentiation result.

Description

The function computes Montgomery exponentiation with the exponent specified by the input positive integer big number to the given positive integer big number of the Montgomery form with respect to the modulus *m*.

The following pseudocode represents this function:

$pR \leftarrow pA^{pE} R^{-(pE-1)} mod\ m$.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsBadArgErr`	Indicates an error condition if *pA* or *pE* is a negative integer.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsScaleRangeErr`	Indicates an error condition if *pA* or *pE* is more than *m*.
`ippStsOutOfRangeErr`	Indicates an error condition if `IppsBigNumState*`*pR*is larger than `IppsMontState*`*m*.
`ippStsContextMatchErr`	Indicates an error condition if any of the context parameters does not match the operation.

NOTE
The size of `IppsBigNumState *`*pR* should not be less than the data length of the modulus *m*.

Pseudorandom Number Generation Functions

Many cryptographic systems rely on pseudorandom number generation functions in their design that make the unpredictable nature inherited from a pseudorandom number generator the security foundation to ensure safe communication over open channels and protection against potential adversaries.

This section describes functions that make the pseudorandom bit sequence generation implemented by a US FIPS-approved method and based on a SHA-1 one-way hash function specified by [FIPS PUB 186-2], *appendix 3*.

The application code for generating a sequence of pseudorandom bits should perform the following sequence of operations:

1. Call the function `PRNGGetSize` to get the size required to configure the `IppsPRNGState` context.
2. Ensure that the required memory space is properly allocated. With the allocated memory, call the `PRNGInit` function to set up the default value of the parameters for pseudorandom generation process.
3. If the default values of the parameters are not satisfied, call the function PRNGSetSeed and/or `PRNGSetAugment` and/or `PRNGSetModulus` and/or `PRNGSetH0` to reset any of the control pseudorandom generator parameters.
4. Keep calling the function `PRNGen` or `PRNGen_BN` to generate pseudo random value of the desired format.
5. Clean up secret data stored in the context.
6. Free the memory allocated for the `IppsPRNGState` context by calling the operating system memory free service function.

See Also

Data Security Considerations

User's Implementation of a Pseudorandom Number Generator

Both functions ippsPRNGGen and ippsPRNGGen_BN, as well as their supplementary functions represent the implementation of the pseudorandom number generator in the IPPCP library. This given implementation is based on recommendations made in [FIPS PUB 186-2]. If you prefer to use the implementation of the pseudorandom number generator which is different from the given, you can still use IPPCP library. To do this, use the following definition of the generator introduced by the IPPCP library:

Syntax

```
typedef IppStatus(_STDCALL *IppBitSupplier)(Ipp32u* pData, int nBits, void*
pEbsParams);
```

Parameters

pData	Pointer to the output data.
nBits	Number of generated data bits.
pEbsParams	Pointer to the user defined context.

Description

This declaration is included in the ippcp.h file. The function generates any data (probably pseudorandom numbers) of the specified *nBits* length.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsErr`	Indicates an error condition.

PRNGGetSize

Gets the size of the `IppsPRNGState` *context in bytes.*

Syntax

```
IppStatus ippsPRNGGetSize(int *pSize);
```

Include Files

`ippcp.h`

Parameters

pSize	Pointer to the `IppsPRNGState` context size in bytes.

Description

The function gets the `IppsPRNGState` context size in bytes and stores it in `*`*pSize*.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.

PRNGInit

Initializes user-supplied memory as `IppsPRNGState` *context for future use.*

Syntax

`IppStatus ippsPRNGInit(int` *seedBits*`, IppsPRNGState*` *pCtx*`);`

Include Files

`ippcp.h`

Parameters

seedBits	Size in bits for the seed value.
pCtx	Pointer to the `IppsPRNGState` context being intialized.

Description

The function initializes the memory pointed by *pCtx* as the `IppsPRNGState` context. In addition, the function sets up the default internal random generator parameters (seed, entropy augment, modulus, and initial hash value H0 of the SHA-1 algorithm). PRNG default parameters are as follows:

- seed =0x0
- entropy augment =0x0
- modulus =0xFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF
- H0 =*0x*C3D2E1F01032547698BADCFEEFCDAB8967452301

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if *seedBits* is less than 1 or greater than 512.

See Also

Data Security Considerations

PRNGSetSeed

Sets up the seed value for the pseudorandom number generator.

Syntax

```
IppStatus ippsPRNGSetSeed(const IppsBigNumState* pSeed, IppsPRNGState* pCtx);
```

Include Files

`ippcp.h`

Parameters

pSeed	Pointer to the seed value being set up.
pCtx	Pointer to the `IppsPRNGState` context.

Description

The function resets the seed value with the supplied value of *`seedBits`* bit length. The supplied big number should be created prior to the function call using the appropriate Big Number Arithmetic functions (see Example "Create a Big Number").

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

NOTE
This function restarts the pseudorandom number generation process, which results in losing already generated pseudorandom numbers.

PRNGGetSeed

Extracts the seed value of the pseudorandom number generator from the context structure.

Syntax

```
IppStatus ippsPRNGGetSeed(const IppsPRNGState* pCtx, IppsBigNumState* pSeed);
```

Include Files

`ippcp.h`

Parameters

pCtx	Pointer to the `IppsPRNGState` context.

pSeed	Pointer to the seed value.

Description

The function extracts the seed value of the pseudorandom number generator from the `IppsPRNGState` context structure into a big number.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if `*pSeed` is not a `IppsBigNumState` structure or `*pCtx` is not a `IppsPRNGState` structure.
`ippOutOfRangeErr`	Indicates an error condition if the length of the actual seed exceeds `*pSeed`.

PRNGSetAugment

Sets the initial state with the given input entropy for the pseudorandom number generation.

Syntax

```
IppStatus ippsPRNGSetAugment(const IppsBigNumState* pAugment, IppsPRNGState* pCtx);
```

Include Files

`ippcp.h`

Parameters

pAugment	Pointer to the entropy augment value being set up.
pCtx	Pointer to the `IppsPRNGState` context.

Description

The function resets entropy augment value with the supplied value of the *seedBits* bit length. The supplied big number should be created prior to the function call using the appropriate Big Number Arithmetic functions (see Example “Create a Big Number”).

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

PRNGSetModulus

Sets the initial state with the given input modulus for the pseudorandom number generation.

Syntax

```
IppStatus ippsPRNGSetModulus(const IppsBigNumState* pMod, IppsPRNGState* pCtx);
```

Include Files

`ippcp.h`

Parameters

pMod	Pointer to the modulus value being set up.
pCtx	Pointer to the `IppsPRNGState` context.

Description

The function resets the modulus value with the supplied value up to 160 bit length. The supplied big number should be created prior to the function call using the appropriate Big Number Arithmetic functions (see Example "Create a Big Number").

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsBadArgErr`	Indicates an error condition if the size of *pMod* is not 160 bit.

PRNGSetH0

Sets the initial state with the given input IV for the SHA-1 algorithm.

Syntax

```
IppStatus ippsPRNGSetH0(const IppsBigNumState* pH0, IppsPRNGState* pCtx);
```

Include Files

`ippcp.h`

Parameters

pH0	Pointer to the initial hash value being set up.
pCtx	Pointer to the `IppsPRNGState` context.

Description

The function resets the initial hash value with the supplied value up to 160 bit length. The supplied big number should be created prior to the function call using the appropriate Big Number Arithmetic functions (see Example "Create a Big Number").

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.

`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

PRNGen

Generates a pseudorandom unsigned Big Number of the specified bit length.

Syntax

`IppStatus ippsPRNGen(Ipp32u* `*`pRand`*`, int `*`nBits`*`, void* `*`pCtx`*`);`

Include Files

`ippcp.h`

Parameters

pRand	Pointer to the output pseudorandom unsigned integer big number.
nBits	The number of the generated pseudorandom bits.
pCtx	Pointer to the `IppsPRNGState` context.

Description

The function generates a pseudorandom unsigned integer big number of the specified *nBits* length.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsLengthErr`	Indicates an error condition if *nBits* is less than 1.

PRNGenRDRAND

Generates a pseudorandom unsigned Big Number of the specified bit length using the RDRAND instruction.

Syntax

`IppStatus ippsPRNGenRDRAND(Ipp32u* `*`pRand`*`, int `*`nBits`*`, void* `*`pCtx`*`);`

Include Files

`ippcp.h`

Parameters

pRand	Pointer to the output pseudorandom unsigned integer big number.
nBits	The number of generated pseudorandom bits.

pCtx	Pointer to the `IppsPRNGState` context. This pointer is unused and can be `NULL`.

Description

The function generates a pseudorandom unsigned integer big number of the specified *nBits* length. The generation is based on the RDRAND instruction available on latest Intel® processors [INTEL_ARCH].

Product and Performance Information

Performance varies by use, configuration and other factors. Learn more at www.Intel.com/PerformanceIndex.

Notice revision #20201201

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsLengthErr`	Indicates an error condition if *nBits* is less than 1.
`ippStsNotSupportedModeErr`	Indicates an error condition if the RDRAND instruction is not available on the target processor.

TRNGenRDSEED

Generates a true random unsigned Big Number of the specified bit length using the RDSEED instruction.

Syntax

```
IppStatus ippsTRNGenRDSEED(Ipp32u* pRand, int nBits, void* pCtx);
```

Include Files

`ippcp.h`

Parameters

pRand	Pointer to the output true random unsigned integer big number.
nBits	The number of generated true random bits.
pCtx	Pointer to the `IppsPRNGState` context. This pointer is unused and can be `NULL`.

Description

The function generates a true random unsigned integer big number of the specified *nBits* length. The generation is based on the RDSEED instruction available on latest Intel® processors [INTEL_ARCH].

Product and Performance Information

Performance varies by use, configuration and other factors. Learn more at www.Intel.com/PerformanceIndex.

Product and Performance Information
Notice revision #20201201

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsLengthErr`	Indicates an error condition if *`nBits`* is less than 1.
`ippStsNotSupportedModeErr`	Indicates an error condition if the RDSEED instruction is not available on the target processor.

PRNGen_BN

Generates a pseudorandom positive Big Number of the specified bitlength.

Syntax

`IppStatus ippsPRNGen_BN(IppsBigNumState*` *`pRandBN`*`, int` *`nBits`*`, void*` *`pCtx`*`);`

Include Files

`ippcp.h`

Parameters

`pRandBN`	Pointer to the output pseudorandom Big Number.
`nBits`	Number of the generated pseudorandom bit.
`pCtx`	Pointer to the `IppsPRNGState` context.

Description

The function generates pseudorandom positive Big Number of the specified *`nBits`* length.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsLengthErr`	Indicates an error condition if *`nBits`* is less than 1.

PRNGenRDRAND_BN

Generates a pseudorandom positive Big Number of the specified bit length using the RDRAND instruction.

Syntax

`IppStatus ippsPRNGenRDRAND_BN(IppsBigNumState* pRand, int nBits, void* pCtx);`

Include Files

`ippcp.h`

Parameters

pRand	Pointer to the output pseudorandom Big Number.
nBits	The number of generated pseudorandom bits.
pCtx	Pointer to the `IppsPRNGState` context. This pointer is unused and can be `NULL`.

Description

The function generates a pseudorandom positive Big Number of the specified *nBits* length. The generation is based on the RDRAND instruction available on latest Intel® processors [INTEL_ARCH].

Product and Performance Information

Performance varies by use, configuration and other factors. Learn more at www.Intel.com/PerformanceIndex.

Notice revision #20201201

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsLengthErr`	Indicates an error condition if *nBits* is less than 1.
`ippStsNotSupportedModeErr`	Indicates an error condition if the RDRAND instruction is not available on the target processor.

TRNGenRDSEED_BN

Generates a true random positive Big Number of the specified bit length using the RDSEED instruction.

Syntax

`IppStatus ippsTRNGenRDSEED_BN(IppsBigNumState* pRand, int nBits, void* pCtx);`

Include Files

`ippcp.h`

Parameters

pRand	Pointer to the output true random Big Number.
nBits	The number of generated true random bits.

pCtx	Pointer to the `IppsPRNGState` context. This pointer is unused and can be `NULL`.

Description

The function generates a true random positive Big Number of the specified *nBits* length. The generation is based on the RDSEED instruction available on latest Intel® processors [INTEL_ARCH].

Product and Performance Information

Performance varies by use, configuration and other factors. Learn more at www.Intel.com/PerformanceIndex.

Notice revision #20201201

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsLengthErr`	Indicates an error condition if *nBits* is less than 1.
`ippStsNotSupportedModeErr`	Indicates an error condition if the RDSEED instruction is not available on the target processor.

Example of Using Pseudorandom Number Generation Functions

Find Pseudorandom Co-primes

```
void  FindCoPrimes(void){
   int size;

   // define Pseudo Random Generator (default settings)
   ippsPRNGGetSize(&size);
   IppsPRNGState* pPrng = (IppsPRNGState*)(new Ipp8u [size] );
   ippsPRNGInit(160,  pPrng);

   // define 256-bits Big Numbers X and Y
   const int bnBitSize = 256;
   IppsBigNumState* bnX = New_BN(bnBitSize/32);
   IppsBigNumState* bnY = New_BN(bnBitSize/32);

   // define temporary Big Numbers GCD and 1
   IppsBigNumState* bnGCD = New_BN(bnBitSize/32);
   Ipp32u one = 1;
   IppsBigNumState* bnOne = New_BN(1, &one);


   // generate pseudo random X and Y
   // while GCD(X,Y) != 1
   Ipp32u result;
   int counter;
   for(counter=0,result=1; result; counter++) {
      ippsPRNGen_BN(bnX, bnBitSize, pPrng);
      ippsPRNGen_BN(bnY, bnBitSize, pPrng);
```

```
        ippsGcd_BN(bnX, bnY, bnGCD);
        ippsCmp_BN(bnGCD, bnOne, &result);
    }

    cout <<"Coprimes:" <<endl;
    Type_BN("X: ", bnX); cout <<endl;
    Type_BN("Y: ", bnY); cout <<endl;
    cout <<"were fond on " <<counter <<" attempt" <<endl;

    delete [] (Ipp8u*)pPrng;
    delete [] (Ipp8u*)bnX;
    delete [] (Ipp8u*)bnY;
    delete [] (Ipp8u*)bnGCD;
    delete [] (Ipp8u*)bnOne;
}
```

Prime Number Generation Functions

This section introduces Intel® Integrated Performance Primitives (Intel® IPP) Cryptography functions for prime number generation.

This section describes Intel IPP Cryptography functions for generating probable prime numbers of variable lengths and validating probable prime numbers through a probabilistic primality test scheme for cryptographic use. A probable prime number is thus defined as an integer that passes the Miller-Rabin probabilistic primality-based test.

The scheme adopted for the probable prime number generation is based on a well-known prime number theorem. Study shows that the number of primitives that are no greater than the given large integer *x* is closely approximated by the expression. Let π(*x*) denote the number of primes that are not greater than x. In this case the statement is true

$$\lim_{x\to\infty}\frac{\pi(x)}{x/(\ln x)} = 1 .$$

Further study indicates that if *X* represents the event where the tested *k*-bit integer *n* is composite and if Y_t denotes the event where the Miller-Rabin test with the security parameter *t* declares *n* to be a prime, the test error probability is upper bounded by

$$P_{k,t} \le k^{2/3} 2^{t-1/2} t 4^{2-\sqrt{tk}} \text{ for } t = 2,\ k \ge 88 \text{ , or } 3 \le t \le k/9$$

Subsequently, a practical strategy for generating a random *k*-bit probable prime is to repeatedly pick *k*-bit random odd integers until finding one integer that can pass a recognized probabilistic primality test scheme as a probable prime. The available set of probable prime number generation functions enables you to specify an appropriate value of the security parameter *t* used in the Miller-Rabin primality test to meet the cryptographic requirements for your application.

All Intel IPP for prime number generation use the context `IppsPrimeState` as an operational vehicle that carries the bitlength of the target probable prime number, the structure capturing the state of the pseudorandom number generation, the structured working buffer used for Montgomery modular computation in the Miller-Rabin primality test, and the buffer to store the generated probable prime number.

The following sequence of operations is required to generate a probable prime number of the specified bitlength:

1. Call the function `PrimeGetSize` to get the size required to configure the `IppsPrimeState` context.
2. Allocate memory through the operating system memory allocation function and configure the `IppsPrimeState` *context* by calling the function`PrimeInit`.

3. Generate a probable prime number of the specified bitlength by calling the function `PrimeGen_BN`. If the returned `IppStatus` is `ippStsInsufficientEntropy`, then change the parameters of the pseudorandom generator and call the function `PrimeGen_BN` again.
4. Clean up secret data stored in the context.
5. Free the memory allocated to the `IppsPrimeState` context by calling the operating system memory-free service function.

See Also

Data Security Considerations

PrimeGetSize

Gets the size of the `IppsPrimeState` *context in bytes.*

Syntax

```
IppStatus ippsPrimeGetSize(int nMaxBits, int* pSize);
```

Include Files

`ippcp.h`

Parameters

nMaxBits	Maximum length of the probable prime number in bits.
pSize	Pointer to the `IppsPrimeState` context size in bytes.

Description

The function gets the `IppsPrimeState` context size in bytes and stores it in *pSize*.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if *nMaxBits* is less than 1.

PrimeInit

Initializes user-supplied memory as `IppsPrimeState` *context for future use.*

Syntax

```
IppStatus ippsPrimeInit(int nMaxBits, IppsPrimeState* pCtx);
```

Include Files

`ippcp.h`

Parameters

nMaxBits	Maximum length of the probable prime number in bits.
pCtx	Pointer to the `IppsPrimeState` context being initialized.

Description

The function initializes the memory pointed by *`pCtx`* as the `IppsPrimeState` context.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if *`nMaxBits`* is less than 1.

See Also

Data Security Considerations

PrimeGen_BN

Generates a random probable prime number of the specified bitlength.

Syntax

```
IppStatus ippsPrimeGen_BN(IppsBigNumState* pPrime, int nBits, int nTrials,
IppsPrimeState* pCtx, IppBitSupplier rndFunc, void* pRndParam);
```

Include Files

`ippcp.h`

Parameters

`pPrime`	Big number to store the generated number in.
`nBits`	Target bitlength for the desired probable prime number.
`nTrials`	Security parameter specified for the Miller-Rabin probable primality.
`pCtx`	Pointer to the `IppsPrimeState` context.
`rndFunc`	Specified Random Generator.
`pRndParam`	Pointer to the Random Generator context.

Description

The function employs the `rndFunc`Random Generator specified by the user to generate a random probable prime number of the *`nBits`* length and stores the generated probable prime number in the *`pPrime`* big number. The generated probable prime number is further validated by the Miller-Rabin primality test scheme with the specified security parameter *`nTrials`*.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if *`nBits`* is less than 1.

`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsBadArgErr`	Indicates an error condition if *`nTrials`* is less than 1.
`ippStsOutOfRangeErr`	Indicates an error condition if *`nBits`* > *`nMaxBits`* (see `PrimeGetSize` and `PrimeInit`)
`ippStsInsufficientEntropy`	Indicates a warning condition if prime generation fails due to poor choice of entropy.

PrimeTest_BN

Tests the given big number for being a probable prime.

Syntax

```
IppStatus ippsPrimeTest_BN(const IppsBigNumState* pPrime, int nTrials, Ipp32u* pResult,
IppsPrimeState* pCtx, IppBitSupplier rndFunc, void* pRndParam);
```

Include Files

`ippcp.h`

Parameters

`pPrime`	The big number to test.
`nTrials`	Security parameter specified for the Miller-Rabin probable primality.
`pResult`	Pointer to the result of the primality test.
`pCtx`	Pointer to the `IppsPrimeState` context.
`rndFunc`	Specified Random Generator.
`pRndParam`	Pointer to the Random Generator context.

Description

The function uses the Miller-Rabin probabilistic primality test scheme with the given security parameter to test whether the given big number is a probable prime. The pseudorandom number used in the Miller-Rabin test is generated by the specified rndFunc Random Generator. The function sets up the *`*pResult`* as IS_PRIME or IS_COMPOSITE to show whether the input probable prime passes the Miller-Rabin test.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsBadArgErr`	Indicates an error condition if *`nTrials`* is less than 1.

PrimeGen

Generates a random probable prime number of the specified bitlength.

Syntax

```
IppStatus ippsPrimeGen(int nBits, int nTrials, IppsPrimeState* pCtx, IppBitSupplier
rndFunc, void* pRndParam);
```

Include Files

`ippcp.h`

Parameters

nBits	Target bitlength for the desired probable prime number.
nTrials	Security parameter specified for the Miller-Rabin probable primality.
pCtx	Pointer to the `IppsPrimeState` context.
rndFunc	Specified Random Generator.
pRndParam	Pointer to the Random Generator context.

Description

The function employs the `rndFunc`Random Generator specified by the user to generate a random probable prime number of the specified *nBits* length. The generated probable prime number is further validated by the Miller-Rabin primality test scheme with the specified security parameter *nTrials*.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if *nBits* is less than 1.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsBadArgErr`	Indicates an error condition if *nTrials* is less than 1.
`ippStsOutOfRangeErr`	Indicates an error condition if *nBits* > *nMaxBits* (see `PrimeGetSize` and `PrimeInit`)
`ippStsInsufficientEntropy`	Indicates a warning condition if prime generation fails due to poor choice of entropy.

PrimeTest

Tests the given integer for being a probable prime.

Syntax

```
IppStatus ippsPrimeTest(int nTrials, Ipp32u *pResult, IppsPrimeState* pCtx,
IppBitSupplier rndFunc, void* pRndParam);
```

Include Files

`ippcp.h`

Parameters

nTrials	Security parameter specified for the Miller-Rabin probable primality.
pResult	Pointer to the result of the primality test.
pCtx	Pointer to the `IppsPrimeState` context.
rndFunc	Specified Random Generator.
pRndParam	Pointer to the Random Generator context.

Description

The function uses the Miller-Rabin probabilistic primality test scheme with the given security parameter to test if the given integer is a probable prime. The pseudorandom number used in the Miller-Rabin test is generated by the specified `rndFunc` Random Generator. The function sets up the **pResult* as `IS_PRIME` or `IS_COMPOSITE` to show if the input probable prime passes the Miller-Rabin test.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsBadArgErr`	Indicates an error condition if *nTrials* is less than 1.

PrimeSet

Sets the Big Number for primality testing.

Syntax

```
IppStatus ippsPrimeSet(const Ipp32u* pBNU, int nBits, IppsPrimeState* pCtx);
```

Include Files

`ippcp.h`

Parameters

pBNU	Pointer to the unsigned integer big number.
nBits	Unsigned integer big number length in bits.
pCtx	Pointer to the `IppsPrimeState` context.

Description

The function sets a probable prime number and its length for the probabilistic primality test.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsLengthErr`	Indicates an error condition if *`nBits`* is less than 1.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsOutOfRangeErr`	Indicates an error condition if *`nBits`* is too large to fit *`pCtx`*.

PrimeSet_BN

Sets the Big Number for primality testing.

Syntax

```
IppStatus ippsPrimeSet_BN(const IppsBigNumState* pBN, IppsPrimeState* pCtx);
```

Include Files

`ippcp.h`

Parameters

`pBN`	Pointer to the Big Number context.
`pCtx`	Pointer to the `IppsPrimeState` context.

Description

The function sets the Big Number for probabilistic primality test.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsOutOfRangeErr`	Indicates an error condition if the Big Number is too large to fit *`pCtx`*.

PrimeGet

Extracts the probable prime unsigned integer big number.

Syntax

```
IppStatus ippsPrimeGet(Ipp32u* pBNU, int *pSize, const IppsPrimeState *pCtx);
```

Include Files

`ippcp.h`

Parameters

pBNU	Pointer to the unsigned integer big number.
pSize	Pointer to the length of the unsinged integer big number.
pCtx	Pointer to the `IppsPrimeState` context.

Description

The function extracts the probable prime number from **pCtx* context and stores it into the specified unsigned integer big number.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

PrimeGet_BN

Extracts the probable prime positive Big Number.

Syntax

`IppStatus ippsPrimeGet_BN(IppsBigNumState* pBN, const IppsPrimeState *pCtx);`

Include Files

`ippcp.h`

Parameters

pBN	Pointer to the Big NUmber context.
pCtx	Pointer to the `IppsPrimeState` context.

Description

The function extracts the probable prime positive big number from the **pCtx* context and stores it into the specified Big Number context.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsOutOfRangeErr`	Indicates an error condition if the Big Number is too small to store probable prime number.

Example of Using Prime Number Generation Functions

Check Primality

```
int  PrimeGen_sample(void){PrimeGen   int error = 0;

   int ctxSize;
   // define 256-bit Prime Generator
   int maxBitSize = 256;
   ippsPrimeGetSize(256,  &ctxSize);
   IppsPrimeState* pPrimeG = (IppsPrimeState*)( new Ipp8u [ctxSize] );
   ippsPrimeInit(256,  pPrimeG);

   // define Pseudo Random Generator (default settings)
   ippsPRNGGetSize(&ctxSize);
   IppsPRNGState* pRand = (IppsPRNGState*)(new Ipp8u [ctxSize] );
   ippsPRNGInit(160,  pRand);

   do {
      Ipp32u result;

      // test primality of the value (known in advance)
      BigNumber  P1("0xDB7C2ABF62E35E668076BEAD208B");
      ippsPrimeTest_BN(P1, 50, &result, pPrimeG, ippsPRNGen, pRand);
      error = IPP_IS_PRIME!=result;
      if(error) {
         cout <<"Primality of the known prime isn't confirmed\n";
         break;
      }
      else cout <<"Primality of the known prime is confirmed\n";

      // generate 256-bit prime
      BigNumber P(0, 256/8);
      while( ippStsNoErr != ippsPrimeGen_BN(P, 256, 50, pPrimeG, ippsPRNGen, pRand) );
      // and test it
      ippsPrimeTest_BN(P, 50, &result, pPrimeG, ippsPRNGen, pRand);
      error = IPP_IS_PRIME!=result;
      if(error) {
         cout <<"Primality of the generated number isn't confirmed\n";
         break;
      }
      else cout <<"Primality of the generated number is confirmed\n";
   } while(0);

   delete [] (Ipp8u*)pRand;
   delete [] (Ipp8u*)pPrimeG;

   return 0==error;
}
```

RSA Algorithm Functions

This section introduces Intel® Integrated Performance Primitives (Intel® IPP) Cryptography functions for RSA algorithm. The section describes a set of primitives to perform operations required for RSA cryptographic systems. This set of primitives offers a flexible user interface that enables scalability of the RSA crypto key size with the limit of up to 4096 bits.

According to [PKCS 1.2.1], a de facto standard for RSA implementations, a pair of keys (public and private) defines forward and inverse transforms of text (or operations on a public and secret key). Mathematical expressions for the forward and inverse transforms are similar. If *x* is plain text and *y* is the corresponding ciphertext, the mathematical expressions are as follows:

- *y = x^e mod n* for the forward transform, or encryption
- *x = y^d mod n* for the inverse transform, or decryption

In these expressions, *e* is the public exponent, *d* is the private exponent, and *n* is the RSA modulus. To enable direct and inverse transforms, a mathematical relationship exists between these values.

The (*n,e*) pair is called the public key. With the known modulus *n*, the public or private exponent determines whether the RSA cryptosystem is public or private. Intel IPP supports these, interrelated, representations of the private key:

- *Private key type 1* is the (*n,d*) pair.
- *Private key type 2* is the (*p,q,dP,dQ,qInv*) quintuple (for details, see [PKCS 1.2.1]).

  This representation speeds computations by using the Chinese Remainder Theorem (CRT).

RSA algorithm functions include:

- Functions for Building RSA System, the system being then used by functions listed below.
- RSA Primitives, which perform RSA encryption and decryption.
- RSA Encryption Schemes and RSA Signature Schemes, which combine RSA cryptographic primitives with other techniques, such as computing hash message digests or applying mask generation functions (MGFs), to achieve a particular security goal.

Important
To provide minimum security, the length of the RSA modulus must be equal to or greater than 1024 bits.

Functions for Building RSA System

You can use the primitives to build an RSA cryptographic system with the supplied randomized seed and stimulus. The function `RSA_GenerateKeys` generates key components for the desired RSA cryptographic system.

RSA Primitives and RSA-based schemes (RSA-OAEP Scheme Functions and RSA-SSA Scheme Functions) use `IppsRSAPublicKeyState` or `IppsRSAPrivateKeyState` context, which is initialized in a call to the `RSA_InitPublicKey, RSA_InitPrivateKeyType1, or RSA_InitPrivateKeyType2` function, as an operational vehicle carrying the RSA public or private keys.

Important
To provide minimum security, the length of the RSA modulus must be equal to or greater than 1024 bits.

RSA_GetSizePublicKey, RSA_GetSizePrivateKeyType1, RSA_GetSizePrivateKeyType2

Get the size of the `IppsRSAPublicKeyState` *or* `IppsRSAPrivateKeyState` *context.*

Syntax

```
IppStatus ippsRSA_GetSizePublicKey(int rsaModulusBitSize, int publicExpBitSize, int*
pKeySize);
```

```
IppStatus ippsRSA_GetSizePrivateKeyType1(int rsaModulusBitSize, int privateExpBitSize,
int* pKeySize);
```

```
IppStatus ippsRSA_GetSizePrivateKeyType2(int factorPBitSize, int factorQBitSize, int*
pKeySize);
```

Include Files

ippcp.h

Parameters

rsaModulusBitSize	Length of the RSA system in bits (that is, the length of the composite RSA modulus n in bits).
publicExpBitSize	Length of the RSA public exponent in bits (that is, the length of the *e* component of the RSA public key).
privateExpBitSize	Length of the RSA private exponent in bits (that is, the length of the *d* component of the RSA private key type 1).
factorPBitSize, *factorQBitSize*	Length in bits of the *p* and *q* factors of the RSA modulus *n* = *p*q*.
pKeySize	Pointer to the IppsRSAPublicKeyState context size in bytes.

Description

These functions get the size of the IppsRSAPublicKeyState or IppsRSAPrivateKeyState context in bytes and stores it in **pKeySize*. Call RSA_GetSizePublicKey to establish an RSA cryptosystem for encryption (or signature verification) operations. Call RSA_GetSizePrivateKeyType1 or RSA_GetSizePrivateKeyType2 to establish an RSA cryptosystem for decryption (or signature generation) operations. The choice between these two functions depends on the representation of the private key to be used.

Return Values

ippStsNoErr	Indicates no error. Any other value indicates an error or warning.
ippStsNullPtrErr	Indicates an error condition if any of the specified pointers is NULL.
ippStsNotSupportedModeErr	Indicates an error condition if *rsaModulusBitSize* < 32, *rsaModulusBitSize* > 4096, *factorPBitSize* + *factorQBitSize* < 32, *factorPBitSize* + *factorQBitSize* > 4096, *factorPBitSize* < 0, or *factorQBitSize* < 0.
ippStsBadArgErr	For RSA_GetSizePublicKey, indicates an error condition if *publicExpBitSize* < 0 or *publicExpBitSize* > *rsaModulusBitSize*. For RSA_GetSizePrivateKeyType1, indicates and error condition if *privateExpBitSize* <0 or *privateExpBitSize* > *rsaModulusBitSize*. For RSA_GetSizePrivateKeyType2, indicates and error condition if *factorPBitSize* <0, *factorPBitSize* < 0, or *factorPBitSize* < *factorQBitSize*.

RSA_InitPublicKey, RSA_InitPrivateKeyType1, RSA_InitPrivateKeyType2

Initialize user-supplied memory as the IppsRSAPublicKeyState *or* IppsRSAPrivateKeyState *context for future use.*

Syntax

IppStatus ippsRSA_InitPublicKey(int *rsaModulusBitSize*, int *publicExpBitSize*, IppsRSAPublicKeyState* *pKey*, int *keyCtxSize*);

IppStatus ippsRSA_InitPrivateKeyType1(int *rsaModulusBitSize*, int *privateExpBitSize*, IppsRSAPrivateKeyState* *pKey*, int *keyCtxSize*);

IppStatus ippsRSA_InitPrivateKeyType2(int *factorPBitSize*, int *FactorQBitSize*, IppsRSAPrivateKeyState* *pKey*, int *keyCtxSize*);

Include Files

ippcp.h

Parameters

rsaModulusBitSize	Length of the RSA system in bits (that is, the length of the composite RSA modulus n in bits).
publicExpBitSize	Length of the RSA public exponent in bits (that is, the length of the *e* component of the RSA public key).
privateExpBitSize	Length of the RSA private exponent in bits (that is, the length of the *d* component of the type 1 RSA private key).
factorPBitSize, *FactorQBitSize*	Length in bits of the *p* and *q* factors of the RSA modulus *n* = *p***q*.
pKey	Pointer to the IppsRSAPublicKeyState or IppsRSAPrivateKeyState context being initialized. The context depends on the function.
keyCtxSize	Available size in bytes of the memory buffer being initialized.

Description

These functions initialize the memory pointed by *pKey* as the IppsRSAPublicKeyState or IppsRSAPrivateKeyState context, depending on the function. To determine the size of the memory buffer, call the appropriate RSA_GetSizePublicKey, RSA_GetSizePrivateKeyType1, RSA_GetSizePrivateKeyType2 function prior to calling any of these functions.

Return Values

ippStsNoErr	Indicates no error. Any other value indicates an error or warning.
ippStsNullPtrErr	Indicates an error condition if any of the specified pointers is NULL.
ippStsNotSupportedModeErr	Indicates an error condition if *rsaModulusBitSize* < 32 or *rsaModulusBitSize* > 4096, *factorPBitSize* < 16 or *factorPBitSize* > 4096, or *factorQBitSize* < 16 or *factorQBitSize* > 4096.
ippStsBadArgErr	Indicates an error condition if *publicExpBitSize* > *rsaModulusBitSize* or *privateExpBitSize* > *rsaModulusBitSize*.
ippStsMemAllocErr	Indicates an error condition if the allocated memory is insufficient for the operation.

See Also

RSA_GetSizePublicKey, RSA_GetSizePrivateKeyType1, RSA_GetSizePrivateKeyType2

~~Data Security Considerations~~

RSA_SetPublicKey, RSA_SetPrivateKeyType1, RSA_SetPrivateKeyType2

Set up an RSA key in the existing RSA key context.

Syntax

IppStatus ippsRSA_SetPublicKey(const IppsBigNumState* *pModulus*, const IppsBigNumState* *pPublicExp*, IppsRSAPublicKeyState* *pKey*);

IppStatus ippsRSA_SetPrivateKeyType1(const IppsBigNumState* *pModulus*, const IppsBigNumState* *pPrivateExp*, IppsRSAPrivateKeyState* *pKey*);

IppStatus ippsRSA_SetPrivateKeyType2(const IppsBigNumState* *pFactorP*, const IppsBigNumState* *pFactorQ*, const IppsBigNumState* *pCrtExpP*, const IppsBigNumState* *pCrtExpQ*, const IppsBigNumState* *pInverseQ*, IppsRSAPrivateKeyState* *pKey*);

Include Files

ippcp.h

Parameters

pModulus	The composite RSA modulus *n*.
pPublicExp	The *e* component of the RSA public key.
pPrivateExp	The *d* component of the type 1 RSA private key.
pFactorP, *pFactorQ*	The *p* and *q* factors of the RSA modulus *n* = *p*q*.
pCrtExpP, *pCrtExpQ*	The *dP* and *dQ* components of the quintuple (*p*,*q*,*dP*,*dQ*,*qInv*), which defines a type 2 private key.
pInverseQ	The *qInv* component of the quintuple (*p*,*q*,*dP*,*dQ*,*qInv*).
pKey	Pointer to the IppsRSAPublicKeyState or IppsRSAPrivateKeyState context.

Description

The RSA_SetPublicKey function sets up the RSA public key (*n*, *e*) in the IppsRSAPublicKeyState context, that is, copies the *n* and *e* components supplied by the user into the context.

The RSA_SetPrivateKeyType1 function sets up the RSA type 1 private key (*n*, *d*) in the IppsRSAPrivateKeyState context, that is, copies the *n* and *d* components supplied by the user into the context.

The RSA_SetPrivateKeyType2 function sets up the RSA type 2 private key (*p*,*q*,*dP*,*dQ*,*qInv*) in the IppsRSAPrivateKeyState context, that is, copies user-supplied *p* and *q* factors of the RSA composite modulus into the context, computes the rest of the key components, and copies them into the context:

- *dP* = *q* mod (*p*-1)
- *dQ* = *p* mod (*q*-1)
- *qInv* = 1/*q* mod *p*

Return Values

ippStsNoErr	Indicates no error. Any other value indicates an error or warning.
ippStsNullPtrErr	Indicates an error condition if any of the specified pointers is NULL.

`ippStsContextMatchErr`	Indicates an error condition if any of the context parameters does not match the operation.
`ippStsSizeErr`	Indicates an error condition if the bit length of a key component specified by the *pModulus*, *pPublicExp*, *pPrivateExp*, *pFactorP*, or *pFactorQ* pointer exceeds the bit length specified at the initialization.
`ippStsOutOfRangeErr`	Indicates an error condition if any key component is not positive.

RSA_GetPublicKey, RSA_GetPrivateKeyType1, RSA_GetPrivateKeyType2

Extracts key components from an RSA key context.

Syntax

`IppStatus ippsRSA_GetPublicKey(IppsBigNumState* pModulus, IppsBigNumState* pPublicExp, const IppsRSAPublicKeyState* pKey);`

`IppStatus ippsRSA_GetPrivateKeyType1(IppsBigNumState* pModulus, IppsBigNumState* pPrivateExp, const IppsRSAPrivateKeyState* pKey);`

`IppStatus ippsRSA_GetPrivateKeyType2(IppsBigNumState* pFactorP, IppsBigNumState* pFactorQ, IppsBigNumState* pCrtExpP, IppsBigNumState* pCrtExpQ, IppsBigNumState* pInverseQ, const IppsRSAPrivateKeyState* pKey);`

Include Files

`ippcp.h`

Parameters

pModulus	The composite RSA modulus *n*.
pPublicExp	The *e* component of the RSA public key.
pPrivateExp	The *d* component of the type 1 RSA private key.
pFactorP, *pFactorQ*	The *p* and *q* factors of the RSA modulus *n* = *p*q*.
pCrtExpP, *pCrtExpQ*	The *dP* and *dQ* components of the quintuple (*p,q,dP,dQ,qInv*).
pInverseQ	The *qInv* component of the quintuple (*p,q,dP,dQ,qInv*).
pKey	Pointer to the `IppsRSAPublicKeyState` or `IppsRSAPrivateKeyState` context.

Description

The RSA_GetPublicKey function extracts components of the RSA public key (*n*, *e*) from the `IppsRSAPublicKeyState` context. The RSA_GetPrivateKeyType1 and RSA_GetPrivateKeyType2 functions extract components of the RSA private key of the respective type from the `IppsRSAPrivateKeyState` context.

To extract key components selectively, set pointers to the key components that do not need to be extracted to NULL.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is NULL.

`ippStsContextMatchErr`	Indicates an error condition if any of the context parameters does not match the operation.
`ippStsSizeErr`	Indicates an error condition if the bit length of any specified key component is not sufficient to hold the value.
`ippStsIncompleteContextErr`	Indicates an error condition if the public or private key is not set up.

NOTE
While you can set up the public key or type 1 private key in a call to `RSA_SetPublicKey` or `RSA_SetPrivateKeyType1`, respectively, you can set up the type 2 private key in a call to either `RSA_SetPrivateKeyType2` or `RSA_GenerateKeys`.

See Also

`RSA_SetPublicKey`, `RSA_SetPrivateKeyType1`, `RSA_SetPrivateKeyType2`
`RSA_GenerateKeys`

RSA_GetBufferSizePublicKey, RSA_GetBufferSizePrivateKey

Get the size of a temporary scratch buffer for future use in RSA operations.

Syntax

```
IppStatus ippsRSA_GetBufferSizePublicKey(int* pBufferSize, const IppsRSAPublicKeyState*
pKey);
```

```
IppStatus ippsRSA_GetBufferSizePrivateKey(int* pBufferSize, const
IppsRSAPrivateKeyState* pKey);
```

Include Files

`ippcp.h`

Parameters

pBufferSize	Pointer to the size of a temporary buffer.
pKey	Pointer to the RSA key context.

Description

These functions get the size of a temporary buffer for future use in public- or private-key RSA operations, respectively.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if any of the context parameters does not match the operation.
`ippStsIncompleteContextErr`	For `RSA_GetBufferSizePublicKey`, indicates an error condition if the public key is not set up.

For `RSA_GetBufferSizePrivateKeyType1`, indicates an error condition if the type 1 private key is not set up.

> **NOTE**
> You can set up the public key or type 1 private key in a call to `RSA_SetPublicKey` or `RSA_SetPrivateKeyType1`, respectively. For the `RSA_GetBufferSizePrivateKeyType2` function, it suffices to initialize the context for the key in a call to `RSA_InitPrivateKeyType2`.

See Also

`RSA_SetPublicKey, RSA_SetPrivateKeyType1`

`RSA_InitPrivateKeyType2`

RSA_MB_GetBufferSizePublicKey, RSA_MB_GetBufferSizePrivateKey

Get the size of a temporary scratch buffer for future use in RSA multi-buffer operations.

Syntax

> **NOTE** This API is deprecated from Intel® IPP Cryptography and is removed since 2021.2 release. It is recommended to switch to Crypto MB library. If you have any concerns, open a ticket and provide feedback at Intel ® online support center.

```
IppStatus ippsRSA_MB_GetBufferSizePublicKey(int*pBufferSize, const
IppsRSAPublicKeyState*pKey);
```

```
IppStatus ippsRSA_MB_GetBufferSizePrivateKey(int*pBufferSize, const
IppsRSAPrivateKeyState*pKey);
```

Include Files

`ippcp.h`

Parameters

pBufferSize	Pointer to the size of a temporary buffer.
pKey	Pointer to the RSA key context.

Description

These functions get the size of a temporary buffer for future use in public- or private-key RSA multi-buffer operations, respectively. The functions require any of 8 contexts that are used in a multi-buffer operation.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL` .
`ippStsContextMatchErr`	Indicates an error condition if any of the context parameters does not match the operation.

`ippStsIncompleteContextErr`	For `RSA_MB_GetBufferSizePublicKey` , indicates an error condition if the public key is not set up. For `RSA_MB_GetBufferSizePrivateKeyType1` , indicates an error condition if the type 1 private key is not set up.

NOTE
You can set up the public key or type 1 private key in a call to `RSA_SetPublicKey` or `RSA_SetPrivateKeyType1` , respectively. For the `RSA_GetBufferSizePrivateKeyType2` function, it is sufficient to initialize the context for the key in a call to `RSA_InitPrivateKeyType2` .

See Also

`RSA_SetPublicKey, RSA_SetPrivateKeyType1`

`RSA_InitPrivateKeyType2`

RSA_GenerateKeys

Generates key components for the desired RSA cryptographic system.

Syntax

```
IppStatus ippsRSA_GenerateKeys(const IppsBigNumState* pSrcPublicExp, IppsBigNumState*
pModulus, IppsBigNumState* pPublicExp, IppsBigNumState* pPrivateExp,
IppsRSAPrivateKeyState* pPrivateKeyType2, Ipp8u* pScratchBuffer, int nTrials,
IppsPrimeState* pPrimeGen, IppBitSupplier rndFunc, void* pRndParam);
```

Include Files

`ippcp.h`

Parameters

pSrcPublicExp	Pointer to the `IppsBigNumState` context of the initial value for searching an RSA public exponent.
pModulus	Pointer to the generated RSA modulus.
pPublicExp	Pointer to the generated RSA public exponent.
pPrivateExp	Pointer to the generated RSA private exponent.
pPrivateKeyType2	Pointer to the generated RSA private key type 2.
pScratchBuffer	Pointer to the temporary buffer of size not less than returned by the `RSA_GetBufferSizePrivateKey` function.
nTrials	Security parameter specified for the Miller-Rabin test for probable primality.
pPrimeGen	Pointer to the prime number generator.
rndFunc	Pseudorandom number generator.
pRndParam	Pointer to the context of the pseudorandom number generator.

Description

This function generates public and private keys of the desired RSA cryptographic system.

This function sequentially performs the following computations:

1. Generates random probable prime numbers *p* and *q* using the specified pseudorandom number generator *rndFunc*.
2. Computes the RSA composite modulus *n* = (*p***q*).
3. Based on the generated *p* and *q* factors, computes all the other CRT-related RSA components: *dP* = *d* mod (*p*-1), *dQ* = *p* mod (*q*-1) and *qInv* = 1/*q* mod *p*.

To generate RSA keys using the RSA_GenerateKeys function, call it in the following sequence of steps:

1. Establish the pseudorandom number generator and prime number generator.
2. Define the RSA private key type 2 in successive calls to the RSA_GetSizePrivateKeyType2 and RSA_InitPrivateKeyType2 functions with desired values of *factorPBitSize* and *factorQBitSize* parameters.
3. Allocate a temporary buffer of a suitable size.
4. Set up the initial value of the public exponent *pSrcPublicExp*.
5. Call RSA_GenerateKeys.

   If RSA_GenerateKeys returns `IppNoErr`, the key pair is generated.

   If RSA_GenerateKeys returns `ippStsInsufficientEntropy`, repeat step 5.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsSizeErr`	Indicates an error condition if the bit length of any key component specified by *pModulus*, *pPublicExp* or *pPrivateExp* is not sufficient to hold the value or the prime number generator, specified by *pPrimeGen*, is not sufficient to generate suitable values.
`ippStsOutOfRangeErr`	Indicates an error condition if the initial value for searching the public exponent, specified by *pSrcPublicExp*, is not positive.
`ippStsBadArgErr`	Indicates an error condition in cases not explicitly mentioned above.
`ippStsInsufficientEntropy`	Indicates a warning condition if the prime number generation fails due to a poor choice of entropy.

See Also

RSA_InitPublicKey, RSA_InitPrivateKeyType1, RSA_InitPrivateKeyType2
RSA_Validate
Pseudorandom Number Generation Functions

RSA_ValidateKeys

Validates key components of the RSA cryptographic system.

Syntax

```
IppStatus ippsRSA_ValidateKeys(int* pResult, const IppsRSAPublicKeyState* pPublicKey,
const IppsRSAPrivateKeyState* pPrivateKeyType2, const IppsRSAPrivateKeyState*
pPrivateKeyType1, Ipp8u* pScratchBuffer, int nTrials, IppsPrimeState* pPrimeGen,
IppBitSupplier rndFunc, void* pRndParam);
```

Include Files

`ippcp.h`

Parameters

pResult	Pointer to the result of validation.
pPublicKey	Pointer to the RSA public key.
pPrivateKeyType2	Pointer to the RSA private key type 2.
pPrivateKeyType1	Pointer to the RSA private key type 1. This parameter is optional and can have the value of `NULL`.
pScratchBuffer	Pointer to the temporary buffer of size not less than returned by the `RSA_GetBufferSizePrivateKey` function.
nTrials	Security parameter specified for the Miller-Rabin test for probable primality.
pPrimeGen	Pointer to the prime number generator.
rndFunc	Pseudorandom number generator.
pRndParam	Pointer to the context of the pseudorandom number generator.

Description

The function validates key components of the RSA cryptographic system and stores the result of the validation procedure in **pResult*.

The meanings of values of **pResult* are as follows:

IS_VALID_KEY	The RSA key pair is valid.
IS_INVALID_KEY	The RSA key is not valid.

The key pair is valid under the following conditions:

- The p and q factors are prime.
- The type 2 private key meets these conditions:
  - $e*dP = 1 \pmod{p-1}$ and $e*dQ = 1 \pmod{q-1}$
  - $q*qInv = 1 \pmod{p}$
- If the *pPrivateKeyType1* parameter is not NULL, the type 1 private key meets the condition $e*d = 1 \bmod ((p-1)*(q-1))$.

Validation of the public and type 1 private key pair requires type 2 private key.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is NULL.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsSizeErr`	Indicates an error condition if the prime number generator, specified by *pPrimeGen*, is not sufficient to generate suitable values.
`ippStsIncompleteContextErr`	Indicates an error condition if the public or private key is not set up.

`ippStsBadArgErr`	Indicates an error condition if any of the RSA keys **pPublicKey*, **pPrivateKeyType2*, or, optional, **pPrivateKeyType1* is not properly set up or generated.

See Also

RSA_GenerateKey

RSA Primitives

The functions described in this section refer to RSA primitives.

The application code for conducting a typical RSA encryption must perform the following sequence of operations, starting with building of a crypto system:

1. Call the function RSA_GetSizePublicKey to get the size required to configure IppsRSAPublicKeyState context.
2. Ensure that the required memory space is properly allocated. With the allocated memory, call the RSA_InitPublicKey function to initialize the context.
3. Call RSA_SetPublicKey to set up RSA public key (*n*, *e*).
4. Call the RSA_GetBufferSizePublicKey function to get the size of a temporary buffer.
5. Invoke the RSA_Encrypt function with the established RSA public key to encode the plaintext into the respective ciphertext.
6. Clean up secret data stored in the context.
7. Free the memory allocated for the IppsRSAPublicKeyState context by calling the operating system memory free service function.

The typical application code for the RSA decryption must perform the following sequence of operations:

1. Call the function GetSizePrivateKeyType1 or RSA_GetSizePrivateKeyType2 to get the size required to configure IppsRSAPrivateKeyState context.
2. Ensure that the required memory space is properly allocated. With the allocated memory, call the InitPrivateKeyType1 or RSA_InitPrivateKeyType2 function to initialize the context.
3. Call the RSA_GetBufferSizePrivateKey function to get the size of a temporary buffer.
4. Establish the RSA private key by means of either the RSA_GenerateKeys function or by the key setup function RSA_SetPrivateKeyType1 or RSA_SetPrivateKeyType2. The RSA_GenerateKeys function can generate both type 1 and type 2 private keys, while the choice of the key setup function depends on the representation of the private key you are using.
5. Invoke the RSA_Decrypt function with the established RSA public key to decode the ciphertext into the respective plaintext.
6. Clean up secret data stored in the context.
7. Free the memory allocated for the IppsRSAPrivateKeyState context by calling the operating system memory free service function.

You can perform up to 8 encryption/decryption operations at once using the RSA_MB_Encrypt and RSA_MB_Decrypt functions. For this, repeat steps 2-4 to set up the required number of keys, and then repeat steps 6-7 for each initialized context.

See Also

Data Security Considerations

RSA_Encrypt

Performs the RSA encryption operation.

Syntax

```
IppStatus ippsRSA_Encrypt(const IppsBigNumState* pPtxt, IppsBigNumState* pCtxt, const
IppsRSAPublicKeyState* pKey, Ipp8u* pScratchBuffer);
```

Include Files

```
ippcp.h
```

Parameters

pPtxt	Pointer to the `IppsBigNumState` context of the plaintext.
pCtxt	Pointer to the `IppsBigNumState` context of the ciphertext.
pKey	Pointer to the `IppsRSAPublicKeyState` context.
pScratchBuffer	Pointer to the temporary buffer of size not less than returned by the `RSA_GetBufferSizePublicKey` function.

Description

The function performs the RSA encryption operation, that is, the RSA operation on a public key.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsIncompleteContextErr`	Indicates an error condition if the public key is not set up. **NOTE** You can set up the public key in a call to `RSA_SetPublicKey`.
`ippStsOutOfRangeErr`	Indicates an error condition if the big number specified by *pPtxt* is not positive or greater than the RSA modulus.
`ippStsSizeErr`	Indicates an error condition if the big number specified by *pCtxt* is not sufficient to hold the result.

See Also

`RSA_SetPublicKey`
`RSA_Decrypt`
Functions for Building RSA System

RSA_MB_Encrypt

Performs the RSA multi-buffer encryption operation.

Syntax

NOTE This API is deprecated from Intel® IPP Cryptography and is removed since 2021.2 release. It is recommended to switch to Crypto MB library. If you have any concerns, open a ticket and provide feedback at Intel ® online support center.

```
IppStatus ippsRSA_MB_Encrypt(const IppsBigNumState*pPtxts[8],
IppsBigNumState*pCtxts[8], const IppsRSAPublicKeyState*pKeys[8], IppStatusstatuses[8],
Ipp8u*pBuffer);
```

Include Files

`ippcp.h`

Parameters

pPtxts[8]	Pointer to the `IppsBigNumState` context of the plaintext for each encryption operation.
pCtxts[8]	Pointer to the `IppsBigNumState` context of the ciphertext for each encryption operation.
pKeys[8]	Pointer to the `IppsRSAPublicKeyState` context for each encryption operation.
statuses	Pointer to the `IppStatus` array that contains statuses for each encryption operation.
pScratchBuffer	Pointer to the temporary buffer of size not less than returned by the `RSA_MB_GetBufferSizePublicKey` function.

Description

The function performs the RSA multi-buffer encryption operation, which is the RSA operation on a public key. The function can perform up to 8 single RSA encryption operations at once.

Each RSA encryption operation requires valid parameters that follow the `ippsRSA_Encrypt` syntax. After execution, the statuses array contains statuses for each single RSA encryption operation returned by `ippsRSA_Encrypt` .

To perform less than 8 operations, set one or more contexts in arrays to NULL. In this case, all single operations with NULL in parameters are not performed, and the function returns `ippStsMbWarning` .

Important
Sizes of all moduli *n* in all the `IppsRSAPublicKeyState` contexts in the *pKeys* array must be equal. Sizes and values of all public exponents *e* in all the `IppsRSAPublicKeyState` contexts in the *pKeys* array must be equal.

Return Values

`ippStsNoErr`	Indicates no error. All single operations are executed without errors. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL` .
`ippStsSizeErr`	Indicates an error condition if the size of modulus *n* in one context is not equal to the size of the modulus *n* in other contexts.
`ippStsBadArgErr`	Indicates an error condition if the size or value of the exponent *e* in one context is not equal to the value and size of *e* in other contexts.
`ippStsMbWarning`	Indicates a warning when one or more performed operations are executed with errors. For details, check the statuses array.

See Also

`RSA_SetPublicKey`
`RSA_MB_Decrypt`
Functions for Building RSA System

RSA_Decrypt

Performs the RSA decryption operation.

Syntax

`IppStatus ippsRSA_Decrypt(const IppsBigNumState* pCtxt, IppsBigNumState* pPtxt, const IppsRSAPrivateKeyState* pKey, Ipp8u* pScratchBuffer);`

Include Files

`ippcp.h`

Parameters

pCtxt	Pointer to the `IppsBigNumState` context of the ciphertext.
pPtxt	Pointer to the `IppsBigNumState` context of the plaintext.
pKey	Pointer to the `IppsRSAPrivateKeyState` context.
pScratchBuffer	Pointer to the scratch buffer of size not less than returned by the `RSA_GetBufferSizePrivateKey` function.

Description

The function performs the RSA encryption operation, that is, the RSA operation on a private key.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsIncompleteContextErr`	Indicates an error condition if the private key is not set up.

NOTE
While you can set up the type 1 private key in a call to `RSA_SetPrivateKeyType1`, you can set up the type 2 private key in a call to either `RSA_SetPrivateKeyType2` or `RSA_GenerateKeys`.

`ippStsOutOfRangeErr`	Indicates an error condition if the big number specified by *pCtxt* is not positive or greater than the RSA modulus.
`ippStsSizeErr`	Indicates an error condition if the big number specified by *pPtxt* is not sufficient to hold the result.

See Also

`RSA_SetPrivateKeyType1`, `RSA_SetPrivateKeyType2`
`RSA_GenerateKeys`
`RSA_Encrypt`
Functions for Building RSA System

RSA_MB_Decrypt

Performs the RSA multi-buffer decryption operation.

Syntax

NOTE This API is deprecated from Intel® IPP Cryptography and is removed since 2021.2 release. It is recommended to switch to Crypto MB library. If you have any concerns, open a ticket and provide feedback at Intel ® online support center.

```
IppStatus ippsRSA_MB_Decrypt(const IppsBigNumState*pCtxts[8],
IppsBigNumState*pPtxts[8], const IppsRSAPrivateKeyState*pKeys[8], IppStatusstatuses[8],
Ipp8u*pBuffer);
```

Include Files

`ippcp.h`

Parameters

pPtxts[8]	Pointer to the `IppsBigNumState` context of the plaintext for each decryption operation.
pCtxts[8]	Pointer to the `IppsBigNumState` context of the ciphertext for each decryption operation.
pKeys[8]	Pointer to the `IppsRSAPublicKeyState` context for each decryption operation.
statuses	Pointer to the `IppStatus` array that contains statuses for each decryption operation.
pScratchBuffer	Pointer to the temporary buffer of size not less than returned by the `RSA_MB_GetBufferSizePrivateKey` function.

Description

The function performs the RSA multi-buffer decryption operation, which is the RSA operation on a private key. The function can perform up to 8 single RSA decryption operations at once.

Each RSA decryption operation requires valid parameters that follow the `ippsRSA_Decrypt` syntax. After execution, the statuses array contains statuses for each single RSA decryption operation returned by `ippsRSA_Decrypt` .

To perform less than 8 operations, set one or more contexts in arrays to NULL. In this case, all single operations with NULL in parameters are not performed, and the function returns `ippStsMbWarning` .

Important
Sizes of all moduli *n* in all the `IppsRSAPrivateKeyState` contexts in the *pKeys* array must be equal. Types of RSA private keys must be the same.

Return Values

`ippStsNoErr`	Indicates no error. All single operations are executed without errors. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is NULL .
`ippStsSizeErr`	Indicates an error condition if the size of modulus *n* in one context is not equal to the size of the modulus *n* in other contexts.

`ippStsBadArgErr`	Indicates an error condition if types of RSA private keys are not the same.
`ippStsMbWarning`	Indicates a warning when one or more performed operations are executed with errors. For details, check the statuses array.

See Also

RSA_SetPrivateKeyType1, RSA_SetPrivateKeyType2

RSA_GenerateKeys

RSA_MB_Encrypt

Functions for Building RSA System

Example of Using RSA Primitive Functions

The following example illustrates the use of RSA primitives. The example uses the `BigNumber` class and functions creating some cryptographic contexts, whose source code can be found in Appendix B.

Use of RSA Primitives

```
// P prime factor
BigNumber     P("0xEECFAE81B1B9B3C908810B10A1B5600199EB9F44AEF4FDA493B81A9E3D84F632"
                  "124EF0236E5D1E3B7E28FAE7AA040A2D5B252176459D1F397541BA2A58FB6599");
// Q prime factor
BigNumber     Q("0xC97FB1F027F453F6341233EAAAD1D9353F6C42D08866B1D05A0F2035028B9D86"
                  "9840B41666B42E92EA0DA3B43204B5CFCE3352524D0416A5A441E700AF461503");
// P's CRT exponent
BigNumber    dP("0x54494CA63EBA0337E4E24023FCD69A5AEB07DDDC0183A4D0AC9B54B051F2B13E"
                  "D9490975EAB77414FF59C1F7692E9A2E202B38FC910A474174ADC93C1F67C981");
// Q's CRT exponent
BigNumber    dQ("0x471E0290FF0AF0750351B7F878864CA961ADBD3A8A7E991C5C0556A94C3146A7"
                  "F9803F8F6F8AE342E931FD8AE47A220D1B99A495849807FE39F9245A9836DA3D");
// CRT coefficient
BigNumber   invQ("0xB06C4FDABB6301198D265BDBAE9423B380F271F73453885093077FCD39E2119F"
                  "C98632154F5883B167A967BF402B4E9E2E0F9656E698EA3666EDFB25798039F7");
// rsa modulus N = P*Q
BigNumber     N("0xBBF82F090682CE9C2338AC2B9DA871F7368D07EED41043A440D6B6F07454F51F"
                  "B8DFBAAF035C02AB61EA48CEEB6FCD4876ED520D60E1EC4619719D8A5B8B807F"
                  "AFB8E0A3DFC737723EE6B4B7D93A2584EE6A649D060953748834B2454598394E"
                  "E0AAB12D7B61A51F527A9A41F6C1687FE2537298CA2A8F5946F8E5FD091DBDCB");
// private exponent
BigNumber     D("0xA5DAFC5341FAF289C4B988DB30C1CDF83F31251E0668B42784813801579641B2"
                  "9410B3C7998D6BC465745E5C392669D6870DA2C082A939E37FDCB82EC93EDAC9"
                  "7FF3AD5950ACCFBC111C76F1A9529444E56AAF68C56C092CD38DC3BEF5D20A93"
                  "9926ED4F74A13EDDFBE1A1CECC4894AF9428C2B7B8883FE4463A4BC85B1CB3C1");
// public exponent
BigNumber     E("0x11");

int RSA_sample(void)
{
   int keyCtxSize;

   // (bit) size of key components
   int bitsN = N.BitSize();
   int bitsE = E.BitSize();
   int bitsP = P.BitSize();
   int bitsQ = Q.BitSize();

   // define and setup public key
```

```
ippsRSA_GetSizePublicKey(bitsN,  bitsE,  &keyCtxSize);
IppsRSAPublicKeyState* pPub = (IppsRSAPublicKeyState*)( new Ipp8u [keyCtxSize] );
ippsRSA_InitPublicKey(bitsN, bitsE, pPub, keyCtxSize);
ippsRSA_SetPublicKey(N, E, pPub);

// define and setup (type2) private key
ippsRSA_GetSizePrivateKeyType2(bitsP,  bitsQ,  &keyCtxSize);
IppsRSAPrivateKeyState* pPrv = (IppsRSAPrivateKeyState*)( new Ipp8u [keyCtxSize] );
ippsRSA_InitPrivateKeyType2(bitsP, bitsQ, pPrv, keyCtxSize);
ippsRSA_SetPrivateKeyType2(P, Q, dP, dQ, invQ, pPrv);

// allocate scratch buffer
int buffSizePublic;
ippsRSA_GetBufferSizePublicKey(&buffSizePublic,   pPub);
int buffSizePrivate;
ippsRSA_GetBufferSizePrivateKey(&buffSizePrivate,   pPrv);
int buffSize = max(buffSizePublic, buffSizePrivate);
Ipp8u* scratchBuffer = NULL;
scratchBuffer = new Ipp8u [buffSize];

// error flag
int error = 0;

do {
   //
   // validate keys
   //

   // random generator
   IppsPRNGState* pRand = newPRNG();
   // prime generator
   IppsPrimeState* pPrimeG = newPrimeGen(P.BitSize());

   int validateRes = IPP_IS_INVALID;
   ippsRSA_ValidateKeys(&validateRes,
                        pPub, pPrv, NULL, scratchBuffer,
                        10, pPrimeG, ippsPRNGen, pRand);

   // delete geterators
   deletePrimeGen(pPrimeG);
   deletePRNG(pRand);

   if(IPP_IS_VALID!=validateRes)  {
      cout <<"validation fail" << endl;
      error = 1;
      break;
   }

   // known plain- and ciper-texts
   BigNumber   kat_PT("0x00EB7A19ACE9E3006350E329504B45E2CA82310B26DCD87D5C68F1EEA8F55267"
                      "C31B2E8BB4251F84D7E0B2C04626F5AFF93EDCFB25C9C2B3FF8AE10E839A2DDB"
                      "4CDCFE4FF47728B4A1B7C1362BAAD29AB48D2869D5024121435811591BE392F9"
                      "82FB3E87D095AEB40448DB972F3AC14F7BC275195281CE32D2F1B76D4D353E2D");
   BigNumber   kat_CT("0x1253E04DC0A5397BB44A7AB87E9BF2A039A33D1E996FC82A94CCD30074C95DF7"
                      "63722017069E5268DA5D1C0B4F872CF653C11DF82314A67968DFEAE28DEF04BB"
                      "6D84B1C31D654A1970E5783BD6EB96A024C2CA2F4A90FE9F2EF5C9C140E5BB48"
                      "DA9536AD8700C84FC9130ADEA74E558D51A74DDF85D8B50DE96838D6063E0955");
      //
      // encrypt message
      //
      BigNumber ct(0, N.DwordSize());
      ippsRSA_Encrypt(kat_PT, ct, pPub, scratchBuffer);
      if(ct!=kat_CT) {
         cout <<"encryption fail" << endl;
         error = 1;
         break;
      }

      //
      // decrypt message
      //
      BigNumber rt(0, N.DwordSize());
      ippsRSA_Decrypt(kat_CT, rt, pPrv, scratchBuffer);
      if(rt!=kat_PT) {
         cout <<"decryption fail" << endl;
         error = 1;
         break;
      }
   } while(0);

   delete [] scratchBuffer;

   delete [] (Ipp8u*) pPub;

   // remove sensitive data before release
   ippsRSA_InitPrivateKeyType2(bitsP, bitsQ, pPrv, keyCtxSize);
   delete [] (Ipp8u*) pPrv;

   return error==0;
}
```

RSA Encryption Schemes

RSA-OAEP Scheme Functions

This subsection describes functions implementing RSA-OAEP encryption scheme, specified in [PKCS 1.2.1].

RSAEncrypt_OAEP
Carries out the RSA-OAEP encryption scheme.

Syntax

`IppStatus ippsRSAEncrypt_OAEP(const Ipp8u* pSrc, int srcLen, const Ipp8u* pLabel, int labLen, const Ipp8u* pSeed, Ipp8u* pDst, const IppsRSAPublicKeyState* pKey, IppHashAlgId hashAlg, Ipp8u* pBuffer);`

`IppStatus ippsRSAEncrypt_OAEP_rmf(const Ipp8u* pSrc, int srcLen, const Ipp8u* pLabel, int labLen, const Ipp8u* pSeed, Ipp8u* pDst, const IppsRSAPublicKeyState* pKey, const IppsHashMethod* pMethod, Ipp8u* pBuffer);`

Include Files

`ippcp.h`

Parameters

pSrc	Pointer to the octet message to be encrypted.
srcLen	Length of the message to be encrypted.
pLabel	Pointer to the optional label to be associated with the message.
labLen	Length of the optional label.
pSeed	Pointer to the random octet string of length *hashLen*, where *hashLen* is the length (in octets) of the hash function output.
pDst	Pointer to the output octet ciphertext string.
pKey	Pointer to the properly initialized `IppsRSAPublicKeyState` context.
hashAlg	ID of the hash algorithm used. For details, see table Supported Hash Algorithms.
pMethod	Pointer to the hash method. For details, see HashMethod functions.
pBuffer	Pointer to a temporary buffer of size not less than returned by the `RSA_GetBufferSizePublicKey` function.

Description

The function carries out the RSA-OAEP encryption scheme, defined in [PKCS 1.2.1]. The length of the encrypted message is equal to the size of the RSA modulus *n*.

NOTE
This function has a *reduced memory footprint* version. To learn more, see Reduced Memory Footprint Functions.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsIncompleteContextErr`	Indicates an error condition if the public key is not set up. **NOTE** You can set up the public key in a call to `RSA_SetPublicKey`.
`ippStsLengthErr`	Indicates an error condition if the any input/output length parameters are inconsistent with one another.
`ippStsNotSupportedModeErr`	if the *hashAlg* parameter does not match any value of `IppHashAlgId` listed in table Supported Hash Algorithms.

See Also

`RSA_SetPublicKey`

RSADecrypt_OAEP

RSADecrypt_OAEP
Carries out the RSA-OAEP decryption scheme.

Syntax

```
IppStatus ippsRSADecrypt_OAEP(const Ipp8u* pSrc, const Ipp8u* pLabel, int labLen,
Ipp8u* pDst, int* pDstLen, const IppsRSAPrivateKeyState* pKey, IppHashAlgId hashAlg,
Ipp8u* pBuffer);
```

```
IppStatus ippsRSADecrypt_OAEP_rmf(const Ipp8u* pSrc, const Ipp8u* pLabel, int labLen,
Ipp8u* pDst, int* pDstLen, const IppsRSAPrivateKeyState* pKey, const IppsHashMethod*
pMethod, Ipp8u* pBuffer);
```

Include Files

`ippcp.h`

Parameters

pSrc	Pointer to the octet ciphertext to be decrypted.
pLabel	Pointer to the optional label to be associated with the message.
labLen	Length of the optional label.
pDst	Pointer to the output octet plaintext message.
pDstLen	Pointer to the length of the decrypted message.
pKey	Pointer to the properly initialized `IppsRSAPrivateKeyState` context.
hashAlg	ID of the hash algorithm used. For details, see table Supported Hash Algorithms.
pMethod	Pointer to the hash method. For details, see HashMethod functions.
pBuffer	Pointer to a temporary buffer of size not less than returned by the `RSA_GetBufferSizePrivateKey` function.

Description

The function carries out the RSA-OAEP decryption scheme defined in [PKCS 1.2.1]. The **pDstLen* parameter returns the length of the decrypted message.

NOTE
This function has a *reduced memory footprint* version. To learn more, see Reduced Memory Footprint Functions.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

`ippStsIncompleteContextErr`	Indicates an error condition if the private key is not set up. **NOTE** While you can set up the type 1 private key in a call to `RSA_SetPrivateKeyType1`, you can set up the type 2 private key in a call to either `RSA_SetPrivateKeyType2` or `RSA_GenerateKeys`.
`ippStsLengthErr`	Indicates an error condition if the any input/output length parameters are inconsistent with one another.
`ippStsNotSupportedModeErr`	Indicates an error condition if the *`hashAlg`* parameter does not match any value of `IppHashAlgId` listed in table Supported Hash Algorithms.

See Also

`RSA_SetPrivateKeyType1, RSA_SetPrivateKeyType2`

`RSAEncrypt_OAEP`

`RSA_GenerateKeys`

PKCS V1.5 Encryption Scheme Functions

NOTE This algorithm is considered weak due to known attacks on it. The functionality remains in the library, but the implementation will no longer be optimized and no security patches will be applied. A more secure alternative is available: RSA-OAEP. For more information, see *PKCS #1 v2.1: RSA Cryptography Standard* (http://www.di-srv.unisa.it/~ads/corso-security/www/CORSO-9900/oracle/pkcsv21.pdf).

This subsection describes functions implementing encryption schemes defined in version 1.5 of the PKCS#1 standard ([PKCS 1.2.1]).

RSAEncrypt_PKCSv15

Performs RSA-OAEP encryption using the RSA-OAEP scheme as defined in the v1.5 version of the PKCS#1 standard (deprecated).

Syntax

```
IppStatus ippsRSAEncrypt_PKCSv15 (const Ipp8u* pSrc, int srcLen, const Ipp8u* pRandPS,
Ipp8u* pDst, const IppsRSAPublicKeyState* pKey, Ipp8u* pBuffer);
```

Include Files

`ippcp.h`

Parameters

`pSrc`	Pointer to the input octet message to be encrypted.
`srcLen`	Length (in bytes) of the message. The message can be empty, that is, *`srcLen`*==0.
`pRandPS`	Pointer to the non-zero octet padding string. *`pRandPS`* can be `NULL`. In this case, the function applies the padding string of 0xFF bytes.

pDst	Pointer to the output message.
pKey	Pointer to the properly initialized `IppsRSAPublicKeyState` context.
pBuffer	Pointer to a buffer of size not less than returned by the `RSA_GetBufferSizePublicKey` function.

Description

NOTE This algorithm is considered weak due to known attacks on it. The functionality remains in the library, but the implementation will no longer be optimized and no security patches will be applied. A more secure alternative is available: RSA-OAEP.

The function performs encryption using the RSA-OAEP scheme according to the v1.5 version of the PKCS#1 standard, defined in [PKCS 1.2.1]. The length of the encrypted message is equal to size of the RSA modulus *n*.

If RSAEncrypt_PKCSv15 receives a non-zero *pRandPS* pointer, the function assumes that the length of the padding string is at least *k*-*srcLen*-3 bytes, where *k* is the length of the RSA modulus in bytes.

Important
The v1.5 version of the PKCS#1 standard requires that you provide a padding string that does not contain zero bytes. If the padding string contains a zero byte, the encryption operation completes successfully, but the inverse decryption fails.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers other than *pRandPS* is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the RSA context parameter does not match the operation.
`ippStsIncompleteContextErr`	Indicates an error condition if the public key is not set up. **NOTE** You can set up the public key in a call to `RSA_SetPublicKey`.
`ippStsSizeErr`	Indicates an error condition if any input/output length parameters are inconsistent with one another.

See Also

`RSA_SetPublicKey`
`RSADecrypt_PKCSv15`

RSADecrypt_PKCSv15
Performs RSA-OAEP decryption using the RSA-OAEP scheme as defined in the v1.5 version of the PKCS#1 standard (deprecated).

Syntax

IppStatus ippsRSADecrypt_PKCSv15 (const Ipp8u* *pSrc*, Ipp8u* *pDst*, int* *pDstLen*, const IppsRSAPrivateKeyState* *pKey*, Ipp8u* *pBuffer*);

Include Files

ippcp.h

Parameters

pSrc	Pointer to the input octet message to be decrypted.
pDst	Pointer to the output message.
pDstLen	Pointer to the length (in bytes) of the decrypted message.
pKey	Pointer to the properly initialized IppsRSAPrivateKeyState context.
pBuffer	Pointer to a temporary buffer of size not less than returned by the RSA_GetBufferSizePrivateKey function.

Description

NOTE This algorithm is considered weak due to known attacks on it. The functionality remains in the library, but the implementation will no longer be optimized and no security patches will be applied. A more secure alternative is available: RSA-OAEP.

The function performs decryption using the RSA-OAEP scheme according to the v1.5 version of the PKCS#1 standard, defined in [PKCS 1.2.1]. The **pDstLen* parameter returns the length of the decrypted message.

NOTE
If an empty message is encrypted by the RSAEncrypt_PKCSv15 function, RSADecrypt_PKCSv15 returns and empty string, that is, **pDstLen*==0.

Return Values

ippStsNoErr	Indicates no error. Any other value indicates an error or warning.
ippStsNullPtrErr	Indicates an error condition if any of the specified pointers is NULL.
ippStsContextMatchErr	Indicates an error condition if the RSA context parameter does not match the operation.
ippStsIncompleteContextErr	Indicates an error condition if the private key is not set up.

NOTE
While you can set up the type 1 private key in a call to RSA_SetPrivateKeyType1, you can set up the type 2 private key in a call to either RSA_SetPrivateKeyType2 or RSA_GenerateKeys.

`ippStsSizeErr`	Indicates an error condition if any input/output length parameters are inconsistent with one another.

See Also

`RSA_SetPrivateKeyType1`, `RSA_SetPrivateKeyType2`

`RSA_GenerateKeys`

`RSAEncrypt_PKCSv15`

RSA Signature Schemes

RSA-SSA Scheme Functions

This subsection describes functions implementing RSASSA-PSS_5 signature scheme with appendix [PKCS 1.2.1].

To invoke RSASign_PSS or RSAVerify_PSS primitive, supply the `IppsRSAPrivateKeyState` and/or `IppsRSAPublicKeyState` context initialized by a suitable function (see `RSA_InitPublicKey`, `RSA_InitPrivateKeyType1`, or `RSA_InitPrivateKeyType2` for details).

RSASign_PSS

Carries out the RSASSA-PSS signature generation scheme.

Syntax

```
IppStatus ippsRSASign_PSS(const Ipp8u* pMsg, int msgLen, const Ipp8u* pSalt, int
saltLen, Ipp8u* pSign, const IppsRSAPrivateKeyState* pPrivateKey, const
IppsRSAPublicKeyState* pPublicKeyOpt, IppHashAlgId hashAlg, Ipp8u* pBuffer);
```

```
IppStatus ippsRSASign_PSS_rmf(const Ipp8u* pMsg, int msgLen, const Ipp8u* pSalt, int
saltLen, Ipp8u* pSign, const IppsRSAPrivateKeyState* pPrivateKey, const
IppsRSAPublicKeyState* pPublicKeyOpt, const IppsHashMethod* pMethod, Ipp8u* pBuffer);
```

Include Files

`ippcp.h`

Parameters

pMsg	Pointer to the octet message to be signed.
msgLen	Length of the input **pMsg* message in octets.
pSalt	Pointer to the random octet salt string.
saltLen	Length of the salt string in octets.
pSign	Pointer to the output octet signature.
pPrivateKey	Pointer to the properly initialized `IppsRSAPrivateKeyState` context.
pPublicKeyOpt	Pointer to the properly initialized optional `IppsRSAPublicKeyState` context.
hashAlg	Identifier of the hash algorithm. For details, see table Supported Hash Algorithms.
pMethod	Pointer to the hash method. For details, see HashMethod functions.

pBuffer	Pointer to a temporary buffer of size not less than returned by each of the functions RSA_GetBufferSizePrivateKey and RSA_GetBufferSizePublicKeyKey.

Description

The function generates the message signature according to the RSASSA-PSS scheme defined in [PKCS 1.2.1] using the hash algorithm defined by the *hashAlg* or *pMethod* parameter.

If you are using an RSA private key type 2 to generate the signature, you can use the optional **pPublicKeyOpt* parameter to mitigate Fault Attack. If you are using an RSA private key type 1 or sure that Fault Attack is not applicable, *pPublicKeyOpt* can be NULL. Passing the NULL value to the *pPublicKeyOpt* parameter saves computation time.

NOTE
This function has a *reduced memory footprint* version. To learn more, see Reduced Memory Footprint Functions.

Return Values

ippStsNoErr	Indicates no error. Any other value indicates an error or warning.
ippStsNullPtrErr	Indicates an error condition if any of the specified pointers is NULL.
ippStsContextMatchErr	Indicates an error condition if any of the context parameters does not match the operation.
ippStsIncompleteContextErr	Indicates an error condition if the public or private key is not set up.
ippStsLengthErr	Indicates an error condition if the value of *saltLen* is negative or any input/output length parameters are inconsistent with one another together (see [PKCS 1.2.1] for details).
ippsStsNotSupportedModeErr	Indicates an error condition if the *hashAlg* parameter does not match any value of IppHashAlgId listed in table Supported Hash Algorithms.

See Also

RSA_SetPublicKey, RSA_SetPrivateKeyType1, RSA_SetPrivateKeyType2

RSA_GenerateKeys

RSAVerify_PSS

RSA_MB_Sign_PSS_rmf

Performs RSA multi-buffer signature generation using RSASSA-PSS scheme.

Syntax

NOTE This API is deprecated from Intel® IPP Cryptography and is removed since 2021.2 release. It is recommended to switch to Crypto MB library. If you have any concerns, open a ticket and provide feedback at Intel ® online support center.

IppStatus ippsRSA_MB_Sign_PSS_rmf(const Ipp8u**pMsgs[8]*,const int*msgLens[8]*, const Ipp8u**pSalts[8]*,const int*saltLens[8]*,Ipp8u**pSignts[8]*, const IppsRSAPrivateKeyState**pPrvKeys[8]*, const IppsRSAPublicKeyState**pPubKeys[8]*, const IppsHashMethod**pMethod*, IppStatus*statuses[8]*, Ipp8u**pBuffer*);

Include Files

ippcp.h

Parameters

pMsgs[8]	Pointer to the array of messages to be signed.
msgLens[8]	Pointer to the array of messages lengths.
pSalts[8]	Pointer to the array of random octet salt strings.
saltLens[8]	Pointer to the array of salts lengths.
pSignts[8]	Pointer to the array of output signatures.
pPrvKeys[8]	Pointer to the array of preliminary initialized IppsRSAPrivateKeyState contexts.
pPubKeys[8]	Pointer to the array of preliminary initialized IppsRSAPublicKeyState contexts.
pMethod	Pointer to the hash method. For details, see HashMethod functions.
statuses[8]	Pointer to the array of execution statuses for each performed operation.
pBuffer	Pointer to a temporary buffer. The size of the buffer must be not less than the value returned by the RSA_MB_GetBufferSizePrivateKey and RSA_MB_GetBufferSizePublicKey functions.

Description

This function generates the message signature according to the RSASSA-PSS scheme defined in [PKCS 1.2.1]. The function can perform up to 8 signature generation operations at once.

Specify parameters for each single signature generation operation under the corresponding index in an input array in accordance with the ippsRSASign_PSS_rmf function API requirements.

To perform less than 8 operations, set one or more pointers to a context in input context arrays to NULL. In this case, each single operation with the context set to NULL will not be performed, and the function will return ippStsMbWarning . Once the function execution is completed, the statuses array will contain return codes for each single signature generation operation according to the ippsRSASign_PSS_rmf return values.

Important

- Sizes of all moduli *n* in all IppsRSAPublicKeyState contexts in the *pPubKeys* array must be equal.
- Sizes and values of all public exponents *e* in all IppsRSAPublicKeyState contexts in the *pPubKeys* array must be equal.
- Types of RSA private keys must be equal.

Return Values

`ippStsNoErr`	Indicates no error. All single operations executed without errors. Any other value indicates an error or warning.
`ippStsMbWarning`	One or more of performed operations executed with error. Check statuses array for details.
`ippStsNullPtrErr`	Any of the input parameters is a NULL pointer.
`ippStsSizeErr`	Indicates a mismatch between moduli *n* sizes in the input contexts.
`ippStsBadArgErr`	Indicates a mismatch between types of private keys or exponents *e* in public keys.
`ippStsContextMatchErr`	No valid keys were found.

See Also

`RSA_SetPublicKey, RSA_SetPrivateKeyType1, RSA_SetPrivateKeyType2` Set up an RSA key in the existing RSA key context.

`RSA_GenerateKeys` Generates key components for the desired RSA cryptographic system.

`RSA_MB_Verify_PSS_rmf` Performs RSA multi-buffer signature verification using RSASSA-PSS scheme.

RSAVerify_PSS

Carries out the RSA-SSA signature verification scheme.

Syntax

IppStatus ippsRSAVerify_PSS(const Ipp8u* *pMsg*, int *msgLen*, const Ipp8u* *pSign*, int* *pIsSignValid*, const IppsRSAPublicKeyState* *pKey*, IppHashAlgId *hashAlg*, Ipp8u* *pBuffer*);

IppStatus ippsRSAVerify_PSS_rmf(const Ipp8u* *pMsg*, int *msgLen*, const Ipp8u* *pSign*, int* *pIsSignValid*, const IppsRSAPublicKeyState* *pKey*, const IppsHashMethod* *pMethod*, Ipp8u* *pBuffer*);

Include Files

ippcp.h

Parameters

pMsg	Pointer to the octet message that has been signed.
msgLen	Length in octets of the **pMsg* message.
pSign	Pointer to the octet signature string to be verified.
pIsSignValid	Pointer to the verification result.
pKey	Pointer to the properly initialized `IppsRSAPublicKeyState` context.
hashAlg	Identifier of the hash algorithm. For details, see table Supported Hash Algorithms.
pMethod	Pointer to the hash method. For details, see HashMethod functions.

pBuffer	Pointer to the scratch buffer of size not less than returned by the `RSA_GetBufferSizePublicKey` function.

Description

The function carries out the RSASSA-PSS signature verification scheme defined in [PKCS 1.2.1]. RSAVerify_PSS verifies the signature generated by the RSASign_PSS function called with the same *hashAlg* or *pMethod* parameter.

> **NOTE**
> This function has a *reduced memory footprint* version. To learn more, see Reduced Memory Footprint Functions.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is NULL.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsIncompleteContextErr`	Indicates an error condition if the public key is not set up.
`ippsStsNotSupportedModeErr`	Indicates an error condition if the *hashAlg* parameter does not match any value of `IppHashAlgId` listed in table Supported Hash Algorithms.

See Also

`RSA_SetPublicKey`

RSA_MB_Verify_PSS_rmf
Performs RSA multi-buffer signature verification using RSASSA-PSS scheme.

Syntax

> **NOTE** This API is deprecated from Intel® IPP Cryptography and is removed since 2021.2 release. It is recommended to switch to Crypto MB library. If you have any concerns, open a ticket and provide feedback at Intel ® online support center.

```
IppStatus ippsRSA_MB_Verify_PSS_rmf(const Ipp8u*pMsgs[8],const intmsgLens[8],const
Ipp8u*pSignts[8],intpIsValid[8], const IppsRSAPublicKeyState*pPubKeys[8], const
IppsHashMethod*pMethod, IppStatusstatuses[8], Ipp8u*pBuffer);
```

Include Files

`ippcp.h`

Parameters

pMsgs[8]	Pointer to the array of messages that have been signed.
msgLens[8]	Pointer to the array of messages lengths.

pSignts[8]	Pointer to the array of signatures to be verified.
pIsValid	Pointer to the array of verification results.
pPubKeys[8]	Pointer to the array of preliminary initialized `IppsRSAPublicKeyState` contexts.
pMethod	Pointer to the hash method. For details, see HashMethod functions.
statuses[8]	Pointer to the array of execution statuses for each performed operation.
pBuffer	Pointer to a temporary buffer. The size of the buffer must be not less than the value returned by the `RSA_MB_GetBufferSizePublicKey` function.

Description

This function carries out the RSASSA-PSS signature verification scheme defined in [PKCS 1.2.1]. The function can perform up to 8 verification operations at once.

Specify parameters for each single signature verification operation under the corresponding index in an input array in accordance with the `ippsRSAVerify_PSS_rmf` function API requirements.

To perform less than 8 operations, set one or more pointers to a context in input context arrays to NULL. In this case, each single operation with the context set to NULL will not be performed, and the function will return `ippStsMbWarning` . Once the function execution is completed, the statuses array will contain return codes for each single signature verification operation according to the `ippsRSAVerify_PSS_rmf` return values.

Important

- Sizes of all moduli *n* in all `IppsRSAPublicKeyState` contexts in the *pPubKeys* array must be equal.
- Sizes and values of all public exponents *e* in all `IppsRSAPublicKeyState` contexts in the *pPubKeys* array must be equal.

Return Values

`ippStsNoErr`	Indicates no error. All single operations executed without errors. Any other value indicates an error or warning.
`ippStsMbWarning`	One or more of performed operations executed with error. Check statuses array for details.
`ippStsNullPtrErr`	Any of the input parameters is a NULL pointer.
`ippStsSizeErr`	Indicates a mismatch between moduli *n* sizes in the input contexts.
`ippStsBadArgErr`	Indicates a mismatch between exponents *e* in public keys.
`ippStsContextMatchErr`	No valid keys were found.

See Also

`RSA_SetPublicKey` Set up an RSA key in the existing RSA key context.
`RSA_MB_Sign_PSS_rmf` Performs RSA multi-buffer signature generation using RSASSA-PSS scheme.

PKCS V1.5 Signature Scheme Functions

NOTE This algorithm is considered weak due to known attacks on it. The functionality remains in the library, but the implementation will no longer be optimized and no security patches will be applied. A more secure alternative is available: RSA-OAEP. For more information, see *PKCS #1 v2.1: RSA Cryptography Standard* (http://www.di-srv.unisa.it/~ads/corso-security/www/CORSO-9900/oracle/pkcsv21.pdf).

This subsection describes functions implementing the RSASSA-PKCS1-v1_5 signature scheme with appendix [PKCS 1.2.1].

RSASign_PKCS1v15
Carries out the RSA-SSA signature generation scheme of PKCS#1 v1.5 .

Syntax

```
IppStatus ippsRSASign_PKCS1v15(const Ipp8u* pMsg, int msgLen, Ipp8u* pSign, const
IppsRSAPrivateKeyState* pPrivateKey, const IppsRSAPublicKeyState* pPublicKeyOpt,
IppHashAlgId hashAlg, Ipp8u* pBuffer);
```

```
IppStatus ippsRSASign_PKCS1v15_rmf(const Ipp8u* pMsg, int msgLen, Ipp8u* pSign, const
IppsRSAPrivateKeyState* pPrivateKey, const IppsRSAPublicKeyState* pPublicKeyOpt, const
IppsHashMethod* pMethod, Ipp8u* pBuffer);
```

Include Files

`ippcp.h`

Parameters

pMsg	Pointer to the message to be signed.
msgLen	Length of the message **pMsg* in octets.
pSign	Pointer to the output octet signature.
pPrivateKey	Pointer to the properly initialized `IppsRSAPrivateKeyState` context.
pPublicKeyOpt	Pointer to the properly initialized optional `IppsRSAPublicKeyState` context.
hashAlg	Identifier of the hash algorithm used. For details, see table Supported Hash Algorithms.
pMethod	Pointer to the hash method. For details, see HashMethod functions.
pBuffer	Pointer to a temporary buffer of size not less than returned by each of the functions `RSA_GetBufferSizePrivateKey` and `RSA_GetBufferSizePublicKeyKey`.

Description

The function computes the message digest specified by the *hashAlg* or *pMethod* parameter and generates the signature according to the RSASSA-PKCS1-v1_5 scheme defined in [PKCS 1.2.1].

If you are using an RSA private key type 2 to generate the signature, you can use the optional *`*pPublicKeyOpt`* parameter to mitigate Fault Attack. If you are using an RSA private key type 1 or sure that Fault Attack is not applicable, *`pPublicKeyOpt`* can be `NULL`. Passing the `NULL` value to the *`pPublicKeyOpt`* parameter saves computation time.

Important
The length of the signature being generated equals the length of the RSA modulus, supplied with the `IppsRSAPrivateKeyState` context. Make sure that *`pSign`* points to a buffer of a sufficient length.

NOTE
This function has a *reduced memory footprint* version. To learn more, see Reduced Memory Footprint Functions.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if any of the context parameters does not match the operation.
`ippStsIncompleteContextErr`	Indicates an error condition if the public or private key is not set up. **NOTE** While you can set up the public key or type 1 private key in a call to `RSA_SetPublicKey` or `RSA_SetPrivateKeyType1`, respectively, you can set up the type 2 private key in a call to either `RSA_SetPrivateKeyType2` or `RSA_GenerateKeys`.
`ippStsLengthErr`	Indicates an error condition if any input/output length parameters are inconsistent with one another.
`ippStsSizeErr`	Indicates an error condition if the length of the RSA modulus is too small (see details in [PKCS 1.2.1].
`ippStsNotSupportedModeErr`	Indicates an error condition if the *`hashAlg`* parameter does not match any value of `IppHashAlgId` listed in table Supported Hash Algorithms.

See Also

`RSA_SetPublicKey, RSA_SetPrivateKeyType1, RSA_SetPrivateKeyType2`

`RSA_GenerateKeys`

`RSAVerify_PKCS1v15`

RSA_MB_Sign_PKCS1v15_rmf

Performs RSA multi-buffer signature generation using PKCS#1 v1.5 scheme.

Syntax

NOTE This API is deprecated from Intel® IPP Cryptography and is removed since 2021.2 release. It is recommended to switch to Crypto MB library. If you have any concerns, open a ticket and provide feedback at Intel ® online support center.

```
IppStatus ippsRSA_MB_Sign_PKCS1v15_rmf(const Ipp8u*pMsgs[8],const intmsgLens[8],Ipp8u*
constpSignts[8], const IppsRSAPrivateKeyState*pPrvKeys[8], const
IppsRSAPublicKeyState*pPubKeys[8], const IppsHashMethod*pMethod, IppStatusstatuses[8],
Ipp8u*pBuffer);
```

Include Files

ippcp.h

Parameters

pMsgs[8]	Pointer to the array of messages to be signed.
msgLens[8]	Pointer to the array of messages lengths.
pSignts[8]	Pointer to the array of output signatures.
pPrvKeys[8]	Pointer to the array of preliminary initialized `IppsRSAPrivateKeyState` contexts.
pPubKeys[8]	Pointer to the array of preliminary initialized `IppsRSAPublicKeyState` contexts.
pMethod	Pointer to the hash method. For details, see HashMethod functions.
statuses[8]	Pointer to the array of execution statuses for each performed operation.
pBuffer	Pointer to a temporary buffer. The size of the buffer must be not less than the value returned by the `RSA_MB_GetBufferSizePrivateKey` and `RSA_MB_GetBufferSizePublicKey` functions.

Description

This function computes the message digest specified by the *pMethod* parameter and generates the message signature according to the RSASSA-PKCS1-v1_5 scheme defined in [PKCS 1.2.1]. The function can perform up to 8 signature generation operations at once.

Specify parameters for each single signature generation operation under the corresponding index in an input array in accordance with the `ippsRSASign_PKCS1v15_rmf` function API requirements.

To perform less than 8 operations, set one or more pointers to a context in input context arrays to NULL. In this case, each single operation with the context set to NULL will not be performed, and the function will return `ippStsMbWarning` . Once the function execution is completed, the statuses array will contain return codes for each single signature generation operation according to the `ippsRSASign_PKCS1v15_rmf` return values.

Important

- Sizes of all moduli *n* in all `IppsRSAPublicKeyState` contexts in the *pPubKeys* array must be equal.
- Sizes and values of all public exponents *e* in all `IppsRSAPublicKeyState` contexts in the *pPubKeys* array must be equal.
- Types of RSA private keys must be equal.

Return Values

`ippStsNoErr`	Indicates no error. All single operations executed without errors. Any other value indicates an error or warning.
`ippStsMbWarning`	One or more of performed operations executed with error. Check statuses array for details.
`ippStsNullPtrErr`	Any of the input parameters is a NULL pointer.
`ippStsSizeErr`	Indicates a mismatch between moduli *n* sizes in the input contexts.
`ippStsBadArgErr`	Indicates a mismatch between types of private keys or exponents *e* in public keys.
`ippStsContextMatchErr`	No valid keys were found.

See Also

`RSA_SetPublicKey, RSA_SetPrivateKeyType1, RSA_SetPrivateKeyType2` Set up an RSA key in the existing RSA key context.

`RSA_GenerateKeys` Generates key components for the desired RSA cryptographic system.

`RSA_MB_Verify_PKCS1v15_rmf` Performs RSA multi-buffer signature verification using PKCS#1 v1.5 scheme.

RSAVerify_PKCS1v15

Carries out the RSA-SSA signature verification scheme of PKCS#1 v1.5.

Syntax

```
IppStatus ippsRSAVerify_PKCS1v15(const Ipp8u* pMsg, int msgLen, const Ipp8u* pSign,
int* pIsSignValid, const IppsRSAPublicKeyState* pKey, IppHashAlgId hashAlg, Ipp8u*
pBuffer);
```

```
IppStatus ippsRSAVerify_PKCS1v15_rmf(const Ipp8u* pMsg, int msgLen, const Ipp8u* pSign,
int* pIsSignValid, const IppsRSAPublicKeyState* pKey, const IppsHashMethod* pMethod,
Ipp8u* pBuffer);
```

Include Files

`ippcp.h`

Parameters

pMsg	Pointer to the message that has been signed.
msgLen	Length of the message **pMsg* in octets.
pSign	Pointer to the signature string to be verified.

pIsSignValid	Pointer to the verification result.
pKey	Pointer to the properly initialized `IppsRSAPublicKeyState` context.
hashAlg	Identifier of the hash algorithm. For details, see table Supported Hash Algorithms.
pMethod	Pointer to the hash method. For details, see HashMethod functions.
pBuffer	Pointer to a temporary buffer of size not less than returned by the `RSA_GetBufferSizePublicKey` function.

Description

The function verifies the signature generated by the RSASign_PKCS1v15 function that uses the same *hashAlg* or *pMethod* parameter against the input message, as defined [PKCS 1.2.1].

NOTE
This function has a *reduced memory footprint* version. To learn more, see Reduced Memory Footprint Functions.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsIncompleteContextErr`	Indicates an error condition if the public key is not set up. **NOTE** You can set up the public key in a call to `RSA_SetPublicKey`.
`ippStsLengthErr`	Indicates an error condition if any input/output length parameters are inconsistent with one another.
`ippsStsNotSupportedModeErr`	Indicates an error condition if the *hashAlg* parameter does not match any value of `IppHashAlgId` listed in table Supported Hash Algorithms.

See Also

`RSA_SetPublicKey`

RSA_MB_Verify_PKCS1v15_rmf

Performs RSA multi-buffer signature verification using PKCS#1 v1.5 scheme.

Syntax

NOTE This API is deprecated from Intel® IPP Cryptography and is removed since 2021.2 release. It is recommended to switch to Crypto MB library. If you have any concerns, open a ticket and provide feedback at Intel ® online support center.

IppStatus ippsRSA_MB_Verify_PKCS1v15_rmf(const Ipp8u**pMsgs[8]*,const int*msgLens[8]*,const Ipp8u**pSignts[8]*,int*pIsValid[8]*, const IppsRSAPublicKeyState**pPubKeys[8]*, const IppsHashMethod**pMethod*, IppStatus*statuses[8]*, Ipp8u**pBuffer*);

Include Files

ippcp.h

Parameters

pMsgs[8]	Pointer to the array of messages that have been signed.
msgLens[8]	Pointer to the array of messages lengths.
pSignts[8]	Pointer to the array of signatures to be verified.
pIsValid	Pointer to the array of verification results.
pPubKeys[8]	Pointer to the array of preliminary initialized IppsRSAPublicKeyState contexts.
pMethod	Pointer to the hash method. For details, see HashMethod functions.
statuses[8]	Pointer to the array of execution statuses for each performed operation.
pBuffer	Pointer to a temporary buffer. The size of the buffer must be not less than the value returned by the RSA_MB_GetBufferSizePublicKey function.

Description

This function verifies the signature generated using PKCS#1 v1.5 scheme that uses the same *pMethod* parameter against the input message, as defined in [PKCS 1.2.1]. The function can perform up to 8 verification operations at once.

Specify parameters for each single signature verification operation under the corresponding index in an input array in accordance with the ippsRSAVerify_PKCS1v15_rmf function API requirements.

To perform less than 8 operations, set one or more pointers to a context in input context arrays to NULL. In this case, each single operation with the context set to NULL will not be performed, and the function will return ippStsMbWarning . Once the function execution is completed, the statuses array will contain return codes for each single signature verification operation according to the ippsRSAVerify_PKCS1v15_rmf return values.

Important

- Sizes of all moduli *n* in all IppsRSAPublicKeyState contexts in the *pPubKeys* array must be equal.
- Sizes and values of all public exponents *e* in all IppsRSAPublicKeyState contexts in the *pPubKeys* array must be equal.

Return Values

`ippStsNoErr`	Indicates no error. All single operations executed without errors. Any other value indicates an error or warning.
`ippStsMbWarning`	One or more of performed operations executed with error. Check statuses array for details.
`ippStsNullPtrErr`	Any of the input parameters is a NULL pointer.
`ippStsSizeErr`	Indicates a mismatch between moduli *n* sizes in the input contexts.
`ippStsBadArgErr`	Indicates a mismatch between exponents *e* in public keys.
`ippStsContextMatchErr`	No valid keys were found.

See Also

`RSA_SetPublicKey` Set up an RSA key in the existing RSA key context.
`RSA_MB_Sign_PKCS1v15_rmf` Performs RSA multi-buffer signature generation using PKCS#1 v1.5 scheme.

Discrete-Logarithm-Based Cryptography Functions

This section introduces Intel® Integrated Performance Primitives (Intel® IPP) Cryptography functions allowing for different operations with Discrete Logarithm (DL) based cryptosystem over a prime finite field GF(*p*). The functions are mainly based on the [IEEE P1363A] standard. Implementation of the Digital Signature operations is based on [FIPS PUB 186-2]. The Diffie-Hellman (DH) Agreement scheme is based on [X9.42].

All functions described in this section employ the `IppsDLPState` context as operational vehicle that carries domain parameters of the DL cryptosystem, a pair of keys, and working buffers.

The application code intended for executing typical operations should perform the following sequence of operations:

1. Call the function `DLPGetSize` to get the size required to configure the `IppsDLPState` context.
2. Ensure that the required memory space is properly allocated. With the allocated memory, call the `DLPInit` function to initialize the context of the DL-based cryptosystem.
3. Set domain parameters of the DL-based cryptosystem by calling the `DLPSet` function, or generate domain parameters by calling the `DLPGenerateDSA` or `DLPGenerateDH`.
4. Call one of the functions `DLPSignDSA`, `DLPVerifyDSA`, and `DLPSharedSecretDH` to compute digital signature, to verify authenticity of the digital signature, and to compute the shared element accordingly.
5. Clean up secret data stored in the context.
6. Free the memory allocated for the `IppsDLPState` context by calling the operating system memory free service function unless the context is no longer needed.

The `IppsDLPState` context is position-dependent. The `DLPPack/DLPUnpack` functions transform the position-dependent context to a position-independent form and vice versa.

See Also

Data Security Considerations

DLPGetSize

Gets the size of the `IppsDLPState` *context.*

Syntax

```
IppStatus ippsDLPGetSize(int peBits, int reBits, int *pSize);
```

Include Files

`ippcp.h`

Parameters

peBits	Bitsize of the GF(*p*) element (that is, the length of the DL-based cryptosystem in bits)
reBits	Bitsize of the multiplicative subgroup GF(*r*).
pSize	Pointer to the `IppsDLPState` context size in bytes.

Description

The function gets the `IppsDLPState` context size in bytes and stores in **pSize*. DL-based cryptosystem over GF(*p*) assumes that *r*/*p* -1 where both *p* and *r* are primes.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsSizeErr`	Indicates an error condition if *peBits*≤ *reBits*.

DLPInit

Initializes user-supplied memory as the `IppsDLPState` *context for future use.*

Syntax

```
IppStatus ippsDLPInit(int peBits, int reBits, IppsDLPState* pCtx);
```

Include Files

`ippcp.h`

Parameters

peBits	Bitsize of the GF(*p*) element (that is, the length of the DL-based cryptosystem in bits)
reBits	Bitsize of the multiplicative subgroup GF(*r*).
pCtx	Pointer to the `IppsDLPState` context being initialized.

Description

The function initializes the memory pointed by *pCtx* as the `IppsDLPState` context.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsSizeErr`	Indicates an error condition if *peBits*≤ *reBits*.

See Also

Data Security Considerations

DLPPack, DLPUnpack

Packs/unpacks the `IppsDLPState` *context into/from a user-defined buffer.*

Syntax

`IppStatus ippsDLPPack (const IppsDLPState* pCtx, Ipp8u* pBuffer);`

`IppStatus ippsDLPUnpack (const Ipp8u* pBuffer, IppsDLPState* pCtx);`

Include Files

`ippcp.h`

Parameters

pCtx	Pointer to the `IppsDLPState` context.
pBuffer	Pointer to the user-defined buffer.

Description

The DLPPack function transforms the **pCtx* context to a position-independent form and stores it in the the **pBuffer* buffer. The DLPUnpack function performs the inverse operation, that is, transforms the contents of the **pBuffer* buffer into a normal `IppsDLPState` context. The DLPPack and DLPUnpack functions enable replacing the position-dependent `IppsDLPState` context in the memory.

Call the `DLPGetSize` function prior to DLPPack/DLPUnpack to determine the size of the buffer.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.

DLPSet

Sets up domain parameters of the DL-based cryptosystem over GF(p).

Syntax

`IppStatus ippsDLPSet(const IppsBigNumState* pP, const IppsBigNumState* pQ, const IppsBigNumState* pG, IppsDLPState* pCtx);`

Include Files

`ippcp.h`

Parameters

pP	Pointer to the characteristic p of the prime finite field GF(p).
pQ	Pointer to the characteristic q of the multiplicative subgroup GF(q).

pG	Pointer to the generator *G* of the multiplicative subgroup GF(*r*).
pCtx	Pointer to the cryptosystem context.

Description

The function sets up DL-based cryptosystem domain parameters into the cryptosystem context.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsRangeErr`	Indicates an error condition if any of the Big Numbers specified by *pP*, *pR*, and *pG* is too big to be stored in the `IppsDLPState` context.

DLPGet

Retrieves domain parameters of the DL-based cryptosystem over GF(p).

Syntax

```
IppStatus ippsDLPGet(IppsBigNumState* pP, IppsBigNumState* pQ, IppsBigNumState* pG,
IppsDLPState* pCtx);
```

Include Files

`ippcp.h`

Parameters

pP	Pointer to the characteristic *p* of the prime finite field GF(*p*).
pQ	Pointer to the characteristic *q* of the multiplicative subgroup GF(*q*).
pG	Pointer to the generator *G* of the multiplicative subgroup GF(*r*).
pCtx	Pointer to the cryptosystem context.

Description

The function retrieves DL-based cryptosystem domain parameters into the cryptosystem context.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

`ippStsIncompleteContextErr`	Indicates an error condition if the cryptosystem context has not been properly set up.
`ippStsRangeErr`	Indicates an error condition if any of the Big Numbers specified by *pP*, *pR*, and *pG* is too small for the DL parameter.

DLPSetDP

Sets up a particular domain parameter of the DL-based cryptosystem over GF(p).

Syntax

`IppStatus ippsDLPSetDP(const IppsBigNumState* pDP, IppDLPKeyTag tag, IppsDLPState* pCtx);`

Include Files

`ippcp.h`

Parameters

pDP	Pointer to the domain parameter value to be set.
tag	Tag specifying the desired domain parameter.
pCtx	Pointer to the cryptosystem context.

Description

The function assigns the value specified by *pDP* to a particular domain parameter of the DL-based cryptosystem. The domain parameter to be set up is determined by *tag* as follows:

- If *tag* == IppDLPkeyP, the function assigns value to the characteristic *p*, the size of the prime finite field GF(*p*).
- If *tag* == IppDLPkeyR, the function assigns value to the characteristic *r*, the prime divisor of (*p*-1) and the order of *g*.
- If *tag* == IppDLPkeyG, the function assigns value to the characteristic *g*, the element of GF(*p*) generating a multiplicative subgroup of order *r*.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsRangeErr`	Indicates an error condition if the Big Number specified by *pDP* is too big to be stored in the `IppsDLPState` context.
`ippStsBadArgErr`	Indicates an error condition if some of the function parameters are invalid: Big Number specified by *pDP* is negative Domain parameter specified by *tag* does not match the `IppsDLPState` context.

DLPGetDP

Retrieves a particular domain parameter of the DL-based cryptosystem over GF(p).

Syntax

```
IppStatus ippsDLPGetDP(IppsBigNumState* pDP, IppDLPKeyTag tag, const IppsDLPState*
pCtx);
```

Include Files

`ippcp.h`

Parameters

pDP	Pointer to the output Big Number context.
tag	Tag specifying the domain parameter to be retrieved.
pCtx	Pointer to the cryptosystem context.

Description

The function retrieves value of a particular domain parameter of the DL-based cryptosystem from the *IppsDLPState* context and stores the value in the Big Number context **pDP*. The domain parameter to be retrieved is determined by *tag* as follows:

- If *tag* == `IppDLPkeyP`, the function retrieves value of the characteristic *p*, the size of the prime finite field GF(*p*).
- If *tag* == `IppDLPkeyR`, the function retrieves value of the characteristic *r*, the prime divisor of (*p*-1) and the order of *g*.
- If *tag* == `IppDLPkeyG`, the function retrieves value of the characteristic *g*, the element of GF(*p*) generating a multiplicative subgroup of order *r*.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsIncompleteContextErr`	Indicates an error condition if the cryptosystem context has not been properly set up.
`ippStsOutOfRangeErr`	Indicates an error condition if the Big Number specified by *pDP* is too small for the DL parameter.
`ippStsBadArgErr`	Indicates an error condition if the domain parameter specified by the tag does not match the `IppsDLPState` context.

DLPGenKeyPair

Generates a private key and computes public keys of the DL-based cryptosystem over GF(p).

Syntax

```
IppStatus ippsDLPGenKeyPair(IppsBigNumState* pPrivate, IppsBigNumState* pPublic,
IppsDLPState* pCtx, IppBitSupplier rndFunc, void* pRndParam);
```

Include Files

`ippcp.h`

Parameters

pPrivate	Pointer to the private key *privKey*.
pPublic	Pointer to the public key *pubKey*.
pCtx	Pointer to the cryptosystem context.
rndFunc	Specifed Random Generator.
pRndParam	Pointer to the Random Generator context.

Description

The function generates a private key *privKey* and computes a public key *pubKey* of the DL-based cryptosystem. The function employs specified *rndFunc* Random Generator to generate a pseudorandom private key. The value of the private key *privKey* is a random number that lies in the range of [2,*R*-2].

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsIncompleteContextErr`	Indicates an error condition if the cryptosystem context has not been properly set up.
`ippStsRangeErr`	Indicates an error condition if any of the Big Numbers specified by *pPrivate* and *pPublic* is too small for the DL key.

DLPPublicKey

Computes a public key from the given private key of the DL-based cryptosystem over GF(p).

Syntax

```
IppStatus ippsDLPPublicKey(const IppsBigNumState* pPrivate, IppsBigNumState* pPublic,
IppsDLPState* pCtx);
```

Include Files

`ippcp.h`

Parameters

pPrivate	Pointer to the input private key *privKey*.
pPublic	Pointer to the output public key *pubKey*.

pCtx	Pointer to the cryptosystem context.

Description

The function computes a public key *pubKey* of the DL-based cryptosystem.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsIncompleteContextErr`	Indicates an error condition if the cryptosystem context has not been properly set up.
`ippStsInvalidPrivateKey`	Indicates an error condition if the *privKey* has an illegal value.
`ippStsRangeErr`	Indicates an error condition if Big Number specified by *pPublic* is too small for the DL public key.

DLPValidateKeyPair

Validates private and public keys of the DL-based cryptosystem over GF(p).

Syntax

```
IppStatus ippsDLPValidateKeyPair(const IppsBigNumState* pPrivate, const
IppsBigNumState* pPublic, IppDLResult* pResult, IppsDLPState* pCtx);
```

Include Files

`ippcp.h`

Parameters

pPrivate	Pointer to the input private key *privKey*.
pPublic	Pointer to the output public key *pubKey*.
pResult	Pointer to the validation result.
pCtx	Pointer to the cryptosystem context.

Description

The function validates the private key *privKey* and the public key *pubKey* of the DL-based cryptosystem. The result of the validation is stored in the **pResult* and may be assigned to one of the enumerators listed below:

`ippDLValid`	Validation has passed successfully.
`ippDLInvalidPrivateKey`	$(1 < private < (R - 1))$ is false.
`ippDLInvalidPublicKey`	$(1 < public \leq (P - 1))$ is false.
`ippDLInvalidKeyPair`	$public \mathrel{!=} G\hat{}private \pmod{P}$.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsIncompleteContextErr`	Indicates an error condition if the cryptosystem context has not been properly set up.

DLPSetKeyPair

Sets private and/or public keys of the DL-based cryptosystem over GF(p).

Syntax

IppStatus ippsDLPSetKeyPair(const IppsBigNumState* *pPrivate*, const IppsBigNumState* *pPublic*, IppsDLPState* *pCtx*);

Include Files

`ippcp.h`

Parameters

pPrivate	Pointer to the input private key *privKey*.
pPublic	Pointer to the output public key *pubKey*.
pCtx	Pointer to the cryptosystem context.

Description

The function stores the private key *priveKey* and public key *pubKey* in the cryptosystem context.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsIncompleteContextErr`	Indicates an error condition if the cryptosystem context has not been properly set up.
`ippStsInvalidPrivateKey`	Indicates an error condition if the parameter pointed by*pPrivate* has memory size smaller than the order *n* of the elliptic curve base point *G*.
`ippStsRangeErr`	Indicates an error condition if the parameter pointed by *pPublic* has memory size smaller than the prime *p* of the elliptic curve base point *G*.

DLPGenerateDSA

Generates domain parameters of the DL-based cryptosystem over GF(p) to use DSA.

Syntax

IppStatus ippsDLPGenerateDSA(const IppsBigNumState* *pSeedIn*, int *nTrials*, IppsDLPState* *pCtx*, IppsBigNumState* *pSeedOut*, int* *pCounter*, IppBitSupplier *rndFunc*, void* *pRndParam*);

Include Files

ippcp.h

Parameters

pSeedIn	Pointer to the input *Seed*.
nTrials	Security parameter specified for the Miller-Rabin probable primality.
pCtx	Pointer to the cryptosystem context.
pSeedOut	Pointer to the output *Seed* value (if requested).
pCounter	Pointer to the *counter* value (if requested).
rndFunc	Specified Random Generator.
pRndParam	Pointer to the Random Generator context.

Description

The function generates domain parameters of the DL-based cryptosystem over GF(*p*) to use DSA. The function uses a procedure specified in [FIPS PUB 186-2] for generating both a 160-bit randomized prime r and a *LpeBits* prime *p* based on the input **pSeedIn*.

Return Values

ippStsNoErr	Indicates no error. Any other value indicates an error or warning.
ippStsNullPtrErr	Indicates an error condition if any of the specified pointers is NULL.
ippStsContextMatchErr	Indicates an error condition if the context parameter does not match the operation.
ippStsSizeErr	Indicates an error condition if: *peBits* < 512, *peBits* is not divided by 64, *reBits* != 160.
ippStsRangeErr	Indicates an error condition if: bitsize of the input *Seed* value is less than 160, bitsize of the input *Seed* value is greater than *peBits*, not enough space to store the output *Seed* value (if requested).
ippStsBadArgErr	Indicates an error condition if *nTrials* < 1.
ippStsInsuffucientEntropy	Indicates a warning condition if prime generation fails due to a poor choice of the entropy.

DLPValidateDSA

Validates domain parameters of the DL-based cryptosystem over GF(p) to use DSA.

Syntax

```
IppStatus ippsDLPValidateDSA(int nTrials, IppDLResult* pResult, IppsDLPState* pCtx,
IppBitSupplier rndFunc, void* pRndParam);
```

Include Files

`ippcp.h`

Parameters

nTrials	Security parameter specified for the Miller-Rabin probable primality.
pResult	Pointer to the validation result.
pCtx	Pointer to the cryptosystem context.
rndFunc	Specified Random Generator.
pRndParam	Pointer to the Random Generator context.

Description

The function validates domain parameters of the DL-based cryptosystem over GF(*p*) to use DSA. The result of validation is stored in the **pResult* and may be assigned to one of the enumerators listed below:

`ippDLValid`	Validation has passed successfully.
`ippDLBaseIsEven`	*P* is even.
`ippDLOrderIsEven`	*R* is even.
`ippDLInvalidBaseRange`	$P \leq 2^{peBits-1}$ or $P \geq 2^{peBits}$.
`ippDLInvalidOrderRange`	$R \leq 2^{reBits-1}$ or $R \geq 2^{reBits}$.
`ippDLCompositeBase`	*P* is not a prime.
`ippDLCompositeOrder`	*R* is not a prime.
`ippDLInvalidCofactor`	*R* is not divisible by (*P* -1).
`ippDLInvalidGenerator`	(1 < *G* < (*P* -1)) is false or *G*^*R* != 1 (mod *P*).

To ensure that both *p* and *r* are primes, the function applies *nTrial*-round Miller-Rabin primality test. Test data for primality test is provided by the specified *rndFunc* Random Generator.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.

`ippStsIncompleteContextErr`	Indicates an error condition if the cryptosystem context has not been properly set up.
`ippStsBadArgErr`	Indicates an error condition if *`nTrials`* < 1.

DLPSignDSA

Performs the DSA digital signature signing operation.

Syntax

```
IppStatus ippsDLPSignDSA(const IppsBigNumState* pMsg, const IppsBigNumState* pPrivate,
IppsBigNumState* pSignR, IppsBigNumState* pSignS, IppsDLPState* pCtx);
```

Include Files

`ippcp.h`

Parameters

`pMsg`	Pointer to the message representation *msgRep* to be signed.
`pPrivate`	Pointer to the signer's private key *privKey*.
`pSignR`	Pointer to the *r*-component of the signature.
`pSignS`	Pointer to the *s*-component of the signature.
`pCtx`	Pointer to the cryptosystem context.

Description

The function performs the DSA digital signature signing operation provided that the ephemeral signer's key pair (both private and public) was previously computed (generated by `DLPGenKeyPair` or computed by `DLPPublicKey`) and then set up into the DLP context by the `DLPSetKeyPair` function.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsIncompleteContextErr`	Indicates an error condition if the cryptosystem context has not been properly set up.
`ippStsMessageErr`	Indicates an error condition if the value of *msgRep* is greater than the multiplicative subgroup characteristic (*q*).
`ippStsInvalidPrivateKey`	Indicates an error condition if an illegal value has been assigned to *privKey*.
`ippStsRangeErr`	Indicates an error condition if any of the signature components has not enough space.

DLPVerifyDSA

Verifies the input DSA digital signature.

Syntax

```
IppStatus ippsDLPVerifyDSA(const IppsBigNumState* pMsg, const IppsBigNumState* pSignR,
const IppsBigNumState* pSignS, IppDLResult* pResult, IppsDLPState* pCtx);
```

Include Files

`ippcp.h`

Parameters

pMsg	Pointer to the message representation *msgRep*.
pSignR	Pointer to the signature *r*-component to be verified.
pSignS	Pointer to the signature *s*-component to be verified.
pResult	Pointer to the result of the verification.
pCtx	Pointer to the cryptosystem context.

Description

The function verifies the input DSA digital signature's components **pSignR* and **pSignS* with the supplied message representation *msgRep*. Signer's public key must be stored by the DLPSetKeyPair function before the DLPVerifyDSA operation.

The function sets the **pResult* to `ippDLValid` if it validates the input DSA digital signature, or to `ippDLInvalidSignature` if the DSA digital signature verification fails.

Example "Use of DLPSignDSA and DLPVerifyDSA" illustrates the use of functions DLPSignDSA and `DLPVerifyDSA`. The example uses the `BigNumber` class and functions creating some cryptographic contexts, whose source code can be found in Appendix B.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsIncompleteContextErr`	Indicates an error condition if the cryptosystem context has not been properly set up.
`ippStsMessageErr`	Indicates an error condition if the value of *msgRep* is negative or greater than the multiplicative subgroup characteristic (*q*). Note, that since IPP 2021.4 the *msgRep* parameter can be any non-negative value.

Example of Using Discrete-logarithm Based Primitive Functions

Use of DLPSignDSA and DLPVerifyDSA

```
//
      // known domain parameters
      //
      static const int M = 512; // DSA system bitsize
      static const int L = 160; // DSA order  bitsize
```

```
static
BigNumber  P("0x8DF2A494492276AA3D25759BB06869CBEAC0D83AFB8D0CF7"  \
             "CBB8324F0D7882E5D0762FC5B7210EAFC2E9ADAC32AB7AAC"  \
             "49693DFBF83724C2EC0736EE31C80291");

static
BigNumber  Q("0xC773218C737EC8EE993B4F2DED30F48EDACE915F");

static
BigNumber  G("0x626D027839EA0A13413163A55B4CB500299D5522956CEFCB"  \
             "3BFF10F399CE2C2E71CB9DE5FA24BABF58E5B79521925C9C"  \
             "C42E9F6F464B088CC572AF53E6D78802");

//
// known DSA regular key pair
//
static
BigNumber  X("0x2070B3223DBA372FDE1C0FFC7B2E3B498B260614");


static
BigNumber  Y("0x19131871D75B1612A819F29D78D1B0D7346F7AA77BB62A85"  \
             "9BFD6C5675DA9D212D3A36EF1672EF660B8C7C255CC0EC74"  \
             "858FBA33F44C06699630A76B030EE333");


int  DSAsign_verify_sample(void)
{
   // DLP context
   IppsDLPState *DLPState = newDLP(M, L);

   // set up DLP crypto system
   ippsDLPSet(P, Q, G, DLPState);

  // message
   Ipp8u message[] = "abc";

   // compute message digest to be signed
   Ipp8u  md[SHA1_DIGEST_LENGTH/8];
   ippsSHA1MessageDigest(message,  sizeof(message)-1,  md);
   BigNumber  digest(0,  BITS_2_WORDS(SHA1_DIGEST_LENGTH));
   ippsSetOctString_BN(md,  SHA1_DIGEST_LENGTH/8,  digest);

   // generate ephemeral key pair (ephX,ephY)
   BigNumber ephX(0, BITS_2_WORDS(L));
   BigNumber ephY(0, BITS_2_WORDS(M));


   IppsPRNGState* pRand = newPRNG();
   ippsDLPGenKeyPair(ephX, ephY, DLPState, ippsPRNGen, pRand);
   deletePRNG(pRand);
   //
   // generate signature
   //
   BigNumber signR(0, BITS_2_WORDS(L));       // R and S signature's component
   BigNumber signS(0, BITS_2_WORDS(L));
   ippsDLPSetKeyPair(ephX, ephY, DLPState);  // set up ephemeral keys
   ippsDLPSignDSA(digest,  X,                // sign digest
                    signR, signS,
                    DLPState);


   //
   // verify signature
   //
   ippsDLPSetKeyPair(0, Y, DLPState);        // set up regular public key
   IppDLResult result;
   ippsDLPVerifyDSA(digest,  signR,signS,    // verify
                     &result, DLPState);

   // remove actual keys from context and release resource
   ippsDLPInit(M, L, DLPState);
   deleteDLP(DLPState);
   return  result==ippDLValid;
}
```

DLPGenerateDH

Generates domain parameters of the DL-based cryptosystem over GF(p) to use the DH Agreement scheme.

Syntax

IppStatus ippsDLPGenerateDH(const IppsBigNumState* *pSeedIn*, int *nTrials*, IppsDLPState* *pCtx*, IppsBigNumState* *pSeedOut*, int* *pCounter*, IppBitSupplier *rndFunc*, void* *pRndParam*);

Include Files

ippcp.h

Parameters

pSeedIn	Pointer to the input *Seed*.
nTrials	Security parameter specified for the Miller-Rabin probable primality.
pCtx	Pointer to the cryptosystem context.
pSeedOut	Pointer to the output *Seed* value (if requested).
pCounter	Pointer to the *counter* value (if requested).
rndFunc	Specified Random Generator.
pRndParam	Pointer to the Random Generator context.

Description

The function generates domain parameters of the DL-based cryptosystem over GF(*p*) to use Diffie-Hellman Agreement scheme. The function uses a procedure specified in [X9.42] for generating both randomized prime *p* and *r* based on the input **pSeedIn*.

Generated primes *r* and *p* are further validated through a *nTrial*-round Miller-Rabin primality test. Both generation and primality test procedures employ specified *rndFunc* Random Generator.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsSizeErr`	Indicates an error condition if: *`peBits`* < 512 or *`reBits`* < 160, *`peBits`* is not divided by 256.
`ippStsRangeErr`	Indicates an error condition if: bitsize of the input *Seed* value is less than *`reBits`*, not enough space to store the output *Seed* value (if requested).
`ippStsBadArgErr`	Indicates an error condition if *`nTrials`* < 1.
`ippStsInsuffucientEntropy`	Indicates a warning condition if prime generation fails due to a poor choice of the entropy.

DLPValidateDH

Validates domain parameters of the DL-based cryptosystem over GF(p) to use the DH Agreement scheme.

Syntax

```
IppStatus ippsDLPValidateDH(int nTrials, IppDLResult* pResult, IppsDLPState* pCtx,
IppBitSupplier rndFunc, void* pRndParam);
```

Include Files

`ippcp.h`

Parameters

`nTrials`	Security parameter specified for the Miller-Rabin probable primality.
`pResult`	Pointer to the validation result.
`pCtx`	Pointer to the cryptosystem context.
`rndFunc`	Specified Random Generator.
`pRndParam`	Pointer to the Random Generator context.

Description

The function validates domain parameters of the DL-based cryptosystem over GF(*p*) to use Diffie-Hellman Agreement scheme. The result of validation is stored in the **`pResult`* and may be assigned to one of the enumerators listed below:

`ippDLValid`	Validation has passed successfully.
`ippDLBaseIsEven`	*P* is even.
`ippDLOrderIsEven`	*R* is even.
`ippDLInvalidBaseRange`	$P \leq 2^{peBits-1}$ or $P \geq 2^{peBits}$.

`ippDLInvalidOrderRange`	$R \leq 2^{reBits-1}$ or $R \geq 2^{reBits}$.
`ippDLCompositeBase`	*P* is not a prime.
`ippDLCompositeOrder`	*R* is not a prime.
`ippDLInvalidCofactor`	*R* is not divisible by (*P* -1).
`ippDLInvalidGenerator`	(1 < *G* < (*P* -1)) is false or *G*^*R* != 1 (mod *P*).

To ensure that both *p* and *r* are primes, the function applies *`nTrial`*-round Miller-Rabin primality test. Test data for primality test is provided by the specified *rndFunc* Random Generator.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsIncompleteContextErr`	Indicates an error condition if the cryptosystem context has not been properly set up.
`ippStsBadArgErr`	Indicates an error condition if *`nTrials`* < 1.

DLPSharedSecretDH

Computes a shared field element by using the Diffie-Hellman scheme.

Syntax

```
IppStatus ippsDLPSharedSecretDH(const IppsBigNumState* pPrivateA, const
IppsBigNumState* pPublicB, IppsBigNumState* pShare, IppsDLPState* pCtx);
```

Include Files

`ippcp.h`

Parameters

`pPrivateA`	Pointer to your own private key *privateKeyA*.
`pPublicB`	Pointer to the public key *pubKeyB* belonging to the other party.
`pShare`	Pointer to the shared secret element *Share*.
`pCtx`	Pointer to the cryptosystem context.

Description

The function computes a shared secret element FG(p) $pubKeyB^{privateKeyA}(modp)$.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.

`ippStsContextMatchErr`	Indicates an error condition if the context parameter does not match the operation.
`ippStsIncompleteContextErr`	Indicates an error condition if the cryptosystem context has not been properly set up.
`ippStsRangeErr`	Indicates an error condition if *Share* does not have enough space.

DLGetResultString

For DL-based cryptosystems, returns the character string corresponding to code that represents the result of validation.

Syntax

```
const char* ippsDLGetResultString(IppDLResult code);
```

Include Files

`ippcp.h`

Parameters

code	The code of the validation result.

Description

For DL-based cryptosystems, the function returns the character string corresponding to code that represents the result of validation.

Return Values

Possible values of code and the corresponding character strings are as follows:

default	"Unknown DL result"
`ippDLValid`	"Validation passed successfully"
`ippDLBaseIsEven`	"Base is even"
`ippDLOrderIsEven`	"Order is even"
`ippDLInvalidBaseRange`	"Invalid Base (*P*) range"
`ippDLInvalidOrderRange`	"Invalid Order (*R*) range"
`ippDLCompositeBase`	"Composite Base (*P*)"
`ippDLCompositeOrder`	"Composite Order (*R*)"
`ippDLInvalidCofactor`	"*R* does not divide (*P* -1)"
`ippDLInvalidGenerator`	"1 != *G*^*R* (mod *P*)"
`ippDLInvalidPrivateKey`	"Invalid Private Key"
`ippDLInvalidPublicKey`	"Invalid Public Key"
`ippDLInvalidKeyPair`	"Invalid Key Pair"
`ippDLInvalidSignature`	"Invalid Signature"

See Also

DLPValidateDH

DLPValidateDSA

DLPValidateKeyPair

Elliptic Curve Cryptography Functions

Cryptography Intel® Integrated Performance Primitives (Intel® IPP) Cryptography offers functions allowing for different operations with an elliptic curve defined over a prime finite field GF(*p*).

The functions are based on standards [IEEE P1363A], [SEC1], [ANSI], and [SM2].

Intel IPP Cryptography supports some elliptic curves with fixed parameters, the so-called standard or recommended curves. These parameters are chosen so that they provide a sufficient level of security and enable efficient implementation.

Functions Based on GF(*p*)

This section describes functions designed to specify the elliptic curve cryptosystem and perform various operations on the elliptic curve defined over a prime finite field. The examples of the operations are shown below:

- Setting up operations: `ECCPSet` sets up elliptic curve domain parameters. `ECCPSetKeyPair` sets a pair of public and private keys for the given cryptosystem.
- Computation operations: `ECCPAddPoint` adds two points on the elliptic curve. `ECCPMulPointScalar` performs the scalar multiplication of a point on the elliptic curve. ECCPSignDSA computes the digital signature of a message.
- Validation operations: `ECCPValidate` checks validity of the elliptic curve domain parameters. `ECCPValidateKeyPair` validates correctness of the public and private keys.
- Generation operations: `ECCPGenKeyPair` generates a private key and computes a public key for the given elliptic cryptosystem.
- Retrieval operations: `ECCPGet` retrieves elliptic curve domain parameters. `ECCPGetOrderBitSize` retrieves the size of a base point in bytes.

All functions described in this section employ a context `IppsECCPState` that catches several auxiliary components specifying operations performed on the elliptic curve or entire elliptic cryptosystem. ECCP stands for Elliptic Curve Cryptography Prime and means that all functions whose name include this abbreviation perform operations over a prime finite field GF(*p*).

The `IppECCType` enumerator lists standard elliptic curves supported. You can select a particular type in a call to ECCPSetStd.

The table below associates each value of `IppECCType` with parameters of the elliptic curve and provides a reference to the appropriate specification.

Standard Elliptic Curves

Value of IppECCType	Name of the Curve	Reference
`ippECarbitrary`	Not applicable	No reference because of arbitrary parameters.
`ippECstd112r1`	`secp112r1`	[SEC2]
`ippECstd112r2`	`secp112r2`	[SEC2]
`ippECstd128r1`	`secp128r1`	[SEC2]
`ippECstd128r2`	`secp128r2`	[SEC2]
`ippECstd160r1`	`secp160r1`	[SEC2]

Value of IppECCType	Name of the Curve	Reference
ippECstd160r2	secp160r2	[SEC2]
ippECstd192r1	secp192r1	[SEC2]
ippECstd224r1	secp224r1	[SEC2]
ippECstd256r1	secp256r1	[SEC2]
ippECstd384r1	secp384r1	[SEC2]
ippECstd521r1	secp521r1	[SEC2]
ippECstdSM2	SM2	[SM2]

For more information on parameters recommended for the functions, see [SEC2] and [SM2].

Important
To provide minimum security of the elliptic curve cryptosystem over a prime finite field, the length of the underlying prime must be equal to or greater than 160 bits.

ECCPGetSize
Gets the size of the `IppsECCPState` *context.*

Syntax

`IppStatus ippsECCPGetSize(int *feBitSize*, int **pSize*);`

Include Files

`ippcp.h`

Parameters

feBitSize	Size (in bits) of the underlying prime number.
pSize	Pointer to the size (in bytes) of the context.

Description

The function computes the size of the context in bytes for the elliptic cryptosystem over a prime finite field GF (*p*).

Context is a structure `IppsECCPState` designed to store information about the cryptosystem status.

NOTE
For security reasons, the length of the underlying prime number is restricted to 1 kilobit.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsSizeErr`	Indicates an error condition if the value of the parameter *feBitSize* is less than 2.

ECCPGetSizeStd

Gets the size of the `IppsECCPState` *context for a standard elliptic curve.*

Syntax

```
IppStatus ippsECCPGetSizeStd128r1(int* pSize);
IppStatus ippsECCPGetSizeStd128r2(int* pSize);
IppStatus ippsECCPGetSizeStd192r1(int* pSize);
IppStatus ippsECCPGetSizeStd224r1(int* pSize);
IppStatus ippsECCPGetSizeStd256r1(int* pSize);
IppStatus ippsECCPGetSizeStd384r1(int* pSize);
IppStatus ippsECCPGetSizeStd521r1(int* pSize);
IppStatus ippsECCPGetSizeStdSM2(int* pSize);
```

Include Files

`ippcp.h`

Parameters

pSize	Pointer to the size (in bytes) of the `IppsECCPState` context for a standard elliptic curve.

Description

Each of these functions computes the size of the context in bytes for the elliptic curve cryptosystem based on a specific standard elliptic curve. For a list of these curves, see table Standard Elliptic Curves.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.

ECCPInit

Initializes the context for the elliptic curve cryptosystem over GF(p).

Syntax

```
IppStatus ippsECCPInit(int feBitSize, IppsECCPState* pECC);
```

Include Files

`ippcp.h`

Parameters

feBitSize	Size (in bits) of the underlying prime number.
pECC	Pointer to the cryptosystem context.

Description

The function initializes the context of the elliptic curve cryptosystem over the prime finite field GF(*p*).

Context is a structure `IppsECCPState` designed to store information about the cryptosystem status.

NOTE
For security reasons, the length of the underlying prime number is restricted to 1 kilobit.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is NULL.
`ippStsSizeErr`	Indicates an error condition if the value of the parameter *`feBitSize`* is less than 2.
`ippStsLengthErr`	Indicates an error condition if the value of the *`feBitsize`* parameter is less than 2 or greater than 1024.

See Also

Data Security Considerations

ECCPInitStd

Initializes the context for the cryptosystem based on a standard elliptic curve.

Syntax

```
IppStatus ippsECCPInitStd128r1(IppsECCPState* pECC);
IppStatus ippsECCPInitStd128r2(IppsECCPState* pECC);
IppStatus ippsECCPInitStd192r1(IppsECCPState* pECC);
IppStatus ippsECCPInitStd224r1(IppsECCPState* pECC);
IppStatus ippsECCPInitStd256r1(IppsECCPState* pECC);
IppStatus ippsECCPInitStd384r1(IppsECCPState* pECC);
IppStatus ippsECCPInitStd521r1(IppsECCPState* pECC);
IppStatus ippsECCPInitStdSM2(IppsECCPState* pECC);
```

Include Files

`ippcp.h`

Parameters

pECC	Pointer to the cryptosystem context based on a standard elliptic curve.

Description

Each of these functions initializes the context of the elliptic curve cryptosystem based on a specific standard elliptic curve. For a list of these curves, see table Standard Elliptic Curves.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is NULL.

See Also

Data Security Considerations

ECCPBindGxyTblStd

Enable the use of base point-based pre-computed tables of standard elliptic curves.

Syntax

```
IppStatus ippsECCPBinfGxyTblStd192r1(IppsECCPState* pEC);
IppStatus ippsECCPBinfGxyTblStd224r1(IppsECCPState* pEC);
IppStatus ippsECCPBinfGxyTblStd256r1(IppsECCPState* pEC);
IppStatus ippsECCPBinfGxyTblStd384r1(IppsECCPState* pEC);
IppStatus ippsECCPBinfGxyTblStd521r1(IppsECCPState* pEC);
IppStatus ippsECCPBinfGxyTblStdSM2(IppsECCPState* pEC);
```

Include Files

`ippcp.h`

Parameters

pEC	Pointer to the context of the elliptic curve

Description

The functions `ECCPValidate`, `ECCPGenKeyPair` and `ECCPVerify` perform time-consuming math operations on the elliptic curve base point. In Intel IPP Cryptography-supported standards, the base point is fixed, and you may use pre-computed values.

The function `ECCPBindGxyTbl` stores a pointer the to the pre-computed base point data in the elliptic curve context. For performance-critical applications, consider calling `ECCPBindGxyTbl` at the completion of elliptic curve initialization. The use of `ECCPBindGxyTbl` improves the performance of `ECCPValidate`, `ECCPGenKeyPair` and `ECCPVerify` up to 2 times.

NOTE
The size of the pre-computed table is quite large (~100-150KB), so using `ECCPBindGxyTbl` increases the size of your application.

Important
The set of `ECCPBindGxyTbl` functions covers only curves defined by the following standards: NIST P-192r1, NIST P-224r1, NIST P-256r1, NIST P-384r1, NIST P521r1, and SM2. Other standard elliptic curves supported in Intel IPP Cryptography do not have a similar mechanism because they do not match modern security strength requirements.

Return Values

`ippsStsNoErr`	Indicates no error. Any other message indicates an error or warning.
`ippsStsNullPtrErr`	Indicates an error condition if *pEC* is `NULL`.
`ippsStsContextMatchErr`	Indicates an error condition if the elliptic curve context is not valid.

ECCPSet

Sets up elliptic curve domain parameters over GF(p).

Syntax

```
IppStatus ippsECCPSet(const IppsBigNumState* pPrime, const IppsBigNumState* pA, const
IppsBigNumState* pB, const IppsBigNumState* pGX, const IppsBigNumState* pGY, const
IppsBigNumState* pOrder, int cofactor, IppsECCPState* pECC);
```

Include Files

`ippcp.h`

Parameters

pPrime	Pointer to the characteristic *p* of the prime finite field GF(*p*).
pA	Pointer to the coefficient *A* of the equation defining the elliptic curve.
pB	Pointer to the coefficient *B* of the equation defining the elliptic curve.
pGX	Pointer to the *x*-coordinate of the elliptic curve base point.
pGY	Pointer to the *y*-coordinate of the elliptic curve base point.
pOrder	Pointer to the order of the elliptic curve base point.
cofactor	Cofactor.
pECC	Pointer to the context of the cryptosystem.

Description

The function sets up the elliptic curve domain parameters over a prime finite field GF(*p*). These are as follows:

- *pPrime* sets up the characteristic *p* of a finite field GF(*p*) where *p* is a prime number.
- *pA*, *pB* set up the coefficients *A* and *B* of the equation defining the elliptic curve:

  $y^2 = x^3 + A\cdot x + B \pmod{p}$.
- *pGX*, *pGY* are pointers to the affine coordinates of the elliptic curve base point *G*.
- *pOrder* is a pointer to the order *n* of the elliptic curve base point *G* such that $n \cdot G = O$, where *O* is the point at infinity and *n* is a prime number.
- *cofactor* sets up the ratio *h* of a general number of points #E on the elliptic curve (including the point at infinity) to the order *n* of the base point:

  $h = \#E/n$.

The domain parameters are set in the cryptosystem context which must be already created by the `ECCPGetSize` and `ECCPInit` functions.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if one of the contexts pointed by *`pPrime`*, *`pA`*, *`pB`*, *`pGX`*, *`pGY`*, *`pOrder`*, and *`pECC`* is not valid.
`ippStsRangeErr`	Indicates an error condition if of one of the parameters pointed by *`pPrime`*, *`pA`*, *`pB`*, *`pGX`*, *`pGY`*, and *`pOrder`* cannot embed the *`feBitSize`* bits length or the value of *`cofactor`* is less than 1.

ECCPSetStd

Sets up a recommended set of domain parameters for an elliptic curve over GF(p).

Syntax

```
IppStatus ippsECCPSetStd128r1(IppsECCPState* pECC);
IppStatus ippsECCPSetStd128r2(IppsECCPState* pECC);
IppStatus ippsECCPSetStd192r1(IppsECCPState* pECC);
IppStatus ippsECCPSetStd224r1(IppsECCPState* pECC);
IppStatus ippsECCPSetStd256r1(IppsECCPState* pECC);
IppStatus ippsECCPSetStd384r1(IppsECCPState* pECC);
IppStatus ippsECCPSetStd521r1(IppsECCPState* pECC);
IppStatus ippsECCPSetStdSM2(IppsECCPState* pECC);
IppStatus ippsECCPSetStd(IppECCType flag, IppsECCPState* pECC);
```

Include Files

`ippcp.h`

Parameters

`flag`	Set specifier.
`pECC`	Pointer to the cryptosystem context.

Description

Each of the `ECCPSetStd` functions sets a recommended set of domain parameters for an elliptic curve over a prime finite field GF(*p*).

Functions with One Parameter

All the functions but the last one set domain parameters for standard elliptic curves, listed in table Standard Elliptic Curves. Before a call to each of these functions, create the cryptosystem context by calling the appropriate ECCPGetSizeStd and ECCPInitStd functions.

Function with Two Parameters

For the last function, the value of the parameter *`flag`* defines the set of domain parameters. Possible values of *`flag`* are as follows:

`IppECCPStd112r1`	For the cryptosystem context where *feBitSize*==112
`IppECCPStd112r2`	For the cryptosystem context where *feBitSize*==112
`IppECCPStd128r1`	For the cryptosystem context where *feBitSize*==128
`IppECCPStd128r2`	For the cryptosystem context where *feBitSize*==128
`IppECCPStd160r1`	For the cryptosystem context where *feBitSize*==160
`IppECCPStd160r2`	For the cryptosystem context where *feBitSize*==160
`IppECCPStd192r1`	For the cryptosystem context where *feBitSize*==192
`IppECCPStd224r1`	For the cryptosystem context where *feBitSize*==224
`IppECCPStd256r1`	For the cryptosystem context where *feBitSize*==256
`IppECCPStd384r1`	For the cryptosystem context where *feBitSize*==384
`IppECCPStd521r1`	For the cryptosystem context where *feBitSize*==521.

For more information on parameter values for the recommended elliptic curves, see [SEC2].

Before a call to this function, create the cryptosystem context by calling the `ECCPGetSize` and `ECCPInit` functions. The value of *feBitSize* is applied when these functions are called and predetermines the choice of the *flag* value.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the cryptosystem context is not valid.
`ippStsECCInvalidFlagErr`	Indicates an error condition if the value of the parameter *flag* is not valid.

ECCPGet

Retrieves elliptic curve domain parameters over GF(p).

Syntax

```
IppStatus ippsECCPGet(IppsBigNumState* pPrime, IppsBigNumState* pA, IppsBigNumState*
pB, IppsBigNumState* pGX,IppsBigNumState* pGY, IppsBigNumState* pOrder, int* cofactor,
IppsECCPState* pECC);
```

Include Files

`ippcp.h`

Parameters

pPrime	Pointer to the characteristic *p* of the prime finite field GF(*p*).
pA	Pointer to the coefficient *A* of the equation defining the elliptic curve.

pB	Pointer to the coefficient *B* of the equation defining the elliptic curve.
pGX	Pointer to the *x*-coordinate of the elliptic curve base point.
pGY	Pointer to the *y*-coordinate of the elliptic curve base point.
pOrder	Pointer to the order *n* of the elliptic curve base point.
cofactor	Pointer to the cofactor *h*.
pECC	Pointer to the context of the cryptosystem.

Description

The function retrieves elliptic curve domain parameters from the context of the elliptic cryptosystem over a finite field GF(*p*) and allocates them in accordance with the pointers *pPrime*, *pA*, *pB*, *pGX*, *pGY*, *pOrder*, and *cofactor*. The elliptic curve domain parameters must be hitherto defined by one of the functions: ECCPSet or ECCPSetStd.

Return Values

ippStsNoErr	Indicates no error. Any other value indicates an error or warning.
ippStsNullPtrErr	Indicates an error condition if any of the specified pointers is NULL.
ippStsContextMatchErr	Indicates an error condition if one of the contexts pointed by *pPrime*, *pA*, *pB*, *pGX*, *pGY*, *pOrder*, or *pECC* is not valid.
ippStsRangeErr	Indicates an error condition if the memory size of one of the parameters pointed by *pPrime*, *pA*, *pB*, *pGX*, *pGY*, *pOrder*, and *pECC* is less than the value of *feBitSize* in the ECCPInit function.

ECCPGetOrderBitSize

Retrieves order size of the elliptic curve base point over GF(p) in bits.

Syntax

```
IppStatus ippsECCPGetOrderBitSize(int* pBitSize, IppsECCPState* pECC);
```

Include Files

ippcp.h

Parameters

pBitSize	Pointer to the size of the base point (in bits).
pECC	Pointer to the cryptosystem context.

Description

The function retrieves the order size (in bits) of the elliptic curve base point *G* from the context of elliptic cryptosystem over a prime finite field GF(*p*) and allocates it in accordance with the pointer *pBitsSize*. The elliptic curve domain parameters must be hitherto defined by one of the functions: ECCPSet or ECCPSetStd.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the cryptosystem contextis not valid.

ECCPValidate

Checks validity of the elliptic curve domain parameters over GF(p).

Syntax

```
IppStatus ippsECCPValidate(int nTrials, IppECResult* pResult, IppsECCPState* pECC,
IppBitSupplier rndFunc, void* pRndParam);
```

Include Files

`ippcp.h`

Parameters

`nTrials`	A number of attempts made to check the number for primality.
`pResult`	Pointer to the result received upon the check of the elliptic curve domain parameters.
`pECC`	Pointer to the cryptosystem context.
`rndFunc`	Specified Random Generator.
`pRndParam`	Pointer to Random Generator context.

Description

The function checks validity of the elliptic curve domain parameters over a prime finite field GF(*p*) and stores the result of the check in accordance with the pointer *`pResult`*.

Elliptic curve domain parameters must be hitherto defined by one of the functions: `ECCPSet` or `ECCPSetStd`. The purpose of the parameters *`rndFunc`*, *`pRndParam`*, and *`nTrials`* is analogous to that of the parameters *`rndFunc`*, *`pRndParam`*, and *`nTrials`* in the `PrimeTest` function.

The result of the elliptic curve domain parameters check can take one of the following values:

`ippECValid`	The parameters are valid.
`ippECCompositeBase`	The prime finite field characterisitc *p* is a composite number.
`ippECIsNotAG`	The solutions of the elliptic curve equation do not form the abelian group because the only requirement that $4 \cdot a^3 + 27 \cdot b^3 \neq 0$ is not met.
`ippECPointIsNotValid`	The base point *G* is not on the elliptic curve.
`ippECCompositeOrder`	The order *n* of the base point *G* is a composite number.

`ippECInvalidOrder`	The order *n* of the base point *G* is not valid because the requirement that *n* ·*G* = *O* where *O* is the point at infinity is not met.
`ippECIsWeakSSSA`	The order *n* of the base point *G* is equal to the finite field characteristic *p*.
`ippECIsWeakMOV`	The curve is excluded because it is subject to the MOV reduction attack.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if one of the contexts pointed by *c* or *pECC* is not valid.
`ippStsBadArgErr`	Indicates an error condition if the memory size of the parameter *seed* is less than five words (32 bytes in each) or the value of the parameter *nTrails* is less than 1.

ECCPPointGetSize

Gets the size of the `IppsECCPPoint` *context in bytes for a point on the elliptic curve point defined over GF(p).*

Syntax

```
IppStatus ippsECCPPointGetSize(int feBitSize, int* pSize);
```

Include Files

`ippcp.h`

Parameters

feBitSize	Size (in bits) of the field element.
pSize	Pointer to the context size.

Description

The function computes the context size in bytes for a point on the elliptic curve defined over a prime finite field GF(*p*).

Context is a structure `IppsECCPPoint` intended for storing the information about a point on the elliptic curve defined over GF(*p*).

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsSizeErr`	Indicates an error condition if the value of the parameter *feBitSize* is less than 2.

ECCPPointInit

Initializes the context for a point on the elliptic curve defined over GF(p).

Syntax

```
IppStatus ippsECCPPointInit(int feBitSize, IppsECCPPointState* pPoint);
```

Include Files

ippcp.h

Parameters

feBitSize	Size (in bits) of the field element.
pPoint	Pointer to the context of the elliptic curve point.

Description

The function initializes the context for a point on the elliptic curve defined over a finite field GF(*p*).

Context is a structure `IppsECCPPointState` intended for storing the information about a point on the elliptic curve defined over GF(*p*).

Return Values

ippStsNoErr	Indicates no error. Any other value indicates an error or warning.
ippStsNullPtrErr	Indicates an error condition if any of the specified pointers is `NULL`.
ippStsSizeErr	Indicates an error condition if the value of the parameter *feBitSize* is less than 2.

See Also

Data Security Considerations

ECCPSetPoint

Sets coordinates of a point on the elliptic curve defined over GF(p).

Syntax

```
IppStatus ippsECCPSetPoint(const IppsBigNumState* pX, const IppsBigNumState* pY,
IppsECCPPointState* pPoint, IppsECCPState* pECC);
```

Include Files

ippcp.h

Parameters

pX	Pointer to the *x*-coordinate of the point on the elliptic curve.
pY	Pointer to the *y*-coordinate of the point on the elliptic curve.
pPoint	Pointer to the context of the elliptic curve point.
pECC	Pointer to the context of the elliptic cryptosystem.

Description

The function sets the coordinates of a point on the elliptic curve defined over a prime finite field GF(*p*).

The context of the point on the elliptic curve must be already created by functions: `ECCPPointGetSize` and `ECCPPointInit`. The elliptic curve domain parameters must be hitherto defined by one of the functions: `ECCPSet` or `ECCPSetStd`.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if one of the contexts pointed by *`pX`*, *`pY`*, *`pPoint`*, or *`pECC`* is not valid.

ECCPSetPointAtInfinity

Sets the point at infinity.

Syntax

```
IppStatus ippsECCPSetPointAtInfinity(IppsECCPPointState* pPoint, IppsECCPState* pECC);
```

Include Files

`ippcp.h`

Parameters

`pPoint`	Pointer to the context of the elliptic curve point.
`pECC`	Pointer to the context of the elliptic cryptosystem.

Description

The function sets the point at infinity. The context of the elliptic curve point must be already created by functions: `ECCPPointGetSize` and `ECCPPointInit`. The elliptic curve domain parameters must be hitherto defined by one of the functions: `ECCPSet` or `ECCPSetStd`.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if one of the contexts pointed by *`pPoint`* or *`pECC`* is not valid.

ECCPGetPoint

Retrieves coordinates of the point on the elliptic curve defined over GF(p).

Syntax

```
IppStatus ippsECCPGetPoint(IppsBigNumState* pX, IppsBigNumState* pY, const
IppsECCPPointState* pPoint, IppsECCPState* pECC);
```

Include Files

`ippcp.h`

Parameters

pX	Pointer to the *x*-coordinate of the point on the elliptic curve.
pY	Pointer to the *y*-coordinate of the point on the elliptic curve.
pPoint	Pointer to the context of the elliptic curve point.
pECC	Pointer to the context of the elliptic cryptosystem.

Description

The function retrieves the coordinates of the point on the elliptic curve defined over a prime finite field GF(*p*) from the point context and allocates them in accordance with the set pointers *pX* and *pY*.

The elliptic curve domain parameters must be hitherto defined by one of the functions: `ECCPSet` or `ECCPSetStd`.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if one of the contexts pointed by *pX*, *pY*, *pPoint*, or *pECC* is not valid.

ECCPCheckPoint

Checks correctness of the point on the elliptic curve defined over GF(p).

Syntax

```
IppStatus ippsECCPCheckPoint(const IppsECCPPointState* pP, IppECResult* pResult,
IppsECCPState* pECC);
```

Include Files

`ippcp.h`

Parameters

pP	Pointer to the elliptic curve point.
pResult	Pointer to the result of the check.
pECC	Pointer to the context of the elliptic cryptosystem.

Description

The function checks the correctness of the point on the elliptic curve defined over a prime finite field GF(*p*) and allocates the result of the check in accordance with the pointer *pResult*.

The elliptic curve domain parameters must be hitherto defined by one of the functions: `ECCPSet` or `ECCPSetStd`.

The result of the check for the correctness of the point can take one of the following values:

`ippECValid`	Point is on the elliptic curve.
`ippECPointIsNotValid`	Point is not on the elliptic curve and is not the point at infinity.
`ippECPointIsAtInfinite`	Point is the point at infinity.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if one of the contexts pointed by *pP* or *pECC* is not valid.

ECCPComparePoint

Compares two points on the elliptic curve defined over GF(p).

Syntax

```
IppStatus ippsECCPComparePoint(const IppsECCPPointState* pP, const IppsECCPPointState*
pQ, IppECResult* pResult, IppsECCPState* pECC);
```

Include Files

`ippcp.h`

Parameters

pP	Pointer to the elliptic curve point *P*.
pQ	Pointer to the elliptic curve point *Q*.
pResult	Pointer to the comparison result of two points: *P* and *Q*.
pECC	Pointer to the context of the elliptic cryptosystem.

Description

The function compares two points *P* and *Q* on the elliptic curve defined over a prime finite field GF(*p*) and allocates the comparison result in accordance with the pointer *pResult*.

The elliptic curve domain parameters must be hitherto defined by one of the functions: `ECCPSet` or `ECCPSetStd`.

The comparison result of two points *P* and *Q* can take one of the following values:

`ippECPointIsEqual`	Points *P* and *Q* are equal.
`ippECPointIsNotEqual`	Points *P* and *Q* are different.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.

`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if one of the contexts pointed by *pP* or *pECC* is not valid.

ECCPNegativePoint

Finds an elliptic curve point which is an additive inverse for the given point over GF(p).

Syntax

```
IppStatus ippsECCPNegativePoint(const IppsECCPPointState* pP, IppsECCPPointState* pR,
IppsECCPState* pECC);
```

Include Files

`ippcp.h`

Parameters

pP	Pointer to the elliptic curve point *P*.
pR	Pointer to the elliptic curve point *R*.
pECC	Pointer to the context of the elliptic cryptosystem.

Description

The function finds an elliptic curve point *R* over a prime finite field GF(*p*), which is an additive inverse of the given point *P*, that is, *R* = - *P* .

The elliptic curve domain parameters must be hitherto defined by one of the functions: `ECCPSet` or `ECCPSetStd`.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if one of the contexts pointed by *pP*, *pR*, or *pECC* is not valid.

ECCPAddPoint

Computes the addition of two elliptic curve points over GF(p).

Syntax

```
IppStatus ippsECCPAddPoint(const IppsECCPPointState* pP, const IppsECCPPointState* pQ,
IppsECCPPointState* pR, IppsECCPState* pECC);
```

Include Files

`ippcp.h`

Parameters

pP	Pointer to the elliptic curve point *P*.
pQ	Pointer to the elliptic curve point *Q*.
pR	Pointer to the elliptic curve point *R*.
pECC	Pointer to the context of the elliptic cryptosystem.

Description

The function calculates the addition of two elliptic curve points *P* and *Q* over a finite field GF(*p*) with the result in a point *R* such that *R* = *P* + *Q*.

The elliptic curve domain parameters must be hitherto defined by one of the functions: `ECCPSet` or `ECCPSetStd`.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if one of the contexts pointed by *pP*, *pQ*, *pR*, or *pECC* is not valid.

ECCPMulPointScalar

Performs scalar multiplication of a point on the elliptic curve defined over GF(p).

Syntax

```
IppStatus ippsECCPMulPointScalar(const IppsECCPPointState* pP, const IppsBigNumState*
pK, IppsECCPPointState* pR, IppsECCPState* pECC);
```

Include Files

`ippcp.h`

Parameters

pP	Pointer to the elliptic curve point *P*.
pK	Pointer to the scalar *K*.
pR	Pointer to the elliptic curve point *R*.
pECC	Pointer to the context of the elliptic cryptosystem.

Description

The function performs the *K* scalar multiplication of an elliptic curve point *P* over GF(*p*) with the result in a point *R* such that *R* = *K* · *P*.

The elliptic curve domain parameters must be hitherto defined by one of the functions: `ECCPSet` or `ECCPSetStd`.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if one of the contexts pointed by *pP*, *pK*, *pR*, or *pECC* is not valid.

ECCPGenKeyPair

Generates a private key and computes public keys of the elliptic cryptosystem over GF(p).

Syntax

```
IppStatus ippsECCPGenKeyPair(IppsBigNumState* pPrivate, IppsECCPPointState* pPublic,
IppsECCPState* pECC, IppBitSupplier rndFunc, void* pRndParam);
```

Include Files

`ippcp.h`

Parameters

pPrivate	Pointer to the private key *privKey*.
pPublic	Pointer to the public key *pubKey*.
pECC	Pointer to the context of the elliptic cryptosystem.
rndFunc	Specified Random Generator.
pRndParam	Pointer to the Random Generator context.

Description

The function generates a private key *privKey* and computes a public key *pubKey* of the elliptic cryptosystem over a finite field GF(*p*). The generation process employs the user specified *rndFunc* Random Generator.

The private key *privKey* is a number that lies in the range of [1, *n*-1] where *n* is the order of the elliptic curve base point.

The public key *pubKey* is an elliptic curve point such that *pubKey* = *privKey*· *G*, where *G* is the base point of the elliptic curve.

The memory size of the parameter *privKey* pointed by *pPrivate* must be less than that of the base point which can also be defined by the function `ECCPGetOrderBitSize`.

The context of the point *pubKey* as an elliptic curve point must be created by using the functions `ECCPPointGetSize` and `ECCPPointInit`.

The elliptic curve domain parameters must be hitherto defined by one of the functions: `ECCPSet` or `ECCPSetStd`.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.

`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if one of the contexts pointed by *`pPrivate`*, *`pPublic`*, or *`pECC`* is not valid.
`ippStsSizeErr`	Indicates an error condition if the memory size of the parameter *privKey* pointed by *`pPrivate`* is less than that of the order of the elliptic curve base point.

ECCPPublicKey

Computes a public key from the given private key of the elliptic cryptosystem over GF(p).

Syntax

```
IppStatus ippsECCPPublicKey(const IppsBigNumState* pPrivate, IppsECCPPointState*
pPublic, IppsECCPState* pECC);
```

Include Files

`ippcp.h`

Parameters

`pPrivate`	Pointer to the private key *privKey*.
`pPublic`	Pointer to the public key *pubKey*.
`pECC`	Pointer to the context of the elliptic cryptosystem.

Description

The function computes the public key *pubKey* from the given private key *privKey* of the elliptic cryptosystem over a finite field GF(*p*).

The private key *privKey* is a number that lies in the range of [1, *n*-1] where *n* is the order of the elliptic curve base point. The public key *pubKey* is an elliptic curve point such that *pubKey* = *privKey*· *G*, where *G* is the base point of the elliptic curve.

The context of the point *pubKey* as an elliptic curve point must be created by using the functions `ECCPPointGetSize` and `ECCPPointInit`.

The elliptic curve domain parameters must be defined by one of the functions: `ECCPSet` or `ECCPSetStd`.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if one of the contexts pointed by *`pPrivate`*, *`pPublic`*, or *`pECC`* is not valid.
`ippStsIvalidPrivateKey`	Indicates an error condition if the value of the private key falls outside the range of [1, *n*-1].

ECCPValidateKeyPair

Validates private and public keys of the elliptic cryptosystem over GF(p).

Syntax

```
IppStatus ippsECCPValidateKeyPair(const IppsBigNumState* pPrivate, const
IppsECCPPointState* pPublic, IppECResult* pResult, IppsECCPState* pECC);
```

Include Files

`ippcp.h`

Parameters

pPrivate	Pointer to the private key *privKey*.
pPublic	Pointer to the public key *pubKey*.
pResult	Pointer to the validation result.
pECC	Pointer to the context of the elliptic cryptosystem.

Description

The function validates the private key *privKey* and public key *pubKey* of the elliptic cryptosystem over a finite field GF(*p*) and allocates the result of the validation in accordance with the pointer *pResult*.

The private key *privKey* is a number that lies in the range of [1, *n*-1] where *n* is the order of the elliptic curve base point. The public key *pubKey* is an elliptic curve point such that *pubKey* = *privKey*· *G*, where *G* is the base point of the elliptic curve.

The elliptic curve domain parameters must be hitherto defined by one of the functions: `ECCPSet` or `ECCPSetStd`.

The result of the cryptosystem keys validation for correctness can take one of the following values:

`ippECValid`	Keys are valid.
`ippECInvalidKeyPair`	Keys are not valid because $privKey \cdot G \neq pubKey$
`ippECInvalidPrivateKey`	Key *privKey* falls outside the range of [1, *n*-1].
`ippECPointIsAtInfinite`	Key *pubKey* is the point at infinity.
`ippECInvalidPublicKey`	Key *pubKey* is not valid because $n \cdot pubKey \neq O$, where *O* is the point at infinity.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if one of the contexts pointed by *pPrivate*, *pPublic*, or *pECC* is not valid.

ECCPSetKeyPair

Sets private and/or public keys of the elliptic cryptosystem over GF(p).

Syntax

```
IppStatus ippsECCPSetKeyPair(const IppsBigNumState* pPrivate, const IppsECCPPointState*
pPublic, IppBool regular, IppsECCPState* pECC);
```

Include Files

`ippcp.h`

Parameters

pPrivate	Pointer to the private key *privKey*.
pPublic	Pointer to the public key *pubKey*.
regular	Key status flag.
pECC	Pointer to the context of the elliptic cryptosystem.

Description

The function sets a private key *privKey* and/or public key *pubKey* in the elliptic cryptosystem defined over a prime finite field GF(*p*).

The private key *privKey* is a number that lies in the range of [1, *n*-1] where *n* is the order of the elliptic curve base point. The public key *pubKey* is an elliptic curve point such that *pubKey* = *privKey*· *G*, where *G* is the base point of the elliptic curve.

The two possible values of the parameter *regular* define the key timeliness status:

`ippTrue`	Keys are regular.
`ippFalse`	Keys are ephemeral.

The elliptic curve domain parameters must be hitherto defined by one of the functions: `ECCPSet` or `ECCPSetStd`.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if one of the contexts pointed by *pPrivate*, *pPublic*, or *pECC* is not valid.

ECCPSharedSecretDH

Computes a shared secret field element by using the Diffie-Hellman scheme.

Syntax

```
IppStatus ippsECCPSharedSecretDH(const IppsBigNumState* pPrivateA, const
IppsECCPPointState* pPublicB, IppsBigNumState* pShare, IppsECCPState* pECC);
```

Include Files

`ippcp.h`

Parameters

pPrivateA	Pointer to your own private key *privKey*.
pPublicB	Pointer to the public key *pubKey*.
pShare	Pointer to the secret number*bnShare*.
pECC	Pointer to the context of the elliptic cryptosystem.

Description

The function computes a secret number *bnShare*, which is a secret key shared between two participants of the cryptosystem.

In cryptography, metasyntactic names such as Alice as Bob are normally used as examples and in discussions and stand for participant A and participant B.

Both participants (Alice and Bob) use the cryptosystem for receiving a common secret point on the elliptic curve called a secret key. To receive a secret key, participants apply the Diffie-Hellman key-agreement scheme involving public key exchange. The value of the secret key entirely depends on participants.

According to the scheme, Alice and Bob perform the following operations:

1. Alice calculates her own public key *pubKeyA* by using her private key *privKeyA*: *pubKeyA* = *privKeyA*· *G*, where *G* is the base point of the elliptic curve. Alice passes the public key to Bob.
2. Bob calculates his own public key *pubKeyB* by using his private key *privKeyB*: *pubKeyB* = *privKeyB*· *G*, where *G* is a base point of the elliptic curve. Bob passes the public key to Alice.
3. Alice gets Bob's public key and calculates the secret point *shareA*. When calculating, she uses her own private key and Bob's public key and applies the following formula: *shareA* = *privKeyA* · *pubKeyB* = *privKeyA* · *privKeyB* · *G*.
4. Bob gets Alice's public key and calculates the secret point *shareB*. When calculating, he uses his own private key and Alice's public key and applies the following formula: *shareB* = *privKeyB* · *pubKeyA* = *privKeyB* · *privKeyA* · *G*.

Because the following equation is true *privKeyA* · *privKeyB* · *G* =*privKeyB* · *privKeyA* · *G*, the result of both calculations is the same, that is, the equation *shareA* = *shareB* is true. The secret point serves as a secret key.

Shared secret *bnShare* is an x-coordinate of the secret point on the elliptic curve.

The elliptic curve domain parameters must be hitherto defined by one of the functions: `ECCPSet` or `ECCPSetStd`.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if one of the contexts pointed by *pPublicB*, *pShare*, or *pECC* is not valid.
`ippStsRangeErr`	Indicates an error condition if the memory size of *bnShare* pointed by *pShare* is less than the value of *feBitSize* in the function `ECCPInit`.
`ippStsShareKeyErr`	Indicates an error condition if the shared secret key is not valid. (For example, the shared secret key is invalid if the result of the secret point calculation is the point at infinity.)

ECCPSharedSecretDHC

Computes a shared secret field element by using the Diffie-Hellman scheme and the elliptic curve cofactor.

Syntax

```
IppStatus ippsECCPSharedSecretDHC(const IppsBigNumState* pPrivateA, const
IppsECCPPointState* pPublicB, IppsBigNumState* pShare, IppsECCPState* pECC);
```

Include Files

`ippcp.h`

Parameters

pPrivateA	Pointer to your own private key *privKey*.
pPublicB	Pointer to the public key *pubKey*.
pShare	Pointer to the secret number *bnShare*.
pECC	Pointer to the context of the elliptic cryptosystem.

Description

The function computes a secret number *bnShare* which is a secret key shared between two participants of the cryptosystem. Both participants (Alice and Bob) use the cryptosystem for getting a common secret point on the elliptic curve by using the Diffie-Hellman scheme and elliptic curve cofactor *h*.

Alice and Bob perform the following operations:

1. Alice calculates her own public key *pubKeyA* by using her private key *privKeyA*: *pubKeyA* = *privKeyA*· *G*, where *G* is the base point of the elliptic curve. Alice passes the public key to Bob.
2. Bob calculates his own public key *pubKeyB* by using his private key *privKeyB*: *pubKeyB* = *privKeyB*· *G*, where *G* is a base point of the elliptic curve. Bob passes the public key to Alice.
3. Alice gets Bob's public key and calculates the secret point *shareA*. When calculating, she uses her own private key and Bob's public key and applies the following formula: *shareA* = *h* · *privKeyA* · *pubKeyB* = *h* · *privKeyA* · *privKeyB* · *G*, where *h* is the elliptic curve cofactor.
4. Bob gets Alice's public key and calculates the secret point *shareB*. When calculating, he uses his own private key and Alice's public key and applies the following formula: *shareB* = *h* · *privKeyB* · *pubKeyA* = *h* · *privKeyB* · *privKeyA* · *G*, where *h* is the elliptic curve cofactor.

Shared secret *bnShare* is an x-coordinate of the secret point on the elliptic curve.

The elliptic curve domain parameters must be hitherto defined by one of the functions: `ECCPSet` or `ECCPSetStd`.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if one of the contexts pointed by *pPublicB*, *pShare*, or *pECC* is not valid.
`ippStsRangeErr`	Indicates an error condition if the memory size of *bnShare* pointed by *pShare* is less than the value of *feBitSize* in the function `ECCPInit`.

`ippStsShareKeyErr`	Indicates an error condition if the shared secret key is not valid. (For example, the shared secret key is invalid if the result of the secret point calculation is the point at infinity.)

ECCPSignDSA
Computes a digital signature over a message digest.

Syntax

IppStatus ippsECCPSignDSA(const IppsBigNumState* *pMsgDigest*, const IppsBigNumState* *pPrivate*, IppsBigNumState* *pSignX*, IppsBigNumState* *pSignY*, IppsECCPState* *pECC*);

Include Files

`ippcp.h`

Parameters

pMsgDigest	Pointer to the message digest *msg* to be digitally signed, that is, to be ecrypted with a private key.
pPrivate	Pointer to the signer's regular private key.
pSignX	Pointer to the integer *r* of the digital signature.
pSignY	Pointer to the integer *s* of the digital signature.
pECC	Pointer to the context of the elliptic cryptosystem.

Description

A message digest is a fixed size number derived from the original message with an applied hash function over the binary code of the message. The signer's private key and the message digest are used to create a signature.

A digital signature over a message consists of a pair of large numbers *r* and *s* which the given function computes.

The scheme used for computing a digital signature is the ECDSA scheme, an elliptic curve analogue of the DSA scheme. ECDSA assumes that the following keys are hitherto set by a message signer:

regPrivKey	Regular private key.
ephPrivKey	Ephemeral private key.
ephPubKey	Ephemeral public key.

For security reasons, each signature must be generated with the unique ephemeral private key. Because of this, the function clears (sets to zero) the input ephemeral key before return. To generate and set up the keys before sign generation, call the `ECCPGenKeyPair` and `ECCPSetKeyPair` functions.

The elliptic curve domain parameters must be hitherto defined by one of the functions: `ECCPSet` or `ECCPSetStd`.

For more information on digital signatures, please refer to the [ANSI] standard.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.

`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if one of the contexts pointed by *`pMsgDigest`*, *`pSignX`*, *`pSignY`*, or *`ECC`* is not valid.
`ippStsMessageErr`	Indicates an error condition if the value of *msg* pointed by *`pMsgDigest`* is negative, or the bit length is greater than the bit length of *n*, where *n* is the order of the elliptic curve base point *G*.
`ippStsRangeErr`	Indicates an error condition if one of the parameters pointed by *`pSignX`* or *`pSignY`* has a memory size smaller than the order *n* of the elliptic curve base point *G*.
`ippStsEphemeralKeyErr`	Indicates an error condition if the values of the ephemeral keys *ephPrivKey* and *ephPubKey* are not valid. (Either *r* = 0 or *s* = 0 is received as a result of the digital signature calculation).
`ippStsInvalidPrivateKey`	Indicates an error condition if the private key value does not belong to the [0, n-1] range, where *n* is the order of the elliptic curve base point *G*.

See Also

Code Example

ECCPVerifyDSA

Verifies authenticity of the digital signature over a message digest (ECDSA).

Syntax

`IppStatus ippsECCPVerifyDSA(const IppsBigNumState* pMsgDigest, const IppsBigNumState* pSignX, const IppsBigNumState* pSignY, IppECResult* pResult, IppsECCPState* pECC);`

Include Files

`ippcp.h`

Parameters

`pMsgDigest`	Pointer to the message digest *msg*.
`pSignX`	Pointer to the integer *r* of the digital signature.
`pSignY`	Pointer to the integer *s* of the digital signature.
`pResult`	Pointer to the digital signature verification result.
`pECC`	Pointer to the context of the elliptic cryptosystem.

Description

The function verifies authenticity of the digital signature over a message digest *msg*. The signature consists of two large integers: *r* and *s*.

The scheme used to verify the signature is an elliptic curve analogue of the DSA scheme and assumes that the following cryptosystem key be hitherto set:

regPubKey	Message sender's regular public key.

The *regPubKey* is set by the function `ECCPSetKeyPair`.

The result of the digital signature verification can take one of two possible values:

`ippECValid`	Digital signature is valid.
`ippECInvalidSignature`	Digital signature is not valid.

The call to the `ECCPVerifyDSA` function must be preceded by the call to the `ECCPSignDSA` function which computes the digital signature over the message digest *msg* and represents the signature with two numbers: *r* and *s*.

The elliptic curve domain parameters must be hitherto defined by one of the functions: `ECCPSet` or `ECCPSetStd`.

For more information on digital signatures, please refer to the [ANSI] standard.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if one of the contexts pointed by *`pMsgDigest`*, *`pSignX`*, *`pSignY`*, or *`ECC`* is not valid.
`ippStsMessageErr`	Indicates an error condition if the value of *msg* pointed by *`pMsgDigest`* falls outside the range of [1, *n*-1] where *n* is the order of the elliptic curve base point *G*.
`ippStsRangeErr`	Indicates an error condition if the value of *`pSignX`* or *`pSignY`* is less than 0.

See Also

Code Example

ECCPSignNR

Computes the digital signature over a message digest (the Nyberg-Rueppel scheme).

Syntax

```
IppStatus ippsECCPSignNR(const IppsBigNumState* pMsgDigest, const IppsBigNumState*
pPrivate, IppsBigNumState* pSignX, IppsBigNumState* pSignY, IppsECCPState* pECC);
```

Include Files

`ippcp.h`

Parameters

`pMsgDigest`	Pointer to the message digest *msg*.
`pPrivate`	Pointer to the private key *privKey*.
`pSignX`	Pointer to the integer *r* of the digital signature.
`pSignY`	Pointer to the integer *s* of the digital signature.
`pECC`	Pointer to the context of the elliptic cryptosystem.

Description

The function computes two large numbers *r* and *s* which form the digital signature over a message digest *msg*.

The scheme used to compute the digital signature is an elliptic curve analogue of the El-Gamal Digital Signature scheme with the message recovery (the Nyberg-Rueppel signature scheme). The scheme that the given function uses assumes that the following cryptosystem keys are hitherto set up by the message sender:

regPrivKey	Regular private key.
ephPrivKey	Ephemeral private key.
ephPubKey	Ephemeral public key.

For security reasons, each signature must be generated with the unique ephemeral private key. Because of this, the function clears (sets to zero) the input ephemeral key before return. To generate and set up the keys before sign generation, call the `ECCPGenKeyPair` and `ECCPSetKeyPair` functions.

The elliptic curve domain parameters must be hitherto defined by one of the functions: `ECCPSet` or `ECCPSetStd`.

For more information on digital signatures, please refer to the [ANSI] standard.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if one of the contexts pointed by *`pMsgDigest`*, *`pSignX`*, *`pSignY`*, or *`ECC`* is not valid.
`ippStsMessageErr`	Indicates an error condition if the value of *msg* pointed by *`pMsgDigest`* falls outside the range of [1, *n*-1] where *n* is the order of the elliptic curve base point *G*.
`ippStsRangeErr`	Indicates an error condition if one of the parameters pointed by *`pSignX`* or *`pSignY`* has memory size smaller than the order *n* of the elliptic curve base point *G*.
`ippStsEphemeralKeyErr`	Indicates an error condition if the values of the ephemeral keys *ephPrivKey* and *ephPubKey* are not valid (*r* = 0 is received as a result of the digital signature calculation).
`ippStsInvalidPrivateKey`	Indicates an error condition if the value of the private key does not belong to the [0, *n*-1] range, where *n* is the order of the elliptic curve base point *G*.

ECCPVerifyNR

Verifies authenticity of the digital signature over a message digest (the Nyberg-Rueppel scheme).

Syntax

```
IppStatus ippsECCPVerifyNR(const IppsBigNumState* pMsgDigest, const IppsBigNumState*
pSignX, const IppsBigNumState* pSignY, IppECResult* pResult, IppsECCPState* pECC);
```

Include Files

`ippcp.h`

Parameters

`pMsgDigest`	Pointer to the message digest *msg*.

pSignX	Pointer to the integer *r* of the digital signature.
pSignY	Pointer to the integer *s* of the digital signature.
pResult	Pointer to the digital signature verification result.
pECC	Pointer to the context of the elliptic cryptosystem.

Description

The function verifies authenticity of the digital signature over a message digest *msg*. The signature is presented with two large integers *r* and *s*.

The scheme used to compute the digital signature is an elliptic curve analogue of the El-Gamal Digital Signature scheme with the message recovery (the Nyberg-Rueppel signature scheme). The scheme that the given function uses assumes that the following cryptosystem keys be hitherto set up by the message sender:

regPubKey	Message sender's regular private key.

The key can be generated and set up by the function ECCPGenKeyPair.

The result of the digital signature verification can take one of two possible values:

ippECValid	The digital signature is valid.
ippECInvalidSignature	The digital signature is not valid.

The call to the ECCPVerifyNR function must be preceded by the call to the ECCPSignNR function which computes the digital signature over the message digest *msg* and represents the signature with two numbers: *r* and *s*.

The elliptic curve domain parameters must be hitherto defined by one of the functions: ECCPSet or ECCPSetStd.

For more information on digital signatures, please refer to the [ANSI] standard.

Return Values

ippStsNoErr	Indicates no error. Any other value indicates an error or warning.
ippStsNullPtrErr	Indicates an error condition if any of the specified pointers is NULL.
ippStsContextMatchErr	Indicates an error condition if one of the contexts pointed by *pMsgDigest*, *pSignX*, *pSignY*, or *ECC* is not valid.
ippStsMessageErr	Indicates an error condition if the value of *msg* pointed by *pMsgDigest* falls outside the range of [1, *n*-1] where *n* is the order of the elliptic curve base point *G*.
ippStsRangeErr	Indicates an error condition if the value of *pSignX* or *pSignY* is less than 0.

ECCPSignSM2

Computes a digital signature over a message digest using the SM2 scheme.

Syntax

```
IppStatus ippsECCPSignSM2(const IppsBigNumState* pMsgDigest, const IppsBigNumState*
pRegPrivate, IppsBigNumState* pEphPrivate, IppsBigNumState* pSignR, IppsBigNumState*
pSignS, IppsECCPState* pECC);
```

Include Files

`ippcp.h`

Parameters

pMsgDigest	Pointer to the message digest *msg*.
pRegPrivate	Pointer to the regular private key *regPrivKey*.
pEphPrivate	Pointer to the ephmeral private key *ephPrivKey*.
pSignR	Pointer to the integer *r* of the digital signature.
pSignS	Pointer to the integer *s* of the digital signature.
pECC	Pointer to the context of the elliptic cryptosystem.

Description

The function computes two big numbers *r* and *s* that form the digital signature over a message digest *msg*.

The digital signature is computed using the SM2 scheme [SM2]. The scheme requires that the following cryptosystem keys are set up by the message sender:

regPrivKey	Regular private key.
ephPrivKey	Ephemeral private key.
ephPubKey	Ephemeral public key.

For security reasons, each signature must be generated with the unique ephemeral private key. Because of this, the function clears (sets to zero) the input ephemeral key before return. To generate and set up the keys, call the `ECCPGenKeyPair` function.

Before calling ECCPSignSM2, set up the domain parameters of the elliptic curve in the **pECC* context by calling one of the functions: `ECCPSet` or `ECCPSetStdSM2`.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if one of the specified contexts is not valid.
`ippStsMessageErr`	Indicates an error condition if the value of *msg* pointed by *pMsgDigest* is negative, or its size (in bits) is more than the order *n* of the elliptic curve base point *G*.
`ippStsRangeErr`	Indicates an error condition if one of the parameters pointed by *pSignR* or *pSignS* has memory size smaller than the order *n* of the elliptic curve base point *G*.
`ippStsEphemeralKeyErr`	Indicates an error condition if: • The value of the ephemeral key does not belong to the [0, *n*-1] range, where *n* is the order of the elliptic curve base point *G*. • The value of *r* or *s* component of signature to be computed is equal to zero.

`ippStsInvalidPrivateKey`	Indicates an error condition if the value of the private key does not belong to the [0, *n*-1] range, where *n* is the order of the elliptic curve base point *G*.

ECCPVerifySM2

Verifies authenticity of a digital signature over a message digest using the SM2 scheme.

Syntax

```
IppStatus ippsECCPVerifySM2(const IppsBigNumState* pMsgDigest, const
IppsECCPPointState* pRegPublic, const IppsBigNumState* pSignR, const IppsBigNumState*
pSignS, IppECResult* pResult, IppsECCPState* pECC);
```

Include Files

`ippcp.h`

Parameters

pMsgDigest	Pointer to the message digest *msg*.
pRegPublic	Pointer to the message sender's regular private key *regPubKey*.
pSignR	Pointer to the integer *r* of the digital signature.
pSignS	Pointer to the integer *s* of the digital signature.
pResult	Pointer to the digital signature verification result.
pECC	Pointer to the context of the elliptic cryptosystem.

Description

The function verifies authenticity of the digital signature, represented as integer big numbers *r* and *s*, over a message digest *msg*. The digital signature over the message digest *msg* must be computed using the SM2 scheme [SM2] by to the ECCPSignSM2 function.

The scheme requires the following cryptosystem key set up by the message sender:

regPubKey	Message sender's regular private key.

You can generate and set up the key in a call to the `ECCPGenKeyPair` function.

The result of the digital signature verification can take one of these values:

`ippECValid`	The digital signature is valid.
`ippECInvalidSignature`	The digital signature is not valid.

Before calling ECCPVerifySM2, set up the domain parameters of the elliptic curve in the **pECC* context by calling one of the functions: `ECCPSet` or `ECCPSetStdSM2`.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.

`ippStsContextMatchErr`	Indicates an error condition if one of the specified contexts is not valid.
`ippStsMessageErr`	Indicates an error condition if the value of *msg* pointed by *pMsgDigest* falls outside the range of [1, *n*-1] where *n* is the order of the elliptic curve base point *G*.
`ippStsRangeErr`	Indicates an error condition if the value of *pSignR* or *pSignS* is less than 0.

Signing/Verification Using the Elliptic Curve Cryptography Functions over a Prime Finite Field

Use of ECCPSignDSA, ECCPVerifyDSA

```
#include <iostream>
#include <vector>
#include <string>
using namespace std;

#include "ippcp.h"


static  IppsECCPState*  newStd_256_ECP(void)
{
   int ctxSize;
   ippsECCPGetSize(256,  &ctxSize);
   IppsECCPState* pCtx = (IppsECCPState*)( new Ipp8u [ctxSize] );
   ippsECCPInit(256,  pCtx);
   ippsECCPSetStd(IppECCPStd256r1,  pCtx);
   return pCtx;
}

static  IppsECCPPointState*  newECP_256_Point(void)
{
   int ctxSize;
   ippsECCPPointGetSize(256,  &ctxSize);
   IppsECCPPointState* pPoint = (IppsECCPPointState*)( new Ipp8u [ctxSize] );
   ippsECCPPointInit(256,  pPoint);
   return pPoint;
}

static IppsBigNumState* newBN(int len, const Ipp32u* pData)
{
   int ctxSize;
   ippsBigNumGetSize(len,  &ctxSize);
   IppsBigNumState* pBN = (IppsBigNumState*)( new Ipp8u [ctxSize] );
   ippsBigNumInit(len,  pBN);
   if(pData)
      ippsSet_BN(IppsBigNumPOS, len, pData, pBN);
   return pBN;
}

IppsPRNGState*  newPRNG(void)
{
   int ctxSize;
   ippsPRNGGetSize(&ctxSize);
   IppsPRNGState* pCtx = (IppsPRNGState*)( new Ipp8u [ctxSize] );
   ippsPRNGInit(160,  pCtx);
   return pCtx;
```

```
}


int main(void)
{
   // define standard 256-bit EC
   IppsECCPState* pECP = newStd_256_ECP();

   // extract or use any other way to get order(ECP)
   const Ipp32u secp256r1_r[] = {0xFC632551, 0xF3B9CAC2, 0xA7179E84, 0xBCE6FAAD
       0xFFFFFFFF, 0xFFFFFFFF, 0x00000000, 0xFFFFFFFF};
   const int ordSize = sizeof(secp256r1_r)/sizeof(Ipp32u);
   IppsBigNumState* pECPorder = newBN(ordSize, secp256r1_r);

   // define a message to be signed; let it be random, for example
   IppsPRNGState* pRandGen = newPRNG(); // 'external' PRNG

   Ipp32u  tmpData[ordSize];
   ippsPRNGen(tmpData, 256, pRandGen);
   IppsBigNumState* pRandMsg = newBN(ordSize, tmpData);  // random 256-bit message
   IppsBigNumState* pMsg = newBN(ordSize, 0);             // msg to be signed
   ippsMod_BN(pRandMsg, pECPorder, pMsg);

   // declare Signer's regular and ephemeral key pair
   IppsBigNumState* regPrivate = newBN(ordSize, 0);
   IppsBigNumState* ephPrivate = newBN(ordSize, 0);
   // define Signer's ephemeral key pair
   IppsECCPPointState* regPublic = newECP_256_Point();
   IppsECCPPointState* ephPublic = newECP_256_Point();

   // generate regular & ephemeral key pairs, should be different each other
   ippsECCPGenKeyPair(regPrivate, regPublic, pECP, ippsPRNGen, pRandGen);
   ippsECCPGenKeyPair(ephPrivate, ephPublic, pECP, ippsPRNGen, pRandGen);


   //
   // signature
   //

   // set ephemeral key pair
   ippsECCPSetKeyPair(ephPrivate, ephPublic, ippFalse, pECP);
   // compure signature
   IppsBigNumState* signX = newBN(ordSize, 0);
   IppsBigNumState* signY = newBN(ordSize, 0);
   ippsECCPSignDSA(pMsg, regPrivate, signX, signY, pECP);

   //
   // verification
   //
   ippsECCPSetKeyPair(NULL, regPublic, ippTrue, pECP);
   IppECResult  eccResult;
   ippsECCPVerifyDSA(pMsg, signX,signY, &eccResult, pECP);
   if(ippECValid == eccResult)
      cout << "signature verificatioin passed" <<endl;
   else
      cout << "signature verificatioin failed" <<endl;

   delete [] (Ipp8u*)signX;
   delete [] (Ipp8u*)signY;
   delete [] (Ipp8u*)ephPublic;
   delete [] (Ipp8u*)regPublic;
   delete [] (Ipp8u*)ephPrivate;
   delete [] (Ipp8u*)regPrivate;
   delete [] (Ipp8u*)pRandMsg;
   delete [] (Ipp8u*)pMsg;
   delete [] (Ipp8u*)pRandGen;
   delete [] (Ipp8u*)pECPorder;
   delete [] (Ipp8u*)pECP;
   return 0;
}
```

Functions based on SM2

Short Description

This section describes functions based on the SM2 encryption standard for elliptic curves. For more information on the Elliptic Curve Integrated Encryption Scheme, see [IEEE P1363A]. The standard operations of GFpEC functions are listed below:

- Compute a shared secret *Z* of the private key *U* and a recipient public key *W*.
- Derive a shared secret key data *K* from the shared secret *Z*.
- Encrypt or decrypt a message using the cipher agreed upon parties and the shared secret key data *K*.
- Compute an authentication tag using the agreed authentication scheme and the secret key data *K*.

As an encryption or decryption result, the Elliptic Curve Encryption Scheme (ECES) returns a buffer with the following components:

- *pk* containing representation of the sender public key;
- *msg* containing the encrypted or decrypted message;
- *tag* containing the authentication tag.

The size of *msg* equals to the size of the plain-text message. To get the size of *pk* or *tag*, call the `ippsGFpECESGetBuffersSize_SM2` function.

For more information on the SM2 cryptographic algorithm based on elliptic curves, see [SM2 PKE].

GFpECESGetSize_SM2

Gets the size of the SM2 elliptic curve encryption context.

Syntax

`IppStatus ippsGFpECESGetSize_SM2(const IppsGFpECState* pEC, int* pSize);`

Include Files

`ippcp.h`

Parameters

pEC	Pointer to the elliptic curve context.
pSize	Pointer to the size, in bytes, of the ECES context.

Description

The function computes the size of the buffer in bytes for the `IppsECES_StateSM2` context to be used later. The *pEC* parameter represents a properly initialized elliptic curve using the encryption scheme.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the `IppsGFpECState` context parameter does not match the operation.
`ippStsNotSupportedModeErr`	Indicates an error condition if the `IppsGFpECState` context parameter defines an elliptic curve over an extension of the prime finite field.

GFpECESInit_SM2

Initializes the ECES context.

Syntax

`IppStatus ippsGFpECESInit_SM2(IppsGFpECState* *pEC*, IppsECES_StateSM2* *pState*, int *availableCtxSize*);`

Include Files

`ippcp.h`

Parameters

pEC	Pointer to the elliptic curve context used in the ECES.
pState	Pointer to the buffer being initialized as the ECES context.
availableCtxSize	Available size of the buffer being initialized.

Description

The function initializes the memory buffer pointed to by *pState* as `IppsECES_StateSM2`.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the `IppsGFpECState` context parameter does not match the operation.
`ippStsNotSupportedModeErr`	Indicates an error condition if the `IppsGFpECState` context parameter defines an elliptic curve over an extension of the prime finite field.
`ippStsSizeErr`	Indicates an error condition if size of the initialized buffer is not big enough for the operation.

GFpECESSetKey_SM2

Computes a shared secret.

Syntax

`IppStatus ippsGFpECESSetKey_SM2(const IppsBigNumState* *pPrivate*, const IppsGFpECPoint* *pPublic*, IppsECES_StateSM2* *pState*, IppsGFpECState* *pEC*, Ipps8u* *pEcScratchBuffer*);`

Include Files

`ippcp.h`

Parameters

pEC	Pointer to the elliptic curve context used in the ECES.
pState	Pointer to the buffer being initialized as the ECES context.
pPrivate	Pointer to the own private keys of the elliptic curve.
pPublic	Pointer to the patry public key of the elliptic curve.
pEcScratchBuffer	Pointer to the scratch buffer for the elliptic curve.

Description

The function computes a shared secret **Z** = [**Private**]* **Public** for future use.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the `IppsGFpECState`, `IppsECES_StateSM2`, `IppsBigNumState`, or `IppsGFpECPoint` context parameter does not match the operation.
`ippStsOutOfRangeErr`	Indicates an error conditions in the following cases: • Any of the specified pointers does not belong to the finite field over that the elliptic curve is initialized. • The scalar values does not belong to the finite field over that the elliptic curve is initialized.
`ippStsNotSupportedModeErr`	Indicates an error condition if the `IppsGFpECState` context parameter defines an elliptic curve over an extension of the prime finite field.
`ippStsBadArgErr`	Indicates an error condition if the `IppsGFpECState` context parameter has an element size that differs from the one used in the ippsGFpECESInit_SM2 function call.
`ippStsPointAtInfinity`	Indicates an error condition if the `IppsGFpECPoint` context parameter defines a point at infinity.

GFpECESStart_SM2

Starts the ECES SM2 encryption or decryption chain.

Syntax

```
IppStatus ippsGFpECESStart_SM2(IppsECES_StateSM2* pState);
```

Include Files

`ippcp.h`

Parameters

pState	Pointer to the buffer being initialized as the ECES context.

Description

The function starts a chain of the ippsGFpECESEncrypt_SM2 or ippsGFpECESDecrypt_SM2 function calls. In fact, the functions starts computing the authentication tag as required in [SM2 PKE].

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the `IppsECES_StateSM2` context parameter does not match the operation.

GFpECESEncrypt_SM2

Encrypts the plaintext data buffer.

Syntax

```
IppStatus ippsGFpECESEncrypt_SM2(const Ipp8u* pInput, Ipp8u* pOutput, int len,
IppsECES_StateSM2* pState);
```

Include Files

`ippcp.h`

Parameters

pInput	Pointer to the plaintext data buffer.
pOutput	Pointer to the ciphertext data buffer.
len	Length of the input and output buffers.
pState	Pointer to the buffer being initialized as the ECES context.

Description

The function encrypts the plaintext data buffer and updates the authentication tag. For more information on encryption and authentication, see [SM2 PKE]

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the `IppsECES_StateSM2` context parameter does not match the operation.
`ippStsSizeErr`	Indicates an error condition if the *len* parameter has a negative value.

GFpECESDecrypt_SM2

Decrypts the ciphertext data buffer.

Syntax

```
IppStatus ippsGFpECESDecrypt_SM2(const Ipp8u* pInput, Ipp8u* pOutput, int len,
IppsECES_StateSM2* pState);
```

Include Files

`ippcp.h`

Parameters

pInput	Pointer to the ciphertext data buffer.
pOutput	Pointer to the plaintext data buffer.
len	Length of the input and output buffers.
pState	Pointer to the buffer being initialized as the ECES context.

Description

The function decrypts the ciphertext data buffer and updates the authentication tag. For more information on decryption and authentication, see [SM2 PKE]

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the `IppsECES_StateSM2` context parameter does not match the operation.
`ippStsSizeErr`	Indicates an error condition if the *len* parameter has a negative value.

GFpECESFinal_SM2

Completes the ECES SM2 encryption or decryption chain.

Syntax

`IppStatus ippsGFpECESFinal_SM2(Ipp8u* pTag, int tagLen, ippsECES_StateSM2* pState);`

Include Files

`ippcp.h`

Parameters

pTag	Pointer to the tag buffer.
tagLen	Requested length of the authentication tag.
pState	Pointer to the buffer being initialized as the ECES context.

Description

The function completes the Elliptic Curve Encryption Scheme (ECES) SM2 algorithm and returns the computed authentication tag.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.

`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the `IppsECES_StateSM2` context parameter does not match the operation.
`ippStsSizeErr`	Indicates an error condition if *`tagLen`*<0 or *`tagLen`*>32.
`ippStsShareKeyErr`	Indicates an error condition if all generated key gammas were zeros in the encryption or decryption steps.

GFpECESGetBufferSize_SM2

Returns sizes of the ECES SM2 buffer components.

Syntax

```
IppStatus ippsGFpECESGetBufferSize_SM2(int* pPubKeySize, int* pTagSize, const
ippsECES_StateSM2* pState);
```

Include Files

`ippcp.h`

Parameters

`pPubKeySize`	Pointer to the size of the public key representation.
`pTagSize`	Pointer to the maximum size of the authentication tag buffer.
`pState`	Pointer to the buffer being initialized as the ECES context.

Description

The function returns buffer sizes for the public key and authentication tag representations.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the `IppsECES_StateSM2` context parameter does not match the operation.

Arithmetic of the Group of Elliptic Curve Points

This section describes the Intel IPP functions that implement arithmetic operations with points of elliptic curves [EC]. The elliptic curve is defined by the following equation:

$y^2 = x^3 + A \cdot x + B$

where

- A and B are the parameters of the curve
- x and y are the coordinates of a point on the curve

This document considers elliptic curves constructed over the finite field GF(p) (prime or its extension), therefore the arithmetic of elliptic curves is based on the arithmetic of the underlying finite field. In the equation above, A, B, x, and y belong to the underlying field GF(p).

GFpECGetSize

Gets the size of an elliptic curve over the finite field.

Syntax

```
IppStatus ippsGFpECGetSize(const IppsGFpState* pGF, int* pSize);
```

Include Files

`ippcp.h`

Parameters

pGF	Pointer to the `IppsGFpState` context of the underlying finite field.
pSize	Buffer size in bytes needed for the `IppsGFpECState` context.

Description

This function returns the size of the buffer associated with the `IppsGFpECState` context, suitable for storing data for the elliptic curve over the finite field specified by the context *pGF*.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the `IppsGFpState` context parameter does not match the operation.

GFpECInit

Initializes the context of an elliptic curve over a finite field.

Syntax

```
IppStatus ippsGFpECInit(const IppsGFpState* pGF, const IppsGFpElement* pA, const
IppsGFpElement* pB, IppsGFpECState* pEC);
```

Include Files

`ippcp.h`

Parameters

pGF	Pointer to the `IppsGFpState` context of the underlying finite field.
pA	Pointer to the coefficient *A* of the equation defining the elliptic curve.
pB	Pointer to the coefficient *B* of the equation defining the elliptic curve.
pEC	Pointer to the context of the elliptic curve being initialized.

Description

This function initializes the memory buffer *pEC* associated with the `IppsGFpECState` context and sets up the parameters of the elliptic curve if they are supplied. The initialized context is used in functions that create contexts of points on the curve (elements of the group of points) and perform operations with the points.

NOTE
Only the *pEC* and *pGF* parameters are required. You can omit the other parameters by setting their values to `NULL` or zero and set them up later on by calling `GFpECSet` or `GFpECSetSubGroup`.

NOTE
When calling arithmetic functions for the elliptic curve defined by *pEC*, a properly initialized *pGF* context of the underlying field is required.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if either *pEC* or *pGF* is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition in the following cases: • `IppsGFpState` context parameter does not match the operation. • *pA* or *pB* is not zero and the corresponding context parameter does not match the operation.

GFpECSet

Sets up the parameters of an elliptic curve over a finite field.

Syntax

```
IppStatus ippsGFpECSet(const IppsGFpElement* pA, const IppsGFpElement* pB,
IppsGFpECState* pEC);
```

Include Files

`ippcp.h`

Parameters

pA	Pointer to the coefficient *A* of the equation defining the elliptic curve.
pB	Pointer to the coefficient *B* of the equation defining the elliptic curve.
pEC	Pointer to the context of the elliptic curve.

Description

This function assigns input values to the parameters of the elliptic curve in the `IppsGFpECState` context, if they are supplied.

NOTE
Only the *pEC* parameter is required. You can omit the other parameters by setting their values to `NULL` or zero.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if *pEC* is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition in the following cases: • `IppsGFpECState` context parameter does not match the operation. • *pA* or *pB* is not zero, and the corresponding context parameter does not match the operation.
`ippStsOutOfRangeErr`	Indicates an error condition if *pA* or *pB* does not belong to the finite field specified by the `pGFp` context.

GFpECSetSubgroup

Sets up the parameters defining an elliptic curve points subgroup.

Syntax

```
IppStatus ippsGFpECSetSubGroup(const IppsGFpElement* pX, const IppsGFpElement* pY,
const IppsBigNumState* pOrder, const IppsBigNumState* pCofactor, IppsGFpECState* pEC);
```

Include Files

`ippcp.h`

Parameters

pX, *pY*	Pointers to the *X* and *Y* coordinates of the base point of the elliptic curve.
pOrder	Pointer to the big number context storing the order of the base point.
pCofactor	Pointer to the big number context storing the cofactor.
pEC	Pointer to the context of the elliptic curve.

Description

This function sets up an elliptic curve as the subgroup generated by the base point over the finite field.

NOTE
Only the *pEC* parameter is required. You can omit the other parameters by setting their values to `NULL` or zero.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if *pEC* is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition in the following cases: • `IppsGFpECState` context parameter does not match the operation. • Any of the pointers to elliptic curve parameters is not zero and the context parameter does not match the operation.

`ippStsBadArgErr`	Indicates an error condition if any of the specified `IppsBigNumState` contexts defines zero or a negative number.
`ippStsOutOfRangeErr`	Indicates an error if the base point coordinates (*pX*, *pY*) do not belong to the finite field over which the elliptic curve is initialized.
`ippStsRangeErr`	Indicates an error condition in the following cases: • The size of the base point order exceeds the maximal size of the order for the given curve. • The bit size of the cofactor exceeds the bit size of the element of the finite field over which the elliptic curve is initialized.

GFpECInitStd

Initializes the context for the cryptosystem based on a standard elliptic curve.

Syntax

```
IppStatus ippsGFpECInitStd128r1(const IppsGFpState* pGFp, IppsGFpECState* pEC);
IppStatus ippsGFpECInitStd128r2(const IppsGFpState* pGFp, IppsGFpECState* pEC);
IppStatus ippsGFpECInitStd192r1(const IppsGFpState* pGFp, IppsGFpECState* pEC);
IppStatus ippsGFpECInitStd224r1(const IppsGFpState* pGFp, IppsGFpECState* pEC);
IppStatus ippsGFpECInitStd256r1(const IppsGFpState* pGFp, IppsGFpECState* pEC);
IppStatus ippsGFpECInitStd384r1(const IppsGFpState* pGFp, IppsGFpECState* pEC);
IppStatus ippsGFpECInitStd521r1(const IppsGFpState* pGFp, IppsGFpECState* pEC);
IppStatus ippsGFpECInitStdSM2(const IppsGFpState* pGFp, IppsGFpECState* pEC);
```

Include Files

`ippcp.h`

Parameters

pGFp	Pointer to the `IppsGFpState` context of the underlying finite field.
pEC	Pointer to the cryptosystem context based on a standard elliptic curve

Description

Each of these functions initializes the context of the elliptic curve cryptosystem based on a specific standard elliptic curve. For a list of these curves, see table Standard Elliptic Curves.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the `IppsGFpECState` context parameter does not match the operation.

`ippStsBadArgErr`	Indicates an error condition if the `IppsGFpECState` context parameter does not specify the finite field over which the given standard elliptic curve is defined.

GFpECGet

Extracts the parameters of an elliptic curve over a finite field from the context.

Syntax

```
IppStatus ippsGFpECGet(IppsGFpState** const ppGF, IppsGFpElement* pA, IppsGFpElement*
pB, const IppsGFpECState* pEC);
```

Include Files

`ippcp.h`

Parameters

ppGF	Double pointer to the context of the elliptic curve underlying finite field.
pA	Pointer to a copy of the coefficient *A* of the equation defining the elliptic curve.
pB	Pointer to a copy of the coefficient *B* of the equation defining the elliptic curve.
pEC	Pointer to the context of the elliptic curve.

Description

This function extracts parameters of the elliptic curve from the input `IppsGFpECState` context. You can get any combination of the following parameters: a reference to the underlying field and copies of the *A* and *B* coefficients. To turn off extraction of a particular parameter of the elliptic curve, set the appropriate function parameter to `NULL`.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if *pEC* is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition in the following cases: • `IppsGFpECState` context parameter does not match the operation. • Either *pA* or *pB* is not zero and the corresponding context parameter does not match the operation.
`ippStsOutOfRangeErr`	Indicates an error if either *pA* or *pB* does not belong to the finite field over which the elliptic curve is initialized.

GFpECGetSubgroup

Extracts the parameters (base point and its order) that define an elliptic curve point subgroup.

Syntax

```
IppStatus ippsGFpECGetSubGroup(IppsGFpState** const ppGF, IppsGFpElement* pX,
IppsGFpElement* pY, IppsBigNumState* pOrder,IppsBigNumState* pCofactor, const
IppsGFpECState* pEC);
```

Include Files

`ippcp.h`

Parameters

ppGF	Pointer to the context of the underlying finite field.
pX, *pY*	Pointers to the *X* and *Y* coordinates of the base point of the elliptic curve.
pOrder	Pointer to the big number context storing the order of the base point.
pCofactor	Pointer to the big number context storing the cofactor.
pEC	Pointer to the context of the elliptic curve.

Description

This function extracts parameters of an elliptic curve subgroup. You can get any combination of the following parameters: the *X* and *Y* coordinates, the order of the base point, and the value of the cofactor. To turn off extraction of a particular parameter of the elliptic curve, set the appropriate function parameter to `NULL`.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if the specified pointer *pEC* is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition in the following cases: • `IppsGFpECState` context parameter does not match the operation. • Any of the pointers to elliptic curve parameters is not zero and the corresponding context parameter does not match the operation.
`ippStsOutOfRangeErr`	Indicates an error if the base point coordinates (*pX*, *pY*) do not belong to the finite field over which the elliptic curve is initialized.
`ippStsLengthErr`	Indicates an error condition in the following cases: • The size of the base point order exceeds the maximal size of the order for the given curve. • The bit size of the cofactor exceeds the bit size of the element of the finite field over which the elliptic curve is initialized.

GFpECScratchBufferSize

Gets the size of the scratch buffer.

Syntax

```
IppStatus ippsGFpECScratchBufferSize(int nScalars, const IppsGFpECState* pEC, int*
pBufferSize);
```

Include Files

`ippcp.h`

Parameters

nScalars	Number of scalar values. This may take the following values:

	• Number of scalar values used in the multiplication operation. • 1 if it is not applicable.
pEC	Pointer to the context of the elliptic curve.
pBufferSize	Pointer to the calculated buffer size in bytes.

Description

This function computes the size of the scratch buffer for functions that require an external scratch buffer.

Return Values

ippStsNoErr	Indicates no error. Any other value indicates an error or warning.
ippStsNullPtrErr	Indicates an error condition if any of the specified pointers is NULL.
ippStsContextMatchErr	Indicates an error condition if the IppsGFpECState context parameter does not match the operation.
ippStsBadArgErr	Indicates an error condition if *nScalars* <= 0 or *nScalars* > 6

GFpECVerify

Verifies the parameters of an elliptic curve.

Syntax

IppStatus ippsGFpECVerify(IppECResult* *pResult*, IppsGFpECState* *pEC*, Ipp8u* *pScratchBuffer*);

Include Files

ippcp.h

Parameters

pResult	Pointer to the verification result.
pEC	Pointer to the context of the elliptic curve.
pScratchBuffer	Pointer to the scratch buffer.

Description

This function verifies the parameters of the elliptic curve from the input IppsGFpECState context and returns the result in *pResult*. The result of the verification may have the following values:

ippECValid	Parameters are valid.
ippECIsZeroDiscriminant	$4 \cdot A^3 + 3 \cdot B^2 = 0$.
ippECPointIsAtInfinity	Base point $G = (x, y)$ is a point at infinity.
ippECPointIsNotValid	Base point $G = (x, y)$ does not belong to the curve.
ippECInvalidOrder	Order of the base point $G = (x, y)$ is invalid.

If the pointer to the scratch buffer is NULL, the function uses a short internal buffer for computations.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the `IppsGFpECState` context parameter does not match the operation.

GFpECPointGetSize

Gets the size of the `IppsGFpECPoint` *context of a point on an elliptic curve.*

Syntax

```
IppStatus ippsGFpECPointGetSize(const IppsGFpECState* pEC, int* pSize);
```

Include Files

`ippcp.h`

Parameters

pEC	Pointer to the context of the elliptic curve.
pSize	Buffer size, in bytes, needed for the `IppsGFpECPoint` context.

Description

This function returns the size of the buffer associated with the `IppsGFpECPoint` context, which you may use to store data for a point on the elliptic curve over the finite field.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the `IppsGFpECState` context parameter does not match the operation.

GFpECPointInit

Initializes the context of a point on an elliptic curve.

Syntax

```
IppStatus ippsGFpECPointInit(const IppsGFpElement* pX, const IppsGFpElement* pY,
IppsGFpECPoint* pPoint, IppsGFpECState* pEC);
```

Include Files

`ippcp.h`

Parameters

pX, *pY*	Pointers to the *X* and *Y* coordinates of a point on the elliptic curve.
pPoint	Pointer to the `IppsGFpECPoint` context being initialized.

pEC	Pointer to the context of the elliptic curve.

Description

This function initializes the `IppsGFpECPoint` context and sets the coordinates of an elliptic curve point to the values stored in *pX* and *pY*. If any of the pointers to the *X* and *Y* coordinates is zero, the function sets the coordinates of the elliptic curve point in the `IppsGFpECPoint` context to the coordinates of a point at infinity.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if either *pPoint* or *pEC* is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition in the following cases: • `IppsGFpECState` context parameter does not match the operation. • Neither of the pointers to the *X* and *Y* coordinates is zero, and any of the corresponding context parameters does not match the operation.
`ippStsOutOfRangeErr`	Indicates an error if the point coordinates (*pX*, *pY*) do not belong to the finite field over which the elliptic curve is initialized.

GFpECSetPointAtInfinity

Sets a point on an elliptic curve as a point at infinity.

Syntax

```
IppStatus ippsGFpECSetPointAtInfinity(IppsGFpECPoint* pPoint, IppsGFpECState* pEC);
```

Include Files

`ippcp.h`

Parameters

pPoint	Pointer to the `IppsGFpECPoint` context.
pEC	Pointer to the context of the elliptic curve.

Description

This function sets the coordinates of an elliptic curve point in the `IppsGFpECPoint` context to the coordinates of a point at infinity.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if *pPoint* or *pEC* is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the `IppsGFpECState` or `IppsGFpECPoint` context parameter does not match the operation.

GFpECSetPoint, GFpECSetPointREgular

Sets up the coordinates of a point on an elliptic curve.

Syntax

```
IppStatus ippsGFpECSetPoint(const IppsGFpElement* pX, const IppsGFpElement* pY,
IppsGFpECPoint* pPoint, IppsGFpECState* pEC);
```

```
IppStatus ippsGFpECSetPointRegular(const IppsBigNumState* pX, const IppsBigNumState*
pY, IppsGFpECPoint* pPoint, IppsGFpECState* pEC);
```

Include Files

`ippcp.h`

Parameters

pX, *pY*	Pointers to the *X* and *Y* coordinates of the point on the elliptic curve.
pPoint	Pointer to the `IppsGFpECPoint` context.
pEC	Pointer to the context of the elliptic curve.

Description

This function sets up the coordinates of a point on the elliptic curve over the finite field.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if any of the specified contexts does not match the operation.
`ippStsOutOfRangeErr`	Indicates an error if the point coordinates (*pX*, *pY*) do not belong to the finite field over which the elliptic curve is initialized.

GFpECSetPointOctString

Sets the coordinates of a point on an elliptic curve defined over GF(p).

Syntax

```
IppStatus ippsGFpECSetPointOctString(const Ipp8u* pStr, int strLen, IppsGFpECPoint*
pPoint, IppsGFpECState* pEC);
```

Include Files

`ippcp.h`

Parameters

pStr	Pointer octet string containing *X* and *Y* coordinates of the point on the elliptic curve.
strLen	Length of the input *pStr* string, in bytes.
pPoint	Pointer to the context of the elliptic curve point.
pEC	Pointer to the context of the elliptic cryptosystem.

Description

This function sets the coordinates of a point on the elliptic curve defined over a prime finite field GF(*p*). The input data is the octet string containing the pair (*X*, *Y*) of coordinates. The left half of the `pStr` string represents an *X*-coordinate and the right half represents a *Y*-coordinate. The left byte in *X* and *Y* representations corresponds to the most significant byte of coordinates. Length of each part is equal to the length of the GF(*p*) field element in bytes. Before using this function, you need to:

- Define the elliptic curve domain parameters using the `GFpECSet` or `GFpECSetStd` and `GFpECSetSubgroup` functions
- Create the context of the point on the elliptic curve using the `GFpECPointGetSize` and `GFpECPointInit` functions

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error when any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error when one of the contexts pointed by *pPoint* or *pEC* is not valid or not a defined subgroup.
`ippStsNotSupportedModeErr`	Indicates an error when the finite field over which the elliptic curve is initialized is not prime.

GFpECSetPointRandom

Sets the coordinates of a point on an elliptic curve to random values.

Syntax

```
IppStatus ippsGFpECSetPointRandom(IppsGFpECPoint* pPoint, IppsGFpECState* pEC,
IppBitSupplier rndFunc, void* pRndParam, Ipp8u* pScratchBuffer);
```

Include Files

`ippcp.h`

Parameters

pPoint	Pointer to the `IppsGFpECPoint` context.
pEC	Pointer to the context of the elliptic curve.
rndFunc	Pesudorandom number generator.
pRndParam	Pointer to the pseudorandom number generator context.
pScratchBuffer	Pointer to the scratch buffer.

Description

This function assigns random values to the coordinates of an elliptic curve point in the `IppsGFpECPoint` context.

If the pointer to the scratch buffer is `NULL`, the function uses a short internal buffer for computations.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.

`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if any of the context parameters does not match the operation.
`ippStsOutOfRangeErr`	Indicates an error if the specified point does not belong to the finite field over which the elliptic curve is initialized.

GFpECMakePoint

Constructs the coordinates of a point on an elliptic curve based on the X-coordinate.

Syntax

IppStatus ippsGFpECMakePoint(const IppsGFpElement* *pX*, IppsGFpECPoint* *pPoint*, IppsGFpECState* *pEC*);

Include Files

`ippcp.h`

Parameters

pX	Pointer to the *X*-coordinate of the point on the elliptic curve.
pPoint	Pointer to the `IppsGFpECPoint` context.
pEC	Pointer to the context of the elliptic curve.

Description

This function computes the coordinates of a point on an elliptic curve based on the *X*-coordinate.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if any of the specified contexts does not match the operation.
`ippStsOutOfRangeErr`	Indicates an error condition in the following cases: • The coordinates of the point *pPoint* do not belong to the finite field over which the elliptic curve is initialized. • The point coordinate *pX* does not belong to the finite field over which the elliptic curve is initialized.
`ippStsBadArgErr`	Indicates an error condition if the finite field over which the elliptic curve is initialized is not prime.
`ippStsQuadraticNonResidueErr`	Indicates an error condition if the square of the *Y*-coordinate of the point is a quadratic non-residue modulo *p*.

GFpECSetPointHash, GFpECSetPointHashBackCompatible, GFpECSetPointHash_rmf, GFpECSetPointHashBackCompatible_rmf

Constructs a point on an elliptic curve based on the hash of the input message.

Syntax

```
IppStatus ippsGFpECSetPointHash(Ipp32u hdr, const Ipp8u* pMsg, int msgLen,
IppsGFpECPoint* pPoint, IppsGFpECState* pEC, IppHashAlgId hashID, Ipp8u*
pScratchBuffer);
```

```
IppStatus ippsGFpECSetPointHash_rmf(Ipp32u hdr, const Ipp8u* pMsg, int msgLen,
IppsGFpECPoint* pPoint, IppsGFpECState* pEC, const IppsHashMethod* pMethod, Ipp8u*
pScratchBuffer);
```

```
IppStatus ippsGFpECSetPointHashBaskComatible(Ipp32u hdr, const Ipp8u* pMsg, int msgLen,
IppsGFpECPoint* pPoint, IppsGFpECState* pEC, IppHashAlgId hashID , Ipp8u*
pScratchBuffer);
```

```
IppStatus ippsGFpECSetPointHashBaskComatible_rmf(Ipp32u hdr, const Ipp8u* pMsg, int
msgLen, IppsGFpECPoint* pPoint, IppsGFpECState* pEC, const IppsHashMethod* pMethod,
Ipp8u* pScratchBuffer);
```

Include Files

`ippcp.h`

Parameters

hdr	Header of the input message.
pMsg	Pointer to the input message.
msgLen	Length of the input message.
pPoint	Pointer to the `IppsGFpECPoint` context.
pEC	Pointer to the context of the elliptic curve.
hashID	ID of the hash algorithm used. For details, see Supported Hash Algorithms.
pMethod	Predefined Hash Algorithm method. For details, see Supported Hash Algorithms.
pScratchBuffer	Pointer to the scratch buffer. Can be `NULL`.

Description

This function makes the coordinates of a point on the elliptic curve over the finite field from a hash of the *X*-coordinate. If the pointer to the scratch buffer is NULL, the function uses a short internal buffer for computations.

The *X*-coordinate is computed by the following pseudocode formula: `X = hash(hdr || message)`.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition in the following cases: • *pPoint* or *pEC* is `NULL`. • Length of the message is more than zero, and the pointer *pMsg* is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if either *pPoint* or *pEC* context parameter does not match the operation.

`ippStsBadArgErr`	Indicates an error condition if the finite field over which the elliptic curve is initialized is not prime.
`ippStsOutOfRangeErr`	Indicates an error condition if the coordinates of the point *`pPoint`* do not belong to the finite field over which the elliptic curve is initialized.
`ippStsLengthErr`	Indicates an error condition if *`msgLen`* is negative.
`ippStsQuadraticNonResidueErr`	Indicates an error condition if the square of the *Y*-coordinate of the point is a quadratic non-residue modulo *p*.

GFpECGetPoint , GFpECGetPointRegular

Retrieves coordinates of a point on an elliptic curve.

Syntax

```
IppStatus ippsGFpECGetPoint(const IppsGFpECPoint* pPoint, IppsGFpElement* pX,
IppsGFpElement* pY, IppsGFpECState* pEC);
```

```
IppStatus ippsGFpECGetPointRegular(const IppsGFpECPoint* pPoint, IppsBigNumState* pX,
IppsBigNumState* pY, IppsGFpECState* pEC);
```

Include Files

`ippcp.h`

Parameters

`pPoint`	Pointer to the `IppsGFpECPoint` context.
`pX`, *`pY`*	Pointers to the *X* and *Y* coordinates of a point on the elliptic curve.
`pEC`	Pointer to the context of the elliptic curve.

Description

This function exports the coordinates of an elliptic curve point from the `IppsGFPECPoint` context to the user-defined elements of the underlying field. To turn off the extraction of a particular coordinate, set the appropriate function parameter to `NULL`.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if *`pPoint`* or *`pEC`* is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if any of the specified contexts does not match the operation.
`ippStsOutOfRangeErr`	Indicates an error condition in the following cases: • The coordinates of the point *`pPoint`* do not belong to the underlying finite field of the elliptic curve. • *`pX`* or *`pY`* does not belong to the underlying finite field of the elliptic curve.

GFpECGetPointOctString

Retrieves coordinates of a point on an elliptic curve defined over GF(p).

Syntax

```
IppStatus ippsGFpECGetPointOctString(const IppsGFpECPointState* pPoint, Ipps8u* pStr,
int lenStr, IppsGFpECState* pEC);
```

Include Files

`ippcp.h`

Parameters

pPoint	Pointer to the context of the elliptic curve point.
pStr	Pointer to the target string of octets.
lenStr	Available length of *pStr*, in bytes.
pEC	Pointer to the context of the elliptic curve cryptosystem.

Description

This function retrieves the coordinates of *pPoint* on the *pEC* elliptic curve from the point context, converts each *X* and *Y* coordinate into the octet string and stores them in *pStr* so that left half contains *X* and right half contains *Y* point's coordinate. Before using this function, define the elliptic curve domain parameters using one of the following functions: `ECCPSet`, or `ECCPSetStd` and `GFpECSetSubgroup`.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error when *pPoint* or *pEC* is `NULL`.
`ippStsContextMatchErr`	Indicates an error when one of the contexts pointed by *pPoint* or *pEC* is not valid or not a defined subgroup.
`ippStsNotSupportedModeErr`	Indicates an error when the finite field over which the elliptic curve is initialized is not prime.
`ippStsOutOfRangeErr`	Indicates an error when the size of a point coordinate is not equal to the size of the GF(*p*) element.
`ippStsSizeErr`	Indicates an error when *strLen* != 2**gfelementLen*, where *gfelementLen* is the size of the GF(*p*) element.

GFpECTstPoint

Checks if a point belongs to an elliptic curve.

Syntax

```
IppStatus ippsGFpECTstPoint(const IppsGFpECPoint* pP, IppECResult* pResult,
IppsGFpECState* pEC);
```

Include Files

`ippcp.h`

Parameters

pP	Pointer to the `IppsGFpECPoint` context.
pResult	Pointer to the result of the check.
pEC	Pointer to the context of the elliptic curve.

Description

This function checks whether the given point belongs to the elliptic curve over the finite field. The result of the testing is returned in *pResult* and may have the following values:

`ippECValid`	The point belongs to the curve.
`ippECPointIsAtInfinite`	The point is a point at infinity.
`ippECPointIsNotValid`	The point does not belong to the curve.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if any of the specified contexts does not match the operation.
`ippStsOutOfRangeErr`	Indicates an error condition if the coordinates of the point *pP* do not belong to the finite field over which the elliptic curve is initialized.

GFpECTstPointInSubgroup

Checks if a point belongs to a specified subgroup.

Syntax

```
IppStatus ippsGFpECTstPointInGroup(const IppsGFpECPoint* pP, IppECResult* pResult,
IppsGFpECState* pEC, Ipp8u* pScratchBuffer);
```

Include Files

`ippcp.h`

Parameters

pP	Pointer to the `IppsGFpECPoint` context.
pResult	Pointer to the result received upon the check that the point belongs to the elliptic curve over the finite field.
pEC	Pointer to the context of the elliptic curve.
pScratchBuffer	Pointer to the scratch buffer; can be `NULL`.

Description

This function checks whether a point belongs to the pre-defined subgroup of the elliptic curve defined over the finite field. The result of the testing is returned in *pResult* and may have the following values:

`ippECValid`	The point is in the subgroup of the curve.
`ippECPointOutOfGroup`	The point is out of the subgroup.

If the pointer to the scratch buffer is NULL, the function uses a short internal buffer for computations.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.

`ippStsNullPtrErr`	Indicates an error condition if any of the pointers *pP*, *pResult*, and *pEC* is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if any of the specified contexts does not match the operation.
`ippStsOutOfRangeErr`	Indicates an error condition if the point does not belong to the finite field over which the elliptic curve is initialized.

GFpECCpyPoint

Copies one point to another.

Syntax

```
IppStatus ippsGFpECCpyPoint(const IppsGFpECPoint* pA, IppsGFpECPoint* pR,
IppsGFpECState* pEC);
```

Include Files

`ippcp.h`

Parameters

pA	Pointer to the context of the elliptic curve point being copied.
pR	Pointer to the context of the elliptic curve point being changed.
pEC	Pointer to the context of the elliptic curve.

Description

This function copies one point of the elliptic curve over the finite field to another.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if any of the specified contexts does not match the operation.
`ippStsOutOfRangeErr`	Indicates an error condition if any of the specified points does not belong to the finite field over which the elliptic curve is initialized.

GFpECCmpPoint

Compares two points.

Syntax

```
IppStatus ippsGFpECCmpPoint(const IppsGFpECPoint* pP, const IppsGFpECPoint* pQ,
IppECResult* pResult, IppsGFpECState* pEC);
```

Include Files

`ippcp.h`

Parameters

pA	Pointer to the context of the first elliptic curve point.
pQ	Pointer to the context of the second elliptic curve point.

pResult	Pointer to the result of the comparison.
pEC	Pointer to the context of the elliptic curve.

Description

This function compares the coordinates of two points on the elliptic curve over the finite field and returns the result in *pResult*. The result of the comparison may have the following values:

ippECPointIsEqual	The points are equal.
ippECPointIsNotEqual	The points are not equal.

Return Values

ippStsNoErr	Indicates no error. Any other value indicates an error or warning.
ippStsNullPtrErr	Indicates an error condition if any of the specified pointers is NULL.
ippStsContextMatchErr	Indicates an error condition if any of the specified contexts does not match the operation.
ippStsOutOfRangeErr	Indicates an error condition if any of the points does not belong to the finite field over which the elliptic curve is initialized.

GFpECNegPoint

Computes the inverse of a point.

Syntax

```
IppStatus ippsGFpECNegPoint(const IppsGFpECPoint* pP, IppsGFpECPoint* pR,
IppsGFpECState* pEC);
```

Include Files

ippcp.h

Parameters

pP	Pointer to the context of the given point on the elliptic curve.
pR	Pointer to the context of the resulting point on the elliptic curve.
pEC	Pointer to the context of the elliptic curve.

Description

For a given point of the elliptic curve over the finite field, this function computes the coordinates of the inverse point. The following pseudocode represents this operation: $R = 0 - P$.

Return Values

ippStsNoErr	Indicates no error. Any other value indicates an error or warning.
ippStsNullPtrErr	Indicates an error condition if any of the specified is NULL.
ippStsContextMatchErr	Indicates an error condition if any of the specified contexts does not match the operation.

`ippStsOutOfRangeErr`	Indicates an error condition if any of the specified points does not belong to the finite field over which the elliptic curve is initialized.

GFpECAddPoint

Computes the sum of two points on an elliptic curve.

Syntax

```
IppStatus ippsGFpECAddPoint(const IppsGFpECPoint* pP, const IppsGFpECPoint* pQ,
IppsGFpECPoint* pR, IppsGFpECState* pEC);
```

Include Files

`ippcp.h`

Parameters

pA	Pointer to the context of the first point on the elliptic curve to be added.
pQ	Pointer to the context of the second point on the elliptic curve to be added.
pR	Pointer to the context of the resulting point on the elliptic curve.
pEC	Pointer to the context of the elliptic curve.

Description

This function computes the coordinates of the elliptic curve point that is equal to the sum of two given points. The following pseudocode represents this operation: $R = P + Q$.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if any of the specified contexts does not match the operation.
`ippStsOutOfRangeErr`	Indicates an error condition if any of the specified points does not belong to the finite field over which the elliptic curve is initialized.

GFpECMulPoint

Multiplies a point on an elliptic curve by a scalar.

Syntax

```
IppStatus ippsGFpECMulPoint(const IppsGFpECPoint* pP, const IppsBigNumState* pN,
IppsGFpECPoint* pR, IppsGFpECState* pEC, Ipp8u* pScratchBuffer);
```

Include Files

`ippcp.h`

Parameters

pP	Pointer to the context of the given point on the elliptic curve.

pN	Pointer to the Big Number context storing the scalar value.
pR	Pointer to the context of the resulting point on the elliptic curve.
pEC	Pointer to the context of the elliptic curve.
pScratchBuffer	Pointer to the scratch buffer. Can be `NULL`.

Description

This function computes the coordinates of the elliptic curve point that equals the product of the given point and a scalar. The following pseudocode represents this operation: *R* = *scalar* · *P*.

If the pointer to the scratch buffer is `NULL`, the function uses a short internal buffer for computations.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if any of the specified contexts does not match the operation.
`ippStsOutOfRangeErr`	Indicates an error condition in the following cases: • Any of the points does not belong to the finite field over which the elliptic curve is initialized. • The scalar value does not belong to the finite field over which the elliptic curve is initialized.

GFpECPrivateKey, GFpECPublicKey, GFpECTstKeyPair

Generates a private key of the elliptic curve cryptosystem over GF(p).

Syntax

```
IppStatus ippsGFpECPrivateKey(IppsBigNumState* pPrivate, IppsGFpECState* pEC,
IppBitSupplier rndFunc, void* pRndParam);
```

```
IppStatus ippsGFpECPublicKey(const IppsBigNumState* pPrivate, IppsGFpECPoint* pPublic,
IppsGFpECState* pEC, Ipp8u* pScratchBuffer);
```

```
IppStatus ippsGFpECTstKeyPair(const IppsBigNumState* pPrivate, const IppsGFpECPoint*
pPublic, IppECResult* pResult, IppsGFpECState* pEC, Ipp8u* pScratchBuffer);
```

Include Files

`ippcp.h`

Parameters

pPrivate	Pointer to the private key *privKey*.
pPublic	Pointer to the public key *pubKey*.
pEC	Pointer to the context of the elliptic curve.
rndFunc	Specified Random Generator.
pRndParam	Pointer to the Random Generator context.

pResult	Pointer to the validation result.
pScratchBuffer	Pointer to the scratch buffer. Can be `NULL`.

Description

The function generates a private key *privKey* of the elliptic cryptosystem over a finite field GF(*p*). The generation process employs the user-specified *rndFunc* Random Generator.

The private key *privKey* is a number that lies in the range of [1, *n*-1] where *n* is the order of the elliptic curve base point.

The memory size of the parameter *privKey* pointed to by *pPrivate* must be not less than order of the base point, which can also be defined by the function GFpECGetSubgroup.

The elliptic curve domain parameters must be hitherto defined by the functions: GFpECInitStd, GFpECInit, GFpECSet, or GFpECSetSubgroup.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if any of the specified contexts does not match the operation.
`ippStsSizeErr`	Indicates an error condition if the parameter pointed to by *pPrivate* has a memory size that is less than the order *n* of the elliptic curve base point *G*.
`ippStsIvalidPrivateKey`	Indicates an error condition if the value of the private key is less than that of the order of the elliptic curve base point.

GFpECPublicKey

Computes a public key from the given private key of the elliptic curve cryptosystem over GF(p).

Syntax

```
IppStatus ippsGFpECPublicKey(const IppsBigNumState* pPrivate, IppsGFpECPoint* pPublic,
IppsGFpECState* pEC, Ipp8u* pScratchBuffer);
```

Include Files

`ippcp.h`

Parameters

pPrivate	Pointer to the private key *privKey*.
pPublic	Pointer to the public key *pubKey*.
pEC	Pointer to the context of the elliptic curve.
pScratchBuffer	Pointer to the scratch buffer.

Description

The function computes the public key *pubKey* from the given private key *privKey* of the elliptic cryptosystem over a finite field GF(*p*).

The private key *privKey* is a number that lies in the range of [1, *n*-1] where *n* is the order of the elliptic curve base point. The public key *pubKey* is an elliptic curve point such that *pubKey* = *privKey* · *G*, where *G* is the base point of the elliptic curve.

The private key *privKey* can be generated by the function GFpECPrivateKey.

The context of the point *pubKey* as an elliptic curve point must be created by using the functions GFpECPointGetSize and GFpECPointInit.

The elliptic curve domain parameters must be defined by the functions: GFpECInitStd, GFpECInit, GFpECSet, or GFpECSetSubgroup.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if any of the contexts pointed to by *`pPrivate`*, *`pPublic`*, or *`pEC`* does not match the operation.
`ippStsIvalidPrivateKey`	Indicates an error condition if the value of the private key falls outside the range of [1, *n*-1].
`ippStsRangeErr`	Indicates an error condition if *`pPublic`* does not belong to the finite field that the elliptic curve is initialized over.

GFpECTstKeyPair

Tests private and public keys of the elliptic curve cryptosystem over GF(p).

Syntax

`IppStatus ippsGFpECTstKeyPair(const IppsBigNumState* `*`pPrivate`*`, const IppsGFpECPoint* `*`pPublic`*`, IppECResult* `*`pResult`*`, IppsGFpECState* `*`pEC`*`, Ipp8u* `*`pScratchBuffer`*`);`

Include Files

`ippcp.h`

Parameters

`pPrivate`	Pointer to the private key privKey.
`pPublic`	Pointer to the public key pubKey.
`pResult`	Pointer to the validation result.
`pEC`	Pointer to the context of the elliptic curve.
`pScratchBuffer`	Pointer to the scratch buffer.

Description

The function tests the private key *privKey* and public key *pubKey* of the elliptic curve cryptosystem over a finite field GF(*p*) and allocates the result of the validation in accordance with the pointer *`pResult`*.

The private key *privKey* is a number that lies in the range of [1, *n*-1] where *n* is the order of the elliptic curve base point. The public key *pubKey* is an elliptic curve point such that *pubKey* = *privKey*· *G*, where *G* is the base point of the elliptic curve.

The elliptic curve domain parameters must be hitherto defined by the functions: GFpECInitStd, GFpECInit, GFpECSet, or GFpECSetSubgroup.

The result of the cryptosystem keys validation for correctness can take one of the following values:

`ippECValid`	Keys are valid.
`ippECInvalidKeyPair`	Keys are not valid because $privKey\cdot G \neq pubKey$
`ippECInvalidPrivateKey`	Key *privKey* falls outside the range of [1, *n*-1].
`ippECPointIsAtInfinite`	Key *pubKey* is the point at infinity.
`ippECInvalidPublicKey`	Key *pubKey* is not valid because $n \cdot pubKey \neq O$, where *O* is the point at infinity.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if any of the contexts pointed by *`pPrivate`*, *`pPublic`*, or *`pEC`* does not match the operation.
`ippStsRangeErr`	Indicates an error condition if the public key point does not belong to the finite field over which the elliptic curve is initialized.

GFpECPSharedSecretDH, GFpECPSharedSecretDHC

Computes a shared secret field element by using the Diffie-Hellman scheme.

Syntax

```
IppStatus ippsGFpECSharedSecretDH(const IppsBigNumState* pPrivateA, const
IppsGFpECPoint* pPublicB, IppsBigNumState* pShare, IppsGFpECState* pEC, Ipp8u*
pScratchBuffer);
```

```
IppStatus ippsGFpECSharedSecretDHC(const IppsBigNumState* pPrivateA, const
IppsGFpECPoint* pPublicB, IppsBigNumState* pShare, IppsGFpECState* pEC, Ipp8u*
pScratchBuffer);
```

Include Files

`ippcp.h`

Parameters

`pPrivateA`	Pointer to your own private key *privKey*.
`pPublicB`	Pointer to the public key *pubKey*.
`pShare`	Pointer to the secret number *bnShare*.
`pEC`	Pointer to the context of the elliptic curve.
`pScratchBuffer`	Pointer to the scratch buffer.

Description

The function computes a secret number *bnShare*, which is a secret key shared between two participants of the cryptosystem.

The `ippsGFpECPSharedSecretDH` function computes elliptic point *P =[pPrivateA]· pPublicB*. In the `ippsGFpECPSharedSecretDHC` function the *h* cofactor is used: *P =[h][pPrivateA]· pPublicB*.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if one of the contexts pointed to by *`pPublicB`*, *`pPrivateA`*, *`pShare`*, or *`pEC`* is not valid.
`ippStsRangeErr`	Indicates an error condition if the memory size of *bnShare* pointed to by *`pShare`* is less than the size of the GFp modulus that is base for the specified elliptic curve.
`ippStsShareKeyErr`	Indicates an error condition if the shared secret key is not valid. (For example, the shared secret key is invalid if the result of the secret point calculation is the point at infinity.)

GFpECSharedSecretDHC

Computes a shared secret field element by using the Diffie-Hellman scheme and the elliptic curve cofactor.

Syntax

```
IppStatus ippsGFpECSharedSecretDHC(const IppsBigNumState* pPrivateA, const
IppsGFpECPoint* pPublicB, IppsBigNumState* pShare, IppsGFpECState* pEC, Ipp8u*
pScratchBuffer);
```

Include Files

`ippcp.h`

Parameters

`pPrivate`	Pointer to your own private key *privKey*.
`pPublic`	Pointer to the public key *pubKey*.
`pShare`	Pointer to the secret number *bnShare*.
`pEC`	Pointer to the context of the elliptic curve.
`pScratchBuffer`	Pointer to the scratch buffer.

Description

The function computes a secret number *bnShare* which is a secret key shared between two participants of the cryptosystem. Both participants (Alice and Bob) use the cryptosystem for getting a common secret point on the elliptic curve by using the Diffie-Hellman scheme and elliptic curve cofactor *h*.

Alice and Bob perform the following operations:

1. Alice calculates her own public key *pubKeyA* by using her private key *privKeyA*: *pubKeyA* = *privKeyA*· *G*, where *G* is the base point of the elliptic curve. Alice passes the public key to Bob.
2. Bob calculates his own public key *pubKeyB* by using his private key *privKeyB*: *pubKeyB* = *privKeyB*· *G*, where *G* is a base point of the elliptic curve. Bob passes the public key to Alice.
3. Alice gets Bob's public key and calculates the secret point *shareA*. When calculating, she uses her own private key and Bob's public key and applies the following formula: *shareA* = *h* · *privKeyA* · *pubKeyB* = *h* · *privKeyA* · *privKeyB* · *G*, where *h* is the elliptic curve cofactor.
4. Bob gets Alice's public key and calculates the secret point *shareB*. When calculating, he uses his own private key and Alice's public key and applies the following formula: *shareB* = *h* · *privKeyB* · *pubKeyA* = *h* · *privKeyB* · *privKeyA* · *G*, where *h* is the elliptic curve cofactor.

Shared secret *bnShare* is the x-coordinate of the secret point on the elliptic curve.

The elliptic curve domain parameters must be hitherto defined by the functions: GFpECInitStd, GFpECInit, GFpECSet, or GFpECSetSubgroup.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if any of the contexts pointed to by *pPrivate*, *pPublic*, *pShare*, or *pEC* does not match the operation.
`ippStsRangeErr`	Indicates an error condition if the memory size of *bnShare* pointed to by *pShare* is less than the size of the GFp modulus that is the base for the specified elliptic curve.
`ippStsShareKeyErr`	Indicates an error condition if the shared secret key is not valid. (For example, the shared secret key is invalid if the result of the secret point calculation is the point at infinity.)

GFpECPSignDSA, GFpECPSignNR, GFpECPSignSM2

Computes a digital signature over a message digest.

Syntax

```
IppStatus ippsGFpECSignDSA(const IppsBigNumState* pMsgDigest, const IppsBigNumState*
pRegPrivate, const IppsBigNumState* pEphPrivate, IppsBigNumState* pSignR,
IppsBigNumState* pSignS, IppsGFpECState* pEC, Ipp8u* pScratchBuffer);
```

```
IppStatus ippsGFpECSignNR(const IppsBigNumState* pMsgDigest, const IppsBigNumState*
pRegPrivate, const IppsBigNumState* pEphPrivate, IppsBigNumState* pSignR,
IppsBigNumState* pSignS, IppsGFpECState* pEC, Ipp8u* pScratchBuffer);
```

```
IppStatus ippsGFpECSignSM2(const IppsBigNumState* pMsgDigest, const IppsBigNumState*
pRegPrivate, const IppsBigNumState* pEphPrivate, IppsBigNumState* pSignR,
IppsBigNumState* pSignS, IppsGFpECState* pEC, Ipp8u* pScratchBuffer);
```

Include Files

`ippcp.h`

Parameters

pMsgDigest	Pointer to the message digest *msg* to be digitally signed, that is, to be ecrypted with a private key.
pRegPrivate	Pointer to the regular private key of the signer.
pEphPrivate	Pointer to the ephemeral private key of the signer.
pSignR	Pointer to the integer *r* of the digital signature.
pSignS	Pointer to the integer *s* of the digital signature.
pEC	Pointer to the context of the elliptic curve.
pScratchBuffer	Pointer to the scratch buffer.

Description

Functions generate a digital signature respectively to DSA [IEEE P1362A], Nyberg-Rueppel [IEEE P1362A] and SM2 [SM2] schemes.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if any of the contexts pointed to by *pMsgDigest*, *pRegPrivate*, *pEphPrivate*, *pSignR*, *pSignS*, or *pEC* does not match the operation.
`ippStsMessageErr`	Indicates an error condition if the value of *msg* pointed to by *pMsgDigest* falls outside the range of [1, *n*-1], where *n* is the order of the elliptic curve base point *G*.
`ippStsRangeErr`	Indicates an error condition if any of the parameters pointed to by *pSignR* or *pSignS* has memory size that is smaller than the order *n* of the elliptic curve base point *G*.
`ippStsIvalidPrivateKey`	Indicates an error condition if any of the parameters pointed to by *pRegPrivate* or *pEphPrivate* has memory size that is smaller than the order *n* of the elliptic curve base point *G*.
`ippStsNotSupportedModeErr`	Indicates an error condition if the finite field GFp under the elliptic curve is not prime.
`ippStsEphemeralKeyErr`	Indicates an error condition if values of the ephemeral keys *ephPrivKey* and *ephPubKey* are not valid: the digital signature calculation returns *r*=0 or *s*=0 as a result.

GFpECPVerifyDSA, GFpECPVerifyNR, GFpECPVerifySM2

Verifies authenticity of the digital signature over a message digest (ECDSA).

Syntax

IppStatus ippsGFpECVerifyDSA(const IppsBigNumState* *pMsgDigest*, const IppsGFpECPoint* *pRegPublic*, const IppsBigNumState* *pSignR*, const IppsBigNumState* *pSignS*, IppECResult* *pResult*, IppsGFpECState* *pEC*, Ipp8u* *pScratchBuffer*);

IppStatus ippsGFpECVerifyNR(onst IppsBigNumState* *pMsgDigest*, const IppsGFpECPoint* *pRegPublic*, const IppsBigNumState* *pSignR*, const IppsBigNumState* *pSignS*, IppECResult* *pResult*, IppsGFpECState* *pEC*, Ipp8u* *pScratchBuffer*);

IppStatus ippsGFpECVerifySM2(const IppsBigNumState* *pMsgDigest*, const IppsGFpECPoint* *pRegPublic*, const IppsBigNumState* *pSignR*, const IppsBigNumState* *pSignS*, IppECResult* *pResult*, IppsGFpECState* *pEC*, Ipp8u* *pScratchBuffer*);

Include Files

`ippcp.h`

Parameters

pMsgDigest	Pointer to the message digest *msg*.
pRegPublic	Pointer to the signer's regular public key.

pSignR	Pointer to the integer *r* of the digital signature.
pSignS	Pointer to the integer *s* of the digital signature.
pResult	Pointer to the digital signature verification result.
pEC	Pointer to the context of the elliptic curve.
pScratchBuffer	Pointer to the scratch buffer.

Description

These functions verify authenticity of the digital signature generated by the `ippsGFpECPSignDSA` , `ippsGFpECPSignNR`, and `ippsGFpECPSignSM2` functions, respectively. The signature consists of two large integers: *r* and *s*.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if any of the contexts pointed to by *pMsgDigest*, *pRegPublic*, *pSignR*, *pSignS*, or *pEC* does not match the operation.
`ippStsMessageErr`	Indicates an error condition if the value of *msg* pointed to by *pMsgDigest* falls outside the range of [1, *n*-1], where *n* is the order of the elliptic curve base point *G*.
`ippStsRangeErr`	Indicates an error condition if any of the parameters pointed to by *pSignR* or *pSignS* is negative.

GFpECSignNR

Computes the digital signature over a message digest (the Nyberg-Rueppel scheme).

Syntax

```
IppStatus ippsGFpECSignNR(const IppsBigNumState* pMsgDigest, const IppsBigNumState*
pRegPrivate, const IppsBigNumState* pEphPrivate, IppsBigNumState* pSignR,
IppsBigNumState* pSignS, IppsGFpECState* pEC, Ipp8u* pScratchBuffer);
```

Include Files

`ippcp.h`

Parameters

pMsgDigest	Pointer to the message digest *msg* to be digitally signed, that is, to be ecrypted with a private key.
pRegPrivate	Pointer to the regular private key of the signer.
pEphPrivate	Pointer to the ephemeral private key of the signer.
pSignR	Pointer to the integer *r* of the digital signature.
pSignS	Pointer to the integer *s* of the digital signature.
pEC	Pointer to the context of the elliptic curve.
pScratchBuffer	Pointer to the scratch buffer.

Description

The function computes two large numbers *r* and *s* which form the digital signature over a message digest *msg*.

The scheme used to compute the digital signature is an elliptic curve analogue of the El-Gamal Digital Signature scheme with the message recovery (the Nyberg-Rueppel signature scheme).

The regular private key *regPrivKey* and the ephemeral private key *ephPrivKey* can be generated by the functions GFpECPrivateKey and GFpECPublicKey with only the requirement that the key *regPrivKey* be different from the key *ephPrivKey*.

The elliptic curve domain parameters must be hitherto defined by the functions: GFpECInitStd, GFpECInit, GFpECSet, or GFpECSetSubgroup.

For more information on digital signatures, please refer to the [ANSI] standard.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if any of the contexts pointed by *`pMsgDigest`*, *`pRegPrivate`*, *`pEphPrivate`*, *`pSignR`*, *`pSignS`*, or *`pEC`* does not match the operation.
`ippStsMessageErr`	Indicates an error condition if the value of *msg* pointed to by *`pMsgDigest`* falls outside the range of [1, *n*-1] where *n* is the order of the elliptic curve base point *G*.
`ippStsRangeErr`	Indicates an error condition if any of the parameters pointed to by *`pSignR`* or *`pSignS`* has a memory size that is less than the order *n* of the elliptic curve base point *G*.
`ippStsIvalidPrivateKey`	Indicates an error condition if any of the parameters pointed to by *`pRegPrivate`* or *`pEphPrivate`* has a memory size that is less than the order *n* of the elliptic curve base point *G*.
`ippStsNotSupportedModeErr`	Indicates an error condition if the finite field GFp under the elliptic curve is not prime.
`ippStsErr`	Indicates an error condition if the ephemeral private key is bad.

GFpECVerifyNR

Verifies authenticity of the digital signature over a message digest (the Nyberg-Rueppel scheme).

Syntax

IppStatus ippsGFpECVerifyNR(onst IppsBigNumState* *pMsgDigest*, const IppsGFpECPoint* *pRegPublic*, const IppsBigNumState* *pSignR*, const IppsBigNumState* *pSignS*, IppECResult* *pResult*, IppsGFpECState* *pEC*, Ipp8u* *pScratchBuffer*);

Include Files

`ippcp.h`

Parameters

`pMsgDigest`	Pointer to the message digest *msg*.

pRegPublic	Pointer to the signer's regular public key.
pSignR	Pointer to the integer *r* of the digital signature.
pSignS	Pointer to the integer *s* of the digital signature.
pResult	Pointer to the digital signature verification result.
pEC	Pointer to the context of the elliptic curve.
pScratchBuffer	Pointer to the scratch buffer.

Description

The function verifies authenticity of the digital signature over a message digest *msg*. The signature consists of two large integers: *r* and *s*.

The scheme used to compute the digital signature is an elliptic curve analogue of the El-Gamal Digital Signature scheme with the message recovery (the Nyberg-Rueppel signature scheme).

You can get the message sender's regular public key *regPubKey* by calling the function GFpECPublicKey.

The result of the digital signature verification can take one of two possible values:

ippECValid	Digital signature is valid.
ippECInvalidSignature	Digital signature is not valid.

The call to the GFpECVerifyNR function must be preceded by a call to the GFpECSignNR function which computes the digital signature over the message digest *msg* and represents the signature with two numbers: *r* and *s*.

The elliptic curve domain parameters must be hitherto defined by the functions: GFpECInitStd, GFpECInit, GFpECSet, or GFpECSetSubgroup.

For more information on digital signatures, please refer to the [ANSI] standard.

Return Values

ippStsNoErr	Indicates no error. Any other value indicates an error or warning.
ippStsNullPtrErr	Indicates an error condition if any of the specified pointers is NULL.
ippStsContextMatchErr	Indicates an error condition if any of the contexts pointed to by *pMsgDigest*, *pRegPublic*, *pSignR*, *pSignS*, or *pEC* does not match the operation.
ippStsMessageErr	Indicates an error condition if the value of *msg* pointed to by *pMsgDigest* falls outside the range of [1, *n*-1] where *n* is the order of the elliptic curve base point *G*.
ippStsRangeErr	Indicates an error condition if any of the parameters pointed to by *pSignR* or *pSignS* is negative.
ippStsOutOfRangeErr	Indicates an error condition if the public key point does not belong to the finite field over which the elliptic curve is initialized.
ippStsNotSupportedModeErr	Indicates an error condition if the finite field GFp under the elliptic curve is not prime.

GFpECSignSM2

Computes a digital signature over a message digest using the SM2 scheme.

Syntax

IppStatus ippsGFpECSignSM2(const IppsBigNumState* *pMsgDigest*, const IppsBigNumState* *pRegPrivate*, const IppsBigNumState* *pEphPrivate*, IppsBigNumState* *pSignR*, IppsBigNumState* *pSignS*, IppsGFpECState* *pEC*, Ipp8u* *pScratchBuffer*);

Include Files

ippcp.h

Parameters

pMsgDigest	Pointer to the message digest *msg* to be digitally signed, that is, to be encrypted with a private key.
pRegPrivate	Pointer to the regular private key of the signer.
pEphPrivate	Pointer to the ephemeral private key of the signer.
pSignR	Pointer to the integer *r* of the digital signature.
pSignS	Pointer to the integer *s* of the digital signature.
pEC	Pointer to the context of the elliptic curve.
pScratchBuffer	Pointer to the scratch buffer.

Description

The function computes two big numbers *r* and *s* that form the digital signature over a message digest *msg*.

The digital signature is computed using the SM2 scheme [SM2].

The regular private key *regPrivKey* and the ephemeral private key *ephPrivKey* can be generated by the functions GFpECPrivateKey and GFpECPublicKey with only the requirement that the key *regPrivKey* be different from the key *ephPrivKey*.

The elliptic curve domain parameters must be hitherto defined by the functions: GFpECInitStd, GFpECInit, GFpECSet, or GFpECSetSubgroup.

Return Values

ippStsNoErr	Indicates no error. Any other value indicates an error or warning.
ippStsNullPtrErr	Indicates an error condition if any of the specified pointers is NULL.
ippStsContextMatchErr	Indicates an error condition if any of the contexts pointed to by *pMsgDigest*, *pRegPrivate*, *pEphPrivate*, *pSignR*, *pSignS*, or *pEC* does not match the operation.
ippStsMessageErr	Indicates an error condition if the value of *msg* pointed to by *pMsgDigest* is negative.
ippStsRangeErr	Indicates an error condition if any of the parameters pointed to by *pSignR* or *pSignS* has a memory size that is smaller than the order *n* of the elliptic curve base point *G*.
ippStsIvalidPrivateKey	Indicates an error condition in the following cases: • Any of the parameters pointed to by *pRegPrivate* or *pEphPrivate* has a memory size that is smaller than the order *n* of the elliptic curve base point *G*.

	• Value of any of the private keys is greater than or equal to the order *n* of the elliptic curve base point *G*.
`ippStsNotSupportedModeErr`	Indicates an error condition if the finite field GFp under the elliptic curve is not prime.
`ippStsEphemeralKeyErr`	Indicates an error condition if values of the ephemeral keys *ephPrivKey* and *ephPubKey* are not valid: the digital signature calculation returns *r*=0 or *s*=0 as a result.

GFpECVerifySM2

Verifies authenticity of a digital signature over a message digest using the SM2 scheme.

Syntax

```
IppStatus ippsGFpECVerifySM2(const IppsBigNumState* pMsgDigest, const IppsGFpECPoint*
pRegPublic, const IppsBigNumState* pSignR, const IppsBigNumState* pSignS, IppECResult*
pResult, IppsGFpECState* pEC, Ipp8u* pScratchBuffer);
```

Include Files

`ippcp.h`

Parameters

pMsgDigest	Pointer to the message digest *msg*.
pRegPublic	Pointer to the signer's regular public key.
pSignR	Pointer to the integer *r* of the digital signature.
pSignS	Pointer to the integer *s* of the digital signature.
pResult	Pointer to the digital signature verification result.
pEC	Pointer to the context of the elliptic curve.
pScratchBuffer	Pointer to the scratch buffer.

Description

The function verifies authenticity of the digital signature, represented as integer big numbers *r* and *s*, over a message digest *msg*. The digital signature over the message digest *msg* must be computed using the SM2 scheme [SM2] by to the GFpECSignSM2 function.

You can get the message sender's regular public key *regPubKey* by calling the function GFpECPublicKey.

The result of the digital signature verification can take one of these values:

`ippECValid`	Digital signature is valid.
`ippECInvalidSignature`	Digital signature is not valid.

The elliptic curve domain parameters must be hitherto defined by the functions: GFpECInitStd, GFpECInit, GFpECSet, or GFpECSetSubgroup.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.

`ippStsContextMatchErr`	Indicates an error condition if any of the contexts pointed to by *pMsgDigest*, *pRegPublic*, *pSignR*, *pSignS*, or *pEC* does not match the operation.
`ippStsMessageErr`	Indicates an error condition if the value of *msg* pointed to by *pMsgDigest* falls outside the range of [1, *n*-1], where *n* is the order of the elliptic curve base point *G*.
`ippStsRangeErr`	Indicates an error condition if any of the parameters pointed to by *pSignR* or *pSignS* is negative.
`ippStsOutOfRangeErr`	Indicates an error condition if the public key point does not belong to the finite field over which the elliptic curve is initialized.
`ippStsNotSupportedModeErr`	Indicates an error condition if the finite field GFp under the elliptic curve is not prime.

ECCGetResultString

For elliptic curve cryptosystems, returns the character string corresponding to code that represents the result of validation.

Syntax

```
const char* ippsECCGetResultString(IppECResult code);
```

Include Files

`ippcp.h`

Parameters

code	The code of the validation result.

Description

For elliptic curve cryptosystems, returns the character string corresponding to code that represents the result of validation.

Return Values

Possible values of code and the corresponding character strings are as follows:

default	"Unknown ECC result"
`ippECValid`	"Validation passed successfully"
`ippECCompositeBase`	"Finite Field produced by Composite"
`ippECComplicatedBase`	"Too many non-zero terms in the polynomial"
`ippECIsZeroDiscriminant`	"Zero discriminant"
`ippECCompositeOrder`	"Composite Base Point order"
`ippECInvalidOrder`	"Composite Base Point order"
`ippECIsWeakMOV`	"EC cover by MOV Reduction Test"
`ippECIsWeakSSSA`	"EC cover by SS-SA Reduction Test"
`ippECIsSupersingular`	"EC is supersingular curve"

`ippECInvalidPrivateKey`	"Invalid Private Key"
`ippECInvalidPublicKey`	"Invalid Public Key"
`ippECInvalidKeyPair`	"Invalid Key Pair"
`ippECPointOutOfGroup`	"Point is out of group"
`ippECPointAtInfinite`	"Point at infinity"
`ippECPointIsNotValid`	"Invalid EC Point"
`ippECPointIsEqual`	"Points are equal"
`ippECPointIsNotEqual`	"Points are different"
`ippECInvalidSignature`	"Invalid Signature"

See Also

`ECCPValidate`
`ECCPValidateKeyPair`

Finite Field Arithmetic

This section describes the Intel® Integrated Performance Primitives Cryptography (Intel® IPP Cryptography) functions that implement arithmetic operations with elements of the following finite fields [ANT]:

GF(p)	A finite field of p elements.
GF(q)	If q is an odd prime number, then the finite field is represented by integers modulo q. This field is also known as the *prime finite field*.
GF(p^d)	If p = q, q is an odd prime number and d > 1, the finite field is represented by polynomials modulo $g(x)$, GF(p)[x]/$g(x)$, where $g(x)$ is an irreducible polynomial over GF(p). This field is also known as *a degree d extension of the GF(p) field*.
GF($((q^{n1})^{n2})^{n3}$)	A very complex extension of the prime finite field GF(q). The initial prime field GF(q) used at the lowest level of the construct is frequently called the *basic finite field* with respect to the extension.

The finite field arithmetic functions use context structures of the `IppsGFpState` and `IppsGFpElement` types to store data of the finite field and the field elements, respectively.

The `IppsGFpElement` type structure is used for *internal* representation of field elements. In application (*or external*) representation of field element is straightforward. Each element E of the prime field GF(q) is an unsigned number in the range [0, q - 1], which is represented by a data array `Ipp32u qe[len32]` , so that

$$E = \sum_{i=0}^{len32-1} qe[i] 2^{32i}$$

where $len32 = \lceil bitsize(q)/32 \rceil$ is the length of the prime q, expressed in *dwords* (32-bit chunks).

Each element E of GF(p^d) is represented by a polynomial of degree less than d. This polynomial is represented by an array of coefficients `pe[d]` that belong to GF(p).

$$E = \sum_{j=0}^{d-1} x^j \left| \sum_{i=0}^{len32-1} qe[i] 2^{32i} \right|$$

Thus,

```
Ipp32u a[4] = {0xBFF9AEE1,0xBF59CC9B,0xD1B3BBFE,0xD6031998};
```

is an external (application-side) representation of an element that belongs to some prime field GF(q), bitsize(q)=128.

Similarly,

```
Ipp32u b[2][4] = { {0xBFF9AEE1,0xBF59CC9B,0xD1B3BBFE,0xD6031998},
                   {0xBB6D8A5D,0xDC2C6558,0x80D02919,0x5EEEFCA3}  };
```

is an external (application-side) representation of an element that belongs to GF(q^2) - a degree 2 extension of some prime field GF(q), bitsize(q)=128.

You can use Intel IPP Cryptography finite field functions to convert between the internal and the external representations of a finite field element.

Prime finite fields are the basic mathematical objects of Elliptic Curve (EC) cryptography. Intel IPP Cryptography supports different kinds of EC over finite fields and, in particular, the *standard* elliptic curves - elliptic curves with pre-defined parameters, including the underlying finite field. The performance of EC functionality directly depends on the efficiently of the implementation of operations with finite field elements such as addition, multiplication, and squaring.

Intel IPP Cryptography contains several different optimized implementations of finite field arithmetic functions. These implementations, referred to in this document as "methods", are grouped together in structures. Intel IPP Cryptography does not reveal the content of these structures. The implementations, including those optimized for a particular prime q, are accessed by special Intel IPP Cryptography functions. For example, `ippsGFpMethod_p192r1()` returns a pointer to the structure containing optimized arithmetic over prime *p192r1* (see `GFpMethod` for details).

Similarly, for GF(p^d), additional knowledge concerning the predefined field polynomial $g(x)$ allows Intel IPP Cryptography to provide a more efficient implementation of finite field arithmetic than in the case of an arbitrary field polynomial $g(x)$. Intel IPP Cryptography contains *methods* dedicated to certain predefined $g(x)$. For example, the functions `ippsGFpxMethod_binom2()` returns a pointer to the structure containing optimized arithmetic over GF(p^2).

The comparison function `GFpCmpElement` returns the result of comparison:

```
#define IPP_IS_EQ (0) // elements are equal
#define IPP_IS_GT (1) // the first element is greater than the second one
#define IPP_IS_LT (2) // the first element is less than the second one
#define IPP_IS_NE (3) // elements are not equal
#define IPP_IS_NA (4) // elements are not comparable
```

Product and Performance Information

Performance varies by use, configuration and other factors. Learn more at www.Intel.com/PerformanceIndex.

Notice revision #20201201

GFpInit

Initializes the context of a prime finite field GF(q).

Syntax

```
IppStatus ippsGFpInit(const IppsBigNumState* pPrime, int primeBitSize, const
IppsGFpMethod* method, IppsGFpState* pGF);
```

Include Files

`ippcp.h`

Parameters

pPrime	Pointer to the Big Number context storing the GF(*q*) modulus.
primeBitSize	Size, in bytes, of the odd prime number *p* (modulus of GF(*q*)).
method	Pointer to the implementation of a basic arithmetic (methods) over the prime finite field GF(*q*). **NOTE** If your application uses one of predefined values of the modulus *q*, the use of the `GFpMethod` function corresponding to that value is preferable. In other cases, use `ippsGfpMethod_pArb()`.
pGF	Pointer to the context of the GF(*q*) field being initialized.

Description

The function initializes the *pGF* context parameter with the values of the input parameters*pPrime*, *primeBitSize*, and *method*. The three parameters have to be compatible with each other.

The *method* parameter must be an output from one of the `GFpMethod` functions with predefined modulus *q*, and the parameters *primeBitSize* and *method* must be compatible with each other.

If *pPrime* is not `NULL`, and *method* is an output from one of the `GFpMethod` functions with predefined modulus *q*, then the pair *pPrime* and *primeBitSize* should define the same prime *q* as defined in *method*.

If both *pPrime* and *method* are not `NULL`, then `ippsGFpInit()` provides the required initialization if the parameters are compatible with each other.

The initialized context is used in the functions that create contexts of elements of the GF(*p*) field, which, in turn, are used to perform operations with the field elements.

NOTE
This function does not check if *pPrime* actually refers to a prime value.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition in the following cases: • *pGF* is `NULL`. • Both *pPrime* and *method* are `NULL`.
`ippStsSizeErr`	Indicates an error condition if *primeBitSize* is less than 2 or greater than 1024.
`ippStsContextMatchErr`	Indicates an error condition if the *pPrime* context parameter is not `NULL` and does not match the operation.
`ippStsBadArgErr`	Indicates an error condition in the following cases: • The modulus *q* defined in *pPrime* is less than 3. • bitsize(*q*) != *primeBitSize*. • *q* is even.

- *method* is not NULL and not an output of GFpMethod.
- *method* is an output from one of the GFpMethod functions with predefined modulus *q*, but:
  - The bit size of *q* of *method* is different from the bit size of the value stored in the context pointed to by *pPrime*.
  - *q* of *method* is different from the value stored in the context pointed to by *pPrime*.

GFpMethod

Returns a reference to an implementation of arithmetic operations over GF(q).

Syntax

```
const IppsGFpMethod* ippsGFpMethod_p192r1(void);

const IppsGFpMethod* ippsGFpMethod_p224r1(void);

const IppsGFpMethod* ippsGFpMethod_p256r1(void);

const IppsGFpMethod* ippsGFpMethod_p384r1(void);

const IppsGFpMethod* ippsGFpMethod_p521r1(void);

const IppsGFpMethod* ippsGFpMethod_p256sm2(void);

const IppsGFpMethod* ippsGFpMethod_pArb(void);
```

Include Files

ippcp.h

Description

Each of these functions returns a pointer to a structure containing an implementation of arithmetic operations over GF(*q*).

ippsGFpMethod_pArb() assumes an arbitrary modulus *q*; each of the rest of the functions returns a pointer to the implementation of arithmetic operations over GF(*q*) tailored for a particular *q*. See the table below for the correspondence between method functions and values of the modulus *q*.

Function	**Value of modulus *q***
ippsGFpMethod_p192r1()	$q = 2^{192} - 2^{64} - 1$
ippsGFpMethod_p224r1()	$q = 2^{224} - 2^{96} - 1$
ippsGFpMethod_p256r1()	$q = 2^{256} - 2^{224} + 2^{192} + 2^{96} - 1$
ippsGFpMethod_p384r1()	$q = 2^{384} - 2^{128} - 2^{96} + 2^{32} - 1$
ippsGFpMethod_p521r1()	$q = 2^{521} - 1$
ippsGFpMethod_p256sm2()	$q = 2^{256} - 2^{224} - 2^{96} + 2^{64} - 1$
ippsGFpMethod_pArb()	Arbitrary modulus *q*

GFpGetSize

Gets the size of the context of a GF(q) field.

Syntax

`IppStatus ippsGFpGetSize(int` *`febitSize`*`, int*` *`pSize`*`);`

Include Files

`ippcp.h`

Parameters

`febitSize`	Size, in bytes, of the odd prime number *q* (modulus of GF(*q*)).
`pSize`	Pointer to the buffer size, in bytes, needed for the `IppsGFpState` context.

Description

This function returns the size of the buffer associated with the `IppsGFpState` context, which you can use to store data of the finite field GF(*q*) determined by the odd prime number *q* of size not greater than *`febitSize`* bit.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsSizeErr`	Indicates an error condition if *`febitSize`* is less than 2 or greater than 1024.

GFpxInitBinomial

Initializes the context of a GF(p^d) field.

Syntax

`IppStatus ippsGFpxInitBinomial(const IppsGFpState*` *`pParentGF`*`, int` *`extDeg`*`, const IppsGFpElement* const` *`pGroundElm`*`, const IppsGFpMethod*` *`method`*`, IppsGFpState*` *`pGFpx`*`);`

Include Files

`ippcp.h`

Parameters

`pParentGF`	Pointer to the context of the finite field GF(*p*) being extended.
`extDeg`	Degree of the extension.
`pGroundElm`	Pointer to the `IppsGFpElement` context containing the trailing coefficient of the field binomial.
`method`	Pointer to the implementation of a basic arithmetic (methods) over GF(p^d).
`pGFpx`	Pointer to the context of the GF(p^d) field being initialized.

Description

This function initializes the memory buffer *pGFpx* associated with the `IppsGFpState` context and sets up the specific irreducible binomial. The initialized context is used in the functions that create contexts of elements of the GF(p^d) field and perform operations with field elements.

NOTE
The function does not check the binomial's irreducibility.

Important
When calling the functions over the GF(p^d) field, a properly initialized *`pParentGF`* context of the finite field GF(p) is required.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if any of the context parameters *`pParentGF`* and *`pGroundElm`* does not match the operation.
`ippStsBadArgErr`	Indicates an error condition in the following cases: • *`extDeg`* > 8 or *`extDeg`* < 2. • *`method`* is not in agreement with other parameters.
`ippStsOutOfRangeErr`	Indicates an error condition if the length of the value defined in *`pGroundElm`* is not equal to that of an element of *`pParentGF`*.

GFpxInit

Initializes the context of a GF(p^d) field.

Syntax

```
IppStatus ippsGFpxInit(const IppsGFpState* pParentGF, int extDeg, const IppsGfpElement*
const ppGroundElm[], int polyTerms, const IppsGFpMethod* method, IppsGFpState* pGFpx);
```

Include Files

`ippcp.h`

Parameters

`pParentGF`	Pointer to the context of the finite field GF(p) being extended.
`extDeg`	Degree of the extension.
`ppGroundElm[]`	Double pointer to the array of `IppsGFpElement` contexts representing coefficients of the field polynomial.
`polyTerms`	Number of the field polynomial coefficients.
`method`	Pointer to the implementation of a basic arithmetic (methods) over the extended GF(p) finite field.

pGFpx	Pointer to the context of the GF(p^d) field being initialized.

Description

The function initializes the memory buffer *pGFpx* associated with the `IppsGFpState` context and sets up the specific irreducible polynomial. The initialized context is used in the functions that create contexts of elements of the GF(p^d) field and perform operations with the field elements. The function assumes the use of a general field polynomial $g(x) = x^d + x^{d-1}a_{d-1} + x^{d-2}a_{d-2} + \cdots + x^1a_1 + a_0$ over GF(p).

NOTE

- The function does not check the polynomial's irreducibility.
- In general, the GF(p^d) extension requires a field polynomial $g(x)$ of degree d. However, because $g(x)$ is considered a monic polynomial (the coefficient of *xd* is always assumed equal to 1), the leading coefficient is not required: *`polyTerms`* <= (*`extDeg`* - 1).

Important

- When calling the functions over the GF(p^d) field, a properly initialized *`pParentGF`* context of the finite field GF(p) is required.
- Do not release the *`pParentGF`* context of the parent field as long as application deals with either the parent or the extended finite field pointed to by *`pGFpx`*.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if any of the context parameters referenced by elements of *`ppGroundElm[]`* or *`pParentGF`* does not match the operation.
`ippStsBadArgErr`	Indicates an error condition in the following cases: • *`extDeg`* > 8 or *`extDeg`* < 2. • *`polyTerms`* > (*`extDeg`* - 1) or *`polyTerms`* < 1. • *`method`* is not an output of a `GFpxMethod` function. • *`method`* is not compatible with the value of *`extDeg`*.
`ippStsOutOfRangeErr`	Indicates an error condition if the length of any of the values defined by *`ppGroundElm[]`* is not equal to the length of an element of the parent finite field *`pParentGF`*.

GFpxMethod

Returns a reference to the implementation of arithmetic operations over GF(p^d).

Syntax

```
const IppsGFpMethod* ippsGFpxMethod_com(void);
```

```
const IppsGFpMethod* ippsGFpxMethod_binom2(void);
const IppsGFpMethod* ippsGFpxMethod_binom3(void);
const IppsGFpMethod* ippsGFpxMethod_binom(void);
```

Include Files

`ippcp.h`

Description

Each of these functions returns a pointer to a structure containing an implementation of arithmetic operations over GF(p^d).

`ippsGFpxMethod_com` assumes an arbitrary value of the field polynomial $g(x)$; each of the rest of the functions returns a pointer to the implementation of arithmetic operations over GF(p^d) tailored for a particular value of $g(x)$. See the table below for the correspondence between method functions and values of the field polynomial $g(x)$.

NOTE
`ippsGFpxMethod_binom2_epid2()` and `ippsGFpxMethod_binom3_epid2()` are designed especially for the construction of finite field extensions for applications that use the Intel® Enhanced Privacy ID 2.0 scheme.

GFpxGetSize

Gets the size of the context of a GF(p^d) field.

Syntax

IppStatus ippsGFpxGetSize(const IppsGFpState* *pParentGF*, int *degree*, int* *pSize*);

Include Files

`ippcp.h`

Parameters

pParentGF	Pointer to the context of the finite field GF(p) being extended.
degree	Degree of the extension.
pSize	Pointer to the buffer size, in bytes, needed for the `IppsGFpState` context.

Description

The function returns the size of the buffer associated with the `IppsGFpState` context, suitable for storing data for the finite field GF(p^d) determined by the extension degree d supplied in the *degree* parameter.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the `IppsGFpState` context parameter does not match the operation.

`ippStsBadArgErr`	Indicates an error condition if the degree of the extension is greater than or equal to 9 or is less than 2.

GFpScratchBufferSize

Gets the size of the scratch buffer.

Syntax

IppStatus ippsGFpScratchBufferSize(int *nExponents*, int *ExpBitSize*, const IppsGFpState* *pGFp*, int* *pBufferSize*);

Include Files

`ippcp.h`

Parameters

nExponents	Number of exponents.
ExpBitSize	Maximum bit size of the exponents.
pGFp	Pointer to the context of the finite field.
pBufferSize	Pointer to the calculated buffer size in bytes.

Description

This function computes the size of the scratch buffer for the `ippsGFpExp` and `ippsGFpMultiExp` functions. The *pGFp* parameter specifies the context of the finite field.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the *pGFp* context parameter does not match the operation.
`ippStsBadArgErr`	Indicates an error condition in the following cases: • The number of exponents is zero or negative. • The number of exponents is greater than 6.

GFpElementGetSize

Gets the size of the context for an element of the finite field.

Syntax

IppStatus ippsGFpElementGetSize(const IppsGFpState* *pGFp*, int* *pElementSize*);

Include Files

`ippcp.h`

Parameters

pGFp	Pointer to the context of the finite field.
pElementSize	Pointer to the buffer size, in bytes, needed for the `IppsGFpElement` context.

Description

This function returns the size of the buffer associated with the `IppsGFpElement` context, suitable for storing an element of the finite field specified by the context *pGFp*.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if the *pGFp* context parameter does not match the operation.

GFpElementInit

Initializes the context of an element of the finite field.

Syntax

```
IppStatus ippsGFpElementInit(const Ipp32u* pA, int nsA, IppsGFpElement* pR,
IppsGFpState* pGF);
```

Include Files

`ippcp.h`

Parameters

pA	Pointer to the data array storing the finite field element.
lenA	Length of the element.
pR	Pointer to the context of the finite field element being initialized.
pGFp	Pointer to the context of the finite field.

Description

This function initializes the memory buffer *pR* associated with the `IppsGFpElement` context and sets up the specific element of the finite field specified by the *pGFp* context. The initialized `IppsGFpElement` context is used in all the operations with this element of the finite field.

If the *lenA* parameter value equals zero, the function initializes a zero element. If the value is less than zero, the function fails.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition in the following cases:

	• *lenA* is not zero and any of the specified pointers is NULL. • *lenA* is zero and *pR* or *pGFp* is NULL.
`ippStsContextMatchErr`	Indicates an error condition if the *pGFp* context parameter does not match the operation.
`ippStsSizeErr`	Indicates an error condition if *lenA* ≤ 0.

GFpSetElement

Assigns a value to an element of the finite field.

Syntax

```
IppStatus ippsGFpSetElement(const Ipp32u* pA, int lenA, IppsGFpElement* pR,
IppsGFpState* pGFp);
```

Include Files

`ippcp.h`

Parameters

pA	Pointer to the data array storing the finite field element.
lenA	Length of the element.
pR	Pointer to the context of the finite field element being assigned.
pGFp	Pointer to the context of the finite field.

Description

This function copies (and converts if needed) the value from the user-defined *pA* buffer to the `IppsGFpElement` context of the finite field element. If *pR* is NULL, `GFpSetElement` assigns zero to the element.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition in the following cases: • Either *pR* or *pGFp* is NULL. • The length of the element *lenA* is greater than zero and the pointer *pA* is NULL.
`ippStsContextMatchErr`	Indicates an error condition if any of the *pGFp* and*pR* context parameters does not match the operation.
`ippStsSizeErr`	Indicates an error condition in the following cases: • *lenA* is not equal to the length of an element of the finite field. • The maximum length of the element stored in the context *pR* exceeds the maximum length of an element of the finite field specified by the context *pGFp*.
`ippStsOutOfRangeErr`	Indicates an error condition if the value contained in *pA* exceeds the modulus *q* of the basic prime finite field.

GFpSetElementOctString

Assigns a value from the input octet string to an element of the finite field.

Syntax

```
IppStatus ippsGFpSetElementOctString(const Ipp8u* pStr, int strSize, IppsGFpElement*
pR, IppsGFpState* pGFp);
```

Include Files

`ippcp.h`

Parameters

pStr	Pointer to the octet string.
strSize	Size of the octet string buffer in bytes.
pR	Pointer to the context of the finite field element.
pGFp	Pointer to the context of the finite field.

Description

This function assigns a value from the input octet string to an element of the finite field.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition in any of the following cases: • Either *pR* or *pGFp* is NULL. • The length of the string is greater than zero and the pointer *pStr* is NULL.
`ippStsContextMatchErr`	Indicates an error condition if any of the *pGFp* and *pR* context parameters does not match the operation.
`ippStsSizeErr`	Indicates an error condition in any of the following cases: • *strSize* exceeds the length of an element of the finite field. • *strSize* ≤ 0. • The maximum length of the element stored in the context *pR* exceeds the maximum length of an element of the finite field specified by the context *pGFp*.
`ippStsOutOfRangeErr`	Indicates an error condition in any of the following cases: • The length of the element stored in the context *pR* is not equal to the length of an element of the finite field specified by the context *pGFp*. • The value defined by *pStr* exceeds the modulus *q* of the basic prime finite field.

GFpSetElementRandom

Assigns a random value to an element of the finite field.

Syntax

```
IppStatus1 ippsGFpSetElementRandom(IppsGFpElement* pR, IppsGFpState* pGFp,
IppBitSupplier rndFunc, void* pRndParam);
```

Include Files

`ippcp.h`

Parameters

pR	Pointer to the context of the finite field element.
pGFp	Pointer to the context of the finite field.
rndFunc	Pseudorandom number generator.
pRndParam	Pointer to the context of the pseudorandom number generator.

Description

This function assigns a random value to an element of the finite field.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the pointers *pR*, *pGFp* and *rndFunc* is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if any of *pGFp* or *pR* context parameters does not match the operation.
`ippStsErr`	Indicates an error condition in the following cases: • A call to the *rndFunc*() function returns a status value other than `ippStsNoErr`. • The maximum length of the element stored in the context *pR* exceeds the maximum length of an element of the finite field specified by the context *pGFp*.
`ippStsOutOfRangeErr`	Indicates an error condition if the length of the element stored in the context *pR* is not equal to the length of an element of the finite field specified by the context *pGFp*.

GFpSetElementHash

Assigns a value from the input hash to an element of the finite field.

Syntax

```
IppStatus ippsGFpSetElementHash(const Ipp8u* pMsg, int msgLen, IppsGFpElement* pElm,
IppsGFpState* pGF, IppHashAlgId hashID);
```

Include Files

`ippcp.h`

Parameters

pMsg	Pointer to the input message.
msgLen	Length of the input message.
pElm	Pointer to the context of the finite field element.
pGF	Pointer to the context of the finite field.
hashID	ID of the hash algorithm used. For details, see table Supported Hash Algorithms.

Description

This function computes an element of the finite field from the hash of the input message.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNotSupportedModeErr`	Indicates an error condition if *hashID* does not correspond to any supported hash ID.
`ippStsNullPtrErr`	Indicates an error condition in one of the following cases: • Any of the pointers *pElm* and *pGF* is `NULL`. • The *msgLen* is greater than zero and the pointer *pMsg* is `NULL`.
`ippStsLengthErr`	Indicates an error condition if *msgLen* is negative.
`ippStsContextMatchErr`	Indicates an error condition if any of the*pGF* and *pElm* context parameters does not match the operation.
`ippStsBadArgErr`	Indicates an error condition if the finite field specified by the context *pGF* is not a prime finite field.
`ippStsOutOfRangeErr`	Indicates an error condition if the length of the element stored in the context *pElm* is not equal to the length of an element of the finite field specified by the context *pGF*.

GFpCpyElement

Copies one element of the finite field to another element.

Syntax

```
IppStatus ippsGFpCpyElement(const IppsGFpElement* pA, IppsGFpElement* pR, IppsGFpState*
pGFp);
```

Include Files

`ippcp.h`

Parameters

pA	Pointer to the context of the finite field element being copied.

pR	Pointer to the context of the finite field element being changed.
pGFp	Pointer to the context of the finite field.

Description

This function copies one element of the finite field to another. The finite field is specified by the context *pGFp*.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if any of the `IppsGFpState` and `IppsGFpElement` context parameters does not match the operation.
`ippStsOutOfRangeErr`	Indicates an error condition if the input elements do not belong to the finite field specified by the context *pGFp*.

GFpGetElement

Extracts an element of the finite field from the context.

Syntax

```
IppStatus ippsGFpGetElement(const IppsGFpElement* pA, Ipp32u* pDataA, int lenA,
IppsGFpState* pGFp);
```

Include Files

`ippcp.h`

Parameters

pA	Pointer to the context of the finite field element.
pDataA	Pointer to the data array to copy the finite field element from.
lenA	Length of the data array.
pGFp	Pointer to the context of the finite field.

Description

This function copies the element of the finite field from the `IppsGFpElement` context to the user-defined *pDataA* buffer. The finite field is specified by the context *pGFp*.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if any of `IppsGFpState` and `IppsGFpElement` context parameters does not match the operation.

`ippStsOutOfRangeErr`	The input elements do not belong to the finite field specified by the context *pGFp*
`ippStsSizeErr`	The length of the data array is negative or less than the finite field element length.

GFpGetElementOctString

Extracts an element of the finite field from the context to the output octet string.

Syntax

`IppStatus ippsGFpGetElementOctString(const IppsGFpElement* pA, Ipp8u* pStr, int strSize, IppsGFpState* pGFp);`

Include Files

`ippcp.h`

Parameters

pA	Pointer to the context of the finite field element.
pStr	Pointer to the octet string.
strSize	Size of the octet string buffer in bytes.
pGFp	Pointer to the context of the finite field.

Description

This function extracts the element of the finite field from the context to the octet string. If the string length is not enough to hold the whole finite field element, the function writes only a part of the element.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if any of the *pGFp* and *pA* context parameters does not match the operation.
`ippStsSizeErr`	Indicates an error if the length of the string is zero or negative.
`ippStsOutOfRangeErr`	Indicates an error condition if the element *pA* does not belong to the finite field specified by the context *pGFp*.

GFpCmpElement

Compares two elements of the finite field.

Syntax

`IppStatus ippsGFpCmpElement(const IppsGFpElement* pA, const IppsGFpElement* pB, int* pResult, const IppsGFpState* pGFp);`

Include Files

`ippcp.h`

Parameters

pA	Pointer to the context of the first finite field element.
pB	Pointer to the context of the second finite field element.
pResult	Pointer to the result of the comparison. For details, see comparison results.
pGFp	Pointer to the context of the finite field.

Description

This function compares two elements of the finite field and returns the result in *pResult*. The finite field is specified by the context *pGFp*.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if any of `IppsGFpState` and `IppsGFpElement` context parameters does not match the operation.
`ippStsOutOfRangeErr`	Indicates an error condition if either *pA* or *pB* does not belong to the finite field specified by the context *pGFp*.

GFpIsZeroElement

Compares an element of the finite field with the zero element.

Syntax

```
IppStatus ippsGFpIsZeroElement(const IppsGFpElement* pA, int* pResult, const
IppsGFpState* pGFp);
```

Include Files

`ippcp.h`

Parameters

pA	Pointer to the context of the first finite field element.
pResult	Pointer to the result of the comparison. For details, see comparison results.
pGFp	Pointer to the context of the finite field.

Description

This function compares an element of the finite field with the zero element. The finite field is specified by the context *pGFp*.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.

`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if any of the `IppsGFpState` and `IppsGFpElement` context parameters does not match the operation.
`ippStsOutOfRangeErr`	Indicates an error condition if *pA* does not belong to the finite field specified by the context *pGFp*.

GFpIsUnityElement

Compares an element of the finite field with the unity element.

Syntax

`IppStatus ippsGFpIsUnityElement(const IppsGFpElement* pA, int* pResult, const IppsGFpState* pGFp);`

Include Files

`ippcp.h`

Parameters

pA	Pointer to the context of the first finite field element.
pResult	Pointer to the result of the comparison.For details, see comparison results.
pGFp	Pointer to the context of the finite field.

Description

This function compares an element of the finite field with the unity element. The finite field is specified by the context *pGFp*.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if any of `IppsGFpState` and `IppsGFpElement` context parameters does not match the operation.
`ippStsOutOfRangeErr`	Indicates an error condition if*pA* does not belong to the finite field specified by the context *pGFp*.

GFpConj

Computes the conjugate of the element of the finite field GF(p^2).

Syntax

`IppStatus ippsGFpConj(const IppsGFpElement* pA, IppsGFpElement* pR, IppsGFpState* pGFp);`

Include Files

`ippcp.h`

Parameters

pA	Pointer to the context of the finite field element.
pR	Pointer to the context of the resulting element of the finite field.
pGFp	Pointer to the context of the finite field.

Description

This function computes the conjugate of an element of the finite field GF(p^2). If the element of the GF(p^2) field is the polynomial $x + a$, the conjugate element is equal to $x - a$, where a is an element of the ground field GF(p).

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if any of `IppsGFpState` and `IppsGFpElement` context parameters does not match the operation.
`ippStsOutOfRangeErr`	Indicates an error condition if the element *pA* does not belong to the finite field specified by the context *pGFp*.
`ippStsBadArgErr`	Indicates an error condition if the element *pA* does not belong to the GF(p^2) field.

GFpNeg

Computes the additive inverse of an element of the finite field.

Syntax

```
IppStatus ippsGFpNeg(const IppsGFpElement* pA, IppsGFpElement* pR, IppsGFpState* pGF);
```

Include Files

`ippcp.h`

Parameters

pA	Pointer to the context of the finite field element.
pR	Pointer to the context of the resulting element of the finite field.
pGFp	Pointer to the context of the finite field.

Description

This function computes the additive inverse of an element of the finite field. The following pseudocode represents this operation: $R + A = 0$. The finite field is specified by the context *pGFp*.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if any of the `IppsGFpState` and `IppsGFpElement` context parameters does not match the operation.
`ippStsOutOfRangeErr`	Indicates an error condition if *pA* does not belong to the finite field specified by the context *pGFp*.

GFpInv

Computes the multiplicative inverse of an element of the finite field.

Syntax

```
IppStatus ippsGFpInv(const IppsGFpElement* pA, IppsGFpElement* pR, IppsGFpState* pGFp);
```

Include Files

`ippcp.h`

Parameters

pA	Pointer to the context of the finite field element.
pR	Pointer to the context of the resulting element of the finite field.
pGFp	Pointer to the context of the finite field.

Description

This function computes the multiplicative inverse of an element of the finite field. The following pseudocode represents this operation: $R \cdot A = 1$. The finite field is specified by the context *pGFp*.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if any of the `IppsGFpState` and `IppsGFpElement` context parameters does not match the operation.
`ippStsOutOfRangeErr`	Indicates an error condition if the element *pA* does not belong to the finite field specified by the context *pGFp*.
`ippStsDivByZeroErr`	Indicates an error condition if *pA* is the zero element.
`ippStsBadArgErr`	Indicates an error condition if a computational error occurs.

GFpSqrt

Computes the square root of an element of the finite field.

Syntax

```
IppStatus ippsGFpSqrt(const IppsGFpElement* pA, IppsGFpElement* pR, IppsGFpState*
pGFp);
```

Include Files

`ippcp.h`

Parameters

pA	Pointer to the context of the finite field element.
pR	Pointer to the context of the resulting element of the finite field.
pGFp	Pointer to the context of the finite field.

Description

This function computes the square root of a given element of the GF(*p*) field. The following pseudocode represents this operation: $R \cdot R = A$. The finite field is specified by the *pGFp* context.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if any of the `IppsGFpState` and `IppsGFpElement` context parameters does not match the operation.
`ippStsOutOfRangeErr`	Indicates an error condition if *pA* does not belong to the finite field specified by the context *pGFp*.
`ippStsBadArgErr`	Indicates an error condition the finite field specified by the context *pGFp* is not prime.
`ippStsQuadraticNonResidueErr`	Indicates an error condition if *pA* is a square non-residue element.

GFpAdd

Computes the sum of two elements of the finite field.

Syntax

```
IppStatus ippsGFpAdd(const IppsGFpElement* pA, const IppsGFpElement* pB,
IppsGFpElement* pR, IppsGFpState* pGFp);
```

Include Files

`ippcp.h`

Parameters

pA	Pointer to the context of the first element of the finite field to be added.
pB	Pointer to the context of the second element of the finite field to be added.
pR	Pointer to the context of the resulting element of the finite field.
pGFp	Pointer to the context of the finite field.

Description

This function computes the sum of the elements of the finite field. The following pseudocode represents this operation: *R* = *A* + *B*. The finite field is specified by the *pGFp* context.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if any of `IppsGFpState` and `IppsGFpElement` context parameters does not match the operation.
`ippStsOutOfRangeErr`	Indicates an error condition if either the *pA* or *pB* element does not belong to the finite field specified by the context *pGFp*.

GFpSub

Subtracts two elements of the finite field.

Syntax

```
IppStatus ippsGFpSub(const IppsGFpElement* pA, const IppsGFpElement* pB,
IppsGFpElement* pR, IppsGFpState* pGFp);
```

Include Files

`ippcp.h`

Parameters

pA	Pointer to the context of the minuend element of the finite field.
pB	Pointer to the context of the subtrahend element of the finite field.
pR	Pointer to the context of the resulting element of the finite field.
pGFp	Pointer to the context of the finite field.

Description

This function computes the difference of the elements of the finite field. The following pseudocode represents this operation: *R* = *A* - *B*. The finite field is specified by the context *pGFp*.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if any of the `IppsGFpState` and `IppsGFpElement` context parameters does not match the operation.
`ippStsOutOfRangeErr`	Indicates an error condition if *pA* or *pB* does not belong to the finite field specified by the context *pGFp*.

GFpMul

Multiplies two elements of the finite field.

Syntax

```
IppStatus ippsGFpMul(const IppsGFpElement* pA, const IppsGFpElement* pB,
IppsGFpElement* pR, IppsGFpState* pGFp);
```

Include Files

`ippcp.h`

Parameters

pA	Pointer to the context of the first multiplicand element of the finite field.
pB	Pointer to the context of the second multiplicand element of the finite field.
pR	Pointer to the context of the resulting element of the finite field.
pGFp	Pointer to the context of the finite field.

Description

This function computes the product of two elements of the finite field. The following pseudocode represents this operation: $R = A \cdot B$. The finite field is specified by the context *pGFp*.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if either `IppsGFpState` or `IppsGFpElement` context parameters do not match the operation.
`ippStsOutOfRangeErr`	Indicates an error condition if *pA* or *pB* does not belong to the finite field specified by the context *pGFp*.

GFpSqr

Computes the square of an element of the finite field.

Syntax

```
IppStatus ippsGFpSqr(const IppsGFpElement* pA, IppsGFpElement* pR, IppsGFpState* pGFp);
```

Include Files

`ippcp.h`

Parameters

pA	Pointer to the context of the finite field element.
pR	Pointer to the context of the resulting element of the finite field.
pGFp	Pointer to the context of the finite field.

Description

This function computes the square of a given element of the finite field. The following pseudocode represents this operation: $R = A^2$. The finite field is specified by the context *pGFp*.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if any of the `IppsGFpState` and `IppsGFpElement` context parameters does not match the operation.
`ippStsOutOfRangeErr`	Indicates an error condition if *pA* does not belong to the finite field specified by the context *pGFp*.

GFpExp

Raises an element of the finite field to the specified power.

Syntax

```
IppStatus ippsGFpExp(const IppsGFpElement* pA, const IppsBigNumState* pE,
IppsGFpElement* pR, IppsGFpState* pGFp, Ipp8u* pScratchBuffer);
```

Include Files

`ippcp.h`

Parameters

pA	Pointer to the context of the element of the finite field representing the base of the exponentiation.
pE	Pointer to the Big Number context storing the exponent.
pR	Pointer to the context of the resulting element of the finite field.
pGFp	Pointer to the context of the finite field.
pScratchBuffer	Pointer to the scratch buffer.

Description

This function raises the element of the finite field to the given non-negative power. The following pseudocode represents this operation: $R = A^E$. The finite field is specified by the context *pGFp*. You can get the size of the scratch buffer by calling the function `GFpScratchBufferSize`.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if any of the `IppsGFpState`, `IppsBigNumState`, and `IppsGFpElement` context parameters does not match the operation.
`ippStsOutOfRangeErr`	Indicates an error condition if *pA* or *pR* does not belong to the finite field specified by the context *pGFp*.

GFpMultiExp

Multiplies exponents of elements of the finite field.

Syntax

```
IppStatus ippsGFpMultiExp(const IppsGFpElement* const ppElmA[], const IppsBigNumState*
const ppE[], int nItems, IppsGFpElement* pElemR, IppsGFpState* pGF, Ipp8u*
pScratchBuffer);
```

Include Files

`ippcp.h`

Parameters

ppElmA	Pointer to the array of contexts of the finite field elements representing the base of the exponentiation.
ppE	Pointer to the array of the Big Number contexts storing the exponents.
nItems	Number of exponents.
pElemR	Pointer to the context of the resulting element of the finite field.
pGFp	Pointer to the context of the finite field.
pScratchBuffer	Pointer to the scratch buffer.

Description

This function multiplies exponents of elements of the finite field. The finite field is specified by the context *pGFp*. You can get the size of the scratch buffer by calling the `ippsGFpScratchBufferSize` function.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.

`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if any of the context parameters `IppsGFpState`, `IppsBigNumState`, and `IppsGFpElement` does not match the operation.
`ippStsOutOfRangeErr`	Indicates an error condition if any of the elements of *`ppElmA`* do not belong to the finite field specified by the context *`pGFp`*.
`ippStsBadArgErr`	Indicates an error condition if *`nItems`* is less than 1 or greater than 6.

GFpAdd_PE

Computes the sum of an element of the finite field and an element of its parent field.

Syntax

```
IppStatus ippsGFpAdd_PE(const IppsGFpElement* pA, const IppsGFpElement* pParentB,
IppsGFpElement* pR, IppsGFpState* pGFp);
```

Include Files

`ippcp.h`

Parameters

`pA`	Pointer to the context of the first element of the finite field to be added.
`pParentB`	Pointer to the context of the second element to be added, which is an element of the parent finite field.
`pR`	Pointer to the context of the resulting element of the finite field.
`pGFp`	Pointer to the context of the finite field.

Description

The function computes the sum of the elements of the finite field specified by the context *`pGFp`* and its ground finite field. The following pseudocode represents this operation: $R = A + B$.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if any of `IppsGFpState` or `IppsGFpElement` context parameter does not match the operation.
`ippStsOutOfRangeErr`	Indicates an error condition in the following cases: • the element *`pA`* does not belong to the finite field specified by the context *`pGFp`*. • the element *`pParentB`* does not belong to the ground field of the finite field specified by the context *`pGFp`*.

`ippStsBadArgErr`	Indicates an error condition if the context *pGFp* does not specify a prime field.

GFpSub_PE

Subtracts an element of the finite field from an element of its parent field.

Syntax

```
IppStatus ippsGFpSub_PE(const IppsGFpElement* pA, const IppsGFpElement* pParentB,
IppsGFpElement* pR, IppsGFpState* pGFp);
```

Include Files

ippcp.h

Parameters

pA	Pointer to the context of the minuend, an element of the finite field.
pParentB	Pointer to the context of the subtrahend, an element of the parent finite field.
pR	Pointer to the context of the resulting element of the finite field.
pGFp	Pointer to the context of the finite field.

Description

This function computes the difference of the elements of the finite field specified by the context *pGFp* and its ground finite field. The following pseudocode represents this operation: $R = A - B$.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if any of `IppsGFpState` and `IppsGFpElement` context parameters does not match the operation.
`ippStsOutOfRangeErr`	Indicates an error condition in the following cases: • The element *pA* does not belong to the finite field specified by the context *pGFp*. • The element *pParentB* does not belong to the ground field of the finite field specified by the context *pGFp*.
`ippStsBadArgErr`	Indicates an error condition if the context *pGFp* does not specify a prime field.

GFpMul_PE

Multiplies an element of the finite field and an element of its parent field.

Syntax

`IppStatus ippsGFpMul_PE(const IppsGFpElement* pA, const IppsGFpElement* pParentB, IppsGFpElement* pR, IppsGFpState* pGFp);`

Include Files

`ippcp.h`

Parameters

pA	Pointer to the context of the first multiplicand, an element of the finite field.
pParentB	Pointer to the context of the second multiplicand, an element of the parent finite field.
pR	Pointer to the context of the resulting element of the finite field.
pGFp	Pointer to the context of the finite field.

Description

This function computes the product of the element *pA* of the finite field specified by the context *pGFp* and the element *pParentB* of its ground finite field. The following pseudocode represents this operation: $R = A \cdot B$.

Return Values

`ippStsNoErr`	Indicates no error. Any other value indicates an error or warning.
`ippStsNullPtrErr`	Indicates an error condition if any of the specified pointers is `NULL`.
`ippStsContextMatchErr`	Indicates an error condition if any of the `IppsGFpState` and `IppsGFpElement` context parameters does not match the operation.
`ippStsOutOfRangeErr`	Indicates an error condition in the following cases: • The element *pA* does not belong to the finite field specified by the context *pGFp*. • The element *pParentB* does not belong to the ground field of the finite field specified by the context *pGFp*.
`ippStsBadArgErr`	Indicates an error condition if the context *pGFp* does not specify a prime field.

Multi-buffer Cryptography Functions

Introduction

`Crypto_mb` library implements well known cryptography algorithms. The feature of `Crypto_mb` is application of the usual cryptography algorithm to different independent data in parallel.

For example, instead of usual (scalar) RSA decryption $x = y^d mod\ n$, `Crpto_mb` consider vector operation $x[i] = y[i]^{d[i]}\ mod\ n[i]$, $0<=i<8$, where all eight operations run simultaneously. The single limitation is the requirement that all the data must be compatible in terms of size. Thus, RSAs moduli *n[i]* must be the same size, as well as ciphertext *y[i]* and recovered text *x[i]*.

Together with new integer AVX512 instructions, this approach provides performance benefit in comparison with scalar approach. This feature of the `Crypto_mb` affects server and cloud applications positively.

Currently `Crypto_mb` supports:

- RSA encryption and decryption of 1, 2 3 and 4Kb
- ECDSA and ECDH/DHE over NIST recommended Elliptic Curves P256, P384 and P521
- ECDH/DHE over Curve25519

APIs, Parameters and Data Representation

Public APIs use parameters that are directly present in the math description of algorithm, avoiding aggregated data structures. Usually, parameters of public APIs are "arrays of pointers to data vectors".

Input and output data is represented as a big endian byte string (i.e. leftmost byte is the most significant and rightmost byte is less significant) of suitable length. The exception is X25519 functional, where a private key is represented as a little endian byte string.

Usually, key stuff (public and private key components) are multi-precision positive integers represented in the memory as a vector of digits in base B $(B = 2^{64})$. Thus, L-digit non-negative integer value x in base B is represented as follows:

$x = x[0]*B^0 + x[1]*B^1 + ... + x[L-1]*B^{(L-1)}$.

In case of OpenSSL-like APIs, the parameters, where it is applicable, are represented by BIGNUM datatype as is customary in OpenSSL.

Return value

APIs return 32-bit group status, allowing to parse each of eight components connected with particular processed dataset. The function `mbx_status MBX_GET_STS(mbx_status status, int numb)` extracts from the group status specified by the *`status`* parameter and returns the status value corresponding to the processed dataset specified by the *numb* parameter. Return value is one of the following:

- `MBX_STATUS_OK` - operation competed successfully
- `MBX_STATUS_MISMATCH_PARAM_ERR` - operation detected any incompatibility in parameters
- `MBX_STATUS_NULL_PARAM_ERR` - operation detected NULL pointer
- `MBX_STATUS_LOW_ORDER_ERR` - computed shared secret is zero
- `MBX_STATUS_SIGNATURE_ERR` - r- or s- component of generated signature is zero

RSA Algorithm Functions

RSA Notation

The following description uses PKCS #1 v2.1: RSA Cryptography Standard conventions:

- *n* - RSA modulus
- *e* - RSA public exponent
- *d* - RSA private exponent, *e*d = mod lambda(n), lambda(n) = LCM*
- *(n, e)* - RSA public key
- a pair *(n, d)* - so-called 1-st representation of the RSA private key
- *p, q* - two prime factors of the RSA modulus *n, n = p*q*
- *dP* - the *p*'s CRT exponent, *e*dP = 1 mod(p-1)*
- *dQ* - the *q*'s CRT exponent, *e*dQ = 1 mod(q-1)*
- *qInv* - the CRT coefficient, *q*qInv = 1 mod(p)*
- a quintuple *(p, q, dP, dQ, qInv)* - so-called 2-nd representation of the RSA private key

All the numbers above are positive integers.

Keep in mind the following assumptions:

- Current implementation supports RSA-1024, RSA-2048, RSA-3072 and RSA-4096 (the number denotes size of RSA modulus in bits)
- Public exponent is fixed, e=65537
- No specific assumption relatively "*d*", except bitsize(d) ~ bitsize(n) and $d<n$
- Size of *p* and *q* in bits is approximately the same and equals bitsize(n)/2

RSA public key operation

$y = x^e \bmod n$, *x* and *y* are plane- and ciphertext correspondingly

RSA private key (1-st representation) operation

$x = y^d \bmod n$, *y* and *x* are cipher- and plaintext correspondingly

RSA private key (2-nd representation) operation or CRT-based RSA private key operation

$x1 = y^{dP} \bmod p$

$x2 = y^{dQ} \bmod q$

$t = (x1-x2) * qInv \bmod p$

$x = x2 + q*t$

mbx_rsa_public

Performs the public key RSA encryption operation.

Syntax

```
mbx_status mbx_rsa_public_mb8(const int8u* const from_pa[8],int8u* const to_pa[8],const
int64u* const n_pa[8], int rsaBitlen, const mbx_RSA_Method* m, int8u* pBuffer);

mbx_status mbx_rsa_public_ssl_mb8(const int8u* const from_pa[8],int8u* const
to_pa[8],const BIGNUM* const e_pa[8], const BIGNUM* const n_pa[8], int rsaBitlen);
```

Include Files

`crypto_mb/rsa.h`

Parameters

from_pa	Array of pointers to the plaintext data vectors.
to_pa	Array of pointers to the ciphertext data vectors.
n_pa	Array of pointers to the RSAs modulus vectors.
rsaBitLen	Size of RSAs moduli in bits.
m	Pointer to the pre-defined data structure specified by the RSA encryption operation.
pBuffer	Pointer to the work buffer.

Description

The `mbx_rsa_public()` function performs independent RSA public key operations using RSA moduli passed though the *n_pa* parameter. The public exponent *e* is fixed and equals to 65537. The size of RSAs moduli must be the same and equal to *rsaBitlen* bits. The function encrypts plaintexts specified by the *from_pa* parameter in parallel, and stores ciphertexts in the memory locations specified by the *to_pa* parameter. Memory buffers of the plain- and ciphertext must be ceil(*rsaBitlen*/8) bytes length.

At the moment, RSA-10024, RSA-2048, RSA-3072 and RSA-4096 are supported only. If *m* is NULL, the function uses mbx_RSA_pub65537_Method(*rsaBitsize*). If *m* is not NULL, it must be assigned to either mbx_RSA1K_pub65537_Method(), mbx_RSA2K_pub65537_Method(), mbx_RSA3K_pub65537_Method() or mbx_RSA4K_pub65537_Method() and match to *rsaBitlen* value.

If *pBuffer* is NULL, then the function allocated a work buffer of suitable size dynamically. An allocated buffer will be released before the function return. If the work buffer is allocated in the application, it affects performance positively. The mbx_RSA_Method_BufSize() function returns the size of the work buffer required for the operation.

The function itself does not support any kind of padding. The application is responsible for the padding if it is required.

NOTE
The mbx_rsa_public_ssl() function is the "twin" of mbx_rsa_public() one. It acts the same. The basic difference in comparison with mbx_rsa_public() is the representation of RSA key stuff. mbx_rsa_public_ssl uses BIGNUM datatype instead of vector.

Return Values

The mbx_rsa_public() function returns the status that indicates whether the operation completed successfully or not. The status value of 0 indicates that all operations completed successfully. The error condition can be analyzed by the MBX_GET_STS() call.

See Also

mbx_RSA_Method_BufSize	Returns the size of a work buffer for a specific RSA operation.

mbx_rsa_private

Performs the private key RSA decryption operation.

Syntax

mbx_status mbx_rsa_private_mb8(const int8u* const *from_pa[8]*, int8u* const *to_pa[8]*, const int64u* const *d_pa[8]*, const int64u* const *n_pa[8]*, int *rsaBitlen*, const mbx_RSA_Method* *m*, int8u* *pBuffer*);

mbx_status mbx_rsa_private_ssl_mb8(const int8u* const *from_pa[8]*, int8u* const *to_pa[8]*, const BIGNUM* const *d_pa[8]*, const BIGNUM* const *n_pa[8]*, int *rsaBitlen*);

Include Files

crypto_mb/rsa.h

Parameters

from_pa	Array of pointers to the ciphertext data vectors.
to_pa	Array of pointers to the recovered data vectors.
d_pa	Array of pointers to the RSAs private exponent vectors.
n_pa	Array of pointers to the RSAs modulus vectors.
rsaBitLen	Size of RSAs moduli in bits.
m	Pointer to the pre-defined data structure specified by the RSA encryption operation.

pBuffer	Pointer to the work buffer.

Description

The `mbx_rsa_private()` function performs independent RSA private key operations using RSA private key in form of a pair - private exponent (*d*) and modulus (*n*). The exponents are passed through *d_pa* and moduli are passed though *n_pa* parameters. The size of RSAs moduli and private exponents must be the same and equal to *rsaBitlen* bits. The function decrypts ciphertexts specified by the *from_pa* parameter in parallel, and stores recovered ciphertexts in the memory locations specified by the *to_pa* parameter. Memory buffers of the plain- and ciphertext must be ceil(*rsaBitlen*/8) bytes length.

At the moment, RSA-10024, RSA-2048, RSA-3072 and RSA-4096 are supported only. If *m* is NULL, the function uses mbx_RSA_private_Method(*rsaBitsize*). If *m* is not NULL, it must be assigned to either `mbx_RSA1K_ private_Method()`, `mbx_RSA2K_ private_Method()`, `mbx_RSA3K_ private_Method()` or `mbx_RSA4K_ private_Method()` and match to *rsaBitlen* value.

If *pBuffer* is NULL, then the function allocated a work buffer of suitable size dynamically. An allocated buffer will be released before the function return. If the work buffer is allocated in the application, it affects performance positively. The mbx_RSA_Method_BufSize() function returns the size of the work buffer required for the operation.

The function itself does not support any kind of padding. The application is responsible for the padding if it is required.

NOTE
The `mbx_rsa_private_ssl()` function is the "twin" of `mbx_rsa_private()` one. It acts the same. The basic difference in comparison with `mbx_rsa_private()` is the representation of RSA key stuff. `mbx_rsa_private_ssl` uses BIGNUM datatype instead of vector.

Return Values

The `mbx_rsa_private()` function returns the status that indicates whether the operation completed successfully or not. The status value of 0 indicates that all operations completed successfully. The error condition can be analyzed by the `MBX_GET_STS()` call.

See Also

mbx_RSA_Method_BufSize	Returns the size of a work buffer for a specific RSA operation.

mbx_rsa_private_crt

Performs the private key RSA decryption operation.

Syntax

```
mbx_status mbx_rsa_private_crt_mb8(const int8u* const from_pa[8], int8u* const
to_pa[8], const int64u* const p_pa[8], const int64u* const q_pa[8], const int64u* const
dp_pa[8], const int64u* const dq_pa[8], const int64u* const iq_pa[8], int rsaBitlen,
const mbx_RSA_Method* m, int8u* pBuffer);

mbx_status mbx_rsa_private_crt_ssl_mb8(const int8u* const from_pa[8], int8u* const
to_pa[8], const BIGNUM* const p_pa[8], const BIGNUM* const q_pa[8], const BIGNUM* const
dp_pa[8], const BIGNUM* const dq_pa[8], const BIGNUM* const iq_pa[8], int rsaBitlen);
```

Include Files

```
crypto_mb/rsa.h
```

Parameters

from_pa	Array of pointers to the ciphertext data vectors.
to_pa	Array of pointers to the recovered data vectors.
p_pa	Array of pointers to the p-prime factor vectors of RSA moduli.
q_pa	Array of pointers to the q-prime factor vectors of RSA moduli.
dp_pa	Array of pointers to the p's CRT private exponent vectors.
dq_pa	Array of pointers to the q's CRT private exponent vectors.
iq_pa	Array of pointers to CRT coefficient (multiplicative inversion of q with respect to p) vectors.
rsaBitLen	Size of RSAs moduli in bits.
m	Pointer to the pre-defined data structure specified by the RSA encryption operation.
pBuffer	Pointer to the work buffer.

Description

The `mbx_rsa_private_crt()` function performs independent CRT-based RSA private key operations using RSA private key in a quintuple form - private factors (*p* and *q*), private exponents (*dp* and *dq*) and CRT coefficient *invq*. The factors are passed through *p_pa* and *q_pa*, exponents are passed though *dp_pa* and *dq_pa* and CRT coefficients are passed through *iq_pa* parameter. The size of RSAs factors, private exponents and CRT coefficients must be the same and equal to *rsaBitlen*/2 bits. The function decrypts ciphertexts specified by the *from_pa* parameter in parallel, and stores recovered ciphertexts in the memory locations specified by the *to_pa* parameter. Memory buffers of the plain- and ciphertext must be ceil(*rsaBitlen*/8) bytes length.

At the moment, RSA-10024, RSA-2048, RSA-3072 and RSA-4096 are supported only. If *m* is `NULL`, the function uses `mbx_RSA_private_crt_Method(`*rsaBitsize*`)`. If *m* is not `NULL`, it must be assigned to either `mbx_RSA1K_ private_crt_Method()`, `mbx_RSA2K_ private_crt_Method()`, `mbx_RSA3K_ private_crt_Method()` or `mbx_RSA4K_ private_crt_Method()` and match to *rsaBitlen* value.

If *pBuffer* is `NULL`, then the function allocated a work buffer of suitable size dynamically. An allocated buffer will be released before the function return. If the work buffer is allocated in the application, it affects performance positively. The `mbx_RSA_Method_BufSize()` function returns the size of the work buffer required for the operation.

The function itself does not support any kind of padding. The application is responsible for the padding if it is required.

NOTE
The `mbx_rsa_private_crt_ssl()` function is the "twin" of `mbx_rsa_private_crt()` one. It acts the same. The basic difference in comparison with `mbx_rsa_private()` is the representation of RSA key stuff. `mbx_rsa_private_crt_ssl` uses BIGNUM datatype instead of vector.

Return Values

The `mbx_rsa_private_crt()` function returns the status that indicates whether the operation completed successfully or not. The status value of 0 indicates that all operations completed successfully. The error condition can be analyzed by the `MBX_GET_STS()` call.

See Also

mbx_RSA_Method_BufSize Returns the size of a work buffer for a specific RSA operation.

mbx_RSA_Method_BufSize

Returns the size of a work buffer for a specific RSA operation.

Syntax

```
int mbx_RSA_Method_BufSize(const mbx_RSA_Method*m);
```

Include Files

```
crypto_mb/rsa.h
```

Parameters

m	Pointer to the pre-defined data structure specified by the RSA encryption operation.

Description

The `mbx_RSA_Method_BufSize()` function returns the size of a work buffer in bytes required for the RSA operation specified by the parameter *m*. If *m* is `NULL`, the function returns 0.

NIST Recommended Elliptic Curve Functions

Elliptic Curve Notation

There are several kinds of defining equation for elliptic curves, but this section deals with *Weierstrass equations*. For the prime finite field *GF(p)*, *p>3*, the Weierstrass equation is $E : y^2 = x^3 + a*x + b$, where *a* and *b* are integers modulo *p*. Number of points on the elliptic curve *E* is denoted by *#E*.

For purpose of cryptography some additional parameters are presented:

- *n* - prime divisor of *#E* and the order of point *G*
- *G* - the point on curve *E* generated subgroup of the order n

The set of *p, a, b, n* and *G* parameters are Elliptic Curve (EC) domain parameter. This section deals with three NIST recommended Elliptic Curves those domain parameters are known and published in [SEC2] (Standards for Efficient Cryptography Group, "Recommended Elliptic Curve Domain Parameters", SEC 2, September 2000).

Elliptic Curve Key Pair

Private key is a positive integer *u* in the range *[1, n-1]*. Public key *V*, which is the point on elliptic curve *E*, where *V = [u]*G*. In cryptography, there are two types of key pairs: regular (or longterm) and ephemeral (or nonce - number that can only be used once). From the math point of view, they are similar.

ECDSA signature generation

Input:

- The EC domain parameters *p, a, b, n* and *G*
- The signer's regular *u* and ephemeral *k* private keys
- The message representative, which is an integer *f>=0*

Output: The signature, which is a pair of integers *(r, s)*, where *r* and *s* belongs the range *[1. r-1]*.

Operation:

1.

1. Compute an ephemeral public key K = [k]G. Let K = (x, y)
2. Compute an integer r = x mod n
3. Compute an integer s = (k-1)*(f + u*r) mod n
4. Return (r, s) as signature

ECDHE generation of shared secret

Input:

- The EC domain parameters *p*, *a*, *b*, *n* and *G*
- The own ephemeral private key *u*
- The party's ephemeral public key *W*

Output: The derived shared secret value *z*, which is the *GF(p)* field element

Operation:

1. Compute an EC point *P = [u]W, P=(xp, yp)*
2. Let *z = xp*
3. Return shared secret *z*

mbx_nistp256/384/521_ecdsa_sign_setup

Precomputes the ECDSA signature.

Syntax

```
mbx_status mbx_nistp256_ecdsa_sign_setup_mb8(int64u* pa_inv_eph_skey[8], int64u*
pa_sign_rp[8], const int64u* const pa_eph_skey[8], int8u* pBuffer);

mbx_status mbx_nistp256_ecdsa_sign_setup_ssl_mb8(BIGNUM* pa_inv_eph_skey[8], BIGNUM*
pa_sign_rp[8], const BIGNUM* const pa_eph_skey[8], int8u* pBuffer);

mbx_status mbx_nistp384_ecdsa_sign_setup_mb8(int64u* pa_inv_eph_skey[8], int64u*
pa_sign_rp[8], const int64u* const pa_eph_skey[8], int8u* pBuffer);

mbx_status mbx_nistp384_ecdsa_sign_setup_ssl_mb8(BIGNUM* pa_inv_eph_skey[8], BIGNUM*
pa_sign_rp[8], const BIGNUM* const pa_eph_skey[8], int8u* pBuffer);

mbx_status mbx_nistp521_ecdsa_sign_setup_mb8(int64u* pa_inv_eph_skey[8], int64u*
pa_sign_rp[8], const int64u* const pa_eph_skey[8], int8u* pBuffer);

mbx_status mbx_nistp521_ecdsa_sign_setup_ssl_mb8(BIGNUM* pa_inv_eph_skey[8], BIGNUM*
pa_sign_rp[8], const BIGNUM* const pa_eph_skey[8], int8u* pBuffer);
```

Include Files

```
crypto_mb/ec_nistp256.h

crypto_mb/ec_nistp384.h

crypto_mb/ec_nistp512.h
```

Parameters

pa_eph_skey	Array of pointers to the ephemeral private key vectors.
pa_inv_eph_skey	Array of pointers to the vectors of ephemeral private key inversion.
pa_sign_rp	Array of pointers to the vectors of pre-computed r-component signatures.

`pBuffer`	Pointer to the work buffer.

Description

Each function targets at the elliptic curve (EC) specified in the name (nistp256, nistp384 or nistp521). This function may be used to precompute a part of the signature operation. Based on ephemeral private keys, specified by *pa_eph_skey* parameter the function precomputes:

- r-component of the signature storing the result specified by *pa_sign_rp* (step 2 of ECDSA operation)
- multiplicative inversion of ephemeral private key (used in step 3 of ECDSA operation) storing the result as specified by *pa_inv_eph_skey* parameter

Precomputed can be used later in suitable `mbx_nistp_ecdsa_sign_complete_mb8()` function.

The work buffer specified by *pBuffer* parameter is not currently used and can be `NULL`.

NOTE
All the functions above have own "twins" with "_ssl" in the name. The "twin" associated with the EC acts the same. The single difference in comparison with `mbx_nistp256/384/521_ecdsa_sign_setup()` is representation of the parameters. `mbx_nistp256/384/521_ecdsa_sign_setup_ssl()` functions use BIGNUM datatype instead of vector.

Return Values

The `mbx_nistp256/384/521_ecdsa_setup` functions return the status that indicates whether the operation completed successfully or not. The status value of 0 indicates that all operations completed successfully. The error condition can be analyzed by the `MBX_GET_STS()` call.

mbx_nistp256/384/521_ecdsa_sign_complete

Completes computation of the ECDSA signature.

Syntax

```
mbx_status mbx_nistp256_ecdsa_sign_complete_mb8(int8u* pa_sign_r[8], int8u*
pa_sign_s[8], const int8u* const pa_msg[8], const int64u* const pa_sgn_rp[8], const
int64u* const pa_inv_eph_skey[8], const int64u* const pa_reg_skey[8], int8u* pBuffer);
```

```
mbx_status mbx_nistp256_ecdsa_sign_complete_ssl_mb8(int8u* pa_sign_r[8], int8u*
pa_sign_s[8], const int8u* const pa_msg[8], const BIGNUM* const pa_sgn_rp[8], const
BIGNUM* const pa_inv_eph_skey[8], const BIGNUM* const pa_reg_skey[8], int8u* pBuffer);
```

```
mbx_status mbx_nistp384_ecdsa_sign_complete_mb8(int8u* pa_sign_r[8], int8u*
pa_sign_s[8], const int8u* const pa_msg[8], const int64u* const pa_sgn_rp[8], const
int64u* const pa_inv_eph_skey[8], const int64u* const pa_reg_skey[8], int8u* pBuffer);
```

```
mbx_status mbx_nistp384_ecdsa_sign_complete_ssl_mb8(int8u* pa_sign_r[8], int8u*
pa_sign_s[8], const int8u* const pa_msg[8], const BIGNUM* const pa_sgn_rp[8], const
BIGNUM* const pa_inv_eph_skey[8], const BIGNUM* const pa_reg_skey[8], int8u* pBuffer);
```

```
mbx_status mbx_nistp521_ecdsa_sign_complete_mb8(int8u* pa_sign_r[8], int8u*
pa_sign_s[8], const int8u* const pa_msg[8], const int64u* const pa_sgn_rp[8], const
int64u* const pa_inv_eph_skey[8], const int64u* const pa_reg_skey[8], int8u* pBuffer);
```

```
mbx_status mbx_nistp521_ecdsa_sign_complete_ssl_mb8(int8u* pa_sign_r[8], int8u*
pa_sign_s[8], const int8u* const pa_msg[8], const BIGNUM* const pa_sgn_rp[8], const
BIGNUM* const pa_inv_eph_skey[8], const BIGNUM* const pa_reg_skey[8], int8u* pBuffer);
```

Include Files

`crypto_mb/ec_nistp256.h`

`crypto_mb/ec_nistp384.h`

`crypto_mb/ec_nistp521.h`

Parameters

pa_sign_r	Array of pointers to the resulting r-components of signature vectors.
pa_sign_s	Array of pointers to the resulting s-components of the signature.
pa_msg	Array of pointers to the message representatives are being signed.
pa_inv_eph_skey	Array of pointers to the inversion of the ephemeral private key.
pa_reg_skey	Array of pointers to the signer's regular private key.
pBuffer	Pointer to the work buffer.

Description

Each function targets at the elliptic curve (EC) specified in the name (`nistp256`, `nistp384` or `nistp521`). The function completes computation of the signature (step 3 of ECDSA operation) using regular private keys specified by the *pa_reg_skey* parameter, converts *r*- and *s*- components of the signature into big endian byte strings and stores them in locations specified by *pa_sign_r* and *pa_sign_s* parameters.

The work buffer specified by the *pBuffer* parameter is not currently used and can be `NULL`.

NOTE
All the functions above have own "twins" with "_ssl" in the name. The "twin" associated with the EC acts the same. The single difference in comparison with `mbx_nistp256/384/521_ecdsa_sign_complete()` is representation of the parameters. `mbx_nistp256/384/521_ecdsa_sign_complete_ssl()` functions use BIGNUM datatype instead of vector.

Return Values

The `mbx_nistp256/384/521_ecdsa_sign_complete` functions return the status that indicates whether the operation completed successfully or not. The status value of 0 indicates that all operations completed successfully. The error condition can be analyzed by the `MBX_GET_STS()` call.

mbx_nistp256/384/521_ecdsa_sign

Generates the ECDSA signature using NIST recommended elliptic curves over prime P256/P384/P521.

Syntax

```
mbx_status mbx_nistp256_ecdsa_sign_mb8(int8u* pa_sign_r[8], int8u* pa_sign_s[8], const
int8u* const pa_msg[8], const int64u* const pa_eph_skey[8], const int64u* const
pa_reg_skey[8], int8u*pBuffer);
```

```
mbx_status mbx_nistp256_ecdsa_sign_ssl_mb8(int8u* pa_sign_r[8], int8u* pa_sign_s[8],
const int8u* const pa_msg[8], const BIGNUM* const pa_eph_skey[8], const BIGNUM* const
pa_reg_skey[8], int8u*pBuffer);
```

```
mbx_status mbx_nistp384_ecdsa_sign_mb8(int8u* pa_sign_r[8], int8u* pa_sign_s[8], const
int8u* const pa_msg[8], const int64u* const pa_eph_skey[8], const int64u* const
pa_reg_skey[8], int8u*pBuffer);
```

```
mbx_status mbx_nistp384_ecdsa_sign_ssl_mb8(int8u* pa_sign_r[8], int8u* pa_sign_s[8],
const int8u* const pa_msg[8], const BIGNUM* const pa_eph_skey[8], const BIGNUM* const
pa_reg_skey[8], int8u*pBuffer);
```

```
mbx_status mbx_nistp521_ecdsa_sign_mb8(int8u* pa_sign_r[8], int8u* pa_sign_s[8], const
int8u* const pa_msg[8], const int64u* const pa_eph_skey[8], const int64u* const
pa_reg_skey[8], int8u*pBuffer);
```

```
mbx_status mbx_nistp521_ecdsa_sign_ssl_mb8(int8u* pa_sign_r[8], int8u* pa_sign_s[8],
const int8u* const pa_msg[8], const BIGNUM* const pa_eph_skey[8], const BIGNUM* const
pa_reg_skey[8], int8u*pBuffer);
```

Include Files

`crypto_mb/ec_nistp256.h`

`crypto_mb/ec_nistp384.h`

`crypto_mb/ec_nistp521.h`

Parameters

pa_sign_r	Array of pointers to the resulting r-components of the signature.
pa_sign_s	Array of pointers to the resulting s-components of the signature.
pa_msg	Array of pointers to the message representatives are being signed.
pa_eph_skey	Array of pointers to the signer's ephemeral private key.
pa_reg_skey	Array of pointers to the signer's regular private key.
pBuffer	Pointer to the work buffer.

Description

Each function targets at the elliptic curve (EC) specified in the name (`nistp256`, `nistp384` or `nistp521`). The function computes digital signature of the message representatives passed by the *pa_msg* parameter using regular and private keys specified by *pa_reg_skey* and *pa_eph_skey* parameters correspondingly. The function assumes that the length of the message representative is equal to length of *r* (order of EC subgroup). Computed signature (steps 1 - 3 of ECDSA operation), converts *r*- and *s*- components of the signature into big endian byte strings and stores them separately in locations specified by *pa_sign_r* and *pa_sign_s* parameters.

The work buffer specified by the *pBuffer* parameter is not currently used and can be `NULL`.

NOTE
All the functions above have own "twins" with "_ssl" in the name. The "twin" associated with the EC acts the same. The single difference in comparison with `mbx_nistp256/384/521_ecdsa_sign()` is representation of the parameters. `mbx_nistp256/384/521_ecdsa_sign_ssl()` functions use BIGNUM datatype instead of vector.

Return Values

The `mbx_nistp256/384/521_ecdsa_sign` functions return the status that indicates whether the operation completed successfully or not. The status value of 0 indicates that all operations completed successfully. The error condition can be analyzed by the `MBX_GET_STS()` call.

mbx_nistp256/384/521_ecdsa_verify

Verifies the ECDSA signature using the NIST recommended elliptic curves over prime P256/P384/ P521.

Syntax

`mbx_status mbx_nistp256_ecdsa_verify_mb8(const int8u* const`*`pa_sign_r`*`[8], const int8u* const`*`pa_sign_s`*`[8], const int8u* const`*`pa_msg`*`[8], const int64u* const`*`pa_pubx`*`[8], const int64u* const`*`pa_puby`*`[8], const int64u* const`*`pa_pubz`*`[8], int8u*`*`pBuffer`*`);`

`mbx_status mbx_nistp256_ecdsa_verify_ssl_mb8(const ECDSA_SIG* const`*`pa_sign`*`[8], const int8u* const`*`pa_msg`*`[8], const BIGNUM* const`*`pa_pubx`*`[8], const BIGNUM* const`*`pa_puby`*`[8], const BIGNUM* const`*`pa_pubz`*`[8], int8u*`*`pBuffer`*`);`

`mbx_status mbx_nistp384_ecdsa_verify_mb8(const int8u* const`*`pa_sign_r`*`[8], const int8u* const`*`pa_sign_s`*`[8], const int8u* const`*`pa_msg`*`[8], const int64u* const`*`pa_pubx`*`[8], const int64u* const`*`pa_puby`*`[8], const int64u* const`*`pa_pubz`*`[8], int8u*`*`pBuffer`*`);`

`mbx_status mbx_nistp384_ecdsa_verify_ssl_mb8(const ECDSA_SIG* const`*`pa_sign`*`[8], const int8u* const`*`pa_msg`*`[8], const BIGNUM* const`*`pa_pubx`*`[8], const BIGNUM* const`*`pa_puby`*`[8], const BIGNUM* const`*`pa_pubz`*`[8], int8u*`*`pBuffer`*`);`

`mbx_status mbx_nistp521_ecdsa_verify_mb8(const int8u* const`*`pa_sign_r`*`[8], const int8u* const`*`pa_sign_s`*`[8], const int8u* const`*`pa_msg`*`[8], const int64u* const`*`pa_pubx`*`[8], const int64u* const`*`pa_puby`*`[8], const int64u* const`*`pa_pubz`*`[8], int8u*`*`pBuffer`*`);`

`mbx_status mbx_nistp521_ecdsa_verify_ssl_mb8(const ECDSA_SIG* const`*`pa_sign`*`[8], const int8u* const`*`pa_msg`*`[8], const BIGNUM* const`*`pa_pubx`*`[8], const BIGNUM* const`*`pa_puby`*`[8], const BIGNUM* const`*`pa_pubz`*`[8], int8u*`*`pBuffer`*`);`

Include Files

`crypto_mb/ec_nistp256.h`

`crypto_mb/ec_nistp384.h`

`crypto_mb/ec_nistp512.h`

Parameters

pa_sign_r	Array of pointers to the r-components of the signature.
pa_sign_s	Array of pointers to the s-components of the signature.
pa_sign	Array of pointers to the ECDSA_SIG structures.

pa_msg	Array of pointers to the message representatives that have been signed.
pa_pubx	Array of pointers to the vectors of signer's public key x-coordinates.
pa_puby	Array of pointers to the vectors of signer's public key y-coordinates.
pa_pubz	Array of pointers to the vectors of signer's public key z-coordinates..
pBuffer	Pointer to the work buffer.

Description

Each function targets at the elliptic curve (EC) specified in the name (`nistp256` , `nistp384` or `nistp521`). This function verifies digital signatures of the message representatives passed by *ps_msg* parameter using public keys specified by *pa_pubx* , *pa_puby* and *pa_pubz* parameters. If the *pa_pubz* parameter is not `NULL` , then it is assumed that signer's public keys are represented in projective coordinates. If the *pa_pubz* parameter is `NULL` , then signer's public keys are considered in affine coordinates.

The function assumes that the length of the message representative is equal to the length of *r* (order of EC subgroup). Signatures are represented as big endian byte strings and *r*- and *s*- components are stored separately in *pa_sign_r* and *pa_sign_s* parameters.

The work buffer specified by *pBuffer* parameter is not currently used and can be `NULL` .

NOTE
All the functions above have own "twins" with "_ssl" in the name. The "twin" associated with the EC acts the same. The differences in comparison with `mbx_nistp256/384/521_ecdsa_verify()` are the following:

- Representation of the key stuff. `mbx_nistp256/384/521_ecdsa_verify_ssl()` functions use BIGNUM datatype instead of vector.
- Representation of the signatures. `mbx_nistp256/384/521_ecdsa_verify_ssl()` functions use ECDSA_SIG structure instead of vectors of *r*- and *s*- components of the signature.

Return Values

The `mbx_nistp256/384/521_ecdsa_verify` functions return the status that indicates whether the operation completed successfully or not. The status value of 0 indicates that all digital signatures were successfully verified. The error condition can be analyzed by the `MBX_GET_STS()` call.

mbx_nistp256/384/521_ecpublic_key

Computes a public key.

Syntax

```
mbx_status mbx_nistp256_ecpublic_key_mb8(int64u* pa_pubx[8], int64u* pa_puby[8], const
int64u* pa_pubz[8], const int64u* const pa_skey[8], int8u* pBuffer);
```

```
mbx_status mbx_nistp256_ecpublic_key_ssl_mb8(BIGNUM* pa_pubx[8], BIGNUM* pa_puby[8],
const BIGNUM* pa_pubz[8], const BIGNUM* const pa_skey[8], int8u* pBuffer);
```

```
mbx_status mbx_nistp384_ecpublic_key_mb8(int64u* pa_pubx[8], int64u* pa_puby[8], const
int64u* pa_pubz[8], const int64u* const pa_skey[8], int8u* pBuffer);
```

mbx_status mbx_nistp384_ecpublic_key_ssl_mb8(BIGNUM* *pa_pubx*[8], BIGNUM* *pa_puby*[8], const BIGNUM* *pa_pubz*[8], const BIGNUM* const *pa_skey*[8], int8u* *pBuffer*);

mbx_status mbx_nistp521_ecpublic_key_mb8(int64u* *pa_pubx*[8], int64u* *pa_puby*[8], const int64u* *pa_pubz*[8], const int64u* const *pa_skey*[8], int8u* *pBuffer*);

mbx_status mbx_nistp521_ecpublic_key_ssl_mb8(BIGNUM* *pa_pubx*[8], BIGNUM* *pa_puby*[8], const BIGNUM* *pa_pubz*[8], const BIGNUM* const *pa_skey*[8], int8u* *pBuffer*);

Include Files

crypto_mb/ec_nistp256.h

crypto_mb/ec_nistp384.h

crypto_mb/ec_nistp521.h

Parameters

pa_pubx	Array of pointers to the vectors of computed public key x-coordinates.
pa_puby	Array of pointers to the vectors of computed public key y-coordinates.
pa_pubz	Array of pointers to the vectors of computed public key z-coordinates.
pa_skey	Array of pointers to the vectors of private keys.
pBuffer	Pointer to the work buffer.

Description

Each function targets at the elliptic curve (EC) specified in the name (nistp256, nistp384 or nistp521). The function computes public keys using private keys specified by the *pa_skey* parameter. If z-coordinate of computed public is required (*pa_pubz* is not NULL), then computed public keys are stored using projective coordinates. If *pa_pubz* is NULL, then computed public keys are stored using affine coordinates.

The work buffer specified by the *pBuffer* parameter is not currently used and can be NULL.

NOTE
All the functions above have own "twins" with "_ssl" in the name. The "twin" associated with the EC acts the same. The single difference in comparison with mbx_nistp256/384/521_ecpublic_key() is representation of the parameters. mbx_nistp256/384/521_ecpublic_key_ssl() functions use BIGNUM datatype instead of vector.

Return Values

The mbx_nistp256/384/521_ecpublic_key functions return the status that indicates whether the operation completed successfully or not. The status value of 0 indicates that all operations completed successfully. The error condition can be analyzed by the MBX_GET_STS() call.

mbx_nistp256/384/521_ecdh

Computes a shared secret.

Syntax

```
mbx_status mbx_nistp256_ecdh_mb8(int8u* pa_shared_key[8], const int64u* const
pa_skey[8], const int64u* const pa_pubx[8], const int64u* const pa_puby[8], const
int64u* const pa_pubz[8], int8u* pBuffer);
```

```
mbx_status mbx_nistp256_ecdh_ssl_mb8(int8u* pa_shared_key[8], const BIGNUM* const
pa_skey[8], const BIGNUM* const pa_pubx[8], const BIGNUM* const pa_puby[8], const
BIGNUM* const pa_pubz[8], int8u* pBuffer);
```

```
mbx_status mbx_nistp384_ecdh_mb8(int8u* pa_shared_key[8], const int64u* const
pa_skey[8], const int64u* const pa_pubx[8], const int64u* const pa_puby[8], const
int64u* const pa_pubz[8], int8u* pBuffer);
```

```
mbx_status mbx_nistp384_ecdh_ssl_mb8(int8u* pa_shared_key[8], const BIGNUM* const
pa_skey[8], const BIGNUM* const pa_pubx[8], const BIGNUM* const pa_puby[8], const
BIGNUM* const pa_pubz[8], int8u* pBuffer);
```

```
mbx_status mbx_nistp521_ecdh_mb8(int8u* pa_shared_key[8], const int64u* const
pa_skey[8], const int64u* const pa_pubx[8], const int64u* const pa_puby[8], const
int64u* const pa_pubz[8], int8u* pBuffer);
```

```
mbx_status mbx_nistp521_ecdh_ssl_mb8(int8u* pa_shared_key[8], const BIGNUM* const
pa_skey[8], const BIGNUM* const pa_pubx[8], const BIGNUM* const pa_puby[8], const
BIGNUM* const pa_pubz[8], int8u* pBuffer);
```

Include Files

`crypto_mb/ec_nistp256.h`

`crypto_mb/ec_nistp384.h`

`crypto_mb/ec_nistp521.h`

Parameters

pa_shared_key	Array of pointers to the vectors of computed shared secret values.
pa_pubx	Array of pointers to the vectors of party's public key x-coordinates.
pa_puby	Array of pointers to the vectors of party's public key y-coordinates.
pa_pubz	Array of pointers to the vectors of party's public key z-coordinates
pa_skey	Array of pointers to the vectors of own private keys.
pBuffer	Pointer to the work buffer.

Description

Each function targets at the elliptic curve (EC) specified in the name (`nistp256`, `nistp384` or `nistp521`). The function computes a shared secret value using own private keys specified by the *pa_skey* parameter and the party's public key specified by *pa_pubx*, *pa_puby* and *pa_pubz* parameters. If the *pa_pubz* parameter is not NULL, then it is assumed that party's public keys are represented in projective coordinates. If the *pa_pubz* parameter is NULL, then party's public keys are considered in affine coordinates.

The work buffer specified by the *pBuffer* parameter is not currently used and can be `NULL`.

NOTE
All the functions above have own "twins" with "_ssl" in the name. The "twin" associated with the EC acts the same. The single difference in comparison with `mbx_nistp256/384/521_ecdh()` is representation of the parameters. `mbx_nistp256/384/521_ecdh_ssl()` functions use BIGNUM datatype instead of vector.

Return Values

The `mbx_nistp256/384/521_ecdh` functions return the status that indicates whether the operation completed successfully or not. The status value of 0 indicates that all operations completed successfully. The error condition can be analyzed by the `MBX_GET_STS()` call.

Montgomery Curve25519 Elliptic Curve Functions

mbx_x25519_public_key

Computes a public key.

Syntax

mbx_status mbx_x25519_public_key_mb8(int8u* const *pa_public_key*[8], const int8u* const *pa_private_key*[8]);

Include Files

`crypto_mb/x25519.h`

Parameters

pa_public_key	Array of pointers to the vectors of computed public key x-coordinates.
pa_private_key	Array of pointers to the vectors of private keys.

Description

This function computes x-coordinates only of pubic keys using private keys specified by *pa_private_key* parameter. Any 256-bit vector is applicable as a private key. Each vector must be at least 32-byte length to store the computed x-coordinate of the public key.

Return Values

The `mbx_ x25519_public_key` function returns the status that indicates whether the operation completed successfully or not. The status value of 0 indicates that all operations completed successfully. The error condition can be analyzed by the `MBX_GET_STS()` call.

mbx_x25519

Computes a shared secret.

Syntax

mbx_status mbx_x25519_mb8(int8u* const *pa_shared_key*[8], const int8u* const *pa_private_key*[8], const int8u* const *pa_public_key*[8]);

Include Files

`crypto_mb/x25519.h`

Parameters

pa_shared_key	Array of pointers to the vectors of computed shared secret values.
pa_private_key	Array of pointers to the vectors of own private keys.
pa_public_key	Array of pointers to the vectors of party's public key x-coordinates.

Description

This function computes a shared secret using own private keys specified by *pa_private_key* and party's public keys specified by *pa_public_key* parameters. Each vector must be at least 32-byte length to store the computed shared secret value.

Return Values

The mbx_ x25519 function returns the status that indicates whether the operation completed successfully or not. The status value of 0 indicates that all operations completed successfully. The error condition can be analyzed by the MBX_GET_STS() call.

Edwards Curve25519 Elliptic Curve Functions

Key generation, sign, and verify functions over Edwards Elliptic Curve.

mbx_ed25519_public_key_mb8

Computes a public key.

Syntax

mbx_status mbx_ed25519_public_key_mb8(ed25519_public_key* *pa_public_key*[8], const ed25519_private_key* const *pa_private_key*[8]);

Include Files

crypto_mb/ed25519.h

Parameters

pa_public_key	Array of pointers to the public keys of 32 bytes length each.
pa_private_key	Array of pointers to the private keys of 32 bytes length each.

Description

The mbx_ed25519_public_key_mb8 function computes public keys pointed by *pa_public_key* parameter using input private keys pointed by the *pa_private_key* parameter. Private key is represented as 32-bytes length string that is kept in secret. The length of each computed public key is 32 bytes too.

Return Values

The mbx_ ed25519_public_key_mb8 function returns the status that indicates whether the operation completed successfully or not. The status value of 0 indicates that all operations completed successfully. The error condition can be analyzed by the MBX_GET_STS() call. The result of verification is returned as status too. The MBX_STATUS_OK value means that signature is verified, else status contains MBX_STATUS_SIGNATURE_ERR value.

mbx_ed25519_sign_mb8

Computes signature.

Syntax

mbx_status mbx_ed25519_sign_mb8(ed25519_sign_component* *pa_sign_r*[8], ed25519_sign_component* *pa_sign_s*[8], const int8u* const *pa_msg*[8], const int32u *msgLen*[8], const ed25519_private_key* const *pa_private_key*[8], const ed25519_public_key* const *pa_public_key*[8]);

Include Files

crypto_mb/ed25519.h

Parameters

pa_sign_r	Array of pointers to the signature's r- components of 32 bytes length each.
pa_sign_s	Array of pointers to the signature's s- components of 32 bytes length each.
pa_msg	Array of pointers to the messages.
msgLen	Array of the message's lengths above in bytes.
pa_public_key	Array of pointers to the public keys of 32 bytes length each.
pa_private_key	Array of pointers to the private keys of 32 bytes length each.

Description

The mbx_ed25519_sign_mb8 function computes r- and s- signature components, each of which corresponds to the message specified by *pa_msg[i]* parameter of *msgLen[i]* length. The pair {private, public} keys specified by *pa_private_key[i]* and *pa_public_key[i]* parameters.

NOTEmbx_ed25519_sign_mb8 is implementing so called PureEDDSA variant of EdDSA. For more information, see RFC 8032.

Return Values

The mbx_ ed25519_public_key_mb8 function returns the status that indicates whether the operation completed successfully or not. The status value of 0 indicates that all operations completed successfully. The error condition can be analyzed by the MBX_GET_STS( ) call. The result of verification is returned as status too. The MBX_STATUS_OK value means that signature is verified, else status contains MBX_STATUS_SIGNATURE_ERR value.

mbx_ed25519_verify_mb8

Verifies signature.

Syntax

mbx_status mbx_ed25519_verify_mb8(const ed25519_sign_component* const *pa_sign_r*[8], const ed25519_sign_component* const *pa_sign_s*[8], const int8u* const *pa_msg*[8], const int32u *msgLen*[8], const ed25519_public_key* const *pa_public_key*[8]);

Include Files

crypto_mb/ed25519.h

Parameters

pa_sign_r	Array of pointers to the signature's r- components of 32 bytes length each.
pa_sign_s	Array of pointers to the signature's s- components of 32 bytes length each.
pa_msg	Array of pointers to the messages.
msgLen	Array of the message's lengths above in bytes.
pa_public_key	Array of pointers to the public keys of 32 bytes length each.

Description

The `mbx_ed25519_verify_mb8` function verifies signatures specified by *pa_sign_r[i]* and *pa_sign_s[i]* parameters. Other parameters *pa_msg[]*, *msgLen[]*, and *pa_public_key[]* specify other input parameters for verification.

NOTE`mbx_ed25519_verify_mb8` is implementing so called PureEDDSA variant of EdDSA. For more information, see RFC 8032.

Return Values

The `mbx_ ed25519_public_key_mb8` function returns the status that indicates whether the operation completed successfully or not. The status value of 0 indicates that all operations completed successfully. The error condition can be analyzed by the `MBX_GET_STS()` call. The result of verification is returned as status too. The `MBX_STATUS_OK` value means that signature is verified, else status contains `MBX_STATUS_SIGNATURE_ERR` value.

SM2 Elliptic Curve Functions

Elliptic Curve Notation

There are several ways of defining equation for elliptic curves, but this section deals with Weierstrass equations. For the prime finite field *GF(p), p>3*, the Weierstrass equation is *E : y = x + a*x + b*, where *a* and *b* are integers modulo *p*. The number of points on the elliptic curve *E* is denoted by *#E*.

For purpose of cryptography some additional parameters are presented:

- *n* - prime divisor of *#E* and the order of point *G*
- *G* - the point on curve *E* generated subgroup of the order *n*

The set of *p, a, b, n*, and *G* parameters are Elliptic Curve (EC) domain parameter.

Elliptic Curve Key Pair

Private key is a positive integer *u* in the range *[1, n-1]*. Public key *V*, which is the point on elliptic curve *E*, where *V = [u] * G*. In cryptography, there are two types of keypairs: regular (long-term) and ephemeral (nonce - number that can only be used once). From the math point of view, they are similar.

Supported Algorithms:

- Public key generation
- ECDHE generation of shared secret
- SM2 ECDSA signature generation
- SM2 ECDSA signature verification

mbx_sm2_ecdsa_sign

Generates the SM2 ECDSA signature.

Syntax

```
mbx_status mbx_sm2_ecdsa_sign_mb8(int8u* pa_sign_r[8], int8u* pa_sign_s[8], const
int8u* const pa_user_id[8], const int user_id_len[8], const int8u* const pa_msg[8],
const int msg_len[8], const int64u* const pa_eph_skey[8], const int64u* const
pa_reg_skey[8], const int64u* const pa_pubx[8], const int64u* const pa_puby[8], const
int64u* const pa_pubz[8], int8u* pBuffer);
```

```
mbx_status mbx_sm2_ecdsa_sign_ssl_mb8(int8u* pa_sign_r[8], int8u* pa_sign_s[8], const
int8u* const pa_user_id[8], const int user_id_len[8], const int8u* const pa_msg[8],
const int msg_len[8], const BIGNUM* const pa_eph_skey[8], const BIGNUM* const
pa_reg_skey[8], const BIGNUM* const pa_pubx[8], const BIGNUM* const pa_puby[8], const
BIGNUM* const pa_pubz[8], int8u* pBuffer);
```

Include Files

`crypto_mb/ec_sm2.h`

Parameters

pa_sign_r	Array of pointers to the resulting r-components of the signature.
pa_sign_s	Array of pointers to the resulting s-components of the signature.
pa_user_id	Array of pointers to the users ID.
user_id_len	Array of users ID length.
pa_msg	Array of pointers to the message representatives are being signed.
msg_len	Array of messages length.
pa_eph_skey	Array of pointers to the signer's ephemeral private key.
pa_reg_skey	Array of pointers to the signer's regular private key.
pa_pubx	Array of pointers to the party's public keys X-coordinates
pa_puby	Array of pointers to the party's public keys Y-coordinates
pa_pubz	Array of pointers to the party's public keys Z-coordinates
pBuffer	Pointer to the work buffer.

Description

The function computes user ids, messages, and signer public keys representative using SM2 hash algorithm. User ids are specified by *pa_user_id* parameter and its length are specified by *user_id_len* parameter. Messages are specified by *pa_msg* parameter and its length are specified by *msg_len* parameter. Public keys are specified by *pa_pubx*, *pa_puby*, and *pa_pubz* parameters. If the *pa_pubz* parameter is not NULL, then it is assumed that signer's public keys are represented in projective coordinates. If the *pa_pubz* parameter is NULL, then signer's public keys are considered in affine coordinates.

Computed input data representative signed using regular and private keys specified by *pa_reg_skey* and *pa_eph_skey* parameters correspondingly. Computed signature converts `r-` and `s-` components of the signature into big endian byte strings and stores them separately in locations specified by *pa_sign_r* and *pa_sign_s* parameters.

The work buffer specified by the *pBuffer* parameter is not currently used and can be `NULL`.

NOTE
The function above has own "twin" with "_ssl" in the name. The only difference in comparison with `mbx_sm2_ecdsa_sign()` is representation of the parameters. `mbx_sm2_ecdsa_sign_ssl()` functions use BIGNUM datatype instead of vector.

Return Values

The `mbx_sm2_ecdsa_sign()` functions return the status that indicates whether the operation completed successfully or not. The status value of 0 indicates that all operations completed successfully. The error condition can be analyzed by the `MBX_GET_STS()` call.

mbx_sm2_ecdsa_verify

Verifies the SM2 ECDSA signature.

Syntax

```
mbx_status mbx_sm2_ecdsa_verify_mb8(const int8u* constpa_sign_r[8], const int8u*
constpa_sign_s[8], const int8u* constpa_user_id[8], const int user_id_len[8], const
int8u* constpa_msg[8], const int msg_len[8], const int64u* constpa_pubx[8], const
int64u* constpa_puby[8], const int64u* const pa_pubz[8], int8u*pBuffer);
```

```
mbx_status mbx_sm2_ecdsa_verify_ssl_mb8(const ECDSA_SIG* constpa_sig[8], const int8u*
constpa_user_id[8], const int user_id_len[8], const int8u* constpa_msg[8], const int
msg_len[8], const BIGNUM* constpa_pubx[8], const BIGNUM* constpa_puby[8], const BIGNUM*
const pa_pubz[8], int8u*pBuffer);
```

Include Files

`crypto_mb/ec_sm2.h`

Parameters

pa_sign_r	Array of pointers to the r-components of the signature.
pa_sign_s	Array of pointers to the s-components of the signature.
pa_user_id	Array of pointers to the users ID.
user_id_len	Array of users ID length.
pa_msg	Array of pointers to the messages are being signed.
msg_len	Array of messages length.
pa_pubx	Array of pointers to the vectors of signer's public key x-coordinates.
pa_puby	Array of pointers to the vectors of signer's public key y-coordinates.
pa_pubz	Array of pointers to the vectors of signer's public key z-coordinates..

pBuffer	Pointer to the work buffer.

Description

The function computes user ids, messages, and signer public keys representative using SM2 hash algorithm. User ids are specified by *pa_user_id* parameter and its length are specified by *user_id_len* parameter. Messages are specified by *pa_msg* parameter and its length are specified by *msg_len* parameter. Public keys are specified by *pa_pubx*, *pa_puby*, and *pa_pubz* parameters. If the *pa_pubz* parameter is not NULL, then it is assumed that signer's public keys are represented in projective coordinates. If the *pa_pubz* parameter is NULL, then signer's public keys are considered in affine coordinates.

Then function verifies digital signatures of the computed input data representative. Signatures are represented as big endian byte strings and `r-` and `s-` components are stored separately in *pa_sign_r* and *pa_sign_s* parameters.

The work buffer specified by *pBuffer* parameter is not currently used and can be NULL .

NOTE
The function above has own "twin" with "_ssl" in the name. The differences in comparison with `mbx_sm2_ecdsa_verify()` are the following:

- Representation of the key stuff. `mbx_sm2_ecdsa_verify_ssl()` functions use BIGNUM datatype instead of vector.
- Representation of the signatures. `mbx_sm2_ecdsa_verify_ssl()` functions use ECDSA_SIG structure instead of vectors of *r*- and *s*- components of the signature.

Return Values

The `mbx_sm2_ecdsa_verify()` functions return the status that indicates whether the operation completed successfully or not. The status value of 0 indicates that all digital signatures were successfully verified. The error condition can be analyzed by the `MBX_GET_STS()` call.

mbx_sm2_ecpublic_key

Computes a public key.

Syntax

```
mbx_status mbx_sm2_ecpublic_key_mb8(int64u* pa_pubx[8], int64u* pa_puby[8], int64u*
pa_pubz[8], const int64u* const pa_skey[8], int8u* pBuffer);
```

```
mbx_status mbx_sm2_ecpublic_key_ssl_mb8(BIGNUM* pa_pubx[8], BIGNUM* pa_puby[8], BIGNUM*
pa_pubz[8], const BIGNUM* const pa_skey[8], int8u* pBuffer);
```

Include Files

`crypto_mb/ec_sm2.h`

Parameters

pa_pubx	Array of pointers to the vectors of computed public key x-coordinates.
pa_puby	Array of pointers to the vectors of computed public key y-coordinates.
pa_pubz	Array of pointers to the vectors of computed public key z-coordinates.

pa_skey	Array of pointers to the vectors of private keys.
pBuffer	Pointer to the work buffer.

Description

The function computes public keys using private keys specified by the *pa_skey* parameter. If z-coordinate of computed public is required (*pa_pubz* is not NULL), then computed public keys are stored using projective coordinates. If *pa_pubz* is NULL, then computed public keys are stored using affine coordinates.

The work buffer specified by the *pBuffer* parameter is not currently used and can be NULL.

NOTE
The function above has own "twin" with "_ssl" in the name. The only difference in comparison with `mbx_sm2_ecpublic_key()` is representation of the parameters. `mbx_sm2_ecpublic_key_ssl()` functions use BIGNUM datatype instead of vector.

Return Values

The `mbx_sm2_ecpublic_key()` function returns the status that indicates whether the operation completed successfully or not. The status value of 0 indicates that all operations completed successfully. The error condition can be analyzed by the `MBX_GET_STS()` call.

mbx_nistp256/384/521_ecdh

Computes a shared secret.

Syntax

```
mbx_status mbx_sm2_ecdh_mb8(int8u* pa_shared_key[8], const int64u* const pa_skey[8],
const int64u* const pa_pubx[8], const int64u* const pa_puby[8], const int64u* const
pa_pubz[8], int8u* pBuffer);
```

```
mbx_status mbx_sm2_ecdh_ssl_mb8(int8u* pa_shared_key[8], const BIGNUM* const
pa_skey[8], const BIGNUM* const pa_pubx[8], const BIGNUM* const pa_puby[8], const
BIGNUM* const pa_pubz[8], int8u* pBuffer);
```

Include Files

`crypto_mb/ec_sm2.h`

Parameters

pa_shared_key	Array of pointers to the vectors of computed shared secret values.
pa_pubx	Array of pointers to the vectors of party's public key x-coordinates.
pa_puby	Array of pointers to the vectors of party's public key y-coordinates.
pa_pubz	Array of pointers to the vectors of party's public key z-coordinates
pa_skey	Array of pointers to the vectors of own private keys.
pBuffer	Pointer to the work buffer.

Description

The function computes a shared secret value using own private keys specified by the *pa_skey* parameter and the party's public key specified by *pa_pubx*, *pa_puby*, and *pa_pubz* parameters. If the *pa_pubz* parameter is not NULL, then it is assumed that party's public keys are represented in projective coordinates. If the *pa_pubz* parameter is NULL, then party's public keys are considered in affine coordinates.

The work buffer specified by the *pBuffer* parameter is not currently used and can be NULL.

NOTE
The function above has own "twin" with "_ssl" in the name. The only difference in comparison with `mbx_sm2_ecdh()` is representation of the parameters. `mbx_sm2_ecdh_ssl()` functions use BIGNUM datatype instead of vector.

Return Values

The `mbx_sm2_ecdh` function returns the status that indicates whether the operation completed successfully or not. The status value of 0 indicates that all operations completed successfully. The error condition can be analyzed by the `MBX_GET_STS()` call.

SM3 Hash Functions

SM3 functionality supports two scenarios of data processing:

1. Processing the entire messages with known length: mbx_sm3_msg_digest_mb16().
2. Streaming processing, when the lengths of the messages are initially unknown: mbx_sm3_init_mb16(), mbx_sm3_update_mb16(), mbx_sm3_final_mb16().

Functions that work in streaming mode operate with the public SM3_CTX_mb16 context. “Public” means that the structure of this context is open and fields of this context are accessible to users. For more information refer to `crypto_mb/sm3.h`. To get started with this context, you need to allocate memory for it and call the `mbx_sm3_init_mb16()` function to set it up.

mbx_sm3_msg_digest_mb16

Computes SM3 digest values of the input messages with known length.

Syntax

```
mbx_status16 mbx_sm3_msg_digest_mb16(const int8u *pa_msg[16], intlen[16], int8u
*pa_hash[16]);
```

Include Files

```
crypto_mb/sm3.h
```

Parameters

pa_msg	Array of pointers to the input message.
len	Array of message lengths in bytes.
pa_hash	Array of pointers to the resultant digests.

Description

The function uses the SM3 hashing scheme to compute digest values of the entire (non-streaming) input messages passed by *pa_msg* parameter in parallel. The lengths of the messages are specified in *len* array and can be different in different buffers. Produced hash values are stored in the memory locations specified by the *pa_hash* parameter.

Return Values

The `mbx_sm3_msg_digest_mb16` function returns the status that indicates whether the operation completed successfully or not. The status value of 0 indicates that digest values for all messages were computed successfully. In case of non-zero status value, `MBX_GET_HIGH_PART_STS16()` and `MBX_GET_LOW_PART_STS16()` can help to get the low and high parts of the `mbx_status16` , which can be analyzed separately with `MBX_GET_STS()` call. The low part includes first eight statuses, while the high part includes remaining 8 statuses for each operation.

mbx_sm3_init_mb16

Initializes the SM3 multi-buffer context for future use.

Syntax

```
mbx_status16 mbx_sm3_init_mb16 (SM3_CTX_mb16*p_state);
```

Include Files

`crypto_mb/sm3.h`

Parameters

p_state	Pointer to the SM3_CTX_mb16 context being initialized.

Description

The function sets up the SM3_CTX_mb16 digest context pointed by *p_state*.

Return Values

The `mbx_sm3_init_mb16` function returns the status that indicates whether the operation completed successfully or not. The status value of 0 indicates that the context was initialized successfully. In case of non-zero status value, `MBX_GET_HIGH_PART_STS16()` and `MBX_GET_LOW_PART_STS16()` can help to get the low and high parts of the `mbx_status16` , which can be analyzed separately with `MBX_GET_STS()` call. The low part includes first eight statuses, while the high part includes remaining 8 statuses for each operation.

mbx_sm3_update_mb16

Digests the current streams of input messages with the specified length.

Syntax

```
mbx_status16 mbx_sm3_update_mb16( const int8u *pa_msg[16], intlen[16],
SM3_CTX_mb16*p_state);
```

Include Files

`crypto_mb/sm3.h`

Parameters

pa_msg	Array of pointers to the buffers containing parts of the whole messages.
len	Array of lengths of the actual parts of the messages in bytes.
p_state	Pointer to the SM3_CTX_mb16 context.

Description

The function digests the current streams of input messages passed by *pa_msg* parameter. The specified messages lengths are passed through *len* array. You can call the function several times with the same *p_state* to produce intermediate hashes values.

The function integrates the previous partial blocks placed in the internal buffer of the SM3_CTX_mb16 context with the input messages streams. Then, produces intermediate hashes values if the summary lengths are bigger than SM3 block size. The remainder of the data, which is not a multiple of the SM3 block size, is added to the internal buffer for the further hashing.

Return Values

The `mbx_sm3_update_mb16` function returns the status the indicates whether the operation completed successfully or not. The status value of 0 indicates that hash values were updated successfully. In case of non-zero status value, `MBX_GET_HIGH_PART_STS16()` and `MBX_GET_LOW_PART_STS16()` can help to get the low and high parts of the `mbx_status16` , which can be analyzed separately with `MBX_GET_STS()` call. The low part includes first eight statuses, while the high part includes remaining 8 statuses for each operation.

mbx_sm3_final_mb16

Completes computation of the SM3 digest values.

Syntax

```
mbx_status16 mbx_sm3_final_mb16(int8u*pa_hash[16], SM3_CTX_mb16*p_state);
```

Include Files

```
crypto_mb/sm3.h
```

Parameters

pa_hash	Array of pointers to the resultant digests.
p_state	Pointer to the SM3_CTX_mb16 context.

Description

The function completes calculation of the digest values and stores the results in the memory specified by the *pa_hash* parameter.

Return Values

The `mbx_sm3_final_mb16` function returns the status that indicates whether the operation completed successfully or not. The status value of 0 indicates that the computation of SM3 digest values was finalized successfully. In case of non-zero status value, `MBX_GET_HIGH_PART_STS16()` and `MBX_GET_LOW_PART_STS16()` can help to get the low and high parts of the `mbx_status16`, which can be analyzed separately with `MBX_GET_STS()` call. The low part includes first eight statuses, while the high part includes remaining 8 statuses for each operation.

SM4 Algorithm Functions

Functions described in this section can be used for various operational modes of SM4 cipher systems.

mbx_sm4_set_key_mb16

Initializes multi buffer key schedule to provide all necessary key material for both encryption and decryption operations.

Syntax

`mbx_status16 mbx_sm4_set_key_mb16(mbx_sm4_key_schedule* key_sched, const sm4_key* pa_key[SM4_LINES]);`

Include Files

`crypto_mb/sm4.h`

Parameters

key_sched	Pointer to key schedule being initialized.
pa_key	Array of pointers to the SM4 secret keys.

Description

Sets up `mbx_sm4_key_schedule` key schedule pointed by *key_sched* using user-supplied secret keys passed through *pa_key* with all necessary key material for both encryption and decryption operations.

Return Values

The `mbx_sm4_set_key_mb16()` function returns the status that indicates whether the operation completed successfully or not. The status value of 0 indicates that the key schedule was successfully initialized. In case of non-zero status value, `MBX_GET_HIGH_PART_STS16()` and `MBX_GET_LOW_PART_STS16()` can help to get the low and high parts of the `mbx_status16`, which can be analyzed separately with `MBX_GET_STS()` call. The low part includes first eight statuses, while the high part includes remaining 8 statuses for each operation.

mbx_sm4_encrypt/decrypt_ecb_mb16

Encryption/decryption of the input data streams by using the SM4 algorithm in the ECB mode.

Syntax

`mbx_status16 mbx_sm4_encrypt_ecb_mb16(int8u* pa_out[SM4_LINES], const int8u* pa_inp[SM4_LINES], const int len[SM4_LINES], const mbx_sm4_key_schedule* key_sched);`

`mbx_status16 mbx_sm4_decrypt_ecb_mb16(int8u* pa_out[SM4_LINES], const int8u* pa_inp[SM4_LINES], const int len[SM4_LINES], const mbx_sm4_key_schedule* key_sched);`

Include Files

`crypto_mb/sm4.h`

Parameters

pa_out	Array of pointers to the output data streams.
pa_inp	Array of pointers to the input data streams.

len	Array of lengths of the input data in bytes.
key_sched	Pointer to key schedule.

Description

These functions encrypt/decrypt the input data streams passed by *pa_inp* of a variable length passed through *len* array according to the ECB cipher scheme and store the results into the memory buffers specified in *pa_out* parameter.

Return Values

The mbx_sm4_encrypt/decrypt_ecb_mb16() function returns the status that indicates whether the operation completed successfully or not. The status value of 0 indicates that data streams were successfully encrypted/decrypted. In case of non-zero status value, MBX_GET_HIGH_PART_STS16() and MBX_GET_LOW_PART_STS16() can help to get the low and high parts of the mbx_status16, which can be analyzed separately with MBX_GET_STS() call. The low part includes first eight statuses, while the high part includes remaining 8 statuses for each operation.

mbx_sm4_encrypt/decrypt_cbc_mb16

Encryption/decryption of the input data streams by using the SM4 algorithm in the CBC mode.

Syntax

```
mbx_status16 mbx_sm4_encrypt_cbc_mb16(int8u* pa_out[SM4_LINES], const int8u*
pa_inp[SM4_LINES], const int len[SM4_LINES], const mbx_sm4_key_schedule* key_sched,
const int8u* pa_iv[SM4_LINES]);
```

```
mbx_status16 mbx_sm4_decrypt_cbc_mb16(int8u* pa_out[SM4_LINES], const int8u*
pa_inp[SM4_LINES], const int len[SM4_LINES], const mbx_sm4_key_schedule* key_sched,
const int8u* pa_iv[SM4_LINES]);
```

Include Files

crypto_mb/sm4.h

Parameters

pa_out	Array of pointers to the output data streams.
pa_inp	Array of pointers to the input data streams.
len	Array of lengths of the input data in bytes.
key_sched	Pointer to key schedule.
pa_iv	Array of pointers to the initialization vectors for the CBC mode operation.

Description

These functions encrypt/decrypt the input data streams passed by *pa_inp* of a variable length passed through *len* array according to the CBC cipher scheme and store the results into the memory buffers specified in *pa_out* parameter.

Return Values

The `mbx_sm4_encrypt/decrypt_cbc_mb16()` function returns the status that indicates whether the operation completed successfully or not. The status value of 0 indicates that data streams were successfully encrypted/decrypted. In case of non-zero status value, `MBX_GET_HIGH_PART_STS16()` and `MBX_GET_LOW_PART_STS16()` can help to get the low and high parts of the `mbx_status16`, which can be analyzed separately with `MBX_GET_STS()` call. The low part includes first eight statuses, while the high part includes remaining 8 statuses for each operation.

mbx_sm4_encrypt/decrypt_ctr128_mb16

Encryption/decryption of the input data streams by using the SM4 algorithm in the CTR mode with 128-bit counter.

Syntax

```
mbx_status16 mbx_sm4_encrypt_ctr128_mb16(int8u* pa_out[SM4_LINES], const int8u*
pa_inp[SM4_LINES], const int len[SM4_LINES], const mbx_sm4_key_schedule* key_sched,
int8u* pa_ctr[SM4_LINES]);
```

```
mbx_status16 mbx_sm4_decrypt_ctr128_mb16(int8u* pa_out[SM4_LINES], const int8u*
pa_inp[SM4_LINES], const int len[SM4_LINES], const mbx_sm4_key_schedule* key_sched,
int8u* pa_ctr[SM4_LINES]);
```

Include Files

`crypto_mb/sm4.h`

Parameters

pa_out	Array of pointers to the output data streams.
pa_inp	Array of pointers to the input data streams.
len	Array of lengths of the input data in bytes.
key_sched	Pointer to key schedule.
pa_ctr	Array of pointers to the 128-bit initialization vectors for the CTR mode operation.

Description

These functions encrypt/decrypt the input data streams passed by *pa_inp* of a variable length passed through *len* array according to the CTR cipher scheme with 128-bit counters *pa_ctr*. The results are stored into the memory buffers specified in *pa_out* parameter.

Return Values

The `mbx_sm4_encrypt/decrypt_ctr128_mb16()` function returns the status that indicates whether the operation completed successfully or not. The status value of 0 indicates that data streams were successfully encrypted/decrypted. In case of non-zero status value, `MBX_GET_HIGH_PART_STS16()` and `MBX_GET_LOW_PART_STS16()` can help to get the low and high parts of the `mbx_status16`, which can be analyzed separately with `MBX_GET_STS()` call. The low part includes first eight statuses, while the high part includes remaining 8 statuses for each operation.

mbx_sm4_encrypt/decrypt_ofb_mb16

Encryption/decryption of the input data streams by using the SM4 algorithm in the OFB mode.

Syntax

mbx_status16 mbx_sm4_encrypt_ofb_mb16(int8u* *pa_out*[SM4_LINES], const int8u* *pa_inp*[SM4_LINES], const int *len*[SM4_LINES], const mbx_sm4_key_schedule* *key_sched*, int8u* *pa_iv*[SM4_LINES]);

mbx_status16 mbx_sm4_decrypt_ofb_mb16(int8u* *pa_out*[SM4_LINES], const int8u* *pa_inp*[SM4_LINES], const int *len*[SM4_LINES], const mbx_sm4_key_schedule* *key_sched*, int8u* *pa_iv*[SM4_LINES]);

Include Files

crypto_mb/sm4.h

Parameters

pa_out	Array of pointers to the output data streams.
pa_inp	Array of pointers to the input data streams.
len	Array of lengths of the input data in bytes.
key_sched	Pointer to key schedule.
pa_iv	Array of pointers to the initialization vectors for the OFB mode operation.

Description

These functions encrypt/decrypt the input data streams passed by *pa_inp* of a variable length passed through *len* array according to the OFB cipher scheme. The results are stored into the memory buffers specified in *pa_out* parameter.

Return Values

The mbx_sm4_encrypt/decrypt_ofb_mb16() function returns the status that indicates whether the operation completed successfully or not. The status value of 0 indicates that data streams were successfully encrypted/decrypted. In case of non-zero status value, MBX_GET_HIGH_PART_STS16() and MBX_GET_LOW_PART_STS16() can help to get the low and high parts of the mbx_status16, which can be analyzed separately with MBX_GET_STS() call. The low part includes first eight statuses, while the high part includes remaining 8 statuses for each operation.

mbx_sm4_encrypt/decrypt_cfb128_mb16

Encryption/decryption of the input data streams by using the SM4 algorithm in the CFB mode with 128-bit CFB block size.

Syntax

mbx_status16 mbx_sm4_encrypt_cfb128_mb16(int8u* *pa_out*[SM4_LINES], const int8u* *pa_inp*[SM4_LINES], const int *len*[SM4_LINES], const mbx_sm4_key_schedule* *key_sched*, const int8u* *pa_iv*[SM4_LINES]);

mbx_status16 mbx_sm4_decrypt_cfb128_mb16(int8u* *pa_out*[SM4_LINES], const int8u* *pa_inp*[SM4_LINES], const int *len*[SM4_LINES], const mbx_sm4_key_schedule* *key_sched*, const int8u* *pa_iv*[SM4_LINES]);

Include Files

crypto_mb/sm4.h

Parameters

pa_out	Array of pointers to the output data streams.
pa_inp	Array of pointers to the input data streams.
len	Array of lengths of the input data in bytes.
key_sched	Pointer to key schedule.
pa_iv	Array of pointers to the 128-bit initialization vectors for the CFB mode operation.

Description

These functions encrypt/decrypt the input data streams passed by *pa_inp* of a variable length passed through *len* array according to the CFB cipher scheme with 128-but CFB block size *pa_iv*. The results are stored into the memory buffers specified in *pa_out* parameter.

Return Values

The `mbx_sm4_encrypt/decrypt_cfb128_mb16()` function returns the status that indicates whether the operation completed successfully or not. The status value of 0 indicates that data streams were successfully encrypted/decrypted. In case of non-zero status value, `MBX_GET_HIGH_PART_STS16()` and `MBX_GET_LOW_PART_STS16()` can help to get the low and high parts of the mbx_status16, which can be analyzed separately with `MBX_GET_STS()` call. The low part includes first eight statuses, while the high part includes remaining 8 statuses for each operation.

Modular Exponentiation

This section describes functions that perform modular exponentiation.

- `mbx_exp_1024_mb8`
- `mbx_exp_2048_mb8`
- `mbx_exp_3072_mb8`
- `mbx_exp_4096_mb8`
- `mbx_exp_mb8`

As well as additional support functions.

- `mbx_exp_BufferSize`

mbx_exp/1024/2048/3072/4096_mb8

Performs modular exponentiation.

Syntax

mbx_status mbx_exp1024_mb8(int64u* const *out_pa*[8], const int64u* const *base_pa*[8], const int64u* const *exp_pa*[8], int *exp_bits*, const int64u* const *mod_pa*[8], int *mod_bits*, int8u* *pBuffer*, int *bufferLen*);

mbx_status mbx_exp2048_mb8(int64u* const *out_pa*[8], const int64u* const *base_pa*[8], const int64u* const *exp_pa*[8], int *exp_bits*, const int64u* const *mod_pa*[8], int *mod_bits*, int8u* *pBuffer*, int *bufferLen*);

mbx_status mbx_exp3072_mb8(int64u* const *out_pa*[8], const int64u* const *base_pa*[8], const int64u* const *exp_pa*[8], int *exp_bits*, const int64u* const *mod_pa*[8], int *mod_bits*, int8u* *pBuffer*, int *bufferLen*);

mbx_status mbx_exp4096_mb8(int64u* const *out_pa*[8], const int64u* const *base_pa*[8], const int64u* const *exp_pa*[8], int *exp_bits*, const int64u* const *mod_pa*[8], int *mod_bits*, int8u* *pBuffer*, int *bufferLen*);

mbx_status mbx_exp_mb8(int64u* const *out_pa*[8], const int64u* const *base_pa*[8], const int64u* const *exp_pa*[8], int *exp_bits*, const int64u* const *mod_pa*[8], int *mod_bits*, int8u* *pBuffer*, int *bufferLen*);

Include Files

crypto_mb/exp.h

Parameters

out_pa	Array of pointers to the computed exponents.
base_pa	Array of pointers to the input bases to be exponentiated.
exp_pa	Array of pointers to the input power values.
exp_bits	Size of power in bits.
mod_pa	Array of pointers to the input modules used for reduction.
mod_bits	Size of modulus in bits.
pBuffer	Pointer to the work buffer.
bufferLen	Size of the work buffer in bytes.

Description

All the functions compute modular exponentiation by the following formula:

$$y[i] = base[i]^{exp[i]} mod n[i]$$

Functions mbx_exp1024_mb8, mbx_exp2048_mb8, mbx_exp3072_mb8, and mbx_exp4096_mb8 are focused on exponentiation over the limited range of modulus n[i] - 1Kb, 2Kb, 3Kb, and 4Kb correspondingly.

Exact ranges of supported modulus are represented in the table below.

function name	modulus range	exact boundaries (min, max) of the modulus size in bits
mbx_exp1024_mb8	1Kb	989, 1038
mbx_exp2048_mb8	2Kb	2029, 2078
mbx_exp3072_mb8	3Kb	3069, 3118
mbx_exp4096_mb8	4Kb	4057, 4106

If actual sizes of modules are different, set the *mod_bits* parameter equal to maximum size of the actual module in bit size and extend all the modules with zero bits to the *mod_bits* value. The same is applicable for the *exp_bits* parameter and actual exponents.

The mbx_exp_mb8 function provides processing of modules belonging to either 1Kb, 2Kb, 3Kb or 4Kb range only, calling appropriate mbx_exp1024_mb8, mbx_exp2048_mb8, mbx_exp3072_mb8 or mbx_exp4096_mb8 function based on *mod_bits* parameter.

Parameters *pBuffer* and *bufferLen* are defining the work buffer used for internal purposes. Minimal size of the work buffer necessary for performing modular exponentiation can be obtained by the call of the mbx_exp_BufferSize function.

Return Values

The `mbx_exp1024_mb8`, `mbx_exp2048_mb8`, `mbx_exp3072_mb8`, `mbx_exp4096_mb8`, and `mbx_exp_mb8` functions return the status that indicates whether the operation completed successfully or not. The status value of 0 indicates that all operations completed successfully. The error condition can be analyzed by the `MBX_GET_STS()` call.

mbx_exp_BufferSize

Returns minimal size of work buffer requested for modular exponentiation.

Syntax

```
int mbx_exp_BufferSize(int mod_bits);
```

Include Files

```
crypto_mb/exp.h
```

Parameters

`mod_bits`	Size of modulus in bits.

Description

The function returns minimal size of work buffer requested for `1Kb, 2Kb, 3Kb or 4Kb` modular exponentiation depending on *`mod_bits`* parameter. If the *`mod_bits`* parameter does not match the supported range of modulo size, it returns 0.

Appendix A: Support Functions and Classes

This appendix contains miscellaneous information on support functions and classes that may be helpful to users of the Intel® Integrated Performance Primitives (Intel® IPP) Cryptography.

The Version Information Function section describes an Intel IPP Cryptography function that provides version information for cryptography software.

The Classes and Functions Used in Examples section presents source code of classes and functions needed for examples given in the document sections.

Security Validation of Library Functions

Most of Intel® Integrated Performance Primitives (Intel® IPP) Cryptography functions use secret data, such as keys, directly. For example, AES functions convert an input secret key into key schedule, which is used by all the cipher modes. The secret data might leak when code processes various secrets with the different executed instructions sequences or memory access patterns.

The difference in code behavior can be observed, analyzed, and, as a result, several bits or the whole secret can be determined. It means the code does not match the constant execution time (CET) design.

To check that the library matches the CET design, a special PINCER (Pin Certification) test suite is used. The PINCER test suite is based on Intel's dynamic binary instrumentation tool - Pin (see *https://software.intel.com/content/www/us/en/develop/articles/pin-a-dynamic-binary-instrumentation-tool.html*) and includes a set of tests, where each test is responsible for one separate library function.

The PINCER test runs the validated library function several times with different inputs and collects two kinds of traces:

- IP (Instruction Pointer) trace, which contains executed instructions addresses
- Memory access trace, which contains memory access addresses and read/write instructions

The function complies with the CET design if collected traces are identical. Otherwise, it does not meet the CET requirements.

Currently, PINCER tests are running on 64-bit Linux architecture and cover a limited list of library functions. The tables below present library functions covered by PINCER tests and their validation status.

AES functions

Function Name	Status
`ippsAESSetKey`	passed
`ippsAES{Encrypt/Decrypt}ECB`	passed
`ippsAES{Encrypt/Decrypt}CBC`	passed
`ippsAES{Encrypt/Decrypt}CBC SC1`	passed
`ippsAES{Encrypt/Decrypt}CBC SC2`	passed
`ippsAES{Encrypt/Decrypt}CBC SC3`	passed
`ippsAES{Encrypt/Decrypt}CFB`	passed
`ippsAES{Encrypt/Decrypt}OFB`	passed
`ippsAES{Encrypt/Decrypt}CTR`	passed
`ippsAES{Encrypt/Decrypt}XTS Direct`	passed
`ippsAES XTS{Encrypt/Decrypt}`	passed
`ippsAES GCM{Start/Encrypt/Decrypt}`	passed
`ippsAES SIV{Encrypt/Decrypt}`	passed
`ippsAES S2V CMAC`	passed
`ippsAES CCM{Encrypt/Decrypt}`	passed
`ippsAES CMAC{Update/Final}`	passed

SMS4 functions

Function Name	Status
`ippsSMS4SetKey`	passed
`ippsSMS4{Encrypt/Decrypt}ECB`	passed
`ippsSMS4{Encrypt/Decrypt}CBC`	passed
`ippsSMS4{Encrypt/Decrypt}CBC SC1`	passed
`ippsSMS4{Encrypt/Decrypt}CBC SC2`	passed
`ippsSMS4{Encrypt/Decrypt}CBC SC3`	passed
`ippsSMS4{Encrypt/Decrypt}CFB`	passed
`ippsSMS4{Encrypt/Decrypt}OFB`	passed
`ippsSMS4{Encrypt/Decrypt}CTR`	passed
`ippsSMS4 CCM{Encrypt/Decrypt}`	passed

HMAC functions

Function Name	Status
`ippsHMACInit rmf`	passed

RSA functions

Function Name	Status
`ippsRSA Decrypt`	passed
`ippsRSADecrypt OAEP`	passed
`ippsRSADecrypt OAEP rmf`	passed
`ipsRSASign PSS`	passed
`ipsRSASign PSS rmf`	passed
`ipsRSASign PKCS1v15`	passed
`ipsRSASign PKCS1v15 rmf`	passed
`ippsRSA MB Decrypt`	passed

DLP functions

Function Name	Status
`ippsDLPPublicKey`	passed
`ippsDLPSharedSecretDH`	passed
`ippsDLPSignDSA`	passed

GFp functions

Function Name	Status
`ippsGFpAdd`	passed
`ippsGFpAdd PE`	passed
`ippsGFpMul`	passed
`ippsGFpMul PE`	passed
`ippsGFpSub`	passed
`ippsGFpSub PE`	passed
`ippsGFpConj`	passed
`ippsGFpNeg`	passed
`ippsGFpSqr`	passed
`ippsGFpExp`	passed
`ippsGFpMultiExp`	passed
`ippsGFpSqrt`	failed
`ippsGFpInv`	passed

/

EC over GFp functions

Function Name	Status
`ippsGFpECAddPoint`	passed
`ippsGFpECNegPoint`	passed
`ippsGFpECMulPoint`	passed
`ippsGFpECPublicKey`	passed
`ippsGFpECSharedSecretDH{C}`	passed
`ippsGFpECSignDSA`	passed
`ippsGFpECSignNR`	passed
`ippsGFpSignSM2`	passed
`ippsGFpECES{Start/Final} SM2`	passed
`ippsGFpECES{Encrypr/Decrypt} SM2`	passed

Version Information Function

GetLibVersion

Returns information about the active version of the Intel IPP software for cryptography.

Syntax

```
const IppLibraryVersion* ippcpGetLibVersion(void);
```

Include Files

`ippcp.h`

Description

This function returns a pointer to a static data structure `IppLibraryVersion` that contains information about the current version of the Intel IPP software for cryptography. There is no need for you to release memory referenced by the returned pointer because it points to a static variable. The following fields of the `IppLibraryVersion` structure are available:

`major`	is the major number of the current library version.
`minor`	is the minor number of the current library version.
`majorBuild`	is the number of builds for the (*`major.miror`*) version.
`build`	is the total number of Intel IPP builds.
`Name`	is the name of the current library version.
`Version`	is the version string.
`BuildDate`	is the actual build date

For example, if the library version is "7.0", library name is "`ippcp.lib`", and build date is "Jul 20 2011", then the fields in this structure are set as follows:

major = 7, *minor* = 0, *Name* = "ippcp_l.lib", *Version* = "7.0 build 205.68", *BuildDate* = "Jul 20 2011".

Example

Example

The code example below shows how to use the function `ippcpGetLibVersion`.

```
void libinfo(void) { const IppLibraryVersion* lib = ippcpGetLibVersion();
```

```
printf("%s %s %d.%d.%d.%d\n", lib->Name, lib->Version, lib->major, lib->minor, lib->majorBuild,
lib->build);
```

```
}
```

Output:

```
ippcp_l.lib 7.0 build 205.68
```

Dispatcher Control Functions

This section describes Intel® Integrated Performance Primitives Cryptography functions that control dispatchers of the merged static libraries.

Init

Automatically initializes the library code that matches the current processor best.

Syntax

`IppStatus ippcpInit(void);`

Include Files

`ippcp.h`

Description

This function detects the processor type of the user system and sets the processor-specific code of the Intel® Integrated Performance Primitives Cryptography library that matches the current processor type best.

Return Values

`ippStsNoErr`	Indicates that the required processor-specific code is successfully set.
`ippStsNotSupportedCpu`	Indicates that the CPU is not supported.
`ippStsNonIntelCpu`	Indicates that the target CPU is not Genuine Intel.

Other Functions

GetCpuFeatures

Retrieves the processor features.

Syntax

`IppStatus ippcpGetCpuFeatures(Ipp64u* pFeaturesMask);`

Include Files

`ippcp.h`

Parameters

`pFeaturesMask`	Pointer to the features mask. Possible value is `ippCPUID_GETINFO_A`.

Description

This function retrieves some of the CPU features returned by the function CPUID.1 and stores them consecutively in the mask *`pFeaturesMask`*. The following table lists the features stored in the mask.

Mask Value	Bit Name	Feature	Mask Bit Number
0x00000001	`ippCPUID_MMX`	MMX™ technology	0
0x00000002	`ippCPUID_SSE`	Intel® Streaming SIMD Extensions	1
0x00000004	`ippCPUID_SSE2`	Intel® Streaming SIMD Extensions 2	2
0x00000008	`ippCPUID_SSE3`	Intel® Streaming SIMD Extensions 3	3
0x00000010	`ippCPUID_SSSE3`	Supplemental Streaming SIMD Extensions	4
0x00000020	`ippCPUID_MOVBE`	MOVBE instruction is supported	5
0x00000040	`ippCPUID_SSE41`	Intel® Streaming SIMD Extensions 4.1	6
0x00000080	`ippCPUID_SSE42`	Intel® Streaming SIMD Extensions 4.2	7
0x00000100	`ippCPUID_AVX`	The processor supports Intel® Advanced Vector Extensions (Intel® AVX) instruction set	8
0x00000200	`ippAVX_ENABLEDBYOS`	The operating system supports Intel® AVX	9
0x00000400	`ippCPUID_AES`	Advanced Encryption Standard (AES) instructions are supported	10
0x00000800	`ippCPUID_CLMUL`	PCLMULQDQ instruction is supported	11
0x00002000	`ippCPUID_RDRAND`	Read Random Number instructions are supported	13

Mask Value	Bit Name	Feature	Mask Bit Number
0x00004000	`ippCPUID_F16C`	16-bit floating point conversion instructions are supported	14
0x00008000	`ippCPUID_AVX2`	Intel® Advanced Vector Extensions 2 (Intel® AVX2) instruction set is supported	15
0x00010000	`ippCPUID_ADCOX`	ADCX and ADOX instructions are supported	16
0x00020000	`ippCPUID_RDSEED`	Read Random SEED instruction is supported.	17
0x00040000	`ippCPUID_PREFETCHW`	PREFETCHW instruction is supported	18
0x00080000	`ippCPUID_SHA`	Intel® Secure Hash Algorithm Extensions (Intel® SHA Extensions) are supported	19
0x00100000	`ippCPUID_AVX512F`	Intel® Advanced Vector Extensions 512 (Intel® AVX-512) foundation instructions are supported	20
0x00200000	`ippCPUID_AVX512CD`	Intel® AVX-512 conflict detection instructions are supported	21
0x00400000	`ippCPUID_AVX512ER`	Intel® AVX-512 exponential and reciprocal instructions are supported	22
0x80000000	`ippCPUID_KNC`	Intel® Xeon Phi™ is supported	23

NOTE
Intel® Itanium® processors are not supported.

Return Values

`ippStsNoErr`	Indicates no error.
`ippStsNullPtrErr`	Indicates an error condition when the *pFeaturesMask* pointer is `NULL`.
`ippStsNotSupportedCpu`	Indicates that the processor is not supported.

SetCpuFeatures

Sets the processor-specific library code for the specified processor features.

Syntax

`IppStatus ippcpSetCpuFeatures(Ipp64u cpuFeatures);`

Include Files

`ippcp.h`

Parameters

cpuFeatures	Features to be supported by the library. Refer to `ippcpdefs.h` for `ippCPUID_xx` definition.

Description

This function sets the processor-specific code of the Intel IPP Cryptography library according to the processor features specified in *cpuFeatures*. You can use the following predefined sets of features (the FM suffix below means *feature mask*):

32-bit code:

```
#define PX_FM ( ippCPUID_MMX | ippCPUID_SSE )
#define W7_FM ( PX_FM | ippCPUID_SSE2 )
#define V8_FM ( W7_FM | ippCPUID_SSE3 | ippCPUID_SSSE3 )
#define S8_FM ( V8_FM | ippCPUID_MOVBE )
#define P8_FM ( V8_FM | ippCPUID_SSE41 | ippCPUID_SSE42 | ippCPUID_AES | ippCPUID_CLMUL |
ippCPUID_SHA )
#define G9_FM ( P8_FM | ippCPUID_AVX | ippAVX_ENABLEDBYOS | ippCPUID_RDRAND | ippCPUID_F16C )
#define H9_FM ( G9_FM | ippCPUID_MOVBE | ippCPUID_AVX2 | ippCPUID_ADCOX | ippCPUID_RDSEED |
ippCPUID_PREFETCHW )
```

64-bit code:

```
#define PX_FM ( ippCPUID_MMX | ippCPUID_SSE | ippCPUID_SSE2 )
#define M7_FM ( PX_FM | ippCPUID_SSE3 )
#define U8_FM ( M7_FM | ippCPUID_SSSE3 )
#define N8_FM ( U8_FM | ippCPUID_MOVBE )
#define Y8_FM ( U8_FM | ippCPUID_SSE41 | ippCPUID_SSE42 | ippCPUID_AES | ippCPUID_CLMUL |
ippCPUID_SHA )
#define E9_FM ( Y8_FM | ippCPUID_AVX | ippAVX_ENABLEDBYOS | ippCPUID_RDRAND | ippCPUID_F16C )
```

```
#define L9_FM ( E9_FM | ippCPUID_MOVBE | ippCPUID_AVX2 | ippCPUID_ADCOX | ippCPUID_RDSEED |
ippCPUID_PREFETCHW )
#define K0_FM ( L9_FM | ippCPUID_AVX512F )
```

NOTE
Do not use any other Intel IPP Cryptography function while `ippcpSetCpuFeatures` is executing. Otherwise, your application behavior is undefined.

NOTE
To avoid initialization of internal structures for one Intel® architecture and then call of the processing function that is optimized for another architecture, do not use the `ippcpSetCpuFeatures` function in chains of Intel IPP Cryptography connected calls like <*processing function*>`GetSize` + <*processing function*>`Init` + <*processing function*>. Otherwise, Intel IPP Cryptography functionality behavior is undefined.

Intel IPP Cryptography library supports two internal sets of CPU features:

- *Real CPU features*: the features that are supported by the CPU at which the library is executed. These features are read-only and can be obtained with the `ippcpGetCpuFeatures` function.
- *Enabled features*: the features that are enabled externally to Intel IPP Cryptography by the application. These features can be set with `ippcpSetCpuFeatures`.

The `ippcpSetCpuFeatures` function provides additional flexibility in measuring performance improvements reached by using specific CPU features. For example, the first call of any Intel IPP Cryptography function in an application running on the 4th Generation Intel® Core™ i7 processor with 64-bit OS installed dispatches the L9 code version optimized for Intel® Advanced Vector Extensions 2 (Intel® AVX2) with several other features like fast 16-bit floating point support, Intel® AES New Instructions (Intel® AES-NI), PCLMULQDQ new instructions support.

To check performance improvement for all Intel IPP Cryptography functionality reached by using Intel® AVX2, you can run a benchmark for the currently dispatched version of code and then compare performance with the Intel® Advanced Vector Extensions (Intel® AVX) version of code with Intel® AVX2 disabled. To disable Intel AVX2, call `ippcpSetCpuFeatures(E9_FM)`. To enable Intel AVX2 back, call `ippcpSetCpuFeatures( L9_FM )`. Thus, you can use the `ippcpSetCpuFeatures` function to dispatch any version of Intel IPP Cryptography code and enable/disable specific CPU features. If you are not well familiar with the features of your CPU, use the auto-initialization mechanism for the default library behavior.

Product and Performance Information
Performance varies by use, configuration and other factors. Learn more at www.Intel.com/PerformanceIndex. Notice revision #20201201

Return Values

`ippStsNoErr`	Indicates that the required processor-specific code is successfully set.
`ippStsCpuMismatch`	Indicates that the specified processor features are not valid. Previously set code is used. If the requested feature is below the minimal supported by the **px** library - that is Intel® Streaming SIMD Extensions (Intel® SSE) for IA-32 and Intel® SSE2 for Intel® 64 architecture, **px** code is dispatched.

`ippStsFeatureNotSupported`	Indicates that the current CPU does not support at least one of the requested features. If the ippCPUID_NOCHECK bit of the *cpuFeatures* parameter is set to 1, these not supported features are enabled, otherwise - disabled.
`ippStsUnknownFeature`	Indicates that at least one of the requested features is unknown. It means that the feature is not defined in the `ippdefs.h` file. Further behavior of the library depends on known features passed to *cpuFeatures*. Unknown features are ignored.
`ippStsFeaturesCombination`	Indicates that the combination of features is not correct. For example, ippCPUID_AVX2 bit is set to 1 in *cpuFeatures*, but at least one of the ippCPUID_MMX, ippCPUID_SSE, ..., ippCPUID_AVX bits is not set. All these missing bits, if supported by CPU, are set to 1. This means that if the library supports the Intel® AVX2 code, it also internally uses all known MMX™, Intel® SSE, and Intel® AVX extensions, which are below Intel® AVX2.

GetEnabledCpuFeatures

Returns a features mask for enabled processor features.

Syntax

```
Ipp64u ippcpGetEnabledCpuFeatures(void);
```

Include Files

`ippcp.h`

Description

This function detects enabled CPU features for the currently loaded libraries and returns the corresponding features mask.

Product and Performance Information
Performance varies by use, configuration and other factors. Learn more at www.Intel.com/PerformanceIndex. Notice revision #20201201

See Also

GetCpuFeatures Retrieves the processor features.

GetCpuClocks

Returns a current value of the time stamp counter (TSC) register.

Syntax

```
Ipp64u ippcpGetCpuClocks(void);
```

Include Files

`ippcp.h`

Description

This function reads the current state of the TSC register and returns its value.

GetNumThreads

Returns the number of existing threads in the multithreading environment.

Syntax

`IppStatus ippcpGetNumThreads(int* pNumThr);`

Include Files

`ippcp.h`

Parameters

pNumThr	Pointer to the number of threads.

Description

This function returns the number of OpenMP* threads specified by the user previously. If it is not specified, the function returns the initial number of threads that depends on the number of logical processors.

Return Values

`ippStsNoErr`	Indicates no error.
`ippStsNullPtrErr`	Indicates an error condition when the *pNumThr* pointer is `NULL`.
`ippStsNoOperation`	Indicates that there is no such operation in the static version of the library.

GetEnabledNumThreads

Returns the number of existing threads in the multithreading environment.

Syntax

`int ippcpGetEnabledNumThreads(void);`

Include Files

`ippcp.h`

Description

This function returns the number of the OpenMP* threads specified by the user. If the number is not specified, the function returns the initial number of threads, which depends on the number of logical processors.

SetNumThreads

Sets the number of threads in the multithreading environment.

Syntax

`IppStatus ippcpSetNumThreads(int numThr);`

Include Files

`ippcp.h`

Parameters

numThr	Number of threads, should be more than zero.

Description

This function sets the number of OpenMP* threads. A number of established threads may be less than specified *numThr*.

Return Values

ippStsNoErr	Indicates no error.
ippStsSizeErr	Indicates an error when *numThr* is less than, or equal to zero.
ippStsNoOperation	Indicates that the function is called from the application linked to the single-threaded version of the library. No operation is performed.

GetStatusString

Translates a status code into a message.

Syntax

const char* ippcpGetStatusString(IppStatus *stsCode*);

Include Files

`ippcp.h`

Parameters

stsCode	Code that indicates the status type.

Description

This function returns a pointer to the text string associated with a status code of `IppStatus` type. Use this function to produce error and warning messages for users. The returned pointer is a pointer to an internal static buffer and does not need to be released.

Classes and Functions Used in Examples

This section presents source code of functions and classes used in Example "Use of RSA Primitives" and Example "Use of DLPSignDSA and DLPVerifyDSA".

BigNumber Class

The section presents source code of the `BigNumber` class.

Declarations

Contents of the header file (`xsample_bignum.h`) declaring the `BigNumber` class are presented below:

```
#if !defined _BIGNUMBER_H_
#define  _BIGNUMBER_H_
```

```
#include "ippcp.h"

#include <iostream>
#include <vector>
#include <iterator>
using namespace std;

class BigNumber
{
public:
   BigNumber(Ipp32u  value=0);
   BigNumber(Ipp32s  value);
   BigNumber(const IppsBigNumState* pBN);
   BigNumber(const Ipp32u* pData, int length=1, IppsBigNumSGN sgn=IppsBigNumPOS);
   BigNumber(const BigNumber& bn);
   BigNumber(const char *s);
   virtual  ~BigNumber();

   // set value
   void Set(const Ipp32u* pData, int length=1, IppsBigNumSGN sgn=IppsBigNumPOS);
   // conversion to IppsBigNumState
   friend IppsBigNumState* BN(const BigNumber& bn) {return bn.m_pBN;}
   operator IppsBigNumState* () const { return m_pBN; }

   // some useful constatns
   static const BigNumber& Zero();
   static const BigNumber& One();
   static const BigNumber& Two();

   // arithmetic operators probably need
   BigNumber& operator = (const BigNumber& bn);
   BigNumber& operator += (const BigNumber& bn);
   BigNumber& operator -= (const BigNumber& bn);
   BigNumber& operator *= (Ipp32u n);
   BigNumber& operator *= (const BigNumber& bn);
   BigNumber& operator /= (const BigNumber& bn);
   BigNumber& operator %= (const BigNumber& bn);
   friend BigNumber operator + (const BigNumber& a, const BigNumber& b);
   friend BigNumber operator - (const BigNumber& a, const BigNumber& b);
   friend BigNumber operator * (const BigNumber& a, const BigNumber& b);
   friend BigNumber operator * (const BigNumber& a, Ipp32u);
   friend BigNumber operator % (const BigNumber& a, const BigNumber& b);
   friend BigNumber operator / (const BigNumber& a, const BigNumber& b);

   // modulo arithmetic
   BigNumber Modulo(const BigNumber& a) const;
   BigNumber ModAdd(const BigNumber& a, const BigNumber& b) const;
   BigNumber ModSub(const BigNumber& a, const BigNumber& b) const;
   BigNumber ModMul(const BigNumber& a, const BigNumber& b) const;
   BigNumber InverseAdd(const BigNumber& a) const;
   BigNumber InverseMul(const BigNumber& a) const;

   // comparisons
   friend bool operator < (const BigNumber& a, const BigNumber& b);
   friend bool operator > (const BigNumber& a, const BigNumber& b);
   friend bool operator == (const BigNumber& a, const BigNumber& b);
   friend bool operator != (const BigNumber& a, const BigNumber& b);
   friend bool operator <= (const BigNumber& a, const BigNumber& b) {return !(a>b);}
   friend bool operator >= (const BigNumber& a, const BigNumber& b) {return !(a<b);}

   // easy tests
   bool IsOdd() const;
   bool IsEven() const { return !IsOdd(); }

   // size of BigNumber
   int MSB() const;
   int LSB() const;
   int BitSize() const { return MSB()+1; }
   int DwordSize() const { return (BitSize()+31)>>5;}
   friend int Bit(const vector<Ipp32u>& v, int n);

   // conversion and output
   void num2hex( string& s ) const; // convert to hex string
   void num2vec( vector<Ipp32u>& v ) const; // convert to 32-bit word vector
   friend ostream& operator << (ostream& os, const BigNumber& a);

protected:
   bool create(const Ipp32u* pData, int length, IppsBigNumSGN sgn=IppsBigNumPOS);
   int compare(const BigNumber& ) const;
   IppsBigNumState*  m_pBN;
};

// convert bit size into 32-bit words
#define BITSIZE_WORD(n) ((((n)+31)>>5))

#endif // _BIGNUMBER_H_
```

Definitions

C++ definitions for the BigNumber class methods are given below. For the declarations to be included, see the preceding Declarations section.

```
#include  "xsample_bignum.h"
//////////////////////////////////////////////////////////////////////
//
// BigNumber
//
//////////////////////////////////////////////////////////////////////
BigNumber::~BigNumber()
{
   delete [] (Ipp8u*)m_pBN;
}

bool BigNumber::create(const Ipp32u* pData, int length, IppsBigNumSGN sgn)
{
   int size;
   ippsBigNumGetSize(length,  &size);
   m_pBN = (IppsBigNumState*)( new Ipp8u[size] );
   if(!m_pBN)
      return false;
   ippsBigNumInit(length,  m_pBN);
   if(pData)
      ippsSet_BN(sgn, length, pData, m_pBN);
   return true;
}
```

```
// constructors
//
BigNumber::BigNumber(Ipp32u  value)
{
   create(&value, 1, IppsBigNumPOS);
}

BigNumber::BigNumber(Ipp32s  value)
{
   Ipp32s avalue = abs(value);
   create((Ipp32u*)&avalue, 1, (value<0)? IppsBigNumNEG : IppsBigNumPOS);
}

BigNumber::BigNumber(const  IppsBigNumState*  pBN)
{
   IppsBigNumSGN bnSgn;
   int bnBitLen;
   Ipp32u* bnData;
   ippsRef_BN(&bnSgn, &bnBitLen, &bnData, pBN);

   create(bnData,  BITSIZE_WORD(bnBitLen),  bnSgn);
}

BigNumber::BigNumber(const Ipp32u* pData, int length, IppsBigNumSGN sgn)
{
   create(pData, length, sgn);
}

static char HexDigitList[] = "0123456789ABCDEF";

BigNumber::BigNumber(const char* s)
{
   bool neg = '-' == s[0];
   if(neg) s++;
   bool hex = ('0'==s[0]) && (('x'==s[1]) || ('X'==s[1]));

   int dataLen;
   Ipp32u base;
   if(hex) {
      s += 2;
      base = 0x10;
      dataLen = (int)(strlen(s) + 7)/8;
   }
   else {
      base = 10;
      dataLen = (int)(strlen(s) + 9)/10;
   }

   create(0, dataLen);
   *(this) = Zero();
   while(*s) {
      char tmp[2] = {s[0],0};
      Ipp32u digit = (Ipp32u)strcspn(HexDigitList, tmp);
      *this = (*this) * base + BigNumber( digit );
      s++;
   }

   if(neg)
```

```
      (*this) = Zero()- (*this);
}

BigNumber::BigNumber(const  BigNumber&  bn)
{
   IppsBigNumSGN bnSgn;
   int bnBitLen;
   Ipp32u* bnData;
   ippsRef_BN(&bnSgn, &bnBitLen, &bnData, bn);

   create(bnData,  BITSIZE_WORD(bnBitLen),  bnSgn);
}

// set value
//
void BigNumber::Set(const Ipp32u* pData, int length, IppsBigNumSGN sgn)
{
   ippsSet_BN(sgn, length, pData, BN(*this));
}

// constants
//
const BigNumber& BigNumber::Zero()
{
   static const BigNumber zero(0);
   return zero;
}

const BigNumber& BigNumber::One()
{
   static const BigNumber one(1);
   return one;
}

const BigNumber& BigNumber::Two()
{
   static const BigNumber two(2);
   return two;
}

// arithmetic operators
//
BigNumber& BigNumber::operator =(const BigNumber& bn)
{
   if(this != &bn) {     // prevent self copy
      IppsBigNumSGN bnSgn;
      int bnBitLen;
      Ipp32u* bnData;
      ippsRef_BN(&bnSgn, &bnBitLen, &bnData, bn);

      delete  (Ipp8u*)m_pBN;
      create(bnData,  BITSIZE_WORD(bnBitLen),  bnSgn);
   }
   return *this;
}

BigNumber& BigNumber::operator += (const BigNumber& bn)
{
   int aBitLen;
   ippsRef_BN(NULL, &aBitLen, NULL, *this);
   int bBitLen;
   ippsRef_BN(NULL, &bBitLen, NULL, bn);
   int rBitLen = IPP_MAX(aBitLen, bBitLen) + 1;

   BigNumber  result(0,  BITSIZE_WORD(rBitLen));
   ippsAdd_BN(*this, bn, result);
   *this = result;
   return *this;
}

BigNumber& BigNumber::operator -= (const BigNumber& bn)
{
   int aBitLen;
   ippsRef_BN(NULL, &aBitLen, NULL, *this);
   int bBitLen;
   ippsRef_BN(NULL, &bBitLen, NULL, bn);
   int rBitLen = IPP_MAX(aBitLen, bBitLen);

   BigNumber  result(0,  BITSIZE_WORD(rBitLen));
   ippsSub_BN(*this, bn, result);
   *this = result;
   return *this;
}

BigNumber& BigNumber::operator *= (const BigNumber& bn)
{
   int aBitLen;
   ippsRef_BN(NULL, &aBitLen, NULL, *this);
   int bBitLen;
   ippsRef_BN(NULL, &bBitLen, NULL, bn);
   int rBitLen = aBitLen + bBitLen;

   BigNumber  result(0,  BITSIZE_WORD(rBitLen));
   ippsMul_BN(*this, bn, result);
   *this = result;
   return *this;
}

BigNumber& BigNumber::operator *= (Ipp32u n)
{
   int aBitLen;
   ippsRef_BN(NULL, &aBitLen, NULL, *this);

   BigNumber  result(0,  BITSIZE_WORD(aBitLen+32));
   BigNumber bn(n);
   ippsMul_BN(*this, bn, result);
   *this = result;
   return *this;
}

BigNumber& BigNumber::operator %= (const BigNumber& bn)
{
   BigNumber  remainder(bn);
   ippsMod_BN(BN(*this),  BN(bn),  BN(remainder));
   *this = remainder;
   return *this;
```

```
}

BigNumber& BigNumber::operator /= (const BigNumber& bn)
{
   BigNumber  quotient(*this);
   BigNumber  remainder(bn);
   ippsDiv_BN(BN(*this), BN(bn), BN(quotient), BN(remainder));
   *this = quotient;
   return *this;
}

BigNumber operator + (const BigNumber& a, const BigNumber& b )
{
   BigNumber r(a);
   return r += b;
}

BigNumber operator - (const BigNumber& a, const BigNumber& b )
{
   BigNumber r(a);
   return r -= b;
}

BigNumber operator * (const BigNumber& a, const BigNumber& b )
{
   BigNumber r(a);
   return r *= b;
}

BigNumber operator * (const BigNumber& a, Ipp32u n)
{
   BigNumber r(a);
   return r *= n;
}

BigNumber operator / (const BigNumber& a, const BigNumber& b )
{
   BigNumber q(a);
   return q /= b;
}

BigNumber operator % (const BigNumber& a, const BigNumber& b )
{
   BigNumber r(b);
   ippsMod_BN(BN(a), BN(b), BN(r));
   return r;
}

// modulo arithmetic
//
BigNumber BigNumber::Modulo(const BigNumber& a) const
{
   return a % *this;
}

BigNumber BigNumber::InverseAdd(const BigNumber& a) const
{
   BigNumber t = Modulo(a);
   if(t==BigNumber::Zero())
      return t;
   else
   return *this - t;
}

BigNumber BigNumber::InverseMul(const BigNumber& a) const
{
   BigNumber r(*this);
   ippsModInv_BN(BN(a), BN(*this), BN(r));
   return r;
}

BigNumber BigNumber::ModAdd(const BigNumber& a, const BigNumber& b) const
{
   BigNumber r = this->Modulo(a+b);
   return r;
}

BigNumber BigNumber::ModSub(const BigNumber& a, const BigNumber& b) const
{
   BigNumber r = this->Modulo(a + this->InverseAdd(b));
   return r;
}

BigNumber BigNumber::ModMul(const BigNumber& a, const BigNumber& b) const
{
   BigNumber r = this->Modulo(a*b);
   return r;
}

// comparison
//
int BigNumber::compare(const BigNumber &bn) const
{
   Ipp32u result;
   BigNumber tmp = *this - bn;
   ippsCmpZero_BN(BN(tmp),  &result);
   return (result==IS_ZERO)? 0 : (result==GREATER_THAN_ZERO)? 1 : -1;
}

bool operator <  (const BigNumber &a, const BigNumber &b) { return a.compare(b) < 0; }
bool operator >  (const BigNumber &a, const BigNumber &b) { return a.compare(b) > 0; }
bool operator == (const BigNumber &a, const BigNumber &b) { return 0 == a.compare(b);}
bool operator != (const BigNumber &a, const BigNumber &b) { return 0 != a.compare(b);}

// easy tests
//
bool BigNumber::IsOdd() const
{
   Ipp32u* bnData;
   ippsRef_BN(NULL, NULL, &bnData, *this);
   return bnData[0]&1;
}

// size of BigNumber
//
int BigNumber::LSB() const
```

```
{
   if( *this == BigNumber::Zero() )
      return 0;

   vector<Ipp32u> v;
   num2vec(v);

   int lsb = 0;
   vector<Ipp32u>::iterator  i;
   for(i=v.begin(); i!=v.end(); i++) {
      Ipp32u x = *i;
      if(0==x)
         lsb += 32;
      else {
         while(0==(x&1)) {
            lsb++;
            x >>= 1;
         }
         break;
      }
   }
   return lsb;
}

int BigNumber::MSB() const
{
   if( *this == BigNumber::Zero() )
      return 0;

   vector<Ipp32u> v;
   num2vec(v);

   int msb = (int)v.size()*32 -1;
   vector<Ipp32u>::reverse_iterator  i;
   for(i=v.rbegin(); i!=v.rend(); i++) {
      Ipp32u x = *i;
      if(0==x)
         msb -=32;
      else {
         while(!(x&0x80000000))  {
            msb--;
            x <<= 1;
         }
         break;
      }
   }
   return msb;
}

int Bit(const vector<Ipp32u>& v, int n)
{
   return 0 != ( v[n>>5] & (1<<(n&0x1F)) );
}

// conversions and output
//
void BigNumber::num2vec( vector<Ipp32u>& v ) const
{
   int bnBitLen;
   Ipp32u* bnData;
   ippsRef_BN(NULL, &bnBitLen, &bnData, *this);

   int len = BITSIZE_WORD(bnBitLen);;
   for(int n=0; n<len; n++)
      v.push_back( bnData[n] );
}

void BigNumber::num2hex( string& s ) const
{
   IppsBigNumSGN bnSgn;
   int bnBitLen;
   Ipp32u* bnData;
   ippsRef_BN(&bnSgn, &bnBitLen, &bnData, *this);

   int len = BITSIZE_WORD(bnBitLen);

   s.append(1, (bnSgn==ippBigNumNEG)? '-' : ' ');
   s.append(1, '0');
   s.append(1, 'x');
   for(int n=len; n>0; n--) {
      Ipp32u x = bnData[n-1];
      for(int nd=8; nd>0; nd--) {
         char c = HexDigitList[(x>>(nd-1)*4)&0xF];
         s.append(1, c);
      }
   }
}

ostream& operator << ( ostream &os, const BigNumber& a)
{
   string s;
   a.num2hex(s);
   os << s.c_str();
   return os;
}
```

Functions for Creation of Cryptographic Contexts

The section presents source code for creation of some cryptographic contexts.

Declarations

Contents of the header file (`xsample_cpobjs.h`) declaring functions for creation of some cryptographic contexts are presented below:

```
#if !defined _CPOBJS_H_
#define _CPOBJS_H_

//
// create new of some ippCP 'objects'
//
#include "ippcp.h"
#include <stdlib.h>

#define BITS_2_WORDS(n) (((n)+31)>>5)
int Bitsize2Wordsize(int nBits);
```

```
Ipp32u* rand32(Ipp32u* pX, int size);

IppsBigNumState* newBN(int len, const Ipp32u* pData=0);
IppsBigNumState* newRandBN(int len);
void deleteBN(IppsBigNumState* pBN);

IppsPRNGState*  newPRNG(int  seedBitsize=160);
void deletePRNG(IppsPRNGState* pPRNG);

IppsPrimeState*  newPrimeGen(int  seedBitsize=160);
void  deletePrimeGen(IppsPrimeState*  pPrime);

IppsRSAState* newRSA(int lenN, int lenP, IppRSAKeyType type);
void deleteRSA(IppsRSAState* pRSA);

IppsDLPState* newDLP(int lenM, int lenL);
void deleteDLP(IppsDLPState* pDLP);

#endif // _CPOBJS_H_
```

Definitions

C++ definitions of functions creating cryptographic contexts are given below. For the declarations to be included, see the preceding Declarations section.

```
#include  "xsample_cpobjs.h"

// convert bitsize into 32-bit wordsize
int Bitsize2Wordsize(int nBits)
{ return (nBits+31)>>5; }

// new BN number
IppsBigNumState* newBN(int len, const Ipp32u* pData)
{
   int size;
   ippsBigNumGetSize(len,  &size);
   IppsBigNumState* pBN = (IppsBigNumState*)( new Ipp8u [size] );
   ippsBigNumInit(len,  pBN);
   if(pData)
      ippsSet_BN(IppsBigNumPOS, len, pData, pBN);
   return pBN;
}
void deleteBN(IppsBigNumState* pBN)
{ delete [] (Ipp8u*)pBN; }

// set up array of 32-bit items random
Ipp32u* rand32(Ipp32u* pX, int size)
{
   for(int n=0; n<size; n++)
      pX[n] = (rand()<<16) + rand();
   return pX;
}

IppsBigNumState* newRandBN(int len)
{
   Ipp32u* pBuffer = new Ipp32u [len];
   IppsBigNumState* pBN = newBN(len, rand32(pBuffer, len));
   delete [] pBuffer;
   return pBN;
}

//
// 'external' PRNG
//
IppsPRNGState* newPRNG(int seedBitsize)
{
   int seedSize = Bitsize2Wordsize(seedBitsize);
   Ipp32u* seed = new Ipp32u [seedSize];
   Ipp32u* augm = new Ipp32u [seedSize];

   int size;
   IppsBigNumState*  pTmp;
   ippsPRNGGetSize(&size);
   IppsPRNGState* pCtx = (IppsPRNGState*)( new Ipp8u [size] );
   ippsPRNGInit(seedBitsize,  pCtx);

   ippsPRNGSetSeed(pTmp=newBN(seedSize,rand32(seed,seedSize)),   pCtx);
   delete [] (Ipp8u*)pTmp;
   ippsPRNGSetAugment(pTmp=newBN(seedSize,rand32(augm,seedSize)),pCtx);
   delete [] (Ipp8u*)pTmp;

   delete [] seed;
   delete [] augm;
   return pCtx;
}
void deletePRNG(IppsPRNGState* pPRNG)
{ delete [] (Ipp8u*)pPRNG; }

//
// Prime Generator context
//
IppsPrimeState* newPrimeGen(int maxBits)
{
   int size;
   ippsPrimeGetSize(maxBits,  &size);
   IppsPrimeState* pCtx = (IppsPrimeState*)( new Ipp8u [size] );
   ippsPrimeInit(maxBits,  pCtx);
   return pCtx;
}
void  deletePrimeGen(IppsPrimeState*  pPrimeG)
{ delete [] (Ipp8u*)pPrimeG; }

//
// RSA context
//
IppsRSAState* newRSA(int lenN, int lenP, IppRSAKeyType type)
{
   int size;
   ippsRSAGetSize(lenN,lenP, type, &size);
   IppsRSAState* pCtx = (IppsRSAState*)( new Ipp8u [size] );
   ippsRSAInit(lenN,lenP, type, pCtx);
   return pCtx;
}
void deleteRSA(IppsRSAState* pRSA)
{ delete [] (Ipp8u*)pRSA; }
```

```
//
// DLP context
//
IppsDLPState* newDLP(int lenM, int lenL)
{
   int size;
   ippsDLPGetSize(lenM, lenL, &size);
   IppsDLPState *pCtx= (IppsDLPState *)new Ipp8u[ size ];
   ippsDLPInit(lenM, lenL, pCtx);
   return pCtx;
}
void deleteDLP(IppsDLPState* pDLP)
{ delete [] (Ipp8u*)pDLP; }
```

Removed Functions

This appendix contains the table that lists the Cryptography functions removed from Intel IPP 9.0. If an application created with the previous versions calls a function listed here, then the source code must be modified. The table also specifies the corresponding Intel IPP 9.0 functions or workaround to replace the removed functions.

Removed from 9.0	Substitution or Workaround
`ippsARCFive128DecryptCBC`	N/A
`ippsARCFive128DecryptCFB`	N/A
`ippsARCFive128DecryptCTR`	N/A
`ippsARCFive128DecryptECB`	N/A
`ippsARCFive128DecryptOFB`	N/A
`ippsARCFive128EncryptCBC`	N/A
`ippsARCFive128EncryptCFB`	N/A
`ippsARCFive128EncryptCTR`	N/A
`ippsARCFive128EncryptECB`	N/A
`ippsARCFive128EncryptOFB`	N/A
`ippsARCFive128GetSize`	N/A
`ippsARCFive128Init`	N/A
`ippsARCFive128Pack`	N/A
`ippsARCFive128Unpack`	N/A
`ippsARCFive64DecryptCBC`	N/A
`ippsARCFive64DecryptCFB`	N/A
`ippsARCFive64DecryptCTR`	N/A
`ippsARCFive64DecryptECB`	N/A
`ippsARCFive64DecryptOFB`	N/A

Removed from 9.0	**Substitution or Workaround**
ippsARCFive64EncryptCBC	N/A
ippsARCFive64EncryptCFB	N/A
ippsARCFive64EncryptCTR	N/A
ippsARCFive64EncryptECB	N/A
ippsARCFive64EncryptOFB	N/A
ippsARCFive64GetSize	N/A
ippsARCFive64Init	N/A
ippsARCFive64Pack	N/A
ippsARCFive64Unpack	N/A
ippsCMACRijndael128Final	ippsAES_CMACFinal
ippsCMACRijndael128GetSize	ippsAES_CMACGetSize
ippsCMACRijndael128Init	ippsAES_CMACInit
ippsCMACRijndael128MessageDigest	ippsAES_CMACGetTag
ippsCMACRijndael128Update	ippsAES_CMACUpdate
ippsCMACSafeRijndael128Init	ippsAES_CMACInit
ippsDAARijndael128Final	N/A
ippsDAARijndael128GetSize	N/A
ippsDAARijndael128Init	N/A
ippsDAARijndael128MessageDigest	N/A
ippsDAARijndael128Update	N/A
ippsDAARijndael192Final	N/A
ippsDAARijndael192GetSize	N/A
ippsDAARijndael192Init	N/A
ippsDAARijndael192MessageDigest	N/A
ippsDAARijndael192Update	N/A
ippsDAARijndael256Final	N/A
ippsDAARijndael256GetSize	N/A
ippsDAARijndael256Init	N/A
ippsDAARijndael256MessageDigest	N/A
ippsDAARijndael256Update	N/A
ippsDAASafeRijndael128Init	N/A
ippsDAATDESFinal	N/A
ippsDAATDESGetSize	N/A

Removed from 9.0	**Substitution or Workaround**
ippsDAATDESInit	N/A
ippsDAATDESMessageDigest	N/A
ippsDAATDESUpdate	N/A
ippsECCBAddPoint	N/A
ippsECCBCheckPoint	N/A
ippsECCBComparePoint	N/A
ippsECCBGenKeyPair	N/A
ippsECCBGet	N/A
ippsECCBGetOrderBitSize	N/A
ippsECCBGetPoint	N/A
ippsECCBGetSize	N/A
ippsECCBInit	N/A
ippsECCBMulPointScalar	N/A
ippsECCBNegativePoint	N/A
ippsECCBPointGetSize	N/A
ippsECCBPointInit	N/A
ippsECCBPublicKey	N/A
ippsECCBSet	N/A
ippsECCBSetKeyPair	N/A
ippsECCBSetPoint	N/A
ippsECCBSetPointAtInfinity	N/A
ippsECCBSetStd	N/A
ippsECCBSharedSecretDH	N/A
ippsECCBSharedSecretDHC	N/A
ippsECCBSignDSA	N/A
ippsECCBSignNR	N/A
ippsECCBValidate	N/A
ippsECCBValidateKeyPair	N/A
ippsECCBVerifyDSA	N/A
ippsECCBVerifyNR	N/A
ippsHMACMD5Duplicate	ippsHMAC_Duplicate
ippsHMACMD5Final	ippsHMAC_Final
ippsHMACMD5GetSize	ippsHMAC_GetSize

Removed from 9.0	Substitution or Workaround
ippsHMACMD5GetTag	ippsHMAC_GetTag
ippsHMACMD5Init	ippsHMAC_Init
ippsHMACMD5MessageDigest	ippsHMAC_Message
ippsHMACMD5Pack	ippsHMAC_Pack
ippsHMACMD5Unpack	ippsHMAC_Unpack
ippsHMACMD5Update	ippsHMAC_Update
ippsHMACSHA1Duplicate	ippsHMAC_Duplicate
ippsHMACSHA1Final	ippsHMAC_Final
ippsHMACSHA1GetSize	ippsHMAC_GetSize
ippsHMACSHA1GetTag	ippsHMAC_GetTag
ippsHMACSHA1Init	ippsHMAC_Init
ippsHMACSHA1MessageDigest	ippsHMAC_Message
ippsHMACSHA1Pack	ippsHMAC_Pack
ippsHMACSHA1Unpack	ippsHMAC_Unpack
ippsHMACSHA1Update	ippsHMAC_Update
ippsHMACSHA224Duplicate	ippsHMAC_Duplicate
ippsHMACSHA224Final	ippsHMAC_Final
ippsHMACSHA224GetSize	ippsHMAC_GetSize
ippsHMACSHA224GetTag	ippsHMAC_GetTag
ippsHMACSHA224Init	ippsHMAC_Init
ippsHMACSHA224MessageDigest	ippsHMAC_Message
ippsHMACSHA224Pack	ippsHMAC_Pack
ippsHMACSHA224Unpack	ippsHMAC_Unpack
ippsHMACSHA224Update	ippsHMAC_Update
ippsHMACSHA256Duplicate	ippsHMAC_Duplicate
ippsHMACSHA256Final	ippsHMAC_Final
ippsHMACSHA256GetSize	ippsHMAC_GetSize
ippsHMACSHA256GetTag	ippsHMAC_GetTag
ippsHMACSHA256Init	ippsHMAC_Init
ippsHMACSHA256MessageDigest	ippsHMAC_Message
ippsHMACSHA256Pack	ippsHMAC_Pack

Removed from 9.0	Substitution or Workaround
ippsHMACSHA256Unpack	ippsHMAC_Unpack
ippsHMACSHA256Update	ippsHMAC_Update
ippsHMACSHA384Duplicate	ippsHMAC_Duplicate
ippsHMACSHA384Final	ippsHMAC_Final
ippsHMACSHA384GetSize	ippsHMAC_GetSize
ippsHMACSHA384GetTag	ippsHMAC_GetTag
ippsHMACSHA384Init	ippsHMAC_Init
ippsHMACSHA384MessageDigest	ippsHMAC_Message
ippsHMACSHA384Pack	ippsHMAC_Pack
ippsHMACSHA384Unpack	ippsHMAC_Unpack
ippsHMACSHA384Update	ippsHMAC_Update
ippsHMACSHA512Duplicate	ippsHMAC_Duplicate
ippsHMACSHA512Final	ippsHMAC_Final
ippsHMACSHA512GetSize	ippsHMAC_GetSize
ippsHMACSHA512GetTag	ippsHMAC_GetTag
ippsHMACSHA512Init	ippsHMAC_Init
ippsHMACSHA512MessageDigest	ippsHMAC_Message
ippsHMACSHA512Pack	ippsHMAC_Pack
ippsHMACSHA512Unpack	ippsHMAC_Unpack
ippsHMACSHA512Update	ippsHMAC_Update
ippsMGF_MD5	ippsMGF
ippsMGF_SHA1	ippsMGF
ippsMGF_SHA224	ippsMGF
ippsMGF_SHA256	ippsMGF
ippsMGF_SHA384	ippsMGF
ippsMGF_SHA512	ippsMGF
ippsRSADecrypt	ippsRSA_Decrypt
ippsRSAEncrypt	ippsRSA_Encrypt
ippsRSAGenerate	ippsRSA_GenerateKeys
ippsRSAGetKey	ippsRSA_GetPublicKey, ippsRSA_GetPrivateKeyType1, ippsRSA_GetPrivateKeyType2

Removed from 9.0	Substitution or Workaround
ippsRSAGetSize	ippsRSA_GetSizePublicKey
ippsRSAInit	ippsRSA_InitPublicKey
ippsRSAOAEPDecrypt	ippsRSADecrypt_OAEP
ippsRSAOAEPDecrypt_MD5	ippsRSADecrypt_OAEP
ippsRSAOAEPDecrypt_SHA1	ippsRSADecrypt_OAEP
ippsRSAOAEPDecrypt_SHA224	ippsRSADecrypt_OAEP
ippsRSAOAEPDecrypt_SHA256	ippsRSADecrypt_OAEP
ippsRSAOAEPDecrypt_SHA384	ippsRSADecrypt_OAEP
ippsRSAOAEPDecrypt_SHA512	ippsRSADecrypt_OAEP
ippsRSAOAEPEncrypt	ippsRSAEncrypt_OAEP
ippsRSAOAEPEncrypt_MD5	ippsRSAEncrypt_OAEP
ippsRSAOAEPEncrypt_SHA1	ippsRSAEncrypt_OAEP
ippsRSAOAEPEncrypt_SHA224	ippsRSAEncrypt_OAEP
ippsRSAOAEPEncrypt_SHA256	ippsRSAEncrypt_OAEP
ippsRSAOAEPEncrypt_SHA384	ippsRSAEncrypt_OAEP
ippsRSAOAEPEncrypt_SHA512	ippsRSAEncrypt_OAEP
ippsRSAPack	N/A
ippsRSASSASign	ippsRSASign_PSS
ippsRSASSASign_MD5	ippsRSASign_PSS
ippsRSASSASign_MD5_PKCSv15	ippsRSASign_PKCS1v15
ippsRSASSASign_SHA1	ippsRSASign_PSS
ippsRSASSASign_SHA1_PKCSv15	ippsRSASign_PKCS1v15
ippsRSASSASign_SHA224	ippsRSASign_PSS
ippsRSASSASign_SHA224_PKCSv15	ippsRSASign_PKCS1v15
ippsRSASSASign_SHA256	ippsRSASign_PSS
ippsRSASSASign_SHA256_PKCSv15	ippsRSASign_PKCS1v15
ippsRSASSASign_SHA384	ippsRSASign_PSS
ippsRSASSASign_SHA384_PKCSv15	ippsRSASign_PKCS1v15
ippsRSASSASign_SHA512	ippsRSASign_PSS
ippsRSASSASign_SHA512_PKCSv15	ippsRSASign_PKCS1v15
ippsRSASSAVerify	ippsRSAVerify_PSS
ippsRSASSAVerify_MD5	ippsRSAVerify_PSS

Removed from 9.0	Substitution or Workaround
ippsRSASSAVerify_MD5_PKCSv15	ippsRSAVerify_PKCS1v15
ippsRSASSAVerify_SHA1	ippsRSAVerify_PSS
ippsRSASSAVerify_SHA1_PKCSv15	ippsRSAVerify_PKCS1v15
ippsRSASSAVerify_SHA224	ippsRSAVerify_PSS
ippsRSASSAVerify_SHA224_PKCSv15	ippsRSAVerify_PKCS1v15
ippsRSASSAVerify_SHA256	ippsRSAVerify_PSS
ippsRSASSAVerify_SHA256_PKCSv15	ippsRSAVerify_PKCS1v15
ippsRSASSAVerify_SHA384	ippsRSAVerify_PSS
ippsRSASSAVerify_SHA384_PKCSv15	ippsRSAVerify_PKCS1v15
ippsRSASSAVerify_SHA512	ippsRSAVerify_PSS
ippsRSASSAVerify_SHA512_PKCSv15	ippsRSAVerify_PKCS1v15
ippsRSASSA_PKCS1v15_Sign	ippsRSASign_PKCS1v15
ippsRSASSA_PKCS1v15_Verify	ippsRSAVerify_PKCS1v15
ippsRSASSA_PSS_Sign	ippsRSASign_PSS
ippsRSASSA_PSS_Verify	ippsRSAVerify_PSS
ippsRSASetKey	ippsRSA_SetPublicKey, ippsRSA_SetPrivateKeyType1, ippsRSA_SetPrivateKeyType2
ippsRSAUnpack	N/A
ippsRSAValidate	ippsRSA_ValidateKeys
ippsRSA_Decrypt_PKCSv15	ippsRSADecrypt_PKCSv15
ippsRSA_Encrypt_PKCSv15	ippsRSAEncrypt_PKCSv15
ippsRSA_OAEPDecrypt	ippsRSADecrypt_OAEP
ippsRSA_OAEPDecrypt_MD5	ippsRSADecrypt_OAEP
ippsRSA_OAEPDecrypt_SHA1	ippsRSADecrypt_OAEP
ippsRSA_OAEPDecrypt_SHA224	ippsRSADecrypt_OAEP
ippsRSA_OAEPDecrypt_SHA256	ippsRSADecrypt_OAEP
ippsRSA_OAEPDecrypt_SHA384	ippsRSADecrypt_OAEP
ippsRSA_OAEPDecrypt_SHA512	ippsRSADecrypt_OAEP
ippsRSA_OAEPEncrypt	ippsRSAEncrypt_OAEP
ippsRSA_OAEPEncrypt_MD5	ippsRSAEncrypt_OAEP
ippsRSA_OAEPEncrypt_SHA1	ippsRSAEncrypt_OAEP

Removed from 9.0	Substitution or Workaround
ippsRSA_OAEPEncrypt_SHA224	ippsRSAEncrypt_OAEP
ippsRSA_OAEPEncrypt_SHA256	ippsRSAEncrypt_OAEP
ippsRSA_OAEPEncrypt_SHA384	ippsRSAEncrypt_OAEP
ippsRSA_OAEPEncrypt_SHA512	ippsRSAEncrypt_OAEP
ippsRSA_SSASign	ippsRSASign_PSS
ippsRSA_SSASign_MD5	ippsRSASign_PSS
ippsRSA_SSASign_MD5_PKCSv15	ippsRSASign_PKCS1v15
ippsRSA_SSASign_SHA1	ippsRSASign_PSS
ippsRSA_SSASign_SHA1_PKCSv15	ippsRSASign_PKCS1v15
ippsRSA_SSASign_SHA224	ippsRSASign_PSS
ippsRSA_SSASign_SHA224_PKCSv15	ippsRSASign_PKCS1v15
ippsRSA_SSASign_SHA256	ippsRSASign_PSS
ippsRSA_SSASign_SHA256_PKCSv15	ippsRSASign_PKCS1v15
ippsRSA_SSASign_SHA384	ippsRSASign_PSS
ippsRSA_SSASign_SHA384_PKCSv15	ippsRSASign_PKCS1v15
ippsRSA_SSASign_SHA512	ippsRSASign_PSS
ippsRSA_SSASign_SHA512_PKCSv15	ippsRSASign_PKCS1v15
ippsRSA_SSAVerify	ippsRSAVerify_PSS
ippsRSA_SSAVerify_MD5	ippsRSAVerify_PSS
ippsRSA_SSAVerify_MD5_PKCSv15	ippsRSAVerify_PKCS1v15
ippsRSA_SSAVerify_SHA1	ippsRSAVerify_PSS
ippsRSA_SSAVerify_SHA1_PKCSv15	ippsRSAVerify_PKCS1v15
ippsRSA_SSAVerify_SHA224	ippsRSAVerify_PSS
ippsRSA_SSAVerify_SHA224_PKCSv15	ippsRSAVerify_PKCS1v15
ippsRSA_SSAVerify_SHA256	ippsRSAVerify_PSS
ippsRSA_SSAVerify_SHA256_PKCSv15	ippsRSAVerify_PKCS1v15
ippsRSA_SSAVerify_SHA384	ippsRSAVerify_PSS
ippsRSA_SSAVerify_SHA384_PKCSv15	ippsRSAVerify_PKCS1v15
ippsRSA_SSAVerify_SHA512	ippsRSAVerify_PSS
ippsRSA_SSAVerify_SHA512_PKCSv15	ippsRSAVerify_PKCS1v15
ippsRijndael128CCMDecrypt	ippsAES_CCMDecrypt

Removed from 9.0	Substitution or Workaround
ippsRijndael128CCMDecryptMessage	ippsAES_CCMDecrypt
ippsRijndael128CCMEncrypt	ippsAES_CCMEncrypt
ippsRijndael128CCMEncryptMessage	ippsAES_CCMEncrypt
ippsRijndael128CCMGetSize	ippsAES_CCMGetSize
ippsRijndael128CCMGetTag	ippsAES_CCMGetTag
ippsRijndael128CCMInit	ippsAES_CCMInit
ippsRijndael128CCMMessageLen	ippsAES_CCMMessageLen
ippsRijndael128CCMStart	ippsAES_CCMStart
ippsRijndael128CCMTagLen	ippsAES_CCMTagLen
ippsRijndael128DecryptCBC	ippsAESDecryptCBC
ippsRijndael128DecryptCFB	ippsAESDecryptCFB
ippsRijndael128DecryptCTR	ippsAESDecryptCTR
ippsRijndael128DecryptECB	ippsAESDecryptECB
ippsRijndael128DecryptOFB	ippsAESDecryptOFB
ippsRijndael128EncryptCBC	ippsAESEncryptCBC
ippsRijndael128EncryptCFB	ippsAESEncryptCFB
ippsRijndael128EncryptCTR	ippsAESEncryptCTR
ippsRijndael128EncryptECB	ippsAESEncryptECB
ippsRijndael128EncryptOFB	ippsAESEncryptOFB
ippsRijndael128GCMDecrypt	ippsAES_GCMDecrypt
ippsRijndael128GCMEncrypt	ippsAES_GCMEncrypt
ippsRijndael128GCMGetSizeManaged	ippsAES_GCMGetSize
ippsRijndael128GCMGetTag	ippsAES_GCMGetTag
ippsRijndael128GCMInitManaged	ippsAES_GCMInit
ippsRijndael128GCMProcessAAD	ippsAES_GCMProcessAAD
ippsRijndael128GCMProcessIV	ippsAES_GCMProcessIV
ippsRijndael128GCMReset	ippsAES_GCMReset
ippsRijndael128GCMStart	ippsAES_GCMStart
ippsRijndael128GetSize	ippsAESGetSize
ippsRijndael128Init	ippsAESInit
ippsRijndael128Pack	ippsAESPack

Removed from 9.0	Substitution or Workaround
ippsRijndael128SetKey	ippsAESSetKey
ippsRijndael128Unpack	ippsAESUnpack
ippsRijndael192DecryptCBC	ippsAESDecryptCBC
ippsRijndael192DecryptCFB	ippsAESDecryptCFB
ippsRijndael192DecryptCTR	ippsAESDecryptCTR
ippsRijndael192DecryptECB	ippsAESDecryptECB
ippsRijndael192DecryptOFB	ippsAESDecryptOFB
ippsRijndael192EncryptCBC	ippsAESEncryptCBC
ippsRijndael192EncryptCFB	ippsAESEncryptCFB
ippsRijndael192EncryptCTR	ippsAESEncryptCTR
ippsRijndael192EncryptECB	ippsAESEncryptECB
ippsRijndael192EncryptOFB	ippsAESEncryptOFB
ippsRijndael192GetSize	ippsAESGetSize
ippsRijndael192Init	ippsAESInit
ippsRijndael192Pack	ippsAESPack
ippsRijndael192Unpack	ippsAESUnpack
ippsRijndael256DecryptCBC	ippsAESDecryptCBC
ippsRijndael256DecryptCFB	ippsAESDecryptOFB
ippsRijndael256DecryptCTR	ippsAESDecryptCTR
ippsRijndael256DecryptECB	ippsAESDecryptECB
ippsRijndael256DecryptOFB	ippsAESDecryptCFB
ippsRijndael256EncryptCBC	ippsAESEncryptCBC
ippsRijndael256EncryptCFB	ippsAESEncryptOFB
ippsRijndael256EncryptCTR	ippsAESEncryptCTR
ippsRijndael256EncryptECB	ippsAESEncryptECB
ippsRijndael256EncryptOFB	ippsAESEncryptCFB
ippsRijndael256GetSize	ippsAESGetSize
ippsRijndael256Init	ippsAESInit
ippsRijndael256Pack	ippsAESPack
ippsRijndael256Unpack	ippsAESUnpack
ippsSafeRijndael128Init	ippsAESInit
ippsXCBCRijndael128Final	N/A

Removed from 9.0	Substitution or Workaround
`ippsXCBCRijndael128GetSize`	N/A
`ippsXCBCRijndael128GetTag`	N/A
`ippsXCBCRijndael128Init`	N/A
`ippsXCBCRijndael128MessageTag`	N/A
`ippsXCBCRijndael128Update`	N/A

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  zlib.h -- interface of the 'zlib' general purpose compression library version 1.2.8, April 28th, 2013

- bzip2:

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