

# DEVELOPING HIGH PERFORMANCE SOFTWARE USING INTEL® VTUNE™ AMPLIFIER



Dr. Sri Doddapaneni  
Senior Director, Developer Products @ Intel

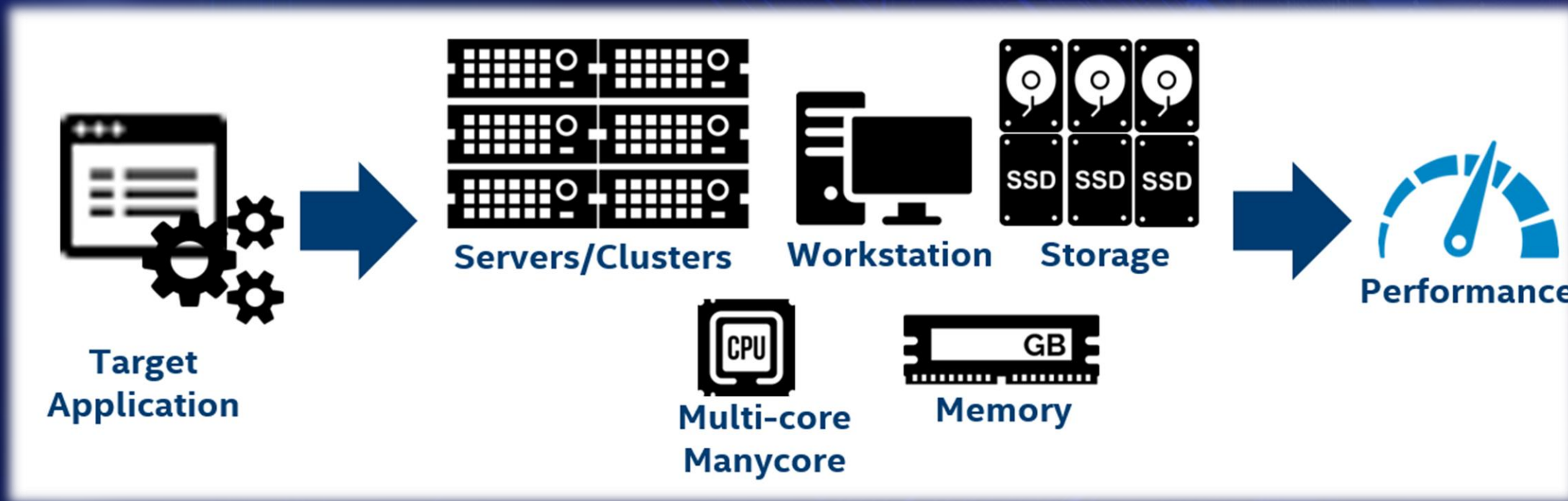
#### Optimization Notice

Copyright © 2019, Intel Corporation. All rights reserved.

\*Other names and brands may be claimed as the property of others.



# How Is My Application Performing?



Am I Getting the “Best” Performance?  
What if I Change Code and/or Change Hardware?

## Optimization Notice

Copyright © 2019, Intel Corporation. All rights reserved.

\*Other names and brands may be claimed as the property of others.



# The Challenge

- What do I need to know to quickly assess my application performance?

Memory Utilization?

Vector Unit  
Utilization?

Communication  
Time vs  
Computation Time  
balanced?

CPU Utilization?

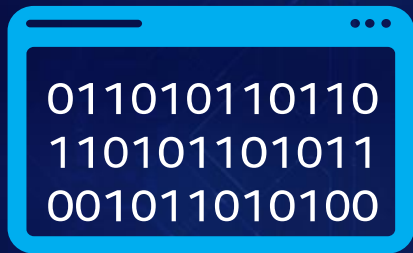
Is Storage Speed  
Slowing Execution?

How Many Flops is  
the Application  
Consuming?

- Need a quick “First Look” at possible opportunities to improve the performance of my application focusing on top level metrics



# Performance is Many Things



**CPI**

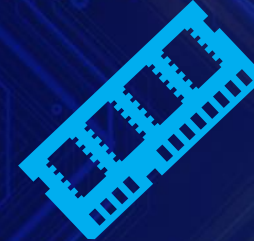


**GHZ**



**SIMD**

**MULTI-CORE**



**CACHE**



**MEMORY**

**IO**

## Optimization Notice

Copyright © 2019, Intel Corporation. All rights reserved.

\*Other names and brands may be claimed as the property of others.



# Many Developer Roles



**DESIGN**



**CODE**



**APPLICATION  
PERFORMANCE**



**SYSTEM  
PERFORMANCE**

Contribute to overall performance



# Role Specific Workflows

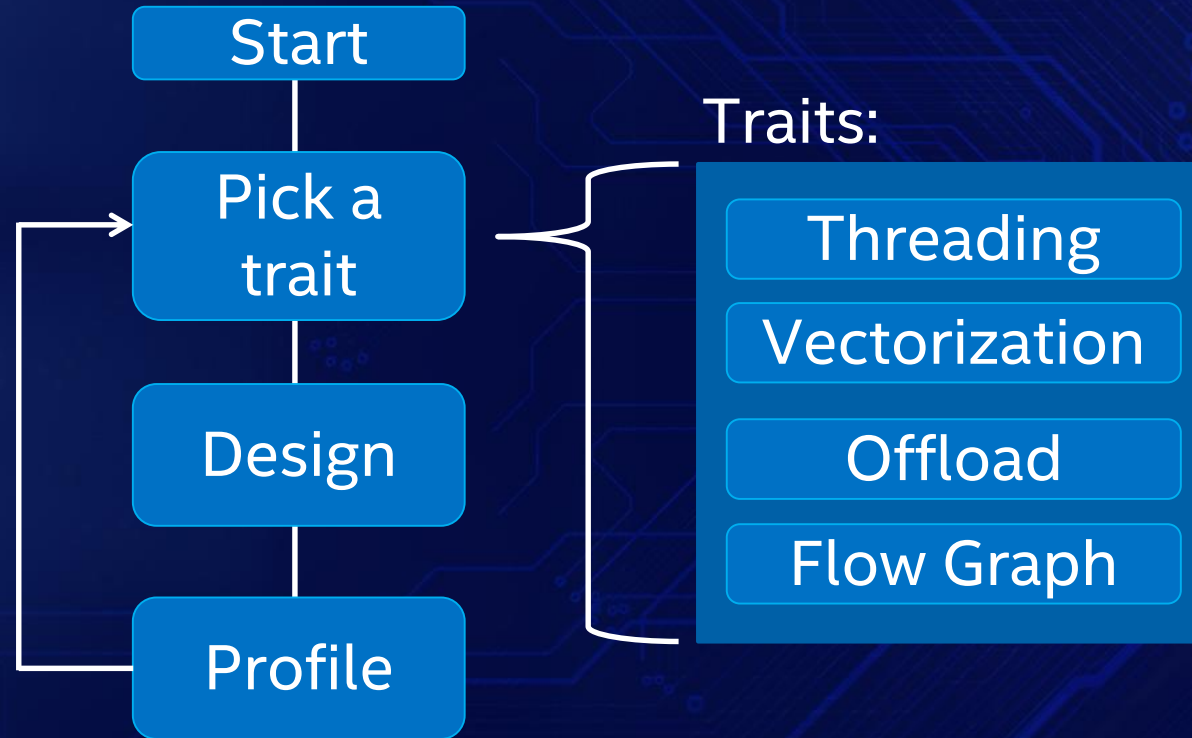
## Optimization Notice

Copyright © 2019, Intel Corporation. All rights reserved.

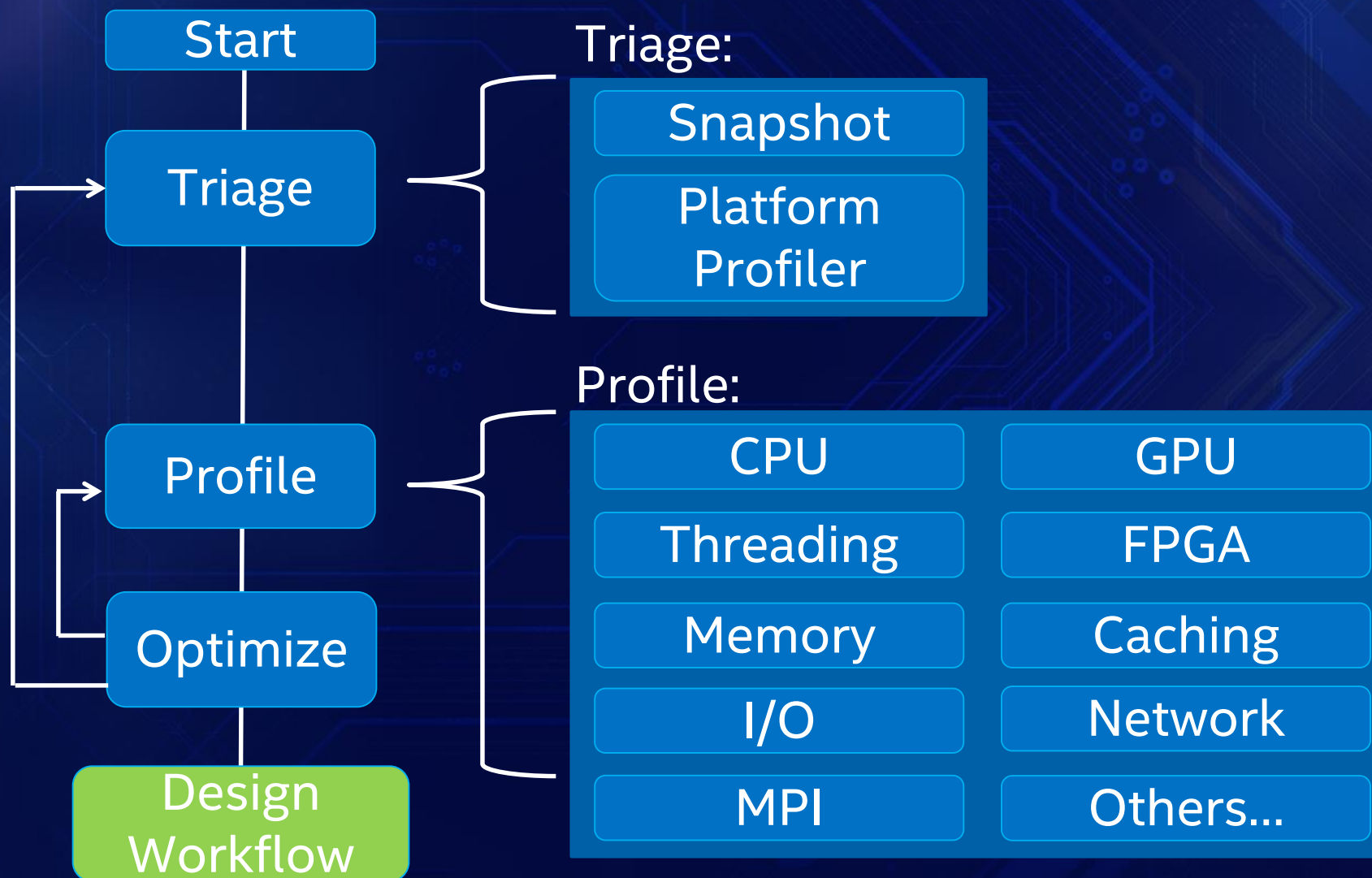
\*Other names and brands may be claimed as the property of others.



# DESIGN WORKFLOW

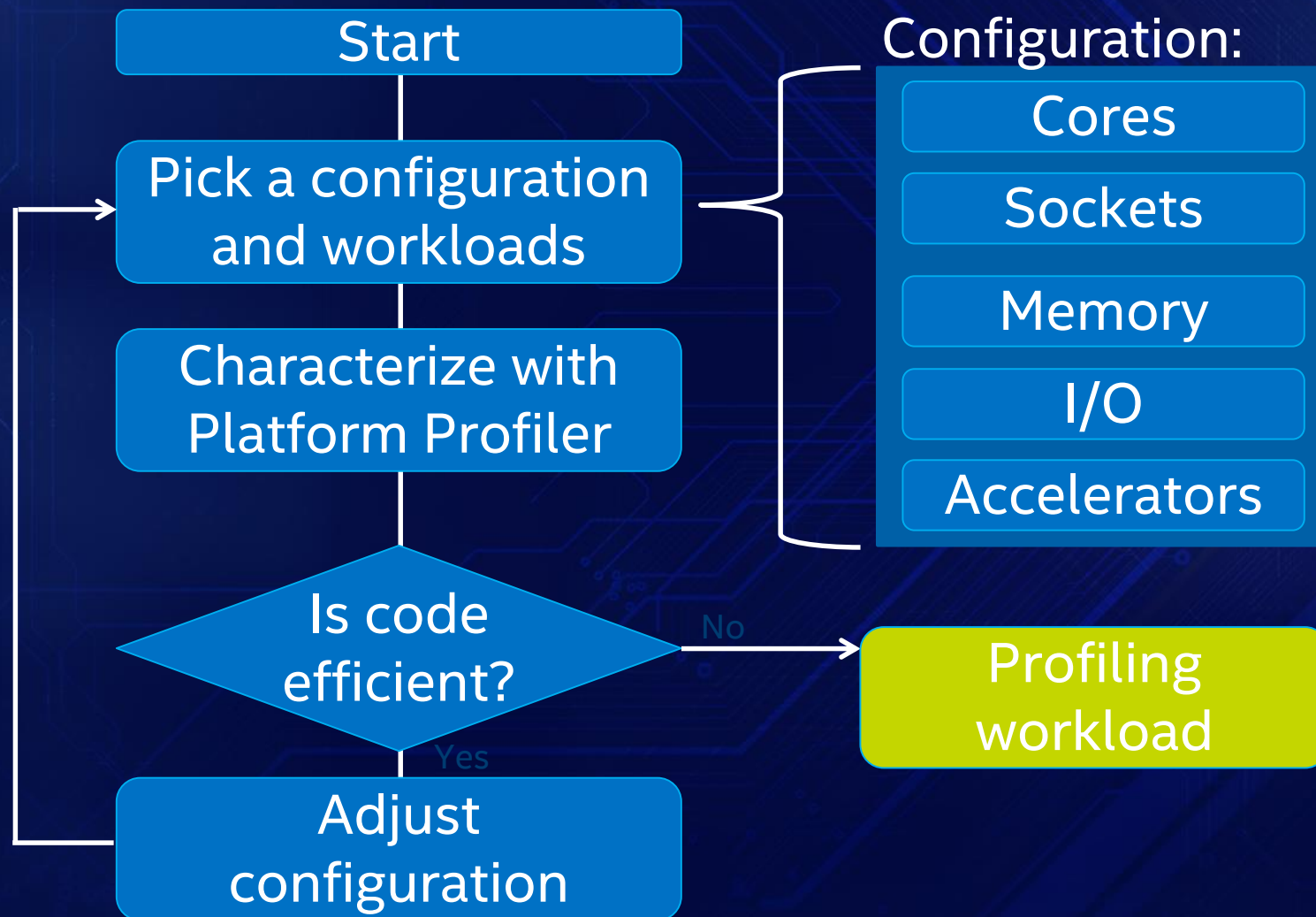


# PROFILING WORKFLOW





# CONFIGURATION WORKFLOW





“If all you have is a Hammer, everything looks like a Nail ...”

**Optimization Notice**

Copyright © 2019, Intel Corporation. All rights reserved.

\*Other names and brands may be claimed as the property of others.





The background of the slide is a dark blue field filled with a complex, glowing circuit pattern. The lines of the circuit are primarily blue and white, with some areas on the right side showing a warm orange and yellow glow. The pattern consists of various geometric shapes, including rectangles, circles, and interconnected lines, creating a sense of depth and technological complexity.

# “The best kept secret”

## Optimization Notice

Copyright © 2019, Intel Corporation. All rights reserved.

\*Other names and brands may be claimed as the property of others.





# You Need a Toolbox

**#1** Intel offers developers a toolbox with rich collection of analysis tools to help developers achieve best performance



**#2** We don't want that to be a secret ...

## Optimization Notice

Copyright © 2019, Intel Corporation. All rights reserved.

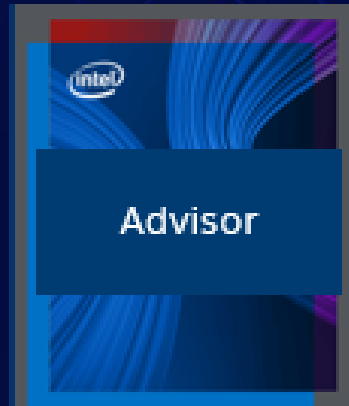
\*Other names and brands may be claimed as the property of others.



# Analysis Tools Overview



Intel® VTune™ Amplifier  
Performance Profiler



Intel® Advisor  
Threading & Vectorization Assistant



Intel® Inspector  
Memory & Thread Debugger

## Optimization Notice

Copyright © 2019, Intel Corporation. All rights reserved.

\*Other names and brands may be claimed as the property of others.





# Rich Set of Profiling Capabilities



## Single Thread

Optimize single-threaded performance.



## Multithreaded

Effectively use all available cores.



## System

See a system-level view of application performance.



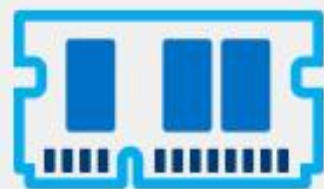
## Media & OpenCL™ Applications

Deliver high-performance image and video processing pipelines.



## HPC & Cloud

Access specialized, in-depth analyses for HPC and cloud computing.



## Memory & Storage Management

Diagnose memory, storage, and data plane bottlenecks.



## Analyze & Filter Data

Mine data for answers.



## Environment

Fits your environment and workflow.

### Optimization Notice


Copyright © 2019, Intel Corporation. All rights reserved.

\*Other names and brands may be claimed as the property of others.



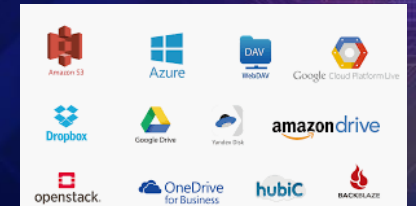


# Does it work?

Artificial Intelligence		23X		
Energy		10X		
EDA		11X		
Science & Research	 4X	 3X	 8X	 1.35X
Manufacturing	 1.4X	 4X		
Government		25X		
Computer Software	 2.5X	 1.25X	 1.3X	
IT	 5X	 2X		
Healthcare		20X		
Digital Media	 15X			
Telecommunications		2.5X		

Many Others

**NETFLIX**



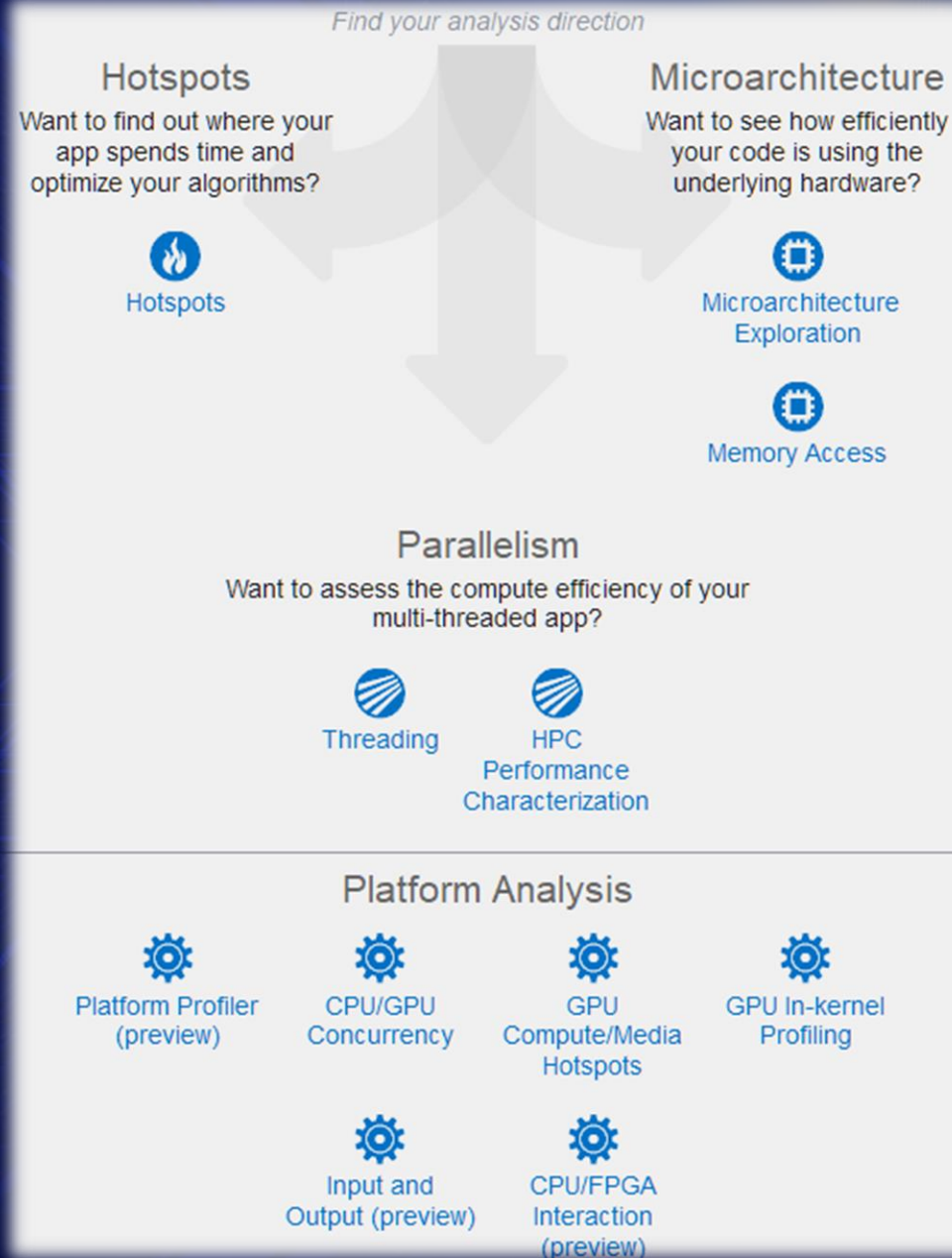
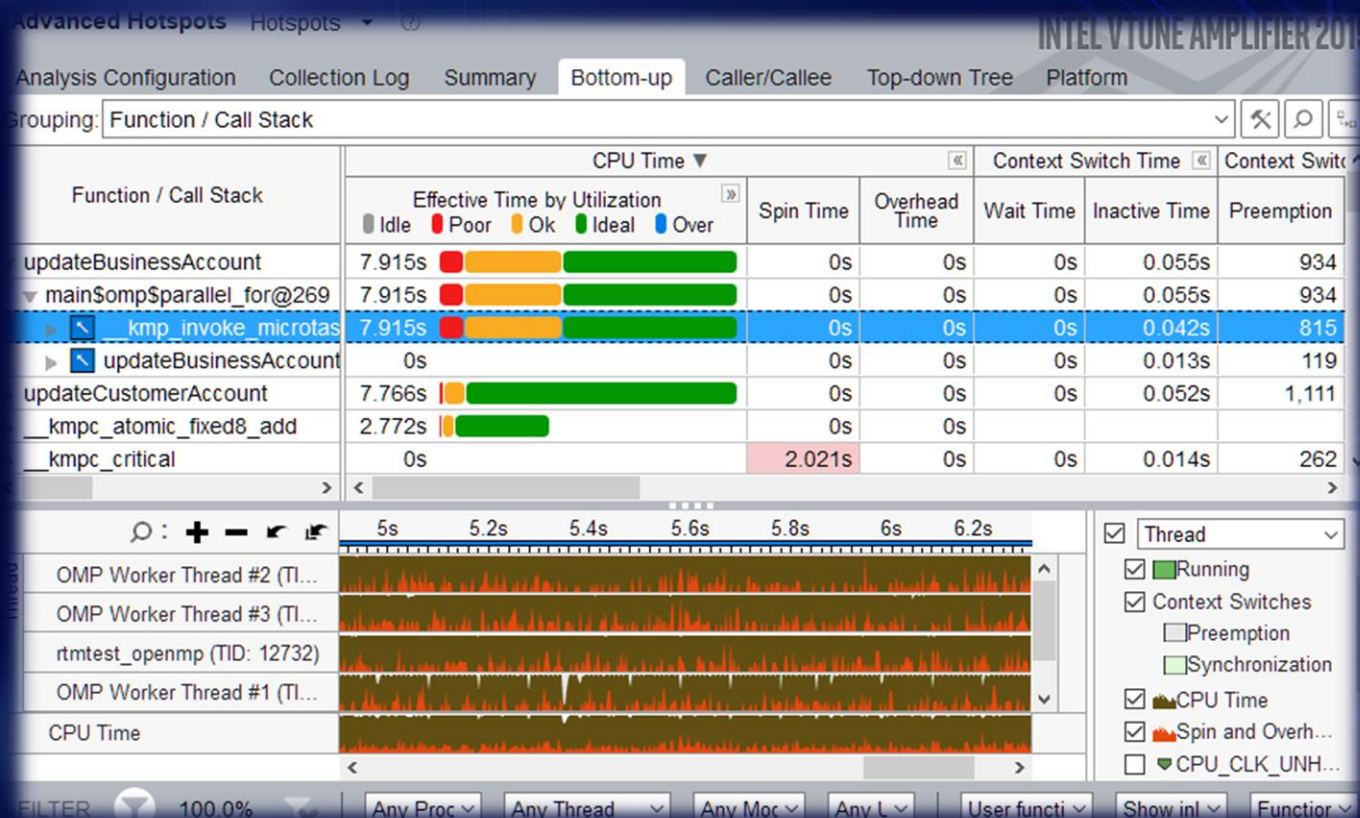
## Optimization Notice

Copyright © 2019, Intel Corporation. All rights reserved.

\*Other names and brands may be claimed as the property of others.



# VTune™ Amplifier



## Optimization Notice

Copyright © 2019, Intel Corporation. All rights reserved.

\*Other names and brands may be claimed as the property of others.





# VTune™ Snapshots

## MPI Performance Snapshot

Your application is OpenMP bound.  
High OpenMP imbalance has been identified.  
Use Intel VTune Amplifier for further analysis.

Application: /home/yschytok/p/omv/testing/h/mvcl/2015.09.23  
12.31.09/tac: /home/yschytok/p/omv/testing/h/mvcl/2015.09.23  
Number of ranks: 4  
Used statistics: app stat, 4p20k.tst, stat, 4p20k.tst  
Creation date: 2015-09-28 14:18:48

Wallclock time  
1.78 sec

Calculation 45.38%

MPI 54.62%

OpenMP 30.53%

OpenMP Imbalance 12.90%

MPI Imbalance

### TOP 5 MPI functions

func	%
Wait	71.98
Barrier	20.62
Init	3.98
Send	2.04
Recv	0.93

### GFLOPS

20.67

### I/O operations

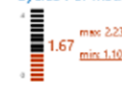
I/O wait: 0.00 sec 0.00%  
max: 0.00%  
min: 0.00%

### Memory usage



Per-process memory usage affects the application scalability.

### Cycles Per Instruction Rate



This could be caused by such issues as memory stalls, instruction starvation, branch misprediction or long latency instructions.

Please use Intel® VTune™ Amplifier XT to identify the cause of this bottleneck. High values are usually bad. The CPI value may be low.

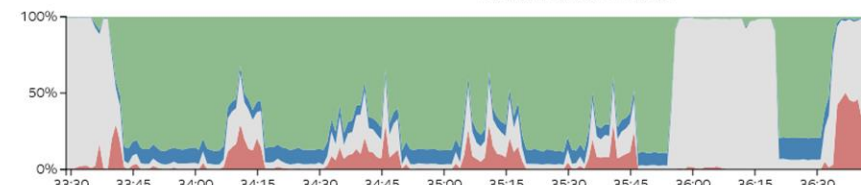
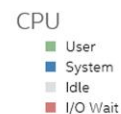
### Memory Bound Coefficient



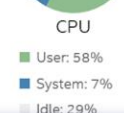
It indicates that the application doesn't spend much time waiting for data. High values are usually bad. The application is not Memory Bound.

Menu Data File kernel-build-hdd.dat

## Observations

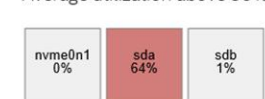


## Overview System



## Disks

Average utilization above 50%



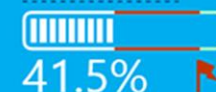
## Application Performance Snapshot

Preview



Elapsed Time  
18.7s  
GFLOPS  
2.9

### CPU Utilization



A low metric value can indicate poor CPU utilization by the application computations.  
49.7% of available CPU time was wasted in OpenMP runtime (not included in CPU utilization). Possible reasons: load imbalance between ranks, scheduling overhead, lock contention.

### Memory Bound



A high metric value can indicate significant execution pipeline stalling on memory operations due to memory-related performance issues like poor cache reuse, excessive NUMA remote accesses, false sharing, bandwidth limited memory access. Use memory access profiling tools to identify.

### FPU Utilization



A low metric value can indicate poor FPU utilization. This is normal if you are not doing floating point math. But, if your app performs significant floating point calculations try vectorization efficiency analysis tools explore on because of non-vectorized floating point operations or inefficient.



## Optimization Notice

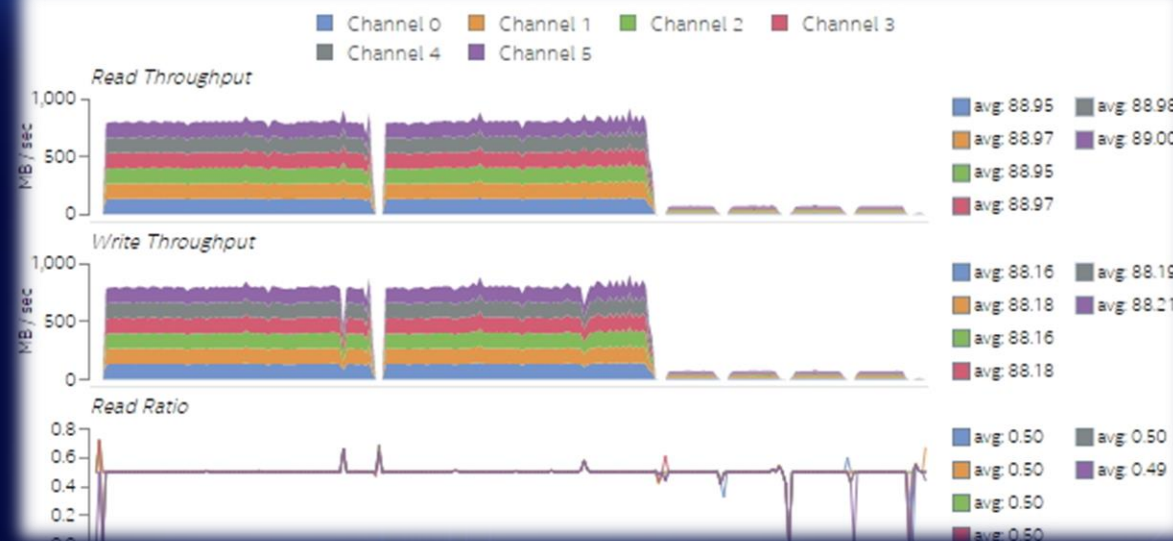
Copyright © 2019, Intel Corporation. All rights reserved.

\*Other names and brands may be claimed as the property of others.

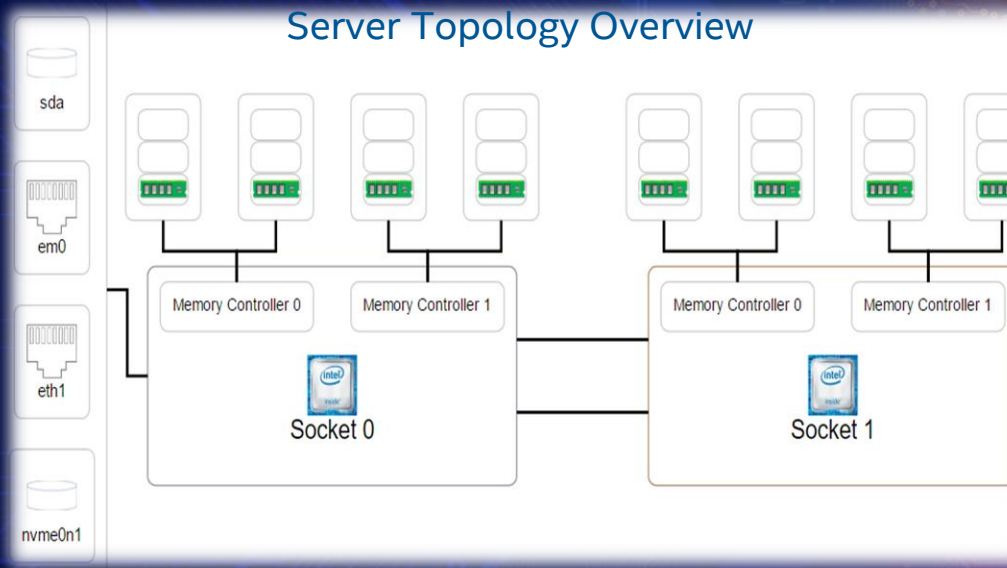


# VTune™ Platform Profiler

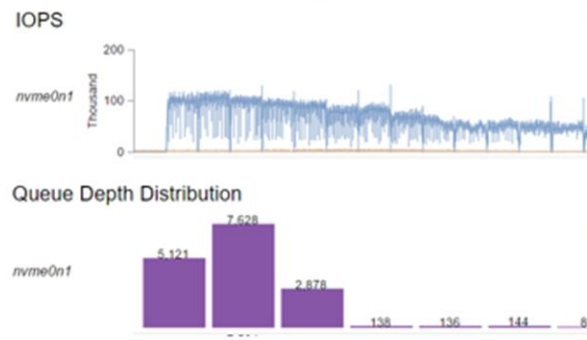
Socket 0 - DDR1



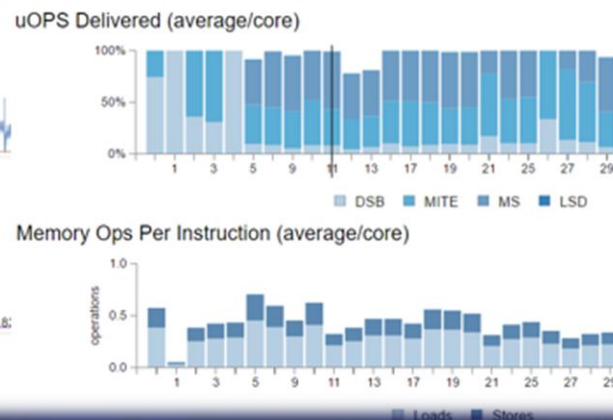
## Server Topology Overview



## Timelines & Histograms



## Core to Core Comparisons

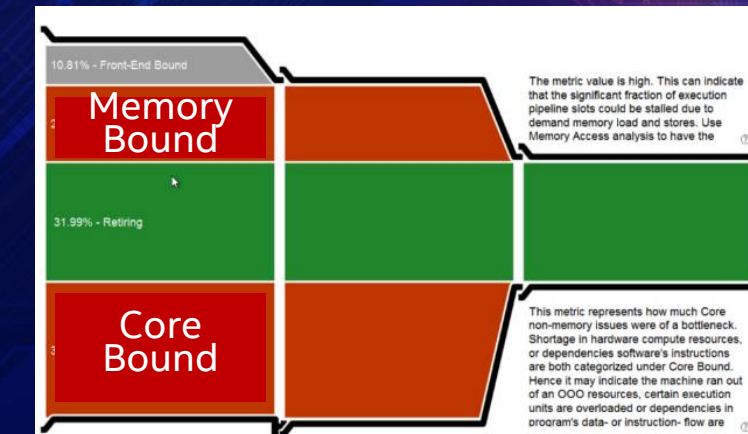
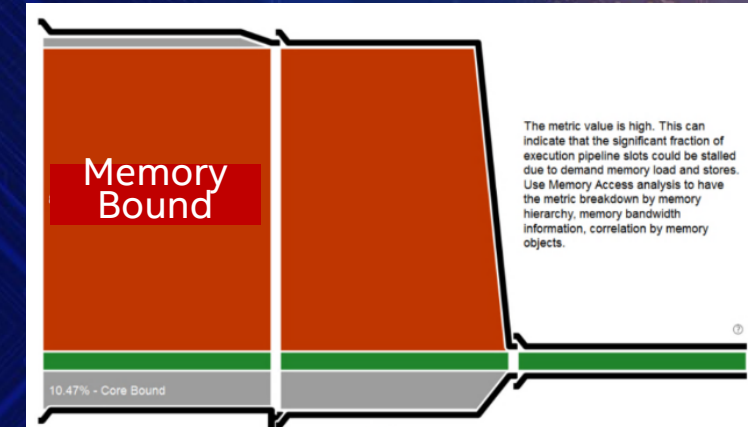
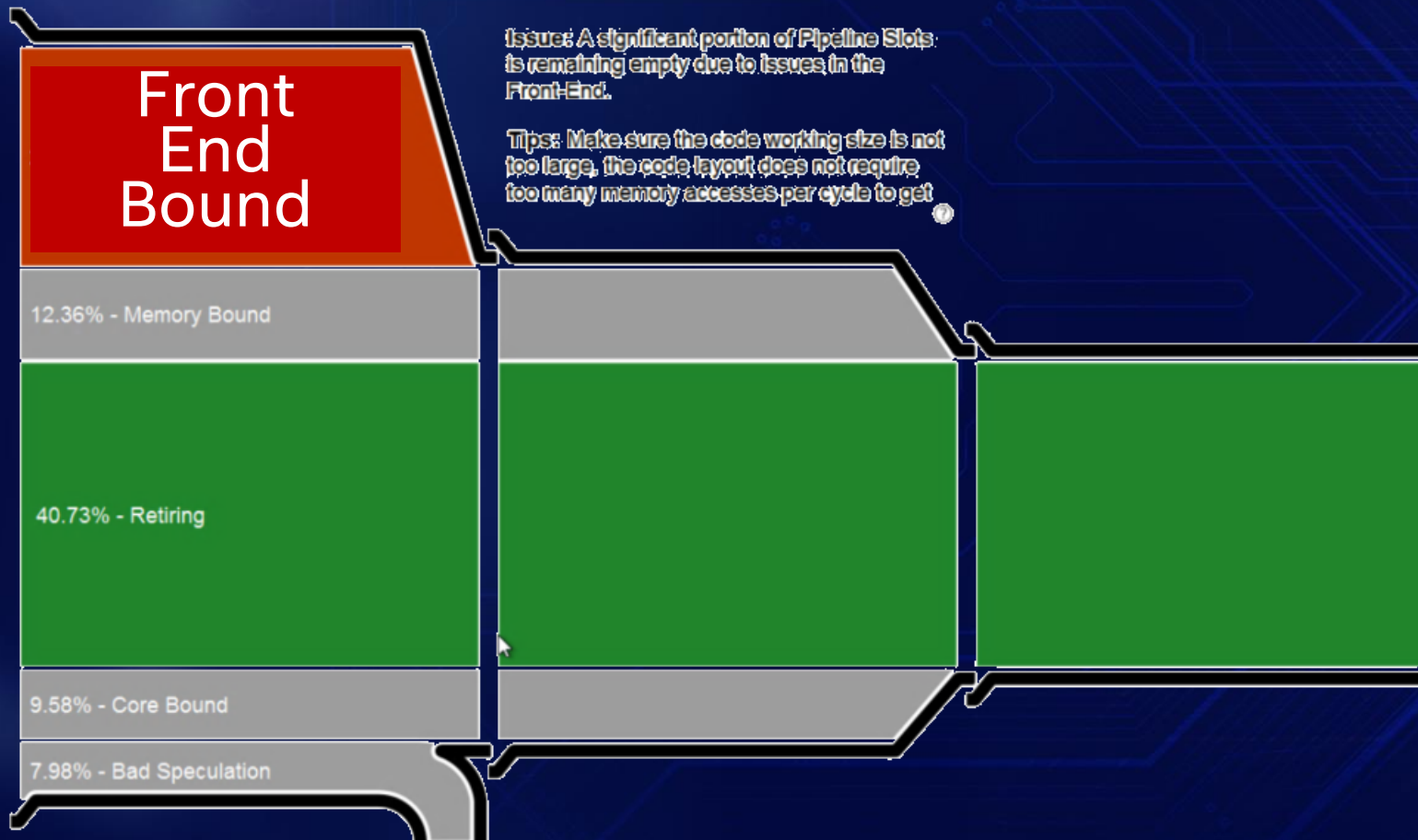


### Optimization Notice

Copyright © 2019, Intel Corporation. All rights reserved.  
\*Other names and brands may be claimed as the property of others.



# VTune™ uArch Analysis



## Optimization Notice

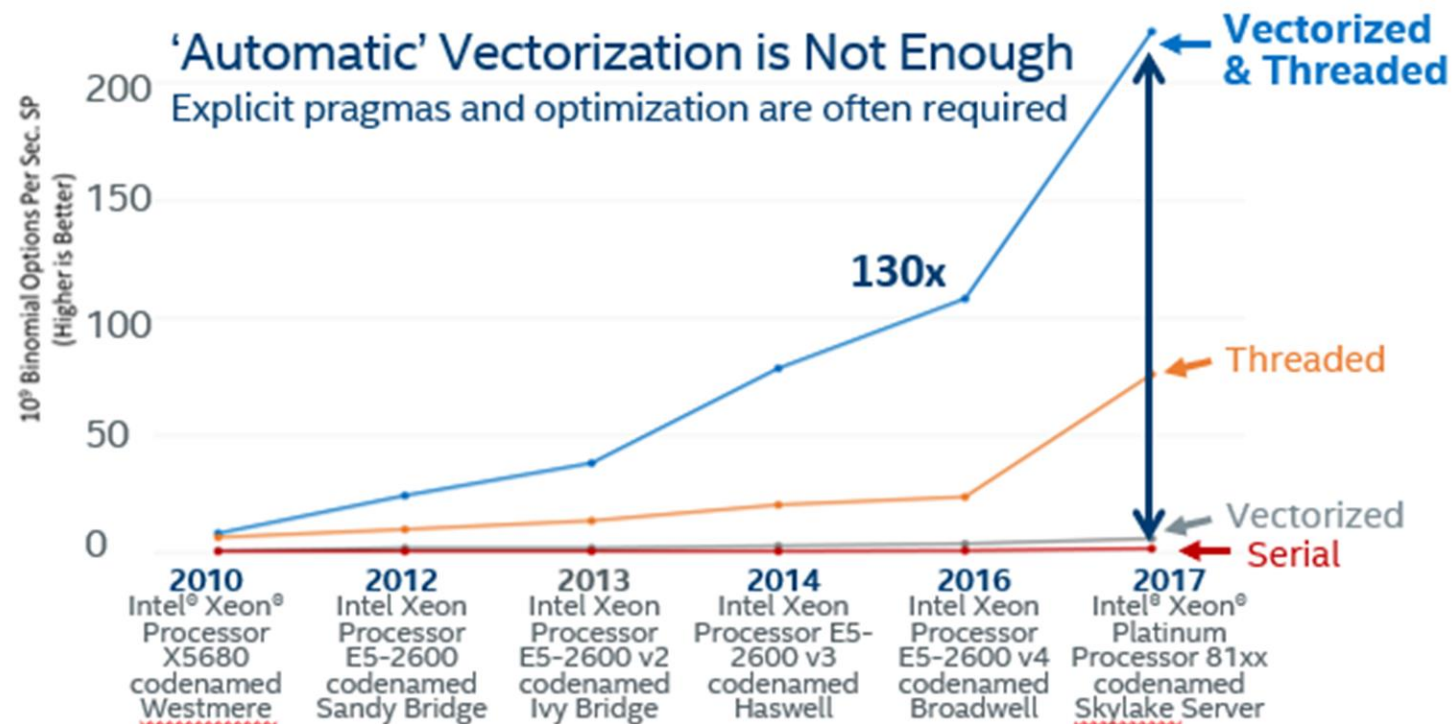
Copyright © 2019, Intel Corporation. All rights reserved.

\*Other names and brands may be claimed as the property of others.





# Intel® Advisor



Elapsed time: 125.72s Vectorized Not Vectorized OFF Smart Mode

FILTER: All Modules All Sources Loops And Functions All Threads

Summary Survey & Roofline Refinement Reports

Function Call Sites and Loops	Perfor... Issues	Self Time	Total Time	Type	Why No Vectorization?	Vectorized Loops					Instruction Set	
						Vect...	Efficiency	Gain...	VL ..	Com...	Traits	Da
[loop in main at roofline.cpp:295]	<input type="checkbox"/>	18.538s	18.538s	Vectorized (B...		AVX	~100%	5.34x	4	5.34x		Flo
[loop in main at roofline.cpp:310]	<input type="checkbox"/>	18.394s	18.394s	Vectorized (Bo...		AVX	~100%	5.34x	4	5.34x		Flo
[loop in main at roofline.cpp:221]	<input checked="" type="checkbox"/>	14.741s	14.741s	Scalar	novector dire...							Flo
[loop in main at roofline.cpp:234]	<input type="checkbox"/>	11.117s	11.117s	Scalar	inner loop w ...							Flo
[loop in main at roofline.cpp:247]	<input type="checkbox"/>	6.967s	6.967s	Vectorized (Bo...		AVX	~31%	1.22x	4	1.22x	Inserts; U...	Flo

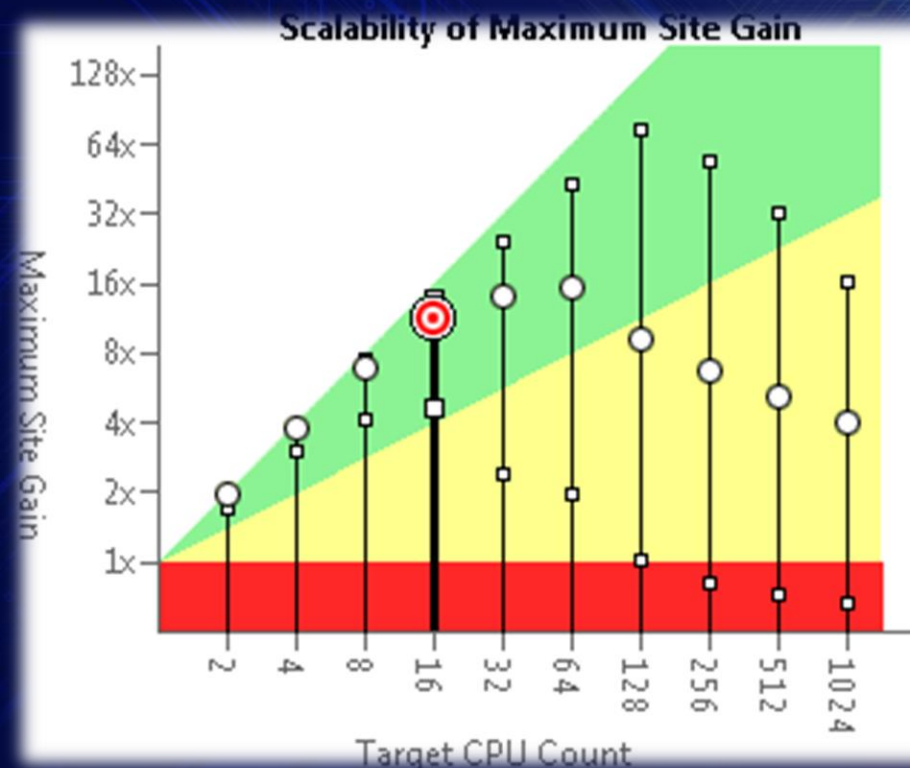
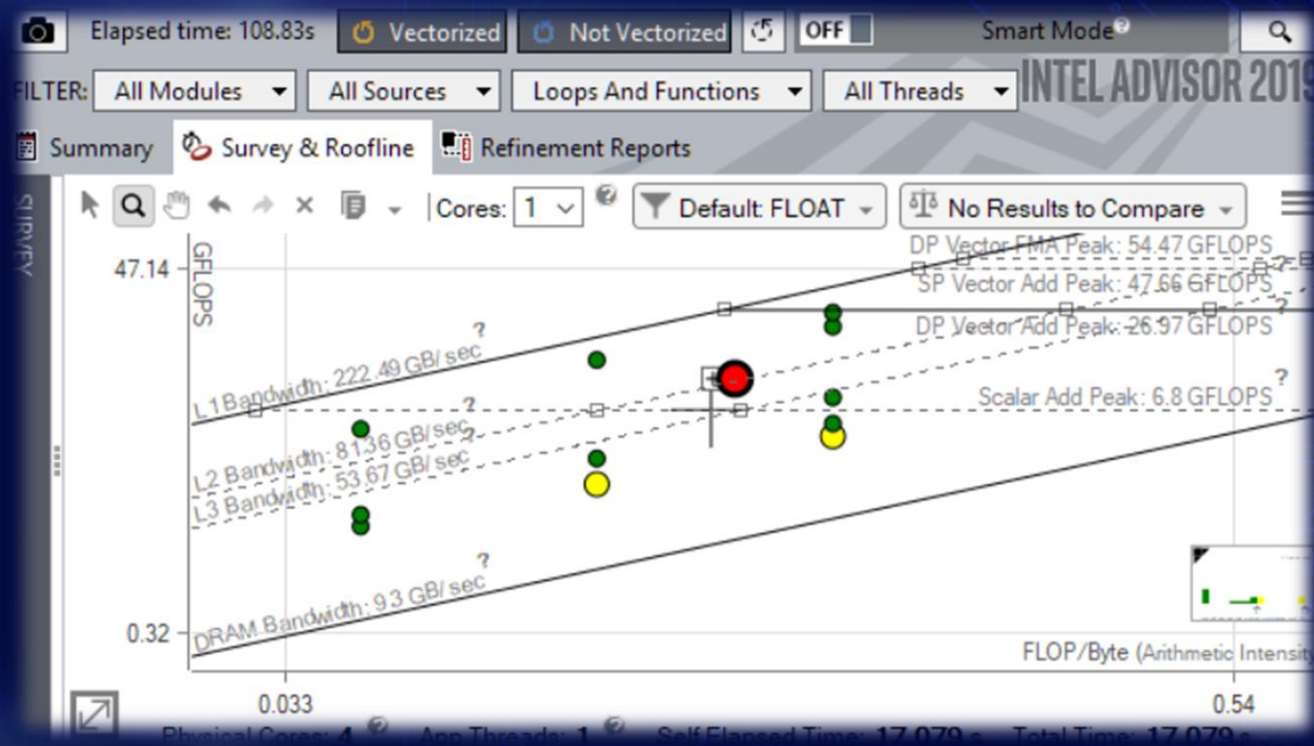
## Optimization Notice

Copyright © 2019, Intel Corporation. All rights reserved.

\*Other names and brands may be claimed as the property of others.



# Intel® Advisor



## Optimization Notice

Copyright © 2019, Intel Corporation. All rights reserved.

\*Other names and brands may be claimed as the property of others.





# Intel® Inspector

## Debug Memory & Threading

INTEL INSPECTOR 2019

Locate Deadlocks and Data Races

Target Analysis Type Collection Log Summary

**Problems**

ID	Type	Sources	Modules	State
P1	Data race	find_and_fix_threading_errors.cpp	find_and_fix_threading_errors.exe	New
P2	Data race	winvideo.h	find_and_fix_threading_errors.exe	Confirmed

1 of 10 All Code Locations: Data race

Description	Source	Function	Module	Variable
Read	winvideo.h:201	loop_once	find_and_fix_threading_errors.exe	g_updates
<pre>199 { 200     // screen update notify 201     if(int updates = g_updates) { 202         g_updates = 0; 203         if(g_video-&gt;updating) { g_skips += up</pre>				
Write	winvideo.h:270	next_frame	find_and_fix_threading_errors.exe	g_updates
<pre>268 { 269     if(!running) return false; 270     g_updates++; // Fast but inaccurate count 271     if(!threaded) while(loop_once(this)); 272     else if(g_handles[1]) {</pre>				

# DOWNLOADS & TECHNICAL ARTICLES

Click **HERE**

**INTEL® VTUNE™ AMPLIFIER**  
Choose & Download

## CHOOSE THE BEST OPTION

Get this software separately or choose a suite of development tools that includes it. Both options include Intel® VTune™ Amplifier plus additional analysis tools, performance libraries, and optimizing compilers.

Only Intel® VTune™ Amplifier  
Performance profiler

Intel® Parallel Studio XE  
Tools for technical, enterprise, and cloud developers

Intel® System Studio  
Tools for embedded system developers

Only Intel® VTune™ Amplifier  
This advanced profiler helps you increase application performance on modern hardware.

**Free Download**  
Download a free copy backed by community forum support.

**Download**

**Buy It Now**

**Download** a free copy of Intel® VTune™ Amplifier performance profiler

OR

Buy a copy with technical support

- [Analysis of SPDK / PMDK I/O](#)
- [Analysis to Intel® Optane™ DC Persistent Memory](#)

## Optimization Notice

Copyright © 2019, Intel Corporation. All rights reserved.

\*Other names and brands may be claimed as the property of others.

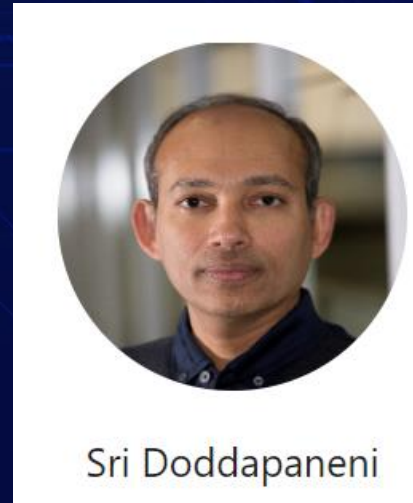




# Day 1

## No.2 Meeting Room

10:55-11:40	VTune and Advisor Overview Part 1
13:30-14:15	VTune and Advisor Overview Part 2



## Ballroom A

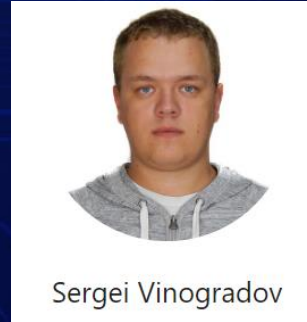
15:25-16:10	Prepare for the next generation of memory, is your application a good candidate?
16:20-17:05	Optimize system configurations and workloads for Intel® Optane™ DC persistent memory



# Day 2

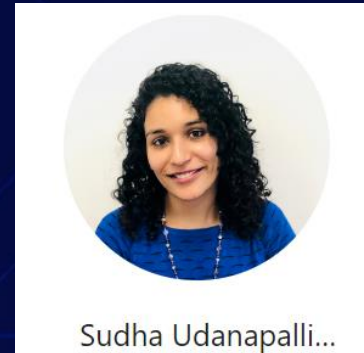
## Ballroom B

09:00-09:45	Optimize your PMDK application performance with the help of Intel® VTune™ Amplifier profiler
-------------	--



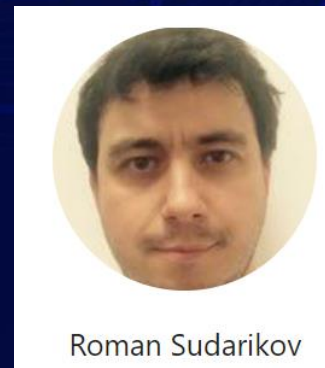
## No.2 Meeting Room

09:55-10:40	Persistent Memory – which mode do I want? Where are the “gotchas” hidden? Part 1
10:55-11:40	Persistent Memory – which mode do I want? Where are the “gotchas” hidden? Part 2



## Ballroom A

13:30-14:15	Optimize system configuration and workload for Intel® Optane™ DC persistent memory
-------------	--





# Key Takeaways

- #1 Performance is many things/roles/workflows
- #2 Require a toolbox filled with many specialized tools
- #3 Intel offers such a toolbox and we continue to add to it



- #4 We like to hear about your performance practices



#### Optimization Notice

Copyright © 2019, Intel Corporation. All rights reserved.

\*Other names and brands may be claimed as the property of others.

