



Intel® VTune™ Amplifier 2019 Update 1

Release Notes

11 January 2019

Customer Support

For technical support, including answers to questions not addressed in this product, visit the technical support forum, FAQs, and other support information at:

- <https://software.intel.com/en-us/vtune/support/get-help>
- <http://www.intel.com/software/products/support/>
- <https://software.intel.com/en-us/vtune>

Please remember to register your product at <https://registrationcenter.intel.com/> by providing your email address. Registration entitles you to free technical support, product updates and upgrades for the duration of the support term. It also helps Intel recognize you as a valued customer in the support forum.

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

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1 Introduction

Intel® VTune™ Amplifier 2019 Update 1 provides an integrated performance analysis and tuning environment with graphical user interface that helps you analyze code performance on systems with IA-32 or Intel® 64 architectures.

This document provides system requirements, issues and limitations, and legal information.

VTune Amplifier has a standalone graphical user interface (GUI) as well as a command-line interface (CLI). Intel® VTune Amplifier for macOS* supports viewing of results collected on other OSs. Native collection on macOS* is not currently available.

To learn more about this product, see:

- New features listed in the [What's New](#) section below.
- The help document at <https://software.intel.com/en-us/vtune-amplifier-help>
- Installation instructions at:
 - Linux*: <https://software.intel.com/en-us/Intel-VTune-Amplifier-XE-Install-Guide-Linux>
 - macOS*: <https://software.intel.com/en-us/Intel-VTune-Amplifier-XE-Install-Guide-OSX>
 - Windows*: <https://software.intel.com/en-us/Intel-VTune-Amplifier-XE-Install-Guide-Windows>

2 What's New

For detailed information on new features, see <https://software.intel.com/en-us/vtune-amplifier-help-whats-new>

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- Threading analysis extended with the lower overhead hardware event-based sampling mode. This mode helps analyze an impact of thread preemption and context switching. On Windows*, this analysis configuration requires the sampling driver. On Linux*, the analysis is available both with the sampling driver and with the Linux Perf* collector for kernels 4.4 and higher.
- Quality and usability improvements:
 - `summary` command line report for the Hotspots analysis enriched with metrics and Top 5 Hotspots table that is also available from the GUI Summary view.
 - A sample `matrix` project added to the Project Navigator to help you get started with the product, review a sample pre-collected Hotspots result, and test other analysis types and source view options. A pre-built version of the `matrix` sample application and associated source files are available installed with Intel® VTune™ Amplifier.
 - Support for Linux* Perf* collection extended with VTune Amplifier metrics with a further option to import the Perf trace to the VTune Amplifier GUI and benefit from predefined viewpoints. This solution could be useful for performance analysis in data centers.

Intel® VTune™ Amplifier 2019

- New Hotspots analysis, combining former Basic Hotspots and Advanced Hotspots analysis configurations, that provides quick understanding of the application performance hotspots and further analysis steps - insights. By default, the Hotspots analysis operates on the user-mode sampling collection mode, but you can enable the lower overhead hardware event-based sampling mode that requires the sampling driver to be installed.
- New Threading analysis combining and replacing former Concurrency and Locks and Waits analysis types
- New Intel VTune Amplifier Platform Profiler tool that provides low-overhead, system-wide analysis and insights into overall system configuration performance and behavior. Use the tool to:
 - Identify bottlenecks by monitoring over- or under-utilized subsystems and buses (CPU, storage, memory, PCIe, and network interfaces) and platform-level imbalances
 - Understand a system topology using diagrams annotated with performance data
 - Capture average-case and transient behaviors for data-center applications
- Microarchitecture analysis improvements:
 - Microarchitecture Exploration (formerly known as General Exploration) analysis configuration split to provide either a lightweight summary analysis or full detailed analysis with all levels of PMU metrics
 - Microarchitecture Exploration analysis view extended with the hardware metric representation that helps easily identify bottlenecks in the hardware usage and benefit from quick insights
- HPC workload profiling improvements:
 - CPU Utilization metric refined to differentiate the utilization on logical vs. physical cores, which is particularly important for HPC applications running on Intel® Xeon® processor family processors

- Intel® Omni-Path Architecture Interconnect Bandwidth and Packet rate metrics added to HPC Performance Characterization analysis to identify performance bottlenecks caused by interconnect limits
- HPC Performance Characterization analysis enriched with a thread affinity report that helps analyze CPU utilization or memory access issues of multithreaded and hybrid MPI and OpenMP* applications
- GPU Compute/Media Hotspots analysis (formerly known as GPU Hotspots) on Linux updated to use Intel Metric Discovery API library for GPU metric collection, which involves support for kernel 4.14 and higher
- Input and Output analysis on Linux* extended to profile DPDK and SPDK IO API. Use this data to correlate CPU activity with the network data plane utilization, visualize PCIe bandwidth utilization per NIC, estimate UPI bandwidth on multi-socket systems, and identify bottlenecks.
- Containerization support improvements:
 - Support for user-mode sampling and tracing collection (Hotspots analysis) added for Docker* container targets
 - Profiling support for targets running in the Singularity* containers
 - Profiling native and Java applications in the Docker and LXC containers
- Managed runtime analysis improvements:
 - Extended JIT profiling for server-side applications running on the LLVM* or HHVM* PHP servers to support the event-based sampling analysis in the attach mode
 - Extended Java* code analysis with support for OpenJDK* 9 and Oracle* Java SE Development Kit 9
 - Improved source code analysis for .NET* Core applications running on Linux and Windows systems
- Analysis on embedded platforms and accelerators:
 - New CPU/FPGA Interaction analysis (PREVIEW) to assess the balance between the CPU and FPGA on systems with a discrete Intel® Arria® 10 FPGA running OpenCL™ applications
 - New GPU Rendering analysis (PREVIEW) for CPU/GPU utilization of your code running on the Xen* virtualization platform installed on a remote embedded target
 - Support for the sampling command-line analysis on remote QNX* embedded systems via ethernet connection

NOTE: A *preview feature* may or may not appear in a future production release. It is available for your use in the hopes that you will provide feedback on its usefulness and help determine its future. Data collected with a preview feature is not guaranteed to be backward compatible with future releases. Please send your feedback to parallel.studio.support@intel.com or to intelsystemstudio@intel.com.

- KVM guest OS profiling extended to profile both KVM kernel and user space from the host system, which is helpful for a full-scale performance analysis of host and guest systems
- Application Performance Snapshot improvements:
 - Added uncore-based metrics for DRAM/MCDRAM memory analysis, which helps identify whether your application is bandwidth bound

- Added the ability to pause/resume collection with MPI_Pcontrol and itt API. The `-start-paused` option was added to exclude application execution from collection from the start to the first collection resume occurrence.
- Enabled selection of which data types are collected to reduce overhead. The choices include MPI tracing, OpenMP tracing, hardware counter based collection, or a combination of the three.
- Exposed the CPU Utilization metric by physical cores on processors that support proper hardware events.
- Significantly reduced MPI tracing overhead when there are a large number of ranks.
- Enriched MPI statistics generated by the `aps-report` utility by showing information about communicators used in the application and to group and filter collective operations by the communicators.
- Improved integration with Intel® Trace Analyzer and Collector by adding the ability to generate profiling configuration files with the `aps-report` option.
- Intel® Omni-Path Architecture Interconnect Bandwidth and Packet rate metrics added to explore MPI communication bottlenecks
- Added an HTML-based rank-to-rank communication diagram to better visualize MPI application communication patterns
- Quality and usability improvements:
 - Optimized product graphical interface with a simplified analysis configuration workflow providing you with pre-selected target and collection options available in the same view
 - Hardware event-based analysis supported for targets running in the Hyper-V* environment on Windows* 10 Fall Creators Update (RedStone3)
 - Default finalization mode set to Fast to minimize post-processing overhead if the number of collected samples exceeds the threshold
 - The Data of Interest type of metric used for the hotspot navigation in the Source view replaced with the explicit metric selection in the grid and applying the Use for Hotspot Navigation context menu command
 - CPU Frequency metric provided for the event-based analysis types (using the sampling driver) is improved to display more reliable data based on the P-State collection. The CPU Frequency metric is not provided for the user-mode sampling and tracing analyses and for analyses using the Perf* collector.
 - A list of supported output formats for the command line reports extended to support XML and HTML options
- Support for new operating systems:
 - SUSE* Linux* Enterprise Server (SLES) 15
 - Red Hat* Enterprise Linux* 7.5
 - Ubuntu* 18.04
 - Fedora* 28
 - Microsoft Windows* 10 RS4

3 System Requirements

Supported Architectures and Terminology

Intel® VTune™ Amplifier supports the following architectures:

- **IA-32 Architecture** refers to systems based on 32-bit processors generally compatible with the Intel Pentium® processors (for example, Intel® Pentium® 4 processor or Intel® Xeon® processor), or processors from other manufacturers supporting the same instruction set, running a 32-bit operating system.
- **Intel® 64 Architecture** refers to systems based on IA-32 architecture processors which have 64-bit architectural extensions, for example, Intel® Core™ architecture processors, running a 64-bit operating system such as Microsoft Windows 8* x64 or a Linux* "x86_64" variant. If the system is running a 32-bit operating system, then IA-32 architecture applies instead.

Hardware Requirements

- At least 2 GB of RAM
- 1.1 GB free disk space required for all product features and all architectures.
- For general operations with user interface and all data collection except Hardware event-based sampling analysis:
 - A PC based on an IA-32 or Intel® 64 architecture processor supporting the Intel® Streaming SIMD Extensions 2 (Intel® SSE2) instructions (Intel® Pentium® 4 processor or later, or compatible non-Intel processor).
 - For the best experience, a multi-core or multi-processor system is recommended.
 - Because the VTune Amplifier requires specific knowledge of assembly-level instructions, its analysis may not operate correctly if a program contains non-Intel instructions. In this case, run the analysis with a target executable that contains only Intel® instructions. After you finish using the VTune Amplifier, you can use the assembler code or optimizing compiler options that provide the non-Intel instructions.
- For Hardware event-based sampling analysis (EBS):
 - EBS analysis makes use of the on-chip Performance Monitoring Unit (PMU) and requires a genuine Intel® processor for collection. EBS analysis is supported on Intel® Xeon® processors and second generation (or later) Intel® Core™ processors. Note that a system does not need to support EBS analysis collection in order to open and view existing EBS results; systems that meet the less restrictive general operation requirements are sufficient for viewing results.
 - EBS analysis within a virtual machine is available in the following environments virtualizing the on-chip Performance Monitoring Unit (PMU):
 - VMware Fusion* 5 and higher
 - KVM with Linux Kernel 3.2 and QEMU 1.4
 - XEN 4.0 and higher for User Domain (domU)
 - Please note:
 - Event-Based Sampling and Sampling with stacks data collection is functional inside a virtual machine only for architectural events. Please see the Performance Monitoring Unit Sharing Guide for more details on the supported architectural events.
 - Hardware Event-based Sampling (EBS) analysis can run a driverless sampling collection via Linux Perf* tool.
- For GPU analyses:
 - All GPU analyses except GPU In-Kernel Profiling require a PC based on an IA-32 or Intel® 64 architecture processor with 7.5 generation of Intel HD or Iris Graphics (formerly Haswell) or newer.

- GPU In-Kernel Profiling analysis requires a PC based on an IA-32 or Intel® 64 architecture processor with 8th generation of Intel HD or Iris Graphics (formerly Broadwell) or newer.
- For Android Targets:
 - Intel Atom® E39XX Processors (code name Apollo Lake)
 - For collection:
 - The collection utilities make use of the Performance Monitoring Unit (PMU) and Architectural Model Specific Registers (MSR) and therefore require a genuine Intel® Atom processor for collection.
 - Collected results can be analyzed using any system meeting the less restrictive general operation requirements.

Software Requirements

NOTE: 32-bit graphical user interface support is removed. A 64-bit operating system host is required to use the Intel® VTune™ Amplifier graphical user interface to analyze collected profile data. Command line profiling and reporting is supported on a 32-bit operating system host. Use the command line installer instructions to install on a 32-bit operating system.

On Linux*, these packages must be installed for the Intel® VTune™ Amplifier standalone GUI:

- GTK+ (2.10 or higher, 2.18 or higher is recommended)
- Pango (1.14 or higher)
- X.Org (1.0 or higher, 1.7 or higher is recommended)

- General requirements:
 - Supported programming languages (see Android* targets bullet for restrictions):
 - Fortran
 - C
 - C++
 - C#
 - Java*
 - OpenCL*
 - Python
 - Go
 - Threading analysis type interprets the use of constructs from the following threading methodologies:
 - Intel® Threading Building Blocks
 - Posix* Threads on Linux
 - Win32* Threads on Windows*
 - OpenMP*
 - Intel's C/C++ Parallel Language Extensions
 - Supported .NET environments:
 - .NET (Windows only)
 - .NET Core
 - Supported Java* environments:
 - Oracle* JVM 6, 7, 8 and 9 – Hotspots and Hardware event-based analysis types
 - OpenJDK 8 and 9 (Linux only)

- Supported OpenCL* environments:
 - Intel® CPU Runtime for OpenCL™ Applications 18.1 and newer
 - Intel® Graphics Compute Runtime for OpenCL™

NOTE: On Windows*, this is part of the GPU driver. On Linux*, it is available on Github*: <https://github.com/intel/compute-runtime>
- Up-to-date drivers are required to collect GPU usage events and processor graphics hardware events on Windows*. Drivers can be requested from Intel Support or downloaded from <https://downloadcenter.intel.com/product/80939/Graphics-Drivers>.
- To view PDF documents, use a PDF reader, such as Adobe Reader*.
- To enable automatic product updates with the Intel® Software Update Manager, use Java* version 1.6 or higher.
- Intel® VTune™ Amplifier Platform Profiler data collector requires Python* 2.7.
- Linux* hosts and targets:
 - Supported operating systems:
 - Red Hat* Enterprise Linux 6 and 7
 - CentOS* versions equivalent to Red Hat* Enterprise Linux* versions listed above
 - SUSE* Linux* Enterprise Server (SLES)12 (SP1, SP2 and SP3) and 15
 - Fedora* 27 and 28
 - Ubuntu* 16.04, 18.04 and 18.10
 - Debian* 8.0 and 9.0

NOTE: Intel® VTune™ Amplifier Platform Profiler host functionality (viewing and analyzing results) does not support Debian* or SUSE* Linux Enterprise Server.
 - For embedded Linux*, the target platform should be based on one of the following environments:
 - Yocto Project* 1.8, 2.0, 2.2, 2.3 and 2.4 based environment
 - Wind River* Linux* 8 and 9-based environment
 - Supported compilers:
 - Intel® C/C++ Compiler 11 and higher
 - Intel® Fortran Compiler 11 and higher
 - GNU* C/C++ Compiler 3.4.6 and higher
 - Supported kernels:
 - Hardware event-based sampling analysis with stacks requirements:
 - Linux kernel version 2.6.32 up to 4.18
 - Driverless hardware event-based sampling analysis requirements:
 - Linux kernel version 2.6.32 up to 4.18, exporting CPU PMU programming details over `/sys/bus/event_source/devices/cpu/format` file system
- Windows* hosts and targets:
 - Supported operating systems:
 - Microsoft* Windows* 7 (deprecated, to be phased out by 2020)
 - Microsoft* Windows* 10 (RS1-RS5)
 - Microsoft* Windows* Server 2012 and 2016
 - Microsoft* Windows* Embedded Standard 7
 - Supported compilers:
 - Intel® C/C++ Compiler 11 and higher
 - Intel® Fortran Compiler 11 and higher

- Intel® Parallel Composer
- Microsoft* Visual Studio* C/C++ Compiler
- Cygwin (tested Cygwin 1.7.17 with GCC 4.5.3)
- MinGW (tested MinGW with GCC 4.6.2)
- Supported versions of Microsoft* Visual Studio*:
 - Microsoft* Visual Studio* 2013 (deprecated, to be phased out by 2020)
 - Microsoft* Visual Studio* 2015
 - Microsoft* Visual Studio* 2017
- MacOS* hosts:
 - Supported operating systems:
 - macOS* 10.13.x and 10.14.x
- FreeBSD* targets:
 - Supported operating systems:
 - FreeBSD* 10 and 11 based environment
- Android* targets:
 - Supported operating systems:
 - Android* 6.x or higher based environment
 - Supported compilers:
 - Intel® C/C++ Compiler 12.1 for Android* and higher
 - GNU* C/C++ Compiler 4.2 and higher for Intel® architecture
 - While samples can be collected for any programming language running on the system, code source can only be viewed for the following:
 - C
 - C++
 - Java (Dalvik and ART*)

Floating Licensing Service Requirements

Floating licenses for version 2019 Update 1 of the Intel® Software Development Tools require the Intel® Software License Manager version 2.7 (INTEL daemon 2.7/lmgrd 11.15.x) or higher for successful installation. To download the latest version of Intel® Software License Manager, please log in to the <https://registrationcenter.intel.com/> and choose the right OS and platform. Only users with floating license registrations have access to download the Intel® Software License Manager.

To get started the with the Intel® Software License Manager, please refer to this tutorial: <https://software.intel.com/en-us/articles/intel-software-license-manager-getting-started-tutorial>

4 Where to Find the Release

If you have a qualifying license for this product (i.e. an unexpired free license or a paid license with active support at the time of the build date for this product release), you can download the installer by logging in to <https://registrationcenter.intel.com/> and selecting the appropriate product.

You may need to create an account and/or register your product. For additional information please see:

- <https://software.intel.com/en-us/faq/registration>
- <https://software.intel.com/en-us/faq/downloading>

5 Installation Notes

For instructions on installing, updating, or removing Intel® VTune™ Amplifier, see the appropriate installation guide for your operating system:

- Linux*: <https://software.intel.com/en-us/Intel-VTune-Amplifier-XE-Install-Guide-Linux>
- macOS*: <https://software.intel.com/en-us/Intel-VTune-Amplifier-XE-Install-Guide-OSX>
- Windows*: <https://software.intel.com/en-us/Intel-VTune-Amplifier-XE-Install-Guide-Windows>

Activation

A valid license is required for installation and use. If you are installing the product for the first time, use one of the following options for activating the license:

- Type in the product serial number (internet connection is required)
- Specify the location of a license file or license server
- Use an evaluation license for 31 days

Intel® Software Manager

Intel® Software Manager installs with Intel Software Development Products on Windows*, Linux*, and Apple OS* X operating systems. Intel Software Manager is a utility that lets you:

- Download and install updates for your Intel® Software Development Products.
- Manage subscription status of installed software.
- Activate serial numbers.
- Find out about the latest news for Intel Software Development Products.

Intel Software Manager requires an Internet connection to connect to a remote server for information and updates.

For more information about the Intel Software Manager, see <https://registrationcenter-ssl.intel.com/Docs/ism.htm>.

Default Installation Folders

The default top-level installation folders for this product are:

- Windows: `C:\Program Files\IntelSWTools\VTune Amplifier 2019`
 - If you are installing on a system with a non-English language version of Windows* OS, the name of the `Program Files` folder may be different. On Intel® 64 systems, the directory name is `Program Files (x86)` or the equivalent.
- Linux: `/opt/intel/vtune_amplifier_2019`

In both cases, there is also a generic soft link to the most recently installed version.

Setting Up the Command Line

Before using Intel® VTune™ Amplifier on the command line, you will need to set up the environment:

- Windows: `<installation_dir>\amplxe-vars.bat`
- Linux: `source <installation_dir>/amplxe-vars.sh`

6 Known Issues

This section is quite long. To skip to operating system specific limitations, use these links:

- [Windows* Specific Limitations](#)
- [Linux* Specific Limitations](#)
- [MacOS* Specific Limitations](#)

Common Limitations

RUNNING TIME IS ATTRIBUTED TO THE NEXT INSTRUCTION (VASP-3854)

To collect the data about time-consuming running regions of the target, the Intel® VTune™ Amplifier interrupts executing target threads and attributes the time to the context IP address.

Due to the collection mechanism, the captured IP address points to an instruction *after* the one that is actually consuming most of the time. This leads to the running time being attributed to the next instruction (or, rarely to one of the subsequent instructions) in the Assembly view. In rare cases, this can also lead to wrong attribution of running time in the source - the time may be erroneously attributed to the source line *after* the actual hot line.

If the inline mode is ON and the program has small functions inlined at the hotspots, this can cause the running time to be attributed to a wrong function since the next instruction can belong to a different function in tightly inlined code.

COLLECTION MISSING DATA FOR CORE_0 ON SKYLAKE-X SYSTEMS (VASP-11480)

On some systems based on Intel microarchitecture code name Skylake-X with enabled SMT mode, VTune Amplifier hardware sampling analysis might collect data against less logical CPUs than available on the system. For example, the problem was reproduced on Intel® Core™ i9-7900X 10C20T CPU installed on an Asus* PRIME X299-DELUXE motherboard.

To work around this problem, upgrade the BIOS and the firmware of the board to version 0802 or later.

AN APPLICATION THAT ALLOCATES MASSIVE CHUNKS OF MEMORY MAY FAIL TO WORK UNDER VTUNE AMPLIFIER

If a 32-bit application allocates massive chunks of memory (close to 2 GB) in the heap, it may fail to launch under the VTune Amplifier while running fine on its own. This happens because the VTune Amplifier requires additional memory when profiling an application. The workaround could be in using larger address space (for example, converting the project to 64-bit).

HARDWARE EVENT-BASED ANALYSIS MAY CRASH CERTAIN INTEL® CORE™ I7 PROCESSOR-BASED SYSTEMS WHEN DEEP SLEEP STATES ARE ENABLED

On some Intel® Core™ i7 processor-based (based on Intel microarchitecture code named Nehalem) systems with C-states enabled, sampling may cause system hanging due to a known hardware issue. To avoid this, disable the “Cn(ACPI Cn) report to OS” BIOS option before sampling with the VTune Amplifier on Intel Core i7 processor-based systems.

INSTRUCTION SET REFERENCE DOCUMENT IS NOT POSITIONED ON DESCRIPTION OF PROPER INSTRUCTION

The reference information for assembly instructions can be opened in any PDF viewer, but only Adobe* Acrobat Reader* supports positioning the instruction reference document on the required page. To ensure

correct functionality of this feature, we recommend installing the latest available version of Adobe Acrobat Reader.

VTUNE AMPLIFIER DOES NOT SUPPORT PROFILING AN APPLICATION LAUNCHED UNDER DEBUGGER

The Hotspots, Threading, Memory Access with object tracking, and Input and Output analysis types provide incorrect results when analyzing an application launched under a debugger. VTune Amplifier does not detect whether a debugger is attached to a profiled application. Make sure that no debugging tools are attached to the application that is profiled with the VTune Amplifier.

ONLY ONE STACK FRAME IS SHOWN IN JAVA CODE IF IBM* J9* JVM IS USED (VASP-3535)

Currently Java* stack unwinding is not supported for IBM* J9* JVM.

RESULTS NOT COLLECTED FOR PROCESSES TERMINATED WITH `TERMINATEPROCESS ()`

No results are displayed for any process being profiled that is terminated by a different process calling `TerminateProcess ()`. Instead, a different method should be used to terminate the process.

DO NOT USE `-IPO (LINUX*)//QIPO (WINDOWS*)` OPTION WITH INTEL COMPILER VERSION EARLIER THAN 13.0. (VASP-3534)

If using the Intel® compiler version earlier than 13.0, to get performance data on inline functions, use the additional option `-inline-debug-info (Linux*)//debug:inline-debug-info (Windows*)`, but avoid using the `/Qipo` option. Currently this option disables generating the inline debug information in the compiler. Note that the Intel compiler integrated into the Microsoft Visual Studio* IDE uses the `-ipo//Qipo` by default in the Release configuration.

JAVA SOURCE LINE MAY BE SHOWN INCORRECTLY FOR ORACLE JDK 6U25 X64

Drilling down to Java source code from VTune Amplifier results may show incorrect source line. The issue occurs with Java applications built with Oracle JDK 6u25 x64. This is the JDK problem, refer to issues JDK-7051767 and JDK-7047624 in Oracle bug database.

RESULT FINALIZATION MAY BE SLOW IF RESULTS ARE LOCATED IN A REMOTE NETWORK DIRECTORY (VASP-995)

The problem is caused by slow network access. To improve performance use local directory for result storage.

CALL STACK CAN'T BE UNWOUND VIA NO RETURN FUNCTIONS (VASP-3350)

If analyzed application contains functions without `ret` instruction (for example, calling `exit ()`), unwinding call stack to its caller and higher may fail (no stack frames shown).

ATTACHING THE VTUNE AMPLIFIER TO A PROCESS MAY TAKE SOME TIME (VASP-2289)

Your target application may complete before the data collection starts, so the VTune Amplifier may report an error. Increase the duration of your test application if necessary.

Command line option "`amplxe-cl -command status`" is currently supported only for user-mode sampling and tracing based analysis types, but not for EBS analysis types.

HARDWARE EVENT-BASED ANALYSIS MAY CAUSE UNPREDICTABLE SYSTEM BEHAVIOR ON PROCESSORS BASED ON INTEL MICROARCHITECTURE CODE NAMED SANDY BRIDGE

On processors based on Intel microarchitecture code name Sandy Bridge, hardware event-based sampling may cause unpredictable system behavior due to a known hardware issue (see erratum BK105 in <http://www.intel.com/content/dam/www/public/us/en/documents/specification-updates/2nd-gen-core-family-mobile-specification-update.pdf>). To avoid this, you are not recommended to run Microarchitecture Exploration (formerly, General Exploration) or Custom Hardware event-based analysis with precise events on these systems unless a BIOS workaround for the erratum is provided.

VTUNE AMPLIFIER MAY DETECT WHICH TIMER SOURCE TO USE INCORRECTLY ON INTEL® XEON® PROCESSOR E5-XXXX PROCESSORS

In User-mode Sampling and Tracing based analysis (Hotspots, Threading), the following message may be displayed in command line or Debug Window:

Warning: Cannot load data file '<path>\data.0\18385-18389.0.trace' (SampleCallback: timestamps aren't ascended!).

To work around the problem, collect results from command line using the `-run-pass-thru` option:

```
amplxe-cl -collect hotspots -run-pass-thru=-timestamp=sys -- <application>
```

HARDWARE EVENT-BASED ANALYSIS DOES NOT WORK IF MORE THAN 128 EVENTS ARE GATHERED SIMULTANEOUSLY (VASP-1992)

Decrease number of PMU events in analysis settings to resolve it.

ITT API TASK OR FRAME IS NOT SHOWN IN RESULTS IF ITS END OCCURS WHEN COLLECTOR IS INACTIVE (VASP-3354)

When ITT task or frame end notification occurs after collection was paused, or detach or stop command issued, the frame or task is not displayed in the result.

AN APPLICATION MAY EXPERIENCE THE STACK OVERFLOW EXCEPTION WHEN RUNNING UNDER THE VTUNE AMPLIFIER (DOC-200)

An application allocating massive chunks of memory on a thread stack may experience the stack overflow exception and fail when running under the VTune Amplifier, while running flawlessly on its own. This happens because the VTune Amplifier requires additional space on an application thread stack for profiling needs. To work around this problem, consider using larger thread stack space.

VTUNE AMPLIFIER CANNOT LOAD DRIVERS INTO KERNEL

Most Android* kernels only allow signed drivers. If you try and install a driver (`sep3_10.ko`, `pax.ko`, `vtssp.ko`, `SOCWATCH1_3.ko` or `apwr3_1.ko`), which has been built after the kernel was built, you will get an error message stating that no signing key is found. To work around, you must build drivers with the exact signing key created when the Android OS (`boot.bin`) was built. The easiest way to do that is to use drivers which have been integrated into the kernel.

INSTALLING AND CONFIGURING THE ORACLE* JAVA* SERVER VM FOR THE PLATFORM PROFILER SERVER

The Platform Profiler server requires a recent version of the Oracle* Java* 8 Server VM to operate properly. Other versions, including Oracle Java 9 and 10, and the OpenJDK* Java implementation, are not supported.

If the Java environment is not properly configured, an attempt to start the Platform Profiler server will result in any of the following error message:

Error: the JAVA_HOME environment variable is not set.

Please install Oracle Java Server VM version 1.8.0_112 or greater and set JAVA_HOME to the Java installation directory.

Or

A Java Client VM was detected. Platform Profiler requires a Java Server VM

Please install Oracle Java Server VM version 1.8.0_112 or greater and set JAVA_HOME to the Java installation directory.

Follow these steps to properly install and configure the Oracle* Java 8 Server VM:

1. Go to the Oracle* Java Server JRE download page: <https://www.java.com/en/download/>
2. Download the package for your operating system.
3. Extract the package to a local directory on your system. For example:
Windows*: C:\Java
Linux*: /opt/java
4. Set the JAVA_HOME environment variable to point to the jre subdirectory. For example:
Windows: set JAVA_HOME=C:\Java\jdk1.8.0_172\jre
Linux: export JAVA_HOME=/opt/java/jdk1.8.0_172/jre

PLATFORM PROFILER COLLECTION MISSING MEMORY AND QPI THROUGHPUT METRICS ON HASWELL SERVER SYSTEMS (DXET-1395)

Platform Profiler memory and Intel® QuickPath Interconnect (Intel® QPI) throughput metrics are not collected on Haswell Server systems.

PLATFORM PROFILER SERVER UNINSTALLER DOES NOT DELETE ALL FILES (DXET-1362)

The Platform Profiler server uninstaller does not properly remove all server files and data.

To work around this problem, follow these steps to remove the Platform Profiler server from your computer:

1. Stop the server.
2. Delete the directory where the server program files are installed. By default:
Windows*: C:\Program Files(x86)\IntelSWTools\VTune Amplifier Platform Profiler
Linux*: /opt/intel/vpp
3. Delete the directory where the server data files are installed. By default:
Windows*: C:\ProgramData\Intel\VTune Amplifier Platform Profiler
Linux*: /opt/intel/vpp-data

SIZE LIMITATIONS WHEN UPLOADING DATA COLLECTION RESULTS TO THE PLATFORM PROFILER SERVER (DXET-1200)

The Platform Profiler server currently supports data collection results up to 1GB in size (compressed). Larger data archives cannot be uploaded at this time.

NO SUPPORT FOR USER AUTHENTICATION AND AUTHORIZATION FOR THE PLATFORM PROFILER SERVER (DXET-1366)

The current version of Platform Profiler is implemented as a single-user system. Data loaded to a server instance is available to any logged on user.

Workaround: To control data access to specific users, install multiple copies of the server on separate machines.

Windows* Specific Limitations

JIT WRITER API CANNOT HANDLE TOO LONG FILE NAMES ON WINDOWS (VASP-484)

This issue happens when file name of JIT trace file is longer than 260 symbols. VTune is then not able to generate a proper result when the result directory has long name.

VTUNE AMPLIFIER IS NOT ABLE TO RESOLVE DEBUG INFORMATION WHEN AN APPLICATION IS COMPILED WITH THE /DEBUG:FASTLINK OPTION. (VASP-3093)

This issue is prevalent only in Microsoft* Visual Studio* 2015. To fix this issue, please use the `/DEBUG` option instead. For more information, please see <https://blogs.msdn.microsoft.com/vcblog/2015/10/16/debugfastlink-for-vs2015-update-1>

THREAD STACK SIZE LIMITATION (VASP-1808)

VTune Amplifier may crash with the following error message:

Error: failed to create a sampling thread: not enough storage is available to process this command.

This happens when the profiled application has big reserved and committed thread stack size (`/STACK:reserve[,commit]` command line switch of `link.exe`). The suggested workaround is reducing the reserved/committed thread stack size to profile the target.

INCORRECT TIMING RESULTS WHEN RUNNING ON A 32-BIT VIRTUAL MACHINE

VTune Amplifier may fail to collect correct timing data when running on a virtual machine with problematic virtualization of time stamp counters. In this case the VTune Amplifier throws a warning message:

Warning: Cannot load data file '<path_to_a_trace_file>.trace' (syncAcquiredHandler: timestamps aren't ascended!)

UNINSTALLING LIMITATION: PIN.EXE STAYS RUNNING AFTER DETACHING.

VTune Amplifier cannot be uninstalled after attaching to the target to be profiled until running the target is over. The cause is that `pin.exe` keeps working after detaching from the target and exits only after the profiled application/process execution finishes.

SECOND ATTACH TO THE SAME APPLICATION SHOULD PRINT AN ERROR AND EXIT IMMEDIATELY

VTune Amplifier allows running the analysis while the previous one is in progress but does not store any data for the second analysis run.

TRUNCATED .NET* MODULE NAMES MAY BE DISPLAYED IN RESULTS VIEW (VASP-3772)

When viewing results collected for a .NET application, you may observe truncated .NET module names. Please make sure a system was rebooted after installing the .NET application and before profiling with the VTune Amplifier.

.NET MODULES LOADED DYNAMICALLY VIA REFLECTION API ARE DISPLAYED AS "UNKNOWN" HOTSPOTS (VASP-1945)

If dynamic .NET modules (e.g. loaded via `Assembly.LoadFrom`) are used in target application, VTune Amplifier will show them as "unknown" functions and modules in hotspots list.

ATTACHMENT AS ADMINISTRATOR TO A PROCESS THAT LAUNCHED BY THE 'SYSTEM' USER FAILS (VASP-476)

You may use a utility from <http://technet.microsoft.com/en-us/sysinternals/bb897553> to profile a system service (for example, `w3wp.exe`-based code) from the command line using `amplxe-cl.exe` that is located in `<product_install_dir>/bin32`. Do the following:

1. Configure the `w3wp` service to run with the permissions you use to log in: Open IIS Manager, right-click an application pool you are using and set "Process model:Identity" to the account under which `w3wp` needs to be run.

2. Run the `w3wp` service and make sure you run it with proper credentials and remember its PID.

3. Start data collection:

```
psexec -i 0 /path/to/amplxe-cl.exe -c=hotspots -r /path/for/your/data_dir --  
target-pid=PID
```

4. Run your workload.

5. Stop data collection:

```
psexec -i 0 /path/to/amplxe-cl.exe -command detach -r  
/path/for/your/data_dir
```

6. Open `/path/for/your/data_dir` in GUI:

```
<product_install_dir>/bin32/amplxe-gui /path/to/your/data_dir
```

LIMITED SUPPORT OF WINDOWS STORE* APPLICATIONS (VASP-531)

VTune Amplifier supports attaching to Windows Store* applications, but not launching them. Only hardware event-based analysis types are supported.

MICROSOFT* VISUAL STUDIO* 2012 HELP MAY BE DISPLAYED INCORRECTLY (DOC-222)

On Microsoft* Windows Server* 2012 systems, if you have problems viewing Microsoft* Visual Studio* 2012 help, check the settings for Internet Explorer in **Tools > Internet Options > Security**. To allow correct display of help, in the Internet zone enable MIME Sniffing and Active scripting.

VTUNE AMPLIFIER ANALYSIS MAY FAIL ON MACHINE WITH VERDASYS DIGITAL GUARDIAN* SOFTWARE INSTALLED. (VASP-2701)

User mode sampling and tracing based analysis types (Hotspots, Threading) run from GUI may fail if Verdasys Digital Guardian* software is installed on the machine. However it is still possible to run collection from command line.

Alternatively EBS collection with stacks can be used, either from GUI or command line.

ANALYZED APPLICATION MAY CRASH DURING ANALYSIS IF "SYMANTEC ENDPOINT PROTECTION APPLICATION AND DEVICE CONTROL" SOFTWARE IS INSTALLED (VASP-2286)

The issue may occur with user mode sampling and tracing based analysis types (Hotspots, Threading). Ways to overcome the problem:

- If user mode sampling and tracing based analysis is needed exclude the analyzed application from the list of monitored applications of "Symantec Endpoint Protection Application and Device Control" software.
- Use the Advanced Hotspots analysis with the **Collect stacks** option turned on instead.

DOCUMENTATION CANNOT BE OPENED IN MICROSOFT INTERNET EXPLORER* 10 ON WINDOWS SERVER* 2012 (DOC-204)

To correct the problem modify security settings in Microsoft Internet Explorer* 10. From **Tools > Internet Options > Security**, add "about:internet" to the list of trusted sites.

CHILD PROCESS ANALYSIS DOES NOT WORK FOR EBS ANALYSIS TYPES IF PROCESS IS RUN FROM SCRIPT USING START COMMAND (DOC-231)

If a process is started from a batch file by the `start` command, it does not have original command interpreter as a parent process. So the new process cannot be identified as a child and not profiled. This is true for all Hardware event-based analyses. Possible workarounds:

- Use user-mode sampling and tracing based analysis types instead
- Use `call` command in a batch file instead of `start`
- Use "attach to process" collection mode to connect directly to the process of interest

RESULTS MAY CONTAIN PROCESS NAME CUT ON THE 14TH CHARACTER (VASP-2702)

VTune Amplifier may cut long process name on the 14th character in results collected with EBS analysis types with stacks. E.g. the result should contain `find_hotspots.exe`, but it contains only `find_hotspots..` This is an operating system limitation.

WARNING "UNSIGNED DRIVER" DURING INSTALLATION FOR SEPDRV AND VTSS DRIVERS ON WINDOWS* 7 AND WINDOWS SERVER* 2008 R2 (VASP-234)

VTune Amplifier hardware event-based sampling drivers (`sepdrv.sys` and `vtss.sys`) are signed with digital SHA-2 certificate key for compliance with Windows 10 requirements.

To install the drivers on Windows* 7 and Windows Server* 2008 R2 operating systems, add functionality for the SHA-2 hashing algorithm to the systems by applying Microsoft Security update 3033929:

<https://technet.microsoft.com/en-us/library/security/3033929>.

Linux* Specific Limitations

SOME FEATURES REQUIRE INSTALLING AS ROOT

Most of Intel® VTune™ Amplifier profiling features work with a non-root install. Many work on either a genuine Intel processor or a compatible processor.

Some advanced features that use event-based sampling require the latest OS kernel or sampling driver to be installed. Intel® Atom™ processors also require this driver for analysis.

To install the driver on a system with a genuine Intel processor, launch the installer as root or ask your system administrator to install the driver later. For information on building and setting up the drivers, see

https://software.intel.com/en-us/sep_driver.

SLES 15 MACHINE REBOOTS WHEN STARTING INPUT/OUTPUT ANALYSIS WITH BOTH PERF/SEP (VASP-14205)

When running Input and Output analysis on SUSE* Enterprise Linux (SLES) 15, consider switching to **Custom Analysis** and turn off page faults collection. This helps prevent a system crash that may happen when kernel trace points for page faults are turned on.

PROXY-RELATED ERRORS WHEN STARTING THE PLATFORM PROFILER SERVER (DXET-1338)

On some systems, starting the server generates the following error:

Malformed Proxy variables. Please set your proxy variables with "http" scheme and restart the PPE server
:[Errno socket error] [Errno 10060] A connection attempt failed because the connected party did not properly respond after a period of time, or established connection failed because connected host has failed to respond

To work around this problem:

1. Remove the following proxy-related environment variables and start the server again: `http_proxy`, `https_proxy`, `noproxy`
2. Start the server using the following commands:

```
cd <server install directory> dist/3rd/python-dist/python scripts/start.py -  
-skip-proxy-check
```

SECURITY-ENHANCED LINUX* IS NOT SUPPORTED

Security-enhanced Linux settings (SELinux) are currently not supported by the VTune Amplifier and need to be either disabled or set to permissive for a successful tool suite installation. If your Linux distribution has SELinux enabled the following error message will be issued by the installer:

Your system is protected with Security-enhanced Linux (SELinux). We currently support only "Permissive" mode, which is not found on the system. To rectify this issue, you may either disable SELinux by - setting the line "SELINUX=disabled" in your /etc/sysconfig/selinux file - adding "selinux=0" kernel argument in lilo.conf or grub.conf files or make SELinux mode adjustment by - setting the line "SELINUX=permissive" in your /etc/sysconfig/selinux file or ask your system administrator to make SELinux mode adjustment. You may need to reboot your system after changing the system parameters. More information about SELinux can be found at <http://www.nsa.gov/selinux/>

VTUNE AMPLIFIER USER MODE COLLECTION MAY FAIL TO RUN ON UBUNTU* (VASP-3352)

VTune Amplifier may fail to collect data for Hotspots and Threading analysis types on the Ubuntu operating system. Once a collection is started, the message appears in the output:

Failed to start profiling because the scope of ptrace() system call application is limited. To enable profiling, please set /proc/sys/kernel/yama/ptrace_scope to 0. See the Release Notes for instructions on enabling it permanently.

To work around this problem for the current session, set contents of the `/proc/sys/kernel/yama/ptrace_scope` `sysctl` file to 0.

To make this change permanent, set `kernel.yama.ptrace_scope` value to 0 at `/etc/sysctl.d/10-ptrace.conf` file using root permissions and reboot the machine.

THREADING ANALYSIS MAY PROVIDE INCORRECT WAIT TIME DATA IF LINUX FUTEXES ARE USED

In certain cases, custom synchronization constructions based on Linux futexes are not detected by the VTune Amplifier. System libraries may also use such constructions. To ensure Wait time correctness in the Threading analysis, use `syscall(SYS_futex, ...)` API in your code.

VTUNE AMPLIFIER MAY CAUSE KVM GUEST VIRTUAL MACHINE TO CRASH (VASP-3806)

In some cases, when you run Event-Based Sampling analysis on a host machine, a guest KVM virtual machine may experience kernel panic. This happens only if precise events are used, for example, with Microarchitecture Exploration (formerly, General Exploration) analysis type. Upgrade KVM to a newer version; there is a KVM patch that fixes the problem.

SYMBOLS ARE NOT RESOLVED FOR BINARIES REMAPPED WITH HUGTLBFS UTILITY (VASP-707)

`hugetlbfs` remaps segments from executable file to its temporary file system or to anonymous memory regions. VTune Amplifier can't map those segments to the original executable.

The workaround for this problem is to rename the original executable to the one that `hugetlb` exposes, i.e. the module name that you see in VTune Amplifier results.

`my_exe` (original executable) → `my_exe_32_2` (file name on `hugetlb` file system in case of sharing between processes)

`my_exe` (original executable) → `libhugetlbfs.tmp.<random hash>` (memory region name in case of anonymous mappings)

RUNNING OTHER PMU-BASED TOOLS SIMULTANEOUSLY WITH HARDWARE EVENT-BASED SAMPLING COLLECTION IS NOT SUPPORTED

The Sampling Driver requires exclusive use of the PMU resources. Running multiple PMU based tools will cause incorrect results and/or system instability.

HOTSPOTS AND THREADING ANALYSIS TYPES MAY NOT WORK ON EXECUTABLES THAT DO NOT DEPEND ON THE LIBPTHREAD.SO.0 LIBRARY

There is currently a limitation in the product regarding profiling application targets where the executable does not depend on the `libpthread.so.0` library. The message "*Link libpthread.so to the application statically*"

and restart profiling" appears when profiling an application where program image does not depend on `libpthread.so.0` but then it `dlopen()`s a shared library which does depend on `libpthread.so.0`. The collector is not able to follow the program execution and module load/unload so the collection results are likely to be misleading. A workaround is to set "`LD_PRELOAD=libpthread.so.0`" before running the collection.

OPENING RESULTS SIGNIFICANTLY DELAYED ON LINUX SYSTEMS CONFIGURED WITH "LARGE PAGES"

To work around this issue make sure that you have `hugectl` utility and `libhugetlbfs` library on the system. VTune Amplifier can be started this way:

```
hugectl --heap <amplxe install dir>/bin32/amplxe-gui
```

```
LD_PRELOAD=libhugetlbfs.so <amplxe install dir>/bin64/amplxe-gui
```

HELP TOC IS TRUNCATED IN SOME LINUX BROWSERS

When using certain HTML browsers to view the VTune Amplifier offline documentation, if the Contents tab width appears truncated and hides some of the topic titles:

- Click the **Index** (or **Search**) button
- Click the **Contents** button

COLLECTION FAILS WITH ERROR "NO CONFIG_PERF_EVENTS=Y KERNEL SUPPORT CONFIGURED" (DOC-241)

Driverless EBS collection on Linux can fail with the error: "*No CONFIG_PERF_EVENTS=y kernel support configured*" even having the kernel config has been set. This is a known Linux kernel issue that is resolved in kernel version 4.1. There is a simple patch that provides a workaround: <http://halobates.de/ivb-allow-mem-load-uops>

USER TASKS, EVENTS AND FRAMES MARKED WITH ITT APIs MAY NOT BE SHOWN IF TARGET APPLICATION IS FINISHED BY CTRL+C (VASP-1367)

Use another method to stop application, or VTune Amplifier `stop` command.

WHEN INSTALLING ON A XEN* VIRTUAL MACHINE, IT MAY HAPPEN THAT INSTALLATION SCRIPT EXITS CLAIMING CPU IS UNSUPPORTED

To skip the check for CPU model, add `--ignore-cpu` parameter to install script command line:

```
./install.sh --ignore-cpu
```

VTUNE AMPLIFIER HELP DOES NOT OPEN FROM GUI ON SOME LINUX SYSTEMS (VASP-3322)

On some Linux* systems, like Wind River Linux, default ways to open web browser may not work. You may export the environment variable `BROWSER` (before starting VTune Amplifier) with the path to the web browser to get VTune Amplifier help working.

For example:

```
$ export BROWSER=/usr/bin/firefox
```

VTUNE AMPLIFIER USER APIS ARE NOT SUPPORTED FOR STATIC BINARIES (VASP-2287)

To use ITT and JIT APIs with software based collectors (Hotspots, Threading) user needs to link their application dynamically. Otherwise ITT and JIT API notifications will be missing in the result.

PLATFORM PROFILER DATA COLLECTOR INSTALL ERROR ON SUSE* ENTERPRISE LINUX (SLES) 12 SP3 (DXET-1266)

The data collector is not fully compatible with SUSE* Enterprise Linux. The installer may generate the following error during installation:

Error: apt-get or yum not found. Please install the aforementioned packages and run install-pgx again.

To work around this problem, manually install the dstat package and run setup again.

To install the dstat package, execute `sudo zypper in dstat`.

PLATFORM PROFILER DATA COLLECTOR PYTHON* COMPATIBILITY ISSUES (DXET-1284)

The data collector requires Python* 2.6 or 2.7 to run properly. When the default environment is configured with Python 3, the following errors may be observed during data collection:

Module dstat_disk_queue failed to load. (invalid syntax (dstat_disk_queue.py, line 41))

Module dstat_disk_time failed to load. (invalid syntax (dstat_disk_time.py, line 41))

To work around this problem:

1. Make sure the default Python version is 2.6 or 2.7.
2. Make sure dstat is configured to use the Python 2.x interpreter.

VTUNE AMPLIFIER TARGET EXECUTABLES DO NOT WORK ON YOCTO PROJECT X64 DUE TO DIFFERENT PATHS TO LD (VASP-8531)

Error message: "`-sh: ./amplxe-runss: No such file or directory`". Usually `ld` is located in `/lib64/ld-linux-x86-64.so.2` but on Yocto x64 it is located in `/lib/ld-linux-x86-64.so.2`. The workaround is to create `/lib64/ld-linux-x86-64.so.2` as a symlink to `/lib/ld-linux-x86-64.so.2`.

EVENT-BASED SAMPLING DRIVER FAILS TO BUILD ON YOCTO PROJECT 1.6 INTEL X86_64 BSPS DUE TO MISSING CONFIG_COMPAT #DEFINE IN LINUX KERNEL HEADERS (VASP-1558)

Sampling driver fails to build on Yocto x86_64 BSPs images that do not have "CONFIG_COMPAT=y" setting (https://bugzilla.yoctoproject.org/show_bug.cgi?id=6777)

To resolve the issue, you need to re-build the image with the option manually.

Change kernel configuration according to <http://www.yoctoproject.org/docs/1.6.1/kernel-dev/kernel-dev.html#changing-the-configuration> :

1. Create the `compat.cfg` file in `meta-yocto-bsp/recipes-kernel/linux/files/` directory with content:

```
CONFIG_IA32_EMULATION=y
CONFIG_COMPAT=y
```

2. Add the following strings to `meta-yocto-bsp/recipes-kernel/linux/linux-yocto_3.10.bbappend`:

```
FILESEXTRAPATHS_prepend := "${THISDIR}/files:"  
SRC_URI += file://compat.cfg
```
3. Clean and build a modified kernel according to <http://www.yoctoproject.org/docs/1.6.1/dev-manual/dev-manual.html#patching-the-kernel> and <http://www.yoctoproject.org/docs/1.6.1/dev-manual/dev-manual.html#build-the-modified-qemu-kernel-image> :

```
$ bitbake linux-yocto -c cleansstate  
$ bitbake -k linux-yocto
```
4. Build image:

```
$ bitbake core-image-sato
```

MacOS* Specific Limitations

NATIVE COLLECTION IS NOT AVAILABLE ON MacOS*

Intel VTune Amplifier for macOS* supports viewing of results collected on other OSs. Native collection on macOS is not currently available.

SOME SYSTEMS DO NOT SUPPORT CONTEXT-SENSITIVE HELP

On some macOS* systems, such as macOS 10.13, VTune Amplifier context-sensitive help is not supported. Please use the help search to find relevant information on a particular GUI view.

7 Attributions

The license information for third party software that was used to develop Intel® VTune™ Amplifier can be found in `<install_dir>/documentation/en/third-party-programs.txt`.

For the avoidance of doubt, the Intel® VTune™ Amplifier is solely governed by the terms and conditions of the End User License Agreement for Intel® Software Development Product that accompanies the Intel® VTune™ Amplifier.

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