Megh VAS Performance and Validation Report on Intel® NUC Kit

Report

September 2023

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Contents

Figures

Tables

Revision History

Date	Revision	Description
September 2023	1.1	Added content to Section 5.0 Conclusion.
August 2023	1.0	Initial release.

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1.0 Overview

This document provides an overview and performance results for validation of a Megh Video Analytics Solution by Megh Computing running on Intel® NUC Kits with 11th or 12th Generation Intel® Core™ Processors.

Video Analytics can be performed either on CPU, or on the integrated GPU. The focus of this report will be running the video analytics on the CPU as well as iGPU as the accelerator.

Configuration for multi-stream in-process analytics (no video stored) includes a pipeline process of video decode, video analytics via AI model with video analytics metadata creation, and injection of metadata.

1.1 Objective

The objective of the validation process is to:

i. Validate and size the system configuration for concurrent multi-stream video analytics.
ii. Confirm CPU/RAM usage at maximum video analytics channel density.
iii. For Video analytics, channels are added till total output frames continue to be above 90% of input frames**.
iv. Confirm that overall software/hardware solution is steady and operates without fail(s) for at least 24 hours.
v. Measure and log key system running parameters:
    - Overall system CPU and memory load: average and standard deviation. Sampling at a cadence of every 5-secs.
    - Video analytic inference, performance in frames per second.

** To maintain the integrity of the analytics, we recommend maintaining an efficiency of 90% and higher to prevent skipping frames or ignoring potential events.

1.2 Megh VAS Architecture

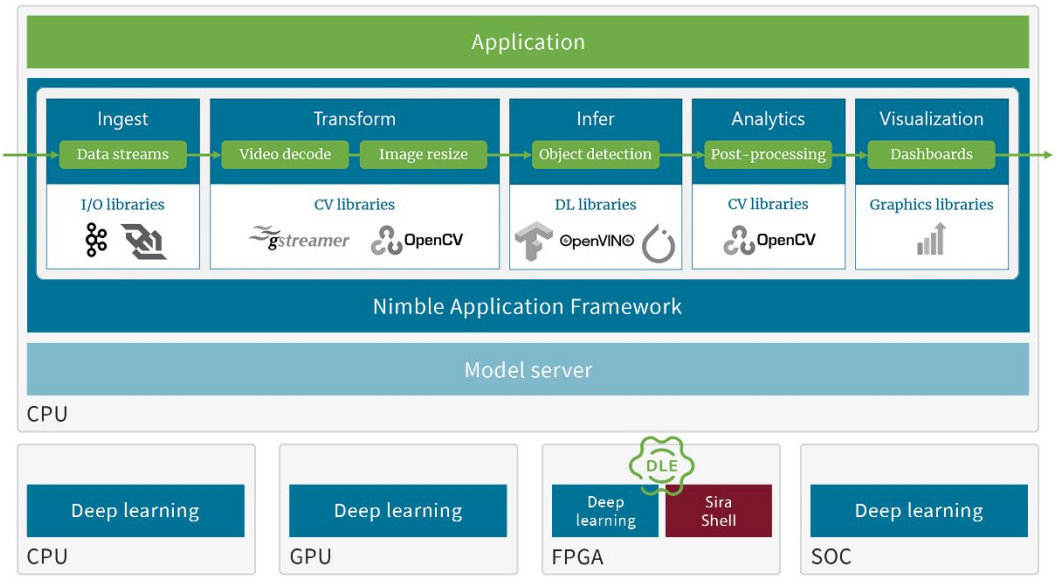
The Megh VAS platform is designed as a distributed microservice architecture. This system supports pipelines on CPU/iGPU/GPU/FPGA/ASIC and a pipeline constitutes a video source, AI, video retention, and analytics dashboards.

For the purpose of this report, we'll focus on the pipelines deployed on a CPU and iGPU.

The video is generated by the camera, in this case we are using a camera emulator that generates a H.264 stream based on a video file.

The video is ingested by the GStreamer service using a camera reader.

Figure 1. Megh Open Analytics Platform



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2.0 System Configuration

Table 1. System Configuration

Components	Intel® NUC Mini PCs			
Hardware				
Model	Processor	RAM	LAN	Storage
NUC11BTMi9	Intel® Core™ i9-11900KB	32 GB	I225-LM, Wi-Fi 6 AX210	512 GB
NUC11TNKi3	Intel® Core™ i3-1115G4	16 GB	I225-LM, Wi-Fi 6 AX201	250 GB
NUC11TNHi5	Intel® Core™ i5-1135G7	16 GB	I225-LM, Wi-Fi 6 AX201	500 GB
NUC12WSHi7	Intel® Core™ i7-1260P	16 GB	I225-V, Alder Lake -P	500 GB
Software				
Operating System	Ubuntu 22.04 LTS			
Kernel	5.15.0-60-generic			
Firmware	20220329.git681281e4-0ubuntu3.10			
Megh VAS	Release 0.16.1			

2.1 Video Stream Configuration

Component	Settings	Comments
Video Analytic Input Video Stream Parameters	1920x1080@25fps (1080p) 1280x720@25fps (720p) 640x480@25fps (480p)	FHD, HD, and SD video streams
Number of Input Video Streams for Analytics (Virtual cameras)	1-n	Each virtual camera stream has high-resolution and low-resolution videos

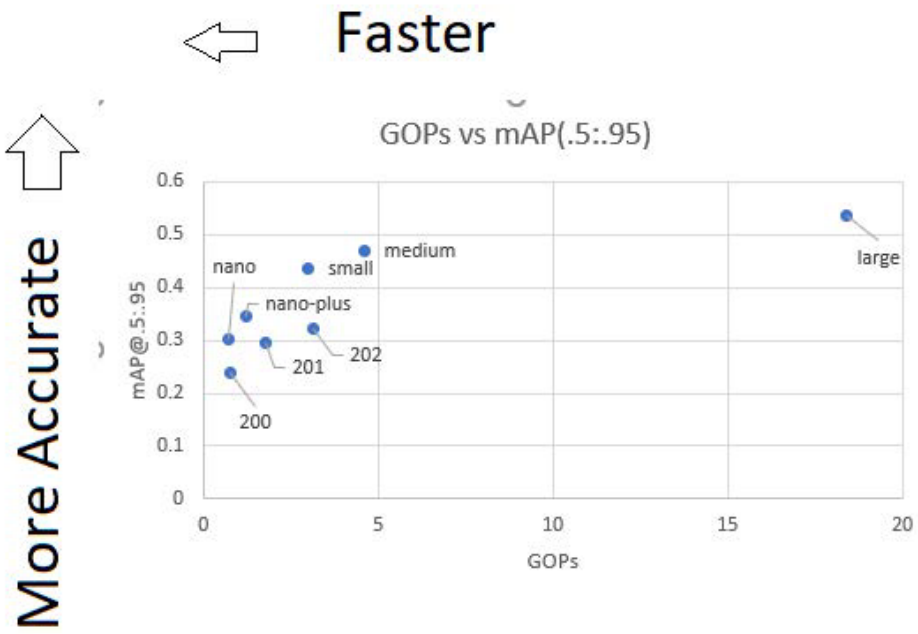
2.2 Video Analytics Algorithm Description and Parameters

Item	Person Detection
Description	Video ingestion and person detection
Detection CNN Architecture	yolov5n6-640
Service Name	Megh Nimble Interference Engine
Version	0.16.1
Date	February 2022

The model used in the person detection is the second-best model in terms of accuracy.

In this performance test we are using the medium model. The figure below shows the accuracy level of various models available on the Megh VAS platform.

Figure 2. Accuracy level of various models on Megh VAS



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3.0 Profiling

3.1 Validation Steps

1. Deploy and Configure Intel® NUC 11 Kit with 11th Generation Intel® Core™ Processors as server.
2. Install Ubuntu* Operating System and Analytics Platform with Testing Criteria.
    a. Set up maximum virtual video streams with specified video sources for high-resolution streams.
    b. Set up Megh VAS video analytics to process the virtual video streams.
3. Run the profiler tools to record hardware usage and other metrics over a given period of time.
4. Process results to generate tabulated data using multiple readings.
5. Analyze results and report.

3.2 Checklist for Results Validation

i. Megh VAS is utilizing the optimum amount of CPU/iGPU without compromising the system accuracy.

ii. Processing frame rate is matching the expectations (>90% of input).

iii. CPU usage and Memory consumption values are consistent during the test.

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4.0 Performance Test Results

To measure system scalability, we sequentially increased the number of streams being processed in parallel while keeping records about hardware utilization and frame output for each stream.

4.1 Analysis

The total memory used by the system grows almost linearly based on the number of streams. Certain services are shared among all AI services, which explains why the growth is not fully linear. In the case of a single stream, the memory usage increment produced by a single AI service is insignificant compared to the idle system.

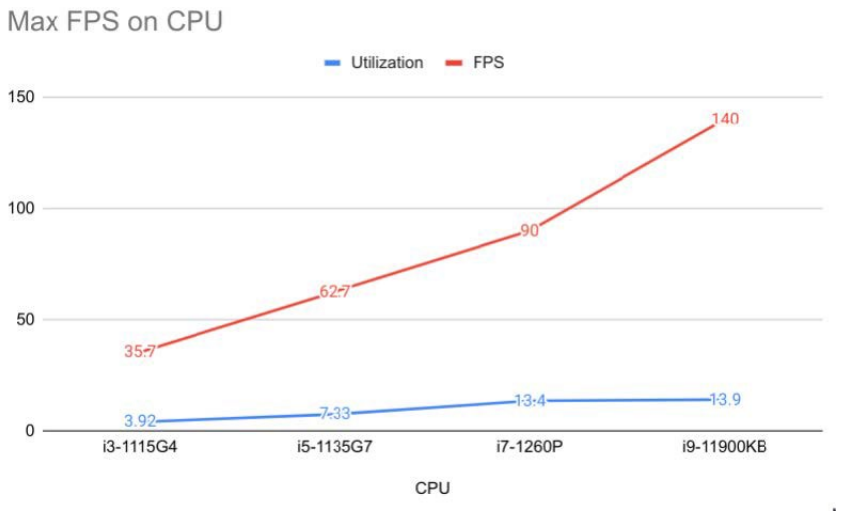
The memory utilization per stream is almost constant and the small variations are due to the dynamic memory allocation as the system processes the streams.

The increment in the CPU is almost linear.

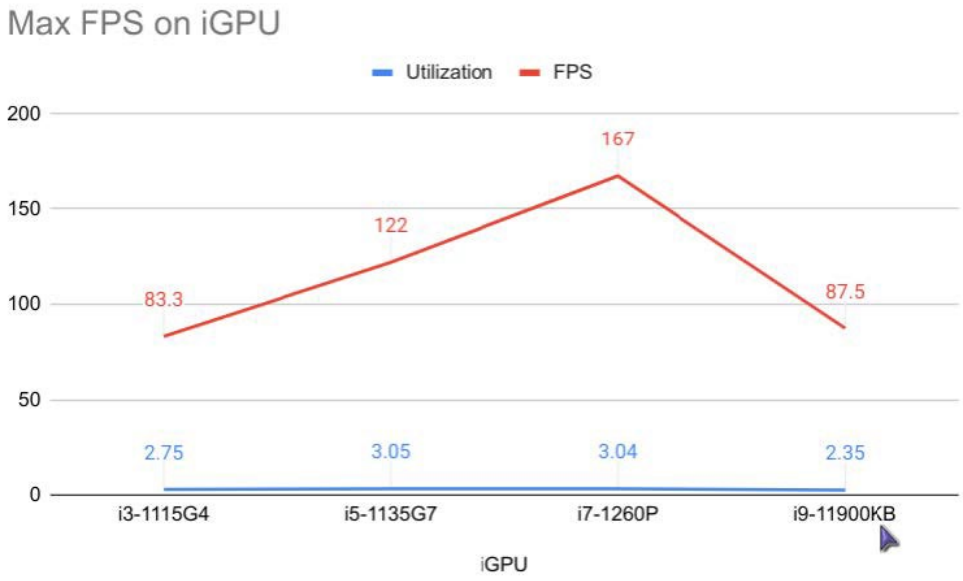
4.2 Practical Maximum FPS

For establishing the maximum FPS throughput possible on the system with the model we can push a random 2D array of 640x480 integers and measure the CPU utilization and FPS output. In this configuration the pipeline does not perform any analytics, thus we can assume that further steps in the pipeline can be at best equal or will be less than this practical FPS limit, for video input of 640x480 or greater.

4.3 Max FPS on CPU

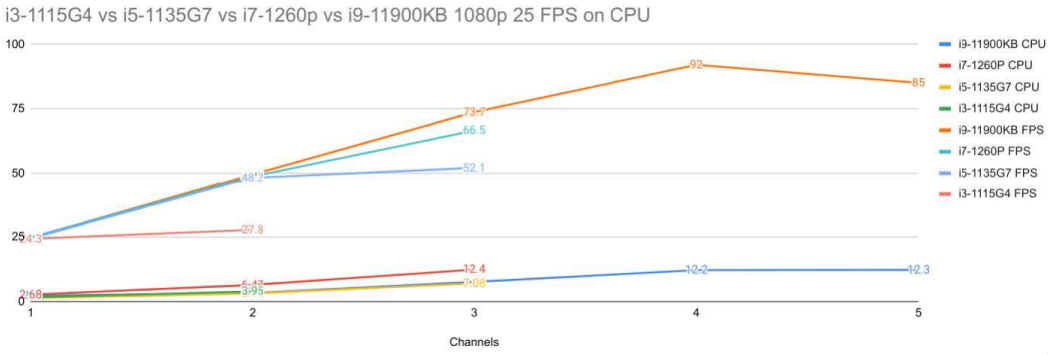


4.4 Max FPS on iGPU



Observation: The lower FPS of the iGPU on the Intel® Core™ i9-11900KB processor compared to the Intel® Core™ i5 and Intel® Core™ i7 processors was caused by the lower number of execution units in the CPU package (of the Intel® Core™ i9 processor).

4.5 CPU and Memory Utilization 1080p - CPU Pipeline



4.5.1 Intel® Core™ i9-11900KB

Number of Streams	vCPU	RAM	Input FPS	Output FPS
Idle	-	-	-	-
1	2.3	816 MB	25	24.7

2	3.34	980 MB	50	49.4
3	7.64	1.34 GB	75	73.7
4	12.2	2.12 GB	100	92
5	12.3	2.36 GB	125	85

4.5.2 Intel® Core™ i7-1260P

Number of Streams	vCPU	RAM	Input FPS	Output FPS
Idle	-	-	-	-
1	2.68	706 MB	25	24.8
2	6.47	1.00 GB	50	48.7
3	12.4	1.95 GB	75	66.5

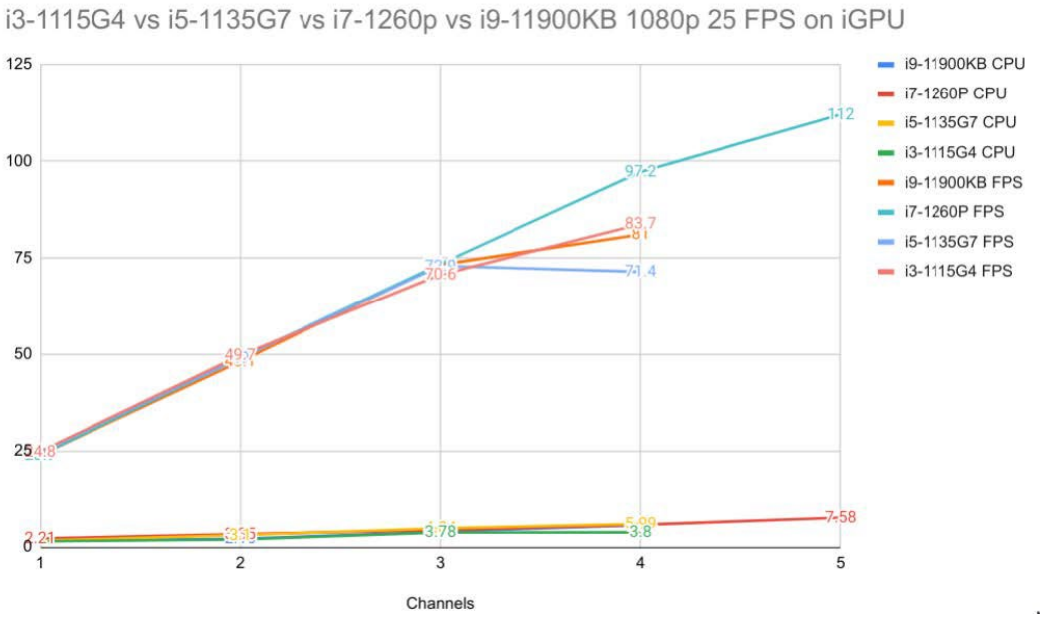
4.5.3 Intel® Core™ i5-1135G7

Number of Streams	vCPU	RAM	Input FPS	Output FPS
Idle	-	-	-	-
1	1.45	824 MB	25	24.7
2	6.51	1.59 GB	50	48.3
3	7.31	2.23 GB	75	42.9

4.5.4 Intel® Core™ i3-1115G4

Number of Streams	vCPU	RAM	Input FPS	Output FPS
Idle	-	-	-	-
1	1.67	767 MB	25	24.3
2	3.95	1.95 GB	50	27.8

4.6 CPU and Memory Utilization 1080p - iGPU Pipeline



4.6.1 Intel® Core™ i9-11900KB

Number of Streams	vCPU	RAM	Input FPS	Output FPS
Idle	-	-	-	-
1	1.58	1.12 GB	25	23.9
2	2.15	1.42 GB	50	48.1
3	3.94	1.67 GB	75	73.2
4	5.64	2.51 GB	100	81

4.6.2 Intel® Core™ i7-1260P

Number of Streams	vCPU	RAM	Input FPS	Output FPS
Idle	-	-	-	-
1	2.21	1.02 GB	25	23.9
2	3.35	1.38 GB	50	49.0
3	4.37	1.41 GB	75	73.4
4	5.74	1.65 GB	100	97.2
5	7.58	2.43 GB	125	112

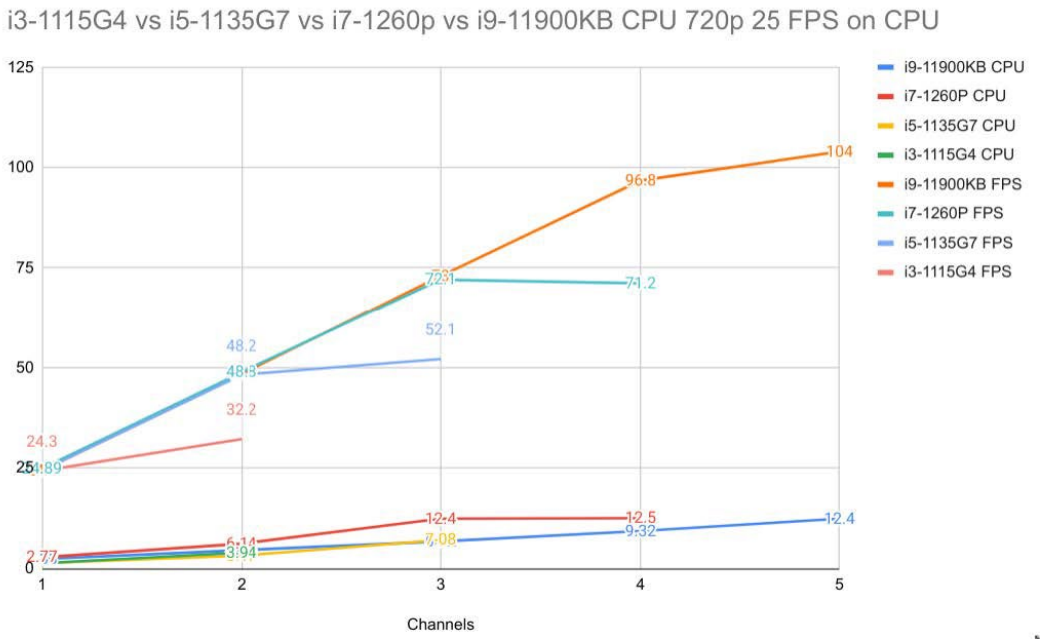
4.6.3 Intel® Core™ i5-1135G7

Number of Streams	vCPU	RAM	Input FPS	Output FPS
Idle	-	-	-	-
1	1.66	914 MB	25	24.8
2	3.10	1.18 GB	50	49
3	4.84	1.75 GB	75	72.9
4	5.99	2.27 GB	100	71.4

4.6.4 Intel® Core™ i3-1115G4

Number of Streams	vCPU	RAM	Input FPS	Output FPS
Idle	-	-	-	-
1	1.48	915 MB	25	24.8
2	1.95	1.21 GB	50	49.7
3	3.78	1.87 GB	75	70.6
4	3.80	2.49 GB	100	83.7

4.7 CPU and Memory Utilization 720p - CPU Pipeline



4.7.1 Intel® Core™ i9-11900KB

Number of Streams	vCPU	RAM	Input FPS	Output FPS
Idle	-	-	-	-
1	2.33	539 MB	25	24.4
2	4.55	743 MB	50	48.3
3	6.72	882 MB	75	73
4	9.32	1.01 GB	100	96.8
5	12.4	1.36 GB	125	104

4.7.2 Intel® Core™ i7-1260P

Number of Streams	vCPU	RAM	Input FPS	Output FPS
Idle	-	-	-	-
1	2.77	548 MB	25	24.89
2	6.14	693 MB	50	48.8
3	12.4	1.07 GB	75	72.1
4	12.5	1.18 GB	100	71.2

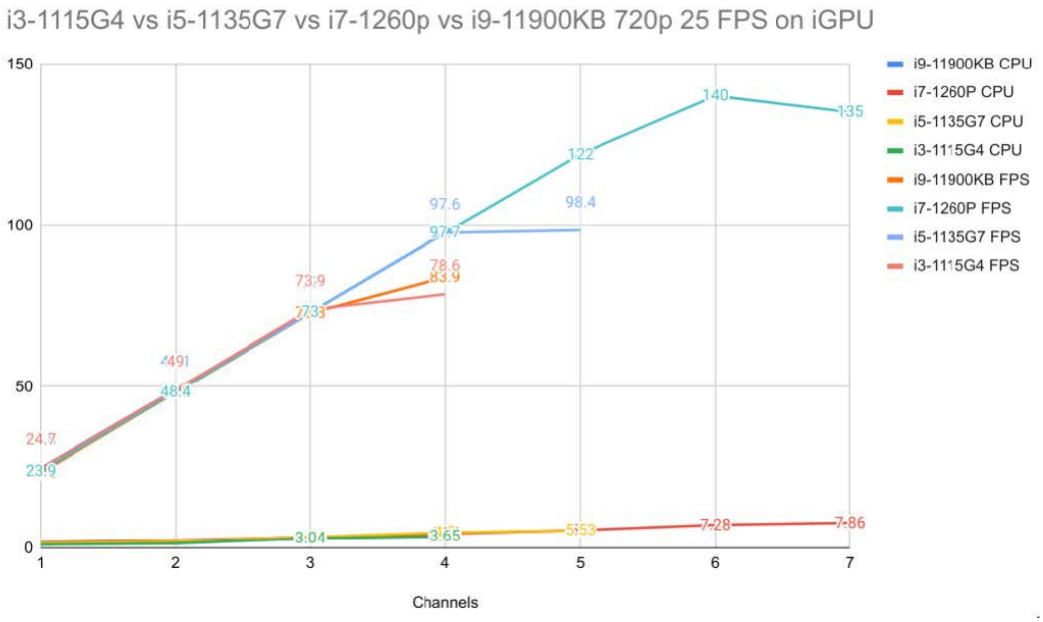
4.7.3 Intel® Core™ i5-1135G7

Number of Streams	vCPU	RAM	Input FPS	Output FPS
Idle	-	-	-	-
1	1.30	615 MB	25	24.4
2	3.17	744 MB	50	48.2
3	7.08	1.26 GB	75	52.1

4.7.4 Intel® Core™ i3-1115G4

Number of Streams	vCPU	RAM	Input FPS	Output FPS
Idle	-	-	-	-
1	1.29	618 MB	25	24.3
2	3.94	1.07 GB	50	32.2

4.8 CPU and Memory Utilization 720p - iGPU Pipeline



4.8.1 Intel® Core™ i9-11900KB

Number of Streams	vCPU	RAM	Input FPS	Output FPS
Idle	-	-	-	-
1	1.37	825 MB	25	23.3
2	1.93	970 MB	50	48.2
3	2.85	1.08 GB	75	72.8
4	4.56	1.49 GB	100	83.9

4.8.2 Intel® Core™ i7-1260P

Number of Streams	vCPU	RAM	Input FPS	Output FPS
Idle	-	-	-	-
1	1.76	833 MB	25	23.9

2	2.41	999 MB	50	48.4
3	3.43	1.07 GB	75	73
4	4.53	1.14 GB	100	97.7
5	5.60	1.24 GB	125	122
6	7.28	1.50 GB	150	140
7	7.86	1.66 GB	175	135

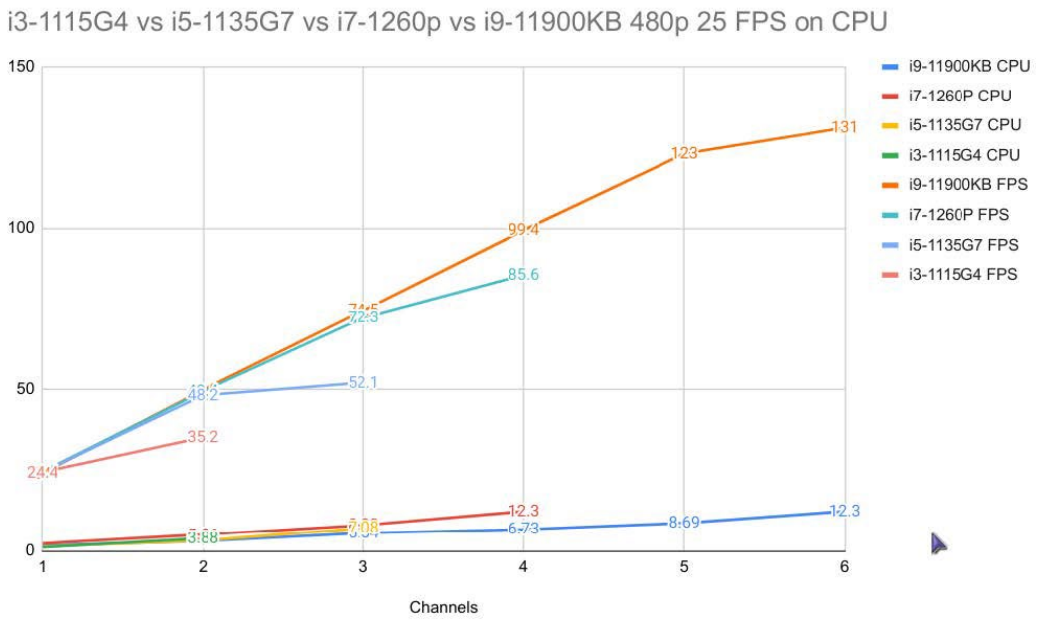
4.8.3 Intel® Core™ i5-1135G7

Number of Streams	vCPU	RAM	Input FPS	Output FPS
Idle	-	-	-	-
1	1.50	679 MB	25	24.8
2	2.05	887 MB	50	49.1
3	3.46	1.07 GB	75	73
4	4.90	1.34 GB	100	97.6
5	5.53	1.46 GB	125	98.4

4.8.4 Intel® Core™ i3-1115G4

Number of Streams	vCPU	RAM	Input FPS	Output FPS
Idle	-	-	-	-
1	1.05	713 MB	25	24.7
2	1.39	831 MB	50	49.0
3	3.04	1.05 GB	75	73.9
4	3.65	1.31 GB	100	78.6

4.9 CPU and Memory Utilization 480p - CPU Pipeline



4.9.1 Intel® Core™ i9-11900KB

Number of Streams	vCPU	RAM	Input FPS	Output FPS
Idle	-	-	-	-
1	1.65	485 MB	25	24
2	3.01	581 MB	50	49.8
3	5.54	544 MB	75	74.5
4	6.73	585 MB	100	99.4
5	8.69	603 MB	125	123
6	12.3	742 MB	150	131

4.9.2 Intel® Core™ i7-1260P

Number of Streams	vCPU	RAM	Input FPS	Output FPS
Idle	-	-	-	-
1	2.29	432 MB	25	24.5
2	5.06	467 MB	50	49.4
3	8.02	532 MB	75	72.3
4	12.3	645 MB	100	85.6

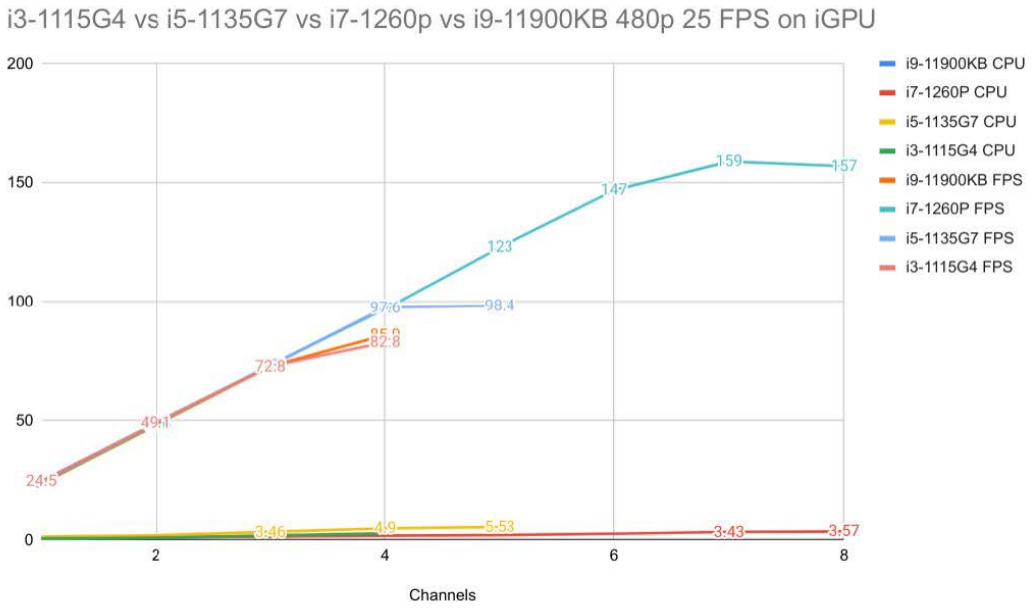
4.9.3 Intel® Core™ i5-1135G7

Number of Streams	vCPU	RAM	Input FPS	Output FPS
Idle	-	-	-	-
1	1.30	615 MB	25	24.4
2	3.17	744 MB	50	48.2
3	7.08	1.26 GB	75	52.1

4.9.4 Intel® Core™ i3-1115G4

Number of Streams	vCPU	RAM	Input FPS	Output FPS
Idle	-	-	-	-
1	1.07	475 MB	25	24.4
2	3.88	627 MB	50	35.2

4.10 CPU and Memory Utilization 480p - iGPU Pipeline



4.10.1 Intel® Core™ i9-11900KB

Number of Streams	vCPU	RAM	Input FPS	Output FPS
Idle	-	-	-	-
1	0.614	721 MB	25	23.5
2	0.969	751 MB	50	48.1
3	1.62	824 MB	75	72.8
4	2.43	917 MB	100	85.9

4.10.2 Intel® Core™ i7-1260P

Number of Streams	vCPU	RAM	Input FPS	Output FPS
Idle	-	-	-	-
1	0.721	650 MB	25	23.9
2	1.23	722 MB	50	48.6

3	1.54	748 MB	75	73.3
4	1.86	774 MB	100	97
5	2.08	813 MB	125	123
6	2.65	887 MB	150	147
7	3.43	934 MB	175	159
8	3.57	1.01 GB	200	157

4.10.3 Intel® Core™ i5-1135G7

Number of Streams	vCPU	RAM	Input FPS	Output FPS
Idle	-	-	-	-
1	1.50	679 MB	25	24.8
2	2.05	887 MB	50	49.1
3	3.46	1.07 GB	75	73
4	4.9	1.34 GB	100	97.6
5	5.53	1.46 GB	125	98.4

4.10.4 Intel® Core™ i3-1115G4

Number of Streams	vCPU	RAM	Input FPS	Output FPS
Idle	-	-	-	-
1	0.708	557	25	24.5
2	0.951	590	50	49.1
3	2.05	625	75	72.8
4	2.85	786	100	82.8

5.0 Conclusion

This report validates Megh Computing's VAS solution running on Intel® NUC Kits with 11th or 12th Generation Intel® Core™ processors. The Intel® NUC Kits are a cost-effective, small-form factor hardware that provides customers with the performance, power, and the accuracy they need to run Megh VAS at the edge. Intel and Megh Computing have validated that the Megh VAS solution enables customer to leverage Intel® NUC Kits to scale the solutions with long term stability.

The total number of streams supported by a system will depend on the camera's resolution (e.g., FHD 1080p or HD 720p) and frame rate in terms of Frames Per Second (e.g., 30 FPS or lower) of the video stream. The resolution and frame rate required for a solution will depend on the use cases deployed. Most physical security use cases like intrusion detection and loiter detection only require 720p resolution at 5 FPS. Other use cases like license plate recognition may require higher resolutions and frame rates.

We demonstrated that by utilizing both the CPU and iGPU simultaneously to analyze video streams, we can scale the solution by varying the resolution and frame rate of the camera streams. Megh VAS supports down sampling of video stream FPS at the inference engine, which allows for more streams to be analyzed on a system by configuring the video stream to a lower FPS than the original stream, for instance a 25 or 30 FPS input stream can be configured to process at 5 FPS after decoding of the video streams. Also, independent of the input resolution, the images are resized to 640x480 pixels before they are analyzed by the inference engine to detect objects. Thus, the change in resolution from 1080p to 720p has less impact on the throughput compared to reducing the frame rate to 5 or 10 FPS. By managing both the resolution and frame rate in the processing pipeline, Megh's VAS is able to deliver very high throughput on the Intel® NUC Kits.

Summary of key results:

- The max FPS using CPUs only (Section 4.3) to implement the complete video analytics pipeline scales linearly with number of cores from 35 FPS on an Intel® Core™ i3 processor to 140/150 FPS on an Intel® Core™ i9 processor while the overall CPU utilization remains low.
- The max FPS using iGPU (Section 4.4) to implement the inferencing while using the CPU to decode the video streams and perform analytics after the detection scales linearly from 83 FPS on an Intel® Core™ i3 processor to 167 on an Intel® Core™ i7 processor but drops to 87 FPS for the Intel® Core™ i9 processor because of the fewer number of iGPU execution units available on an Intel® Core™ i9 processor. The CPU utilization remains low in this configuration also.

- Performance on an Intel® NUC 12 Pro Kit NUC12WSHi7 with an Intel® Core™ i7-1260P processor, the CPU only (Section 4.5.2) throughput for example is 66.5 FPS and the iGPU only (Section 4.6.2) throughput is 112.0 FPS which translates to a maximum of 13 streams and 22 streams respectively at 5 FPS. By utilizing both the CPU and iGPU, up to 35 video streams can be analyzed with the Megh VAS solution on the NUC12WSHi7 kit.

In summary, we have defined the specifications required for the CPU and iGPU hardware to be deployed for scaling the Megh Video Analytics Solution (VAS) running on Intel® NUC Kits with 11th or 12th Generation Intel® Core™ processors.

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