



Intel® VTune™ Amplifier XE Generics

Presenter: Georg Zitzlsberger

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Agenda

Introduction to Intel® VTune™ Amplifier XE profiler

High-level Features

Types of Analysis

Hotspot analysis

- Basic Hotspots
- Advanced Hotspots
- Lab 1: Find the Performance Hotspot

Concurrency Analysis

- Lab 2: Analyzing Parallelism

Locks and Waits Analysis

- Lab 3: Identifying Parallelism issues

User and Synchronization API, Frame/Task Analysis

- Lab 4: Instrumenting user source code

Command Line Interface, Installation, Remote Collection

Conclusion

Intel® VTune™ Amplifier XE

Performance Profiler

Where is my application...

Spending Time?

Function - Call Stack ▾	CPU Time ▾
algorithm_2	3.560s
do_xform ←	3.560s
algorithm_1	1.412s
BaseThreadInitTh	0.000s





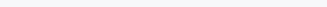


- Focus tuning on functions taking time
- See call stacks
- See time on source

Wasting Time?

Line		MEM_LOAD... LLC_MISS
475	float rx, ry, rz =	
476	float param1 = (AP	30,000
477	float param2 = (AP	
478	bool neg = (rz < 0	

- See cache misses on your source
- See functions sorted by # of cache misses

Waiting Too Long?

Wait Time▼				Wait Count				
	Idle		Poor		Ok		Ideal	
176.504s								18,277
84.681s								5,499
84.612s								5,489

- See locks by wait time
- Red/Green for CPU utilization during wait

- Windows & Linux
- Low overhead
- No special recompiles

Advanced Profiling For Scalable Multicore Performance

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Tune Applications for Scalable Multicore Performance

Fast, Accurate Performance Profiles

- Hotspot (Statistical call tree)
- Call counts (Statistical)
- Hardware-Event Sampling

Thread Profiling

- Visualize thread interactions on timeline
- Balance workloads

Easy set-up

- Pre-defined performance profiles
- Use a normal production build

Find Answers Fast

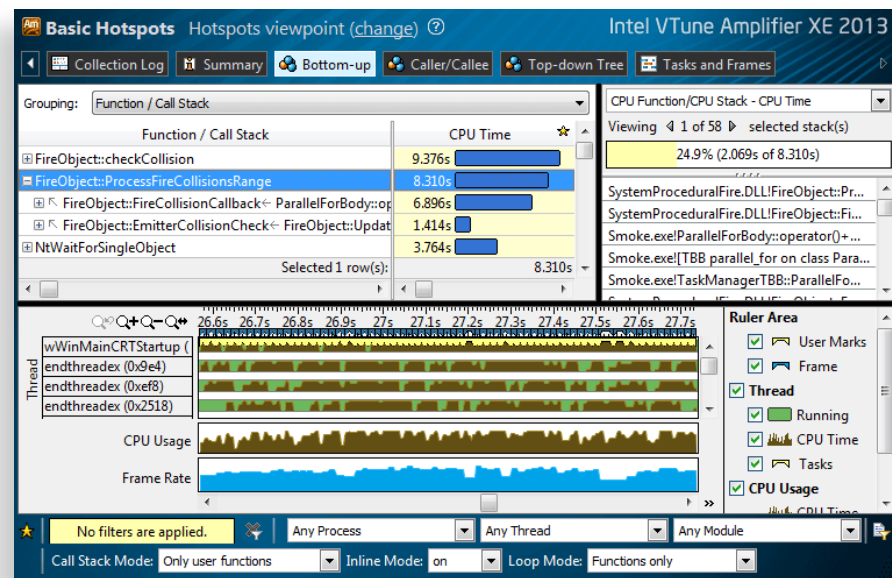
- Filter extraneous data
- View results on the source / assembly

Compatible

- Microsoft, GCC, Intel compilers
- C/C++, Fortran, Assembly, .NET, Java
- Latest Intel® processors
and compatible processors¹

Windows or Linux

- Visual Studio Integration (Windows)
- Standalone user i/f and command line
- 32 and 64-bit



¹ IA32 and Intel® 64 architectures.
Many features work with compatible processors.
Event based sampling requires a genuine Intel® Processor.

A set of instruments to identify performance problems

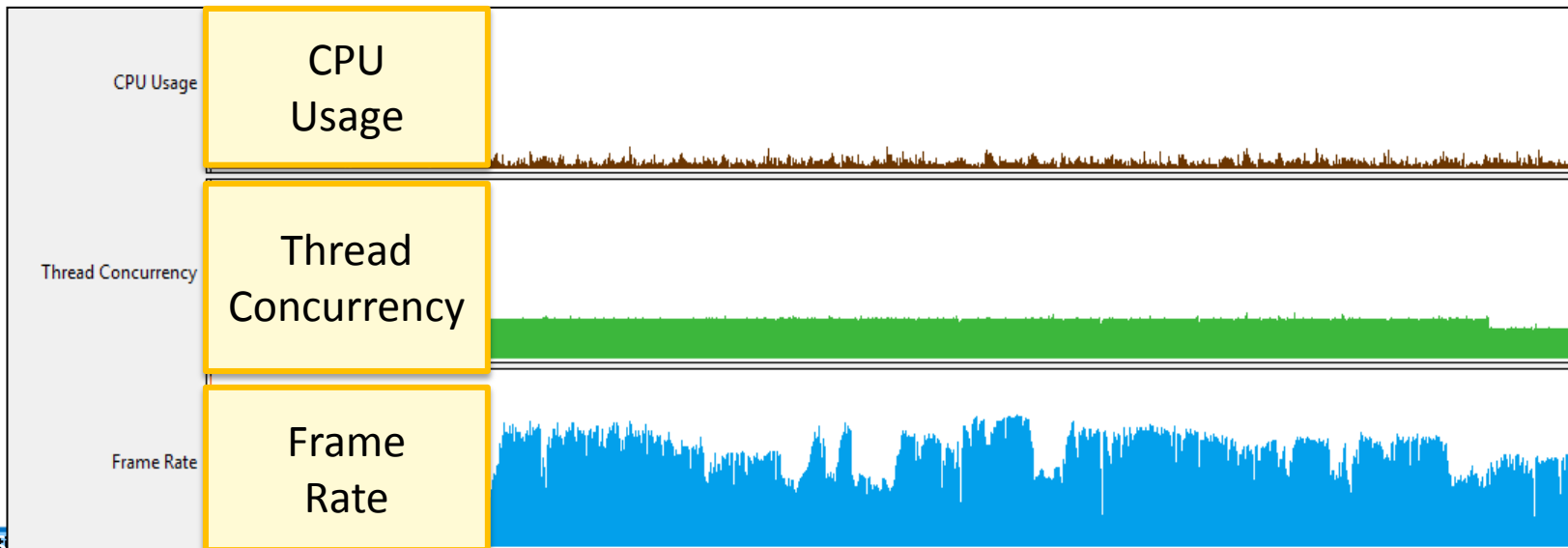
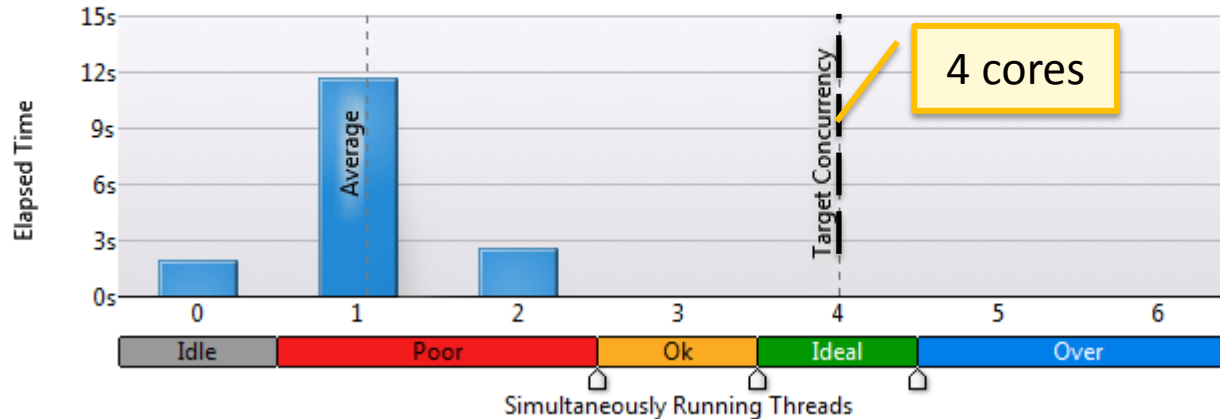
Quick Overview

Intel® VTune™ Amplifier XE

Get a quick snapshot

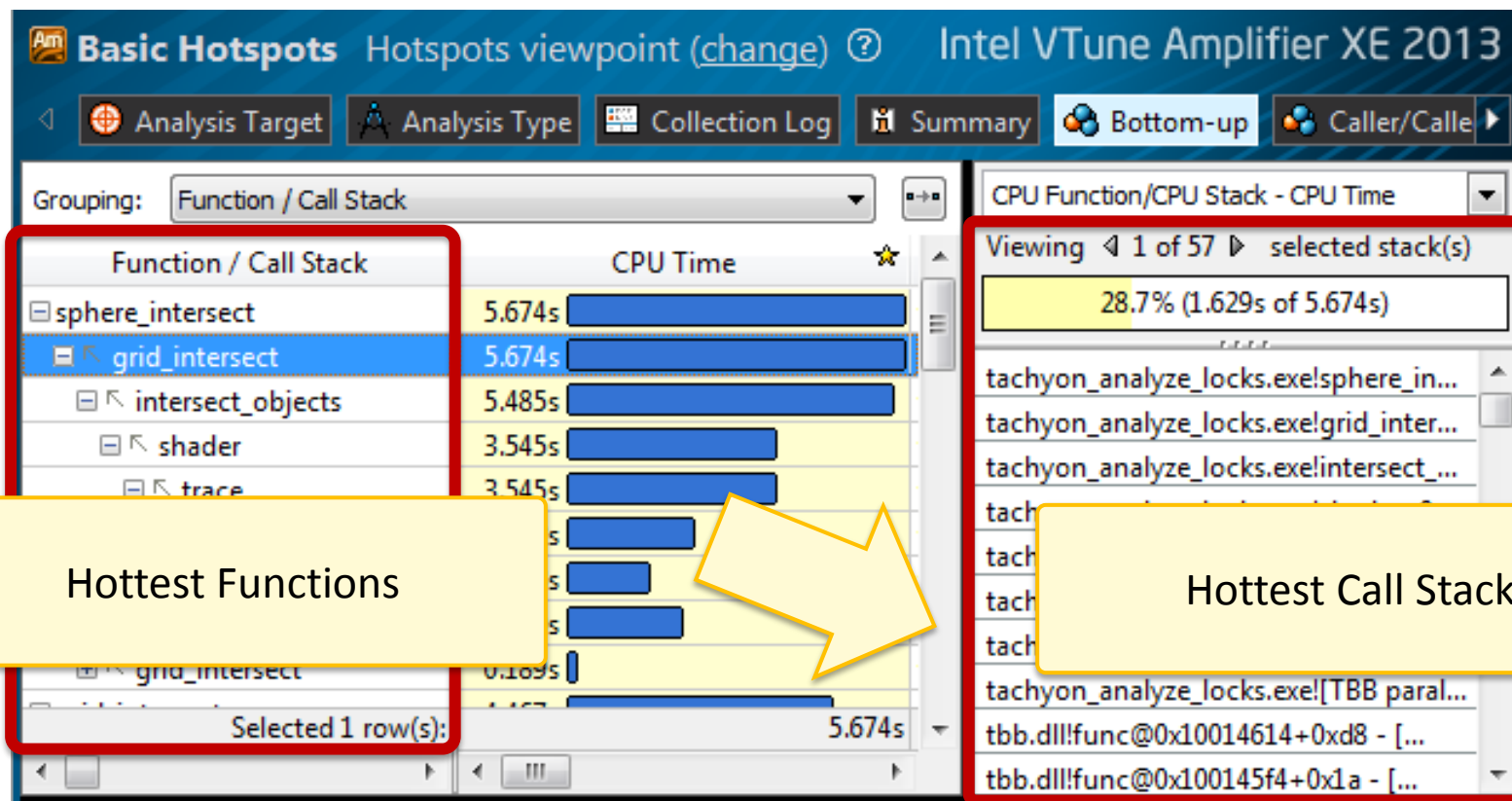
Thread Concurrency Histogram

This histogram represents a breakdown of the Elapsed Time. It visualizes the percentage of the wall time the specific number of threads were considered running if they are either actually running on a CPU or are in the runnable state in the OS scheduler. Essentially, Thread Concurrency that were not waiting. Thread Concurrency may be higher than CPU usage if threads are in the runnable state and not consuming CPU time.



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Identify hotspots

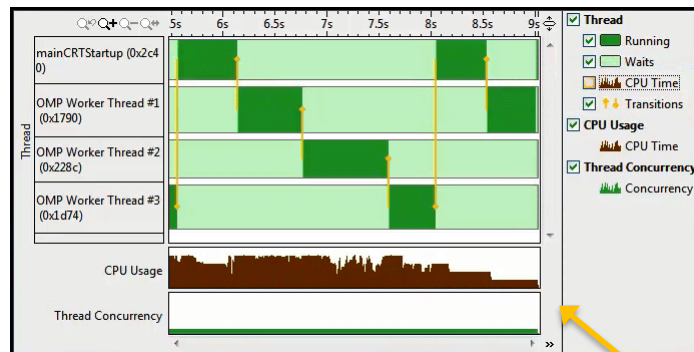


Quickly identify what is important

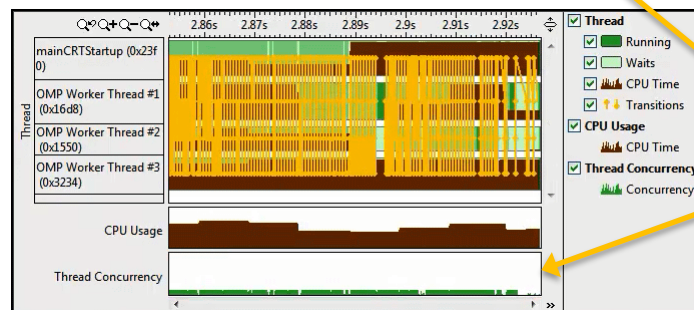
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Identify threading inefficiency

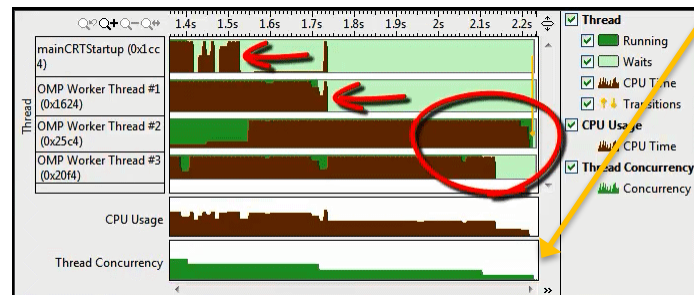
Coarse Grain
Locks



High Lock
Contention



Load
Imbalance



Low
Concurrency

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Find Answers Fast

Adjust Data Grouping

Function - Call Stack
Module - Function - Call Stack
Source File - Function - Call Stack
Thread - Function - Call Stack

Click [+] for Call Stack

Double Click Function to View Source

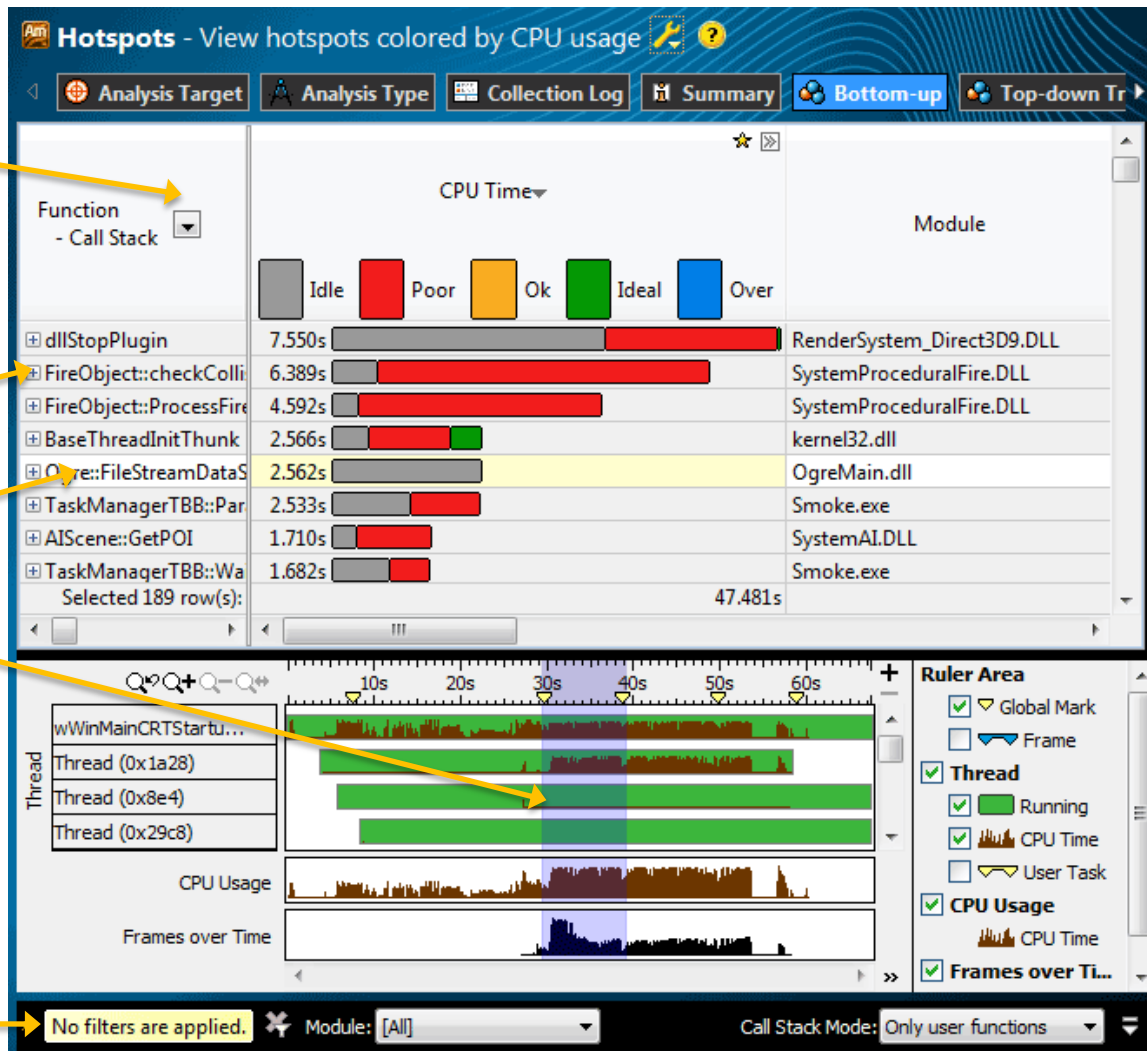
Filter by Timeline Selection (or by Grid selection)

Zoom In And Filter On Selection

Filter In by Selection

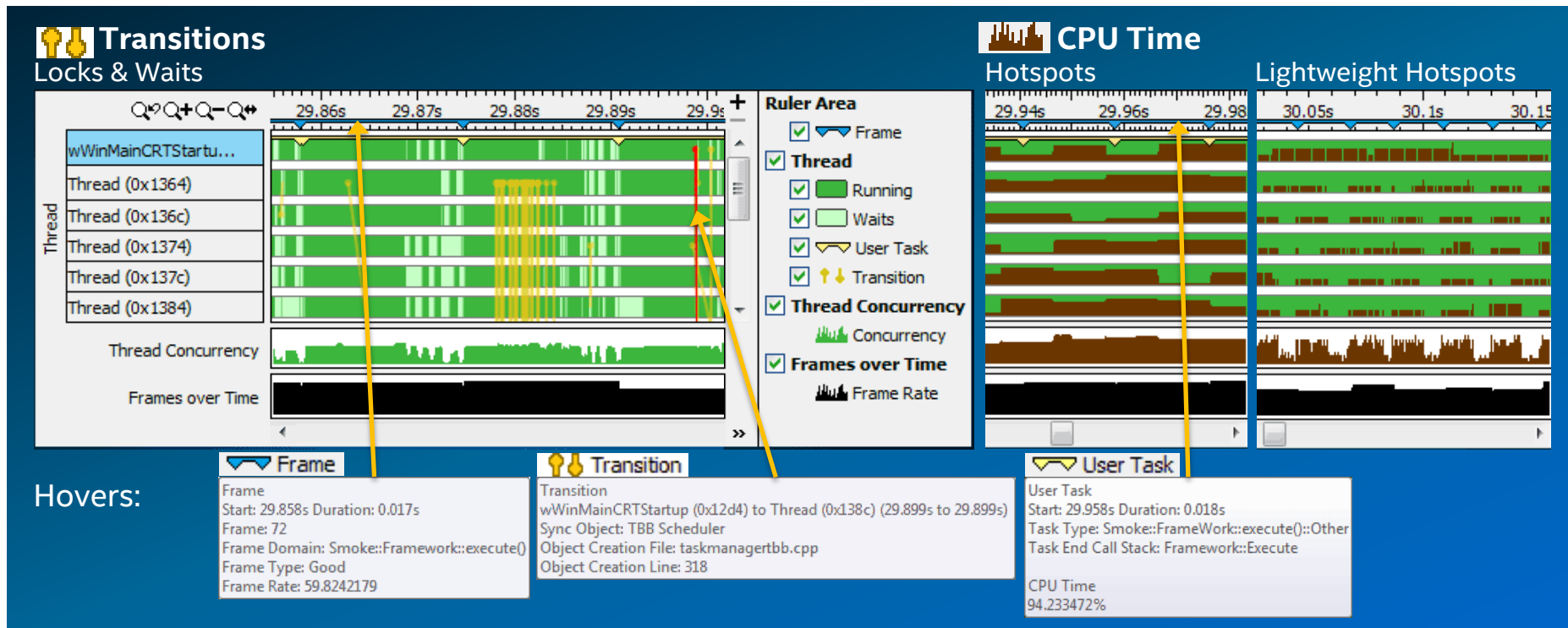
Remove All Filters

Filter by Module & Other Controls



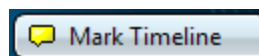
Intel® VTune™ Amplifier XE

Timeline Visualizes Thread Behavior



Optional: Use API to mark frames and user tasks

Optional: Add a mark during collection



Intel® VTune™ Amplifier XE

See Profile Data On Source / Asm

The screenshot displays the Intel VTune Amplifier XE 2011 interface. The top bar shows the title 'Hotspots - View CPU time hotspots and stacks' and the version 'Intel VTune Amplifier XE 2011'. Below the bar are tabs for 'Analysis Target', 'Analysis Type', 'Collection Log', 'Summary', 'Bottom-up', 'Top-down Tree', and 'FireObje...'. The main window is divided into two panes: 'Source' on the left and 'Assembly' on the right. The 'Source' pane shows a list of lines with source code and CPU time. The 'Assembly' pane shows a list of instructions with addresses and CPU time. Callouts highlight various features: 'Time on Source / Asm' points to the CPU Time column in the Source view; 'Quick Asm navigation: Select source to highlight Asm' points to the Source view; 'Quickly scroll to hot spots.' points to the CPU Time column in the Source view; 'Right click for instruction reference manual' points to a right-click context menu in the Assembly view; and 'Click jump to scroll Asm' points to a jump instruction in the Assembly view.

Line	Source	CPU Time	Address	Assembly	CPU Time
469	FireObject::checkCollision(V3 pos, V3 pre	0.476s	0x388c	fld st0, dword ptr [esp+0xc]	0.004s
			0x3890	fld st0, st0	0.993s
			0x3892	fmulp st2, st0	0.787s
			0x3894	fxch st0, st1	1.465s
			0x3896	fstp dword ptr [esp+0x8], st0	0.325s
472	#define FMax std::max<float>	0.561s	0x389a	fld st0, dword ptr [esp+0x40]	0.014s
			0x389e	fsubrp st2, st0	
			0x38a0	fld st0, st0	0.010s
			0x38a2	fmulp st2, st0	0.233s
			0x38a4	fxch st0, st1	0.247s
			0x38a6	fstp dword ptr [esp+0xc], st0	0.326s
			0x38aa	fcomp st0, st2	0.032s
			0x38ac	fnstsw ax	
			0x38ae	test ah, 0x5	
			0x38b1	jp 0x100038b5	
			0x38b3	Block 2:	
			0x38b3	mov dl, 0x1	
			0x38b5	lea ecx, ptr [esp+0xc]	0.024s
			0x38b9	jmp 0x100038c1 <Block 4>	
			0x38bb	Block 3:	
			0x38bb	xor dl, dl	0.159s

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Click jump to scroll Asm

High-level Features

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Feature Highlights

Basic Hot Spot Analysis (Statistical Call Graph)

- Locates the time consuming regions of your application
- Provides associated call-stacks that let you know how you got to these time consuming regions
- Call-tree built using these call stacks

Advanced Hotspot and architecture analysis

- Based on Hardware Event-based Sampling (EBS)
- Pre-defined tuning experiments

Thread Profiling

- Visualize thread activity and lock transitions in the timeline
- Provides lock profiling capability
- Shows CPU/Core utilization and concurrency information

GPU Compute Performance Analysis

- Collect GPU data for tuning OpenCL applications. Correlate GPU and CPU activities

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Feature Highlights

Attach to running processes

- Hotspot and Concurrency analysis modes can attach to running processes

System wide data collection

- EBS modes allows system wide data collection and the tool provides the ability to filter this data

GUI

- Standalone GUI available on Windows* and Linux
- Microsoft* Visual Studio integration

Command Line

- Comprehensive support for regression analysis and remote collection

Platform & application support

- Windows* and Linux (Android, Tizen, Yocto – in the ISS)
- Microsoft* .NET/C# applications
- Java* and mixed applications
- Fortran applications

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Feature Highlights

Event multiplexing

- Gather more information with each profiling run

Timeline correlation of thread and event data

- Populates thread active time with event data collected for that thread
- Ability to filter regions on the timeline

Advanced Source / Assembler View

- See event data graphed on the source / assembler
- View and analyze assembly as basic blocks
- Review the quality of vectorization in the assembly code display of your hot spot

Provides pre-defined tuning experiments

- Predefined profiles for quick analysis configuration
- A user profile can be created on a basis of a predefined profile

User API

- Rich set of user API for collection control, events highlighting, code instrumentation, and visualization enhancing.

Data Collectors and Analysis Types

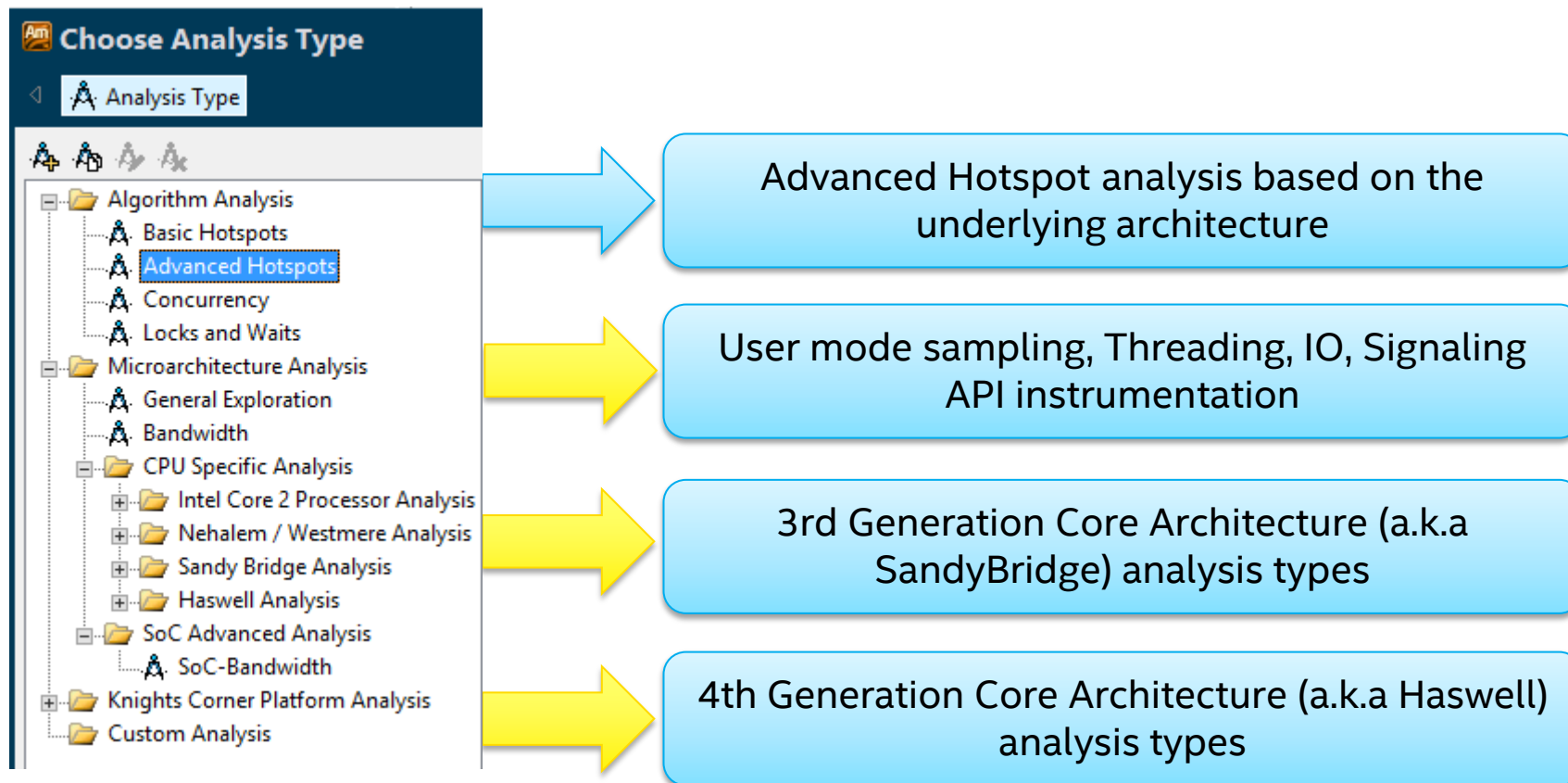
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Analysis Types (based on technology)

Software Collector Any x86 processor, any virtual, no driver	Hardware Collector Higher res., lower overhead, system wide
Basic Hotspots Which functions use the most time?	Advanced Hotspots Which functions use the most time? Where to inline? – Statistical call counts
Concurrency Tune parallelism. Colors show number of cores used.	General Exploration Where is the biggest opportunity? Cache misses? Branch mispredictions?
Locks and Waits Tune the #1 cause of slow threaded performance – waiting with idle cores.	Advanced Analysis Dig deep to tune bandwidth, cache misses, access contention, etc.

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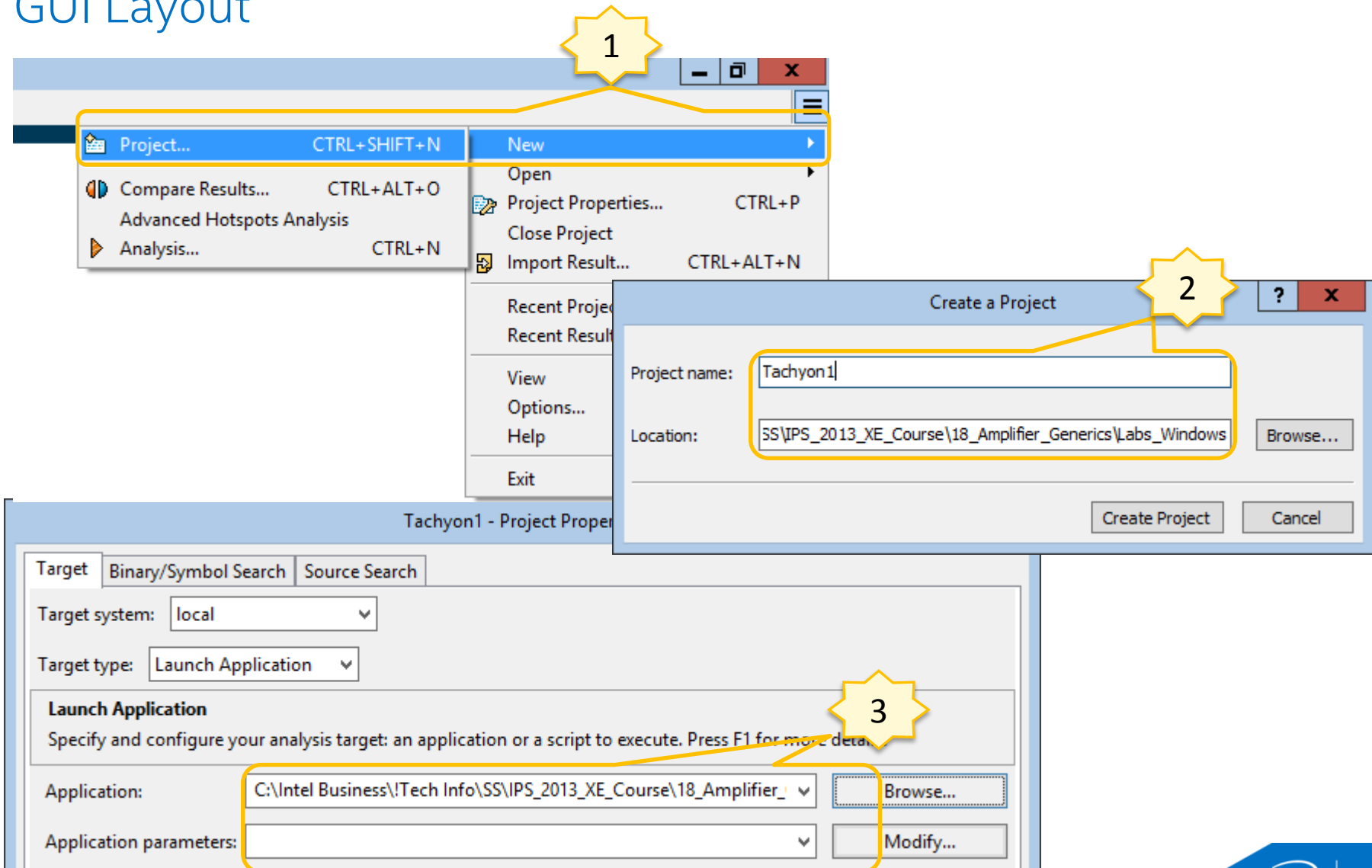
Pre-defined Analysis Types



GUI Layout

Creating a Project

GUI Layout



Selecting type of data collection

GUI Layout

The screenshot shows the 'Choose Analysis Type' dialog box in Intel VTune Amplifier XE 2015. The dialog is divided into several sections:

- Analysis Type:** A tree view on the left showing various analysis categories. A yellow callout points to this section, stating: "All available analysis types".
- My Custom:** A section on the right for creating custom analysis types. It includes buttons for 'Copy', 'Edit', and 'Delete'. A yellow callout points to this section, stating: "Different ways to start the analysis".
- Event Name:** A table listing event names. A yellow callout points to this section, stating: "Helps creating new analysis types".
- Start:** A large button on the right to start the analysis. A yellow callout points to this button, stating: "Copy the command line to clipboard".
- Start Paused:** A button on the right to start the analysis paused.
- Project Properties:** A button on the right to access project properties.
- Command Line:** A button at the bottom right to copy the command line to the clipboard.

The 'My Custom' section contains the following text:

Analyze general issues with the performance of your application.

NOTE: For analysis purposes, Intel VTune Amplifier XE 2015 may adjust the Sample After values in the table below by a multiplier. The

Event Name
BR_MISP_RETIRED.ALL_BRANCHES_PS
CPU_CLK_UNHALTED.REF_TSC
...
DTLB_LOAD_MISSES.STLB_HIT_4K

The 'Event Name' table is partially visible, showing the following events:

- BR_MISP_RETIRED.ALL_BRANCHES_PS
- CPU_CLK_UNHALTED.REF_TSC
- ...
- DTLB_LOAD_MISSES.STLB_HIT_4K

The 'My Custom' section also includes a context menu with the following options:

- Copy from Current
- New Hardware Event-based Sampling Analysis
- New Knights Corner Hardware Event-based Sampling Analysis
- New User-mode Sampling and Tracing Analysis
- Edit
- Delete

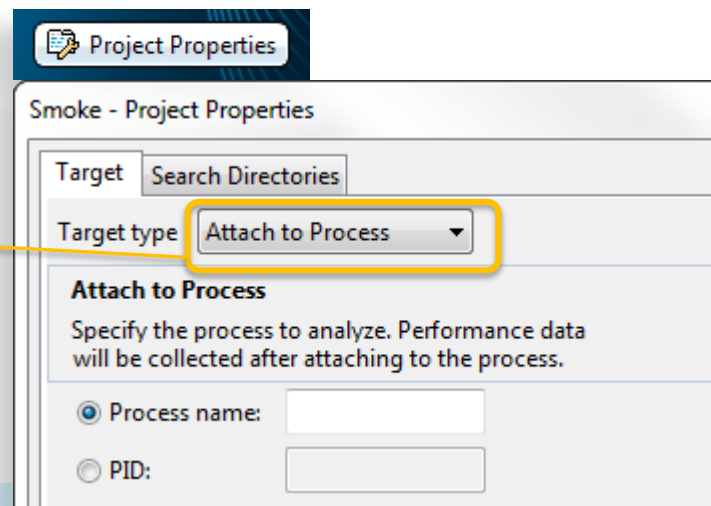
Profile a Running Application

No need to stop and re-launch the app when profiling

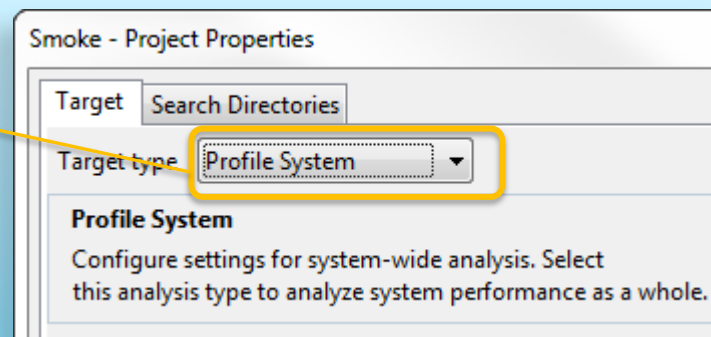
Two Techniques:

Attach to Process:

- Any type of analysis

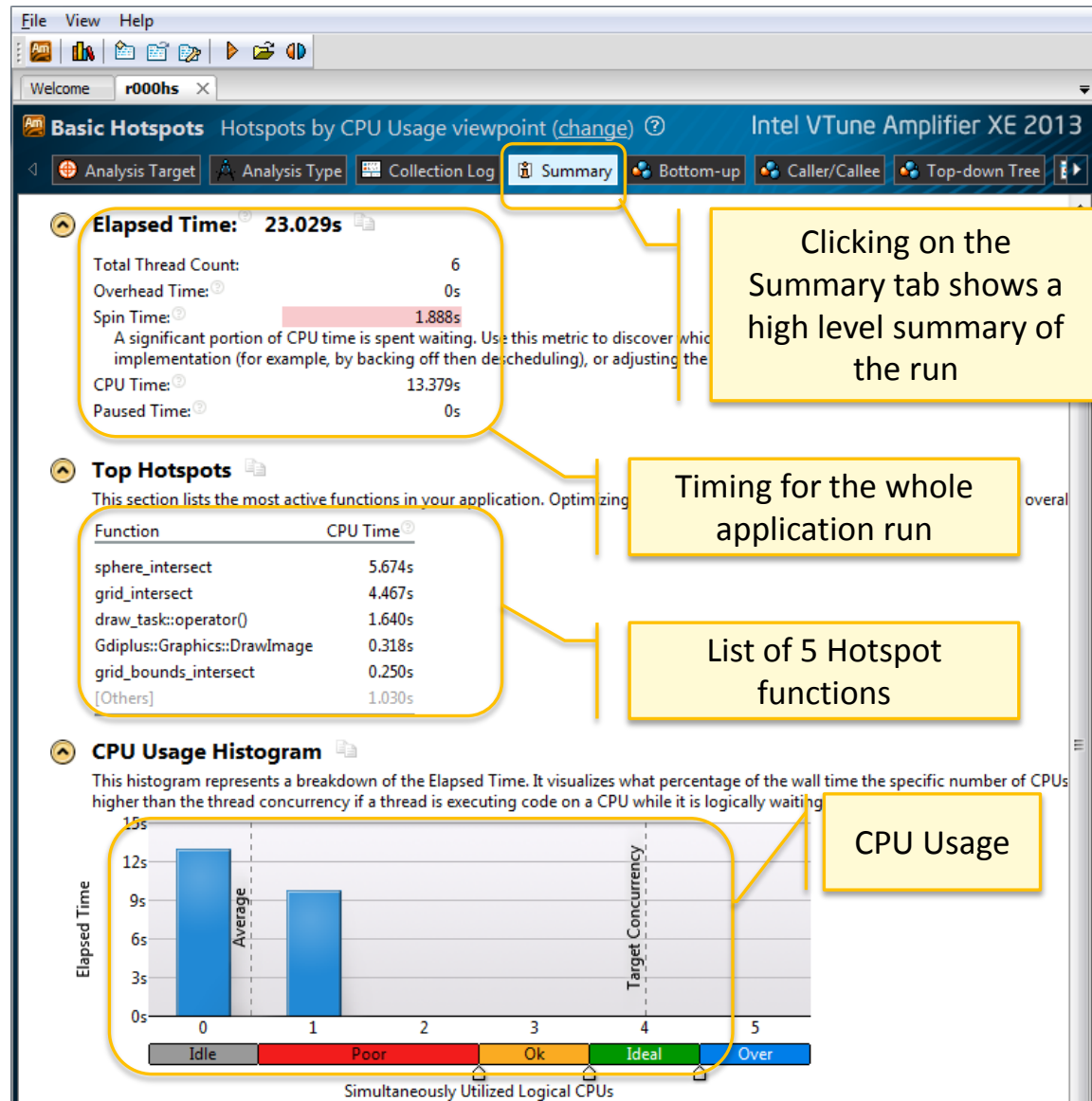


- Advanced Hotspots & Custom EBS
- Optional: Filter by process after collection



Summary View

GUI Layout



Clicking on the Summary tab shows a high level summary of the run

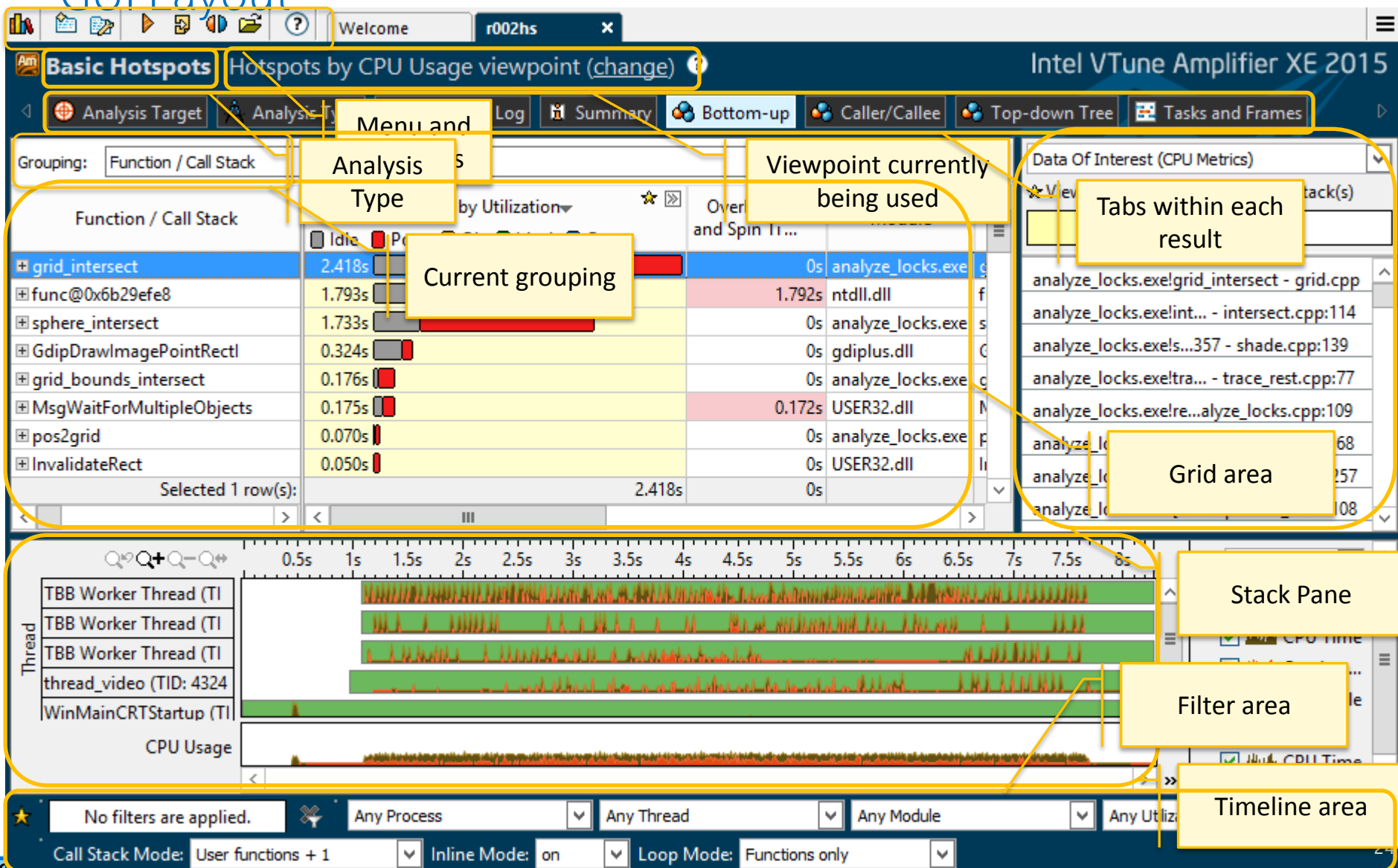
Timing for the whole application run

List of 5 Hotspot functions

CPU Usage

Bottom-Up View

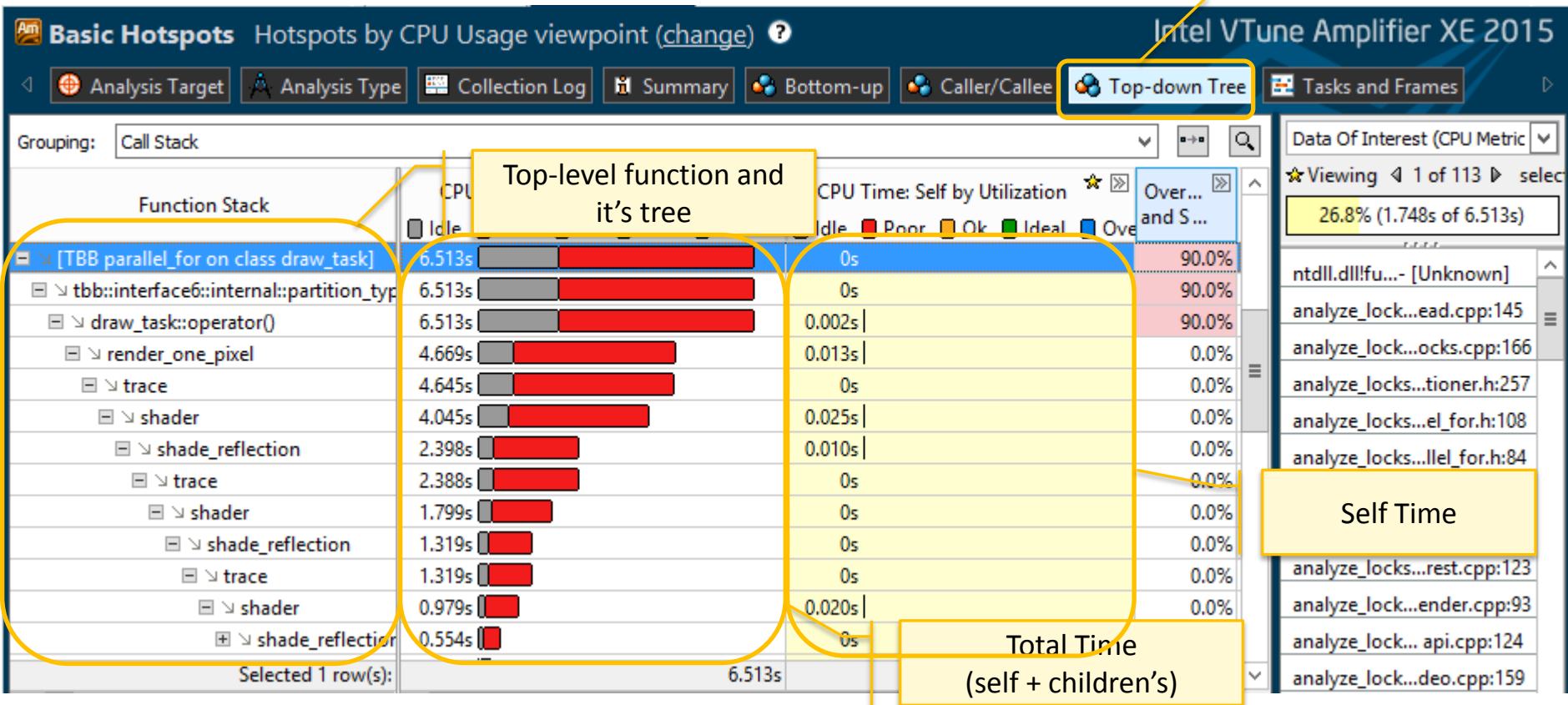
GUI layout



Top-Down View

GUI Layout

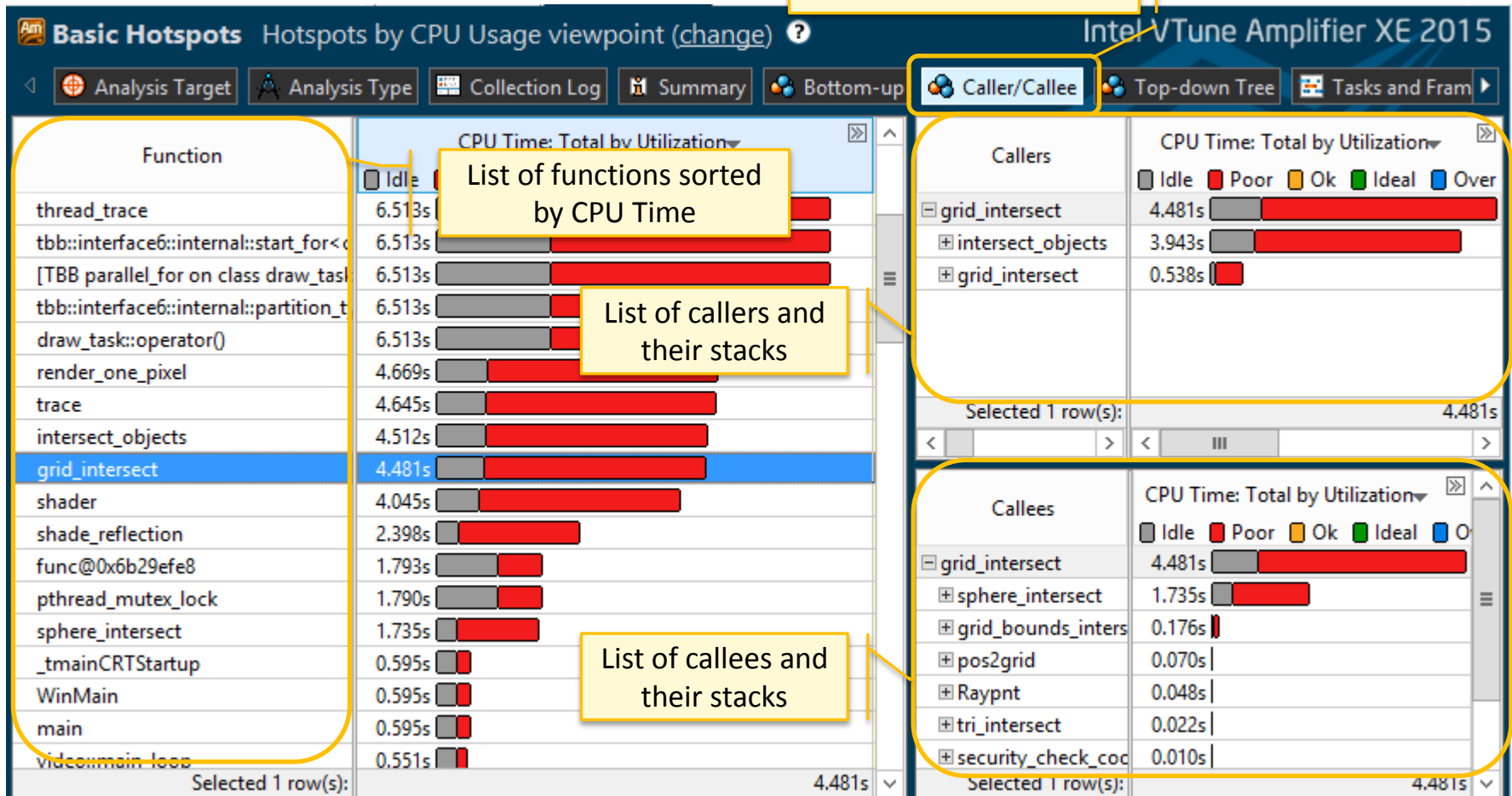
Clicking on the Top-Down Tree tab changes stack representation in the Grid



Caller/Callee View

GUI Layout

Select a function in the Bottom-Up and find the caller/callee



Adding User Marks to the Timeline

GUI Controls

The screenshot displays the Intel VTune GUI interface. On the left, a control panel contains buttons for 'Start', 'Start Paused', 'Project Properties', 'Resume', 'Pause', 'Stop', 'Cancel', and 'Mark Timeline'. The 'Start Paused' button is highlighted with a yellow box and an annotation: 'Start application without data collection'. The 'Resume' button is also highlighted with a yellow box and an annotation: 'Resume data collection when needed'. The 'Mark Timeline' button is highlighted with a yellow box and an annotation: 'Click "Mark Timeline" during collection'. Below the control panel, a timeline view shows a horizontal axis with time markers from 5s to 40.538s. A yellow vertical bar is positioned at approximately 40.538s, with an annotation: 'Observe the mark on the Time Line'. The timeline view also shows a list of threads on the left, including 'wWinMainCRTStartu...', 'Thread (0x1598)', and several 'TBB Worker Thread ...' entries. A yellow box highlights the 'Mark Timeline' button and the yellow vertical bar on the timeline, with an annotation: 'Observe paused region on the Time Line'. The bottom of the timeline view shows 'CPU Usage' and 'Thread Concurrency' graphs.

Start application without data collection

Resume data collection when needed

Click "Mark Timeline" during collection

Observe the mark on the Time Line

Observe paused region on the Time Line

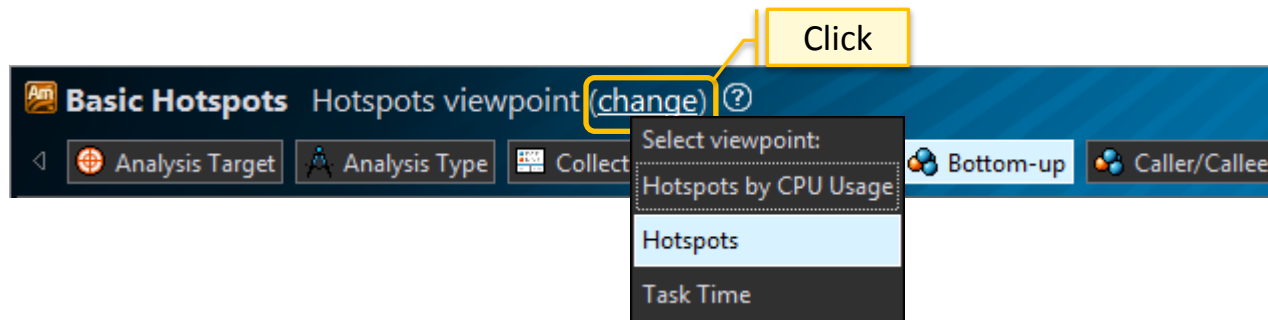
Key Result Analysis and GUI Concepts

Result Analysis

GUI Concepts

Viewpoints

- It is a pre-defined view that determines what needs to be displayed in the grid and timeline for a given analysis type
- An analysis type may support more than one view points
- To change viewpoints, select a viewpoint by clicking on

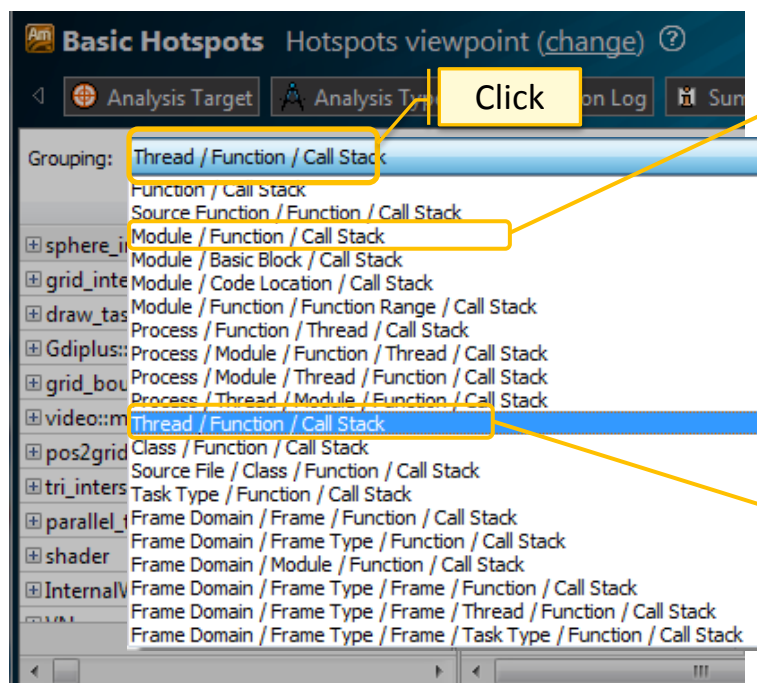


Result Analysis

GUI Concepts

Groupings

- Each analysis type has many viewpoints
- Each viewpoint has pre-defined groupings
- Allows you to analyze the data in different hierarchies and granularities



Grouping: Module / Function / Call Stack

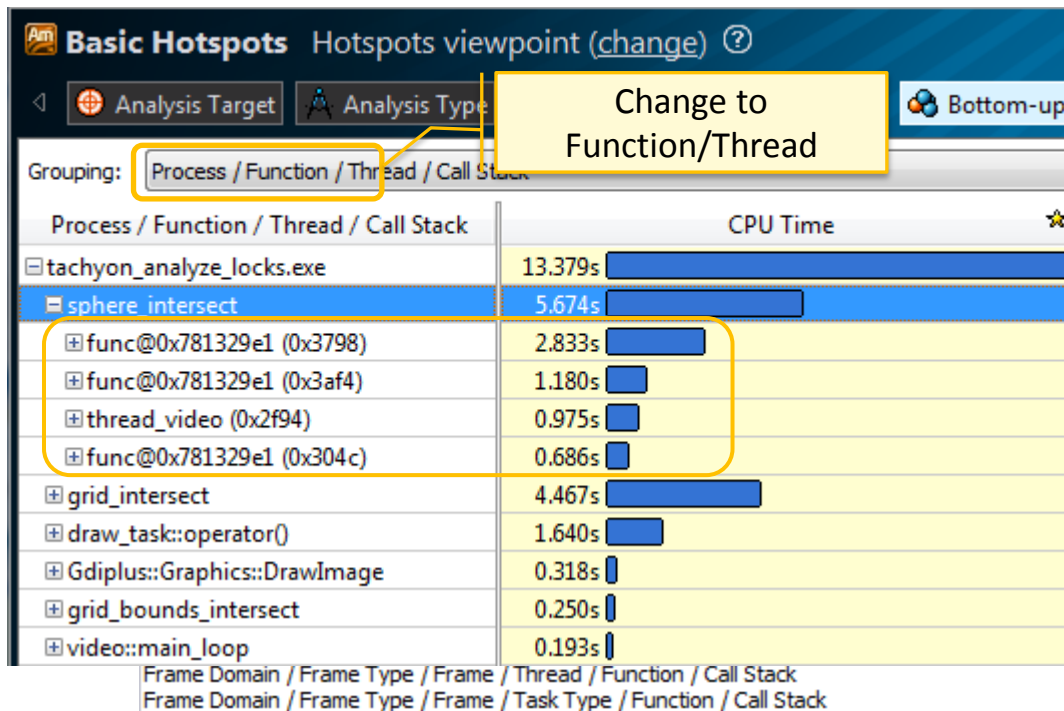
Module / Function / Call Stack	CPU Time
tachyon_analyze_locks.exe	13.367s
sphere_intersect	5.674s
grid_intersect	5.674s
grid_intersect	4.467s
intersect_objects	4.053s
grid_intersect	0.414s
draw_task::operator()	1.640s

Grouping: Thread / Function / Call Stack

Thread / Function / Call Stack	CPU Time
func@0x781329e1 (0x3798)	5.983s
func@0x781329e1 (0x3af4)	2.598s
thread_video (0x2f94)	2.384s
sphere_intersect	0.975s
grid_intersect	0.975s
intersect_objects	0.957s
shader	0.625s
trace	0.333s

Viewpoints and Groupings

For example, pre-defined groupings can be used to determine load imbalance



Key Concepts

Results Comparison

VTune™ Amplifier XE allows comparison of two similar runs

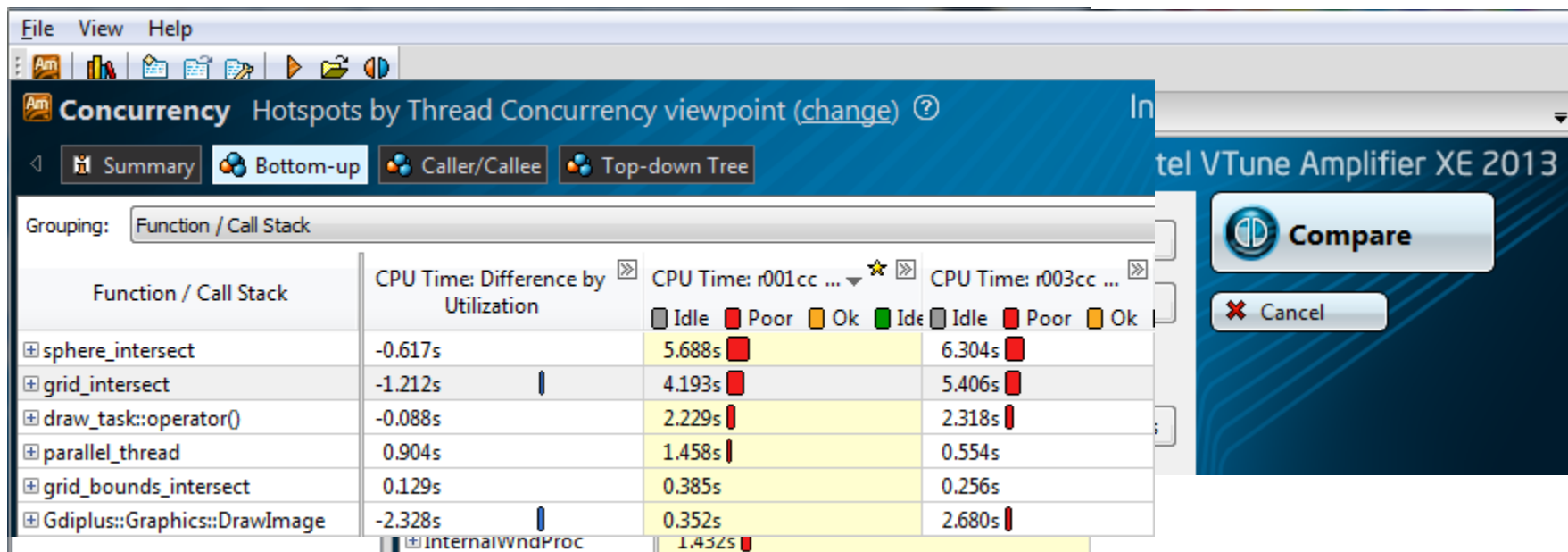
Extremely useful for:

- Benchmarking
- Regression analysis
- Testing

During performance optimization work source code may change

- Binary recompiled: compare based on source function
- Inside a function: compare based on functions level
- Functions changed: group by source files and compare
- Source files changed: compare by modules

Results Comparison



Analysis Types Revisited

Lab Activities

Reminding the methodology of performance profiling and tuning

The Goal: minimize the time it takes your program / module / function to execute

- Identify Hotspots and focus on them
- It's just a few functions (20% of code does 80% of job)
- Optimize them (with compiler or hand optimizations)
- Check for hotspots again, and find new ones

How to optimize the Hotspots?

- Maximize CPU utilization and minimize elapsed time
- Ensure CPU is busy all the time
- All Cores busy – parallelism
- Busy with useful tasks
- Optimize tasks execution

Performance profiling

Terminology

Elapsed Time

The total time your target application ran. Wall clock time at end of application
– Wall clock time at start of application

CPU Time

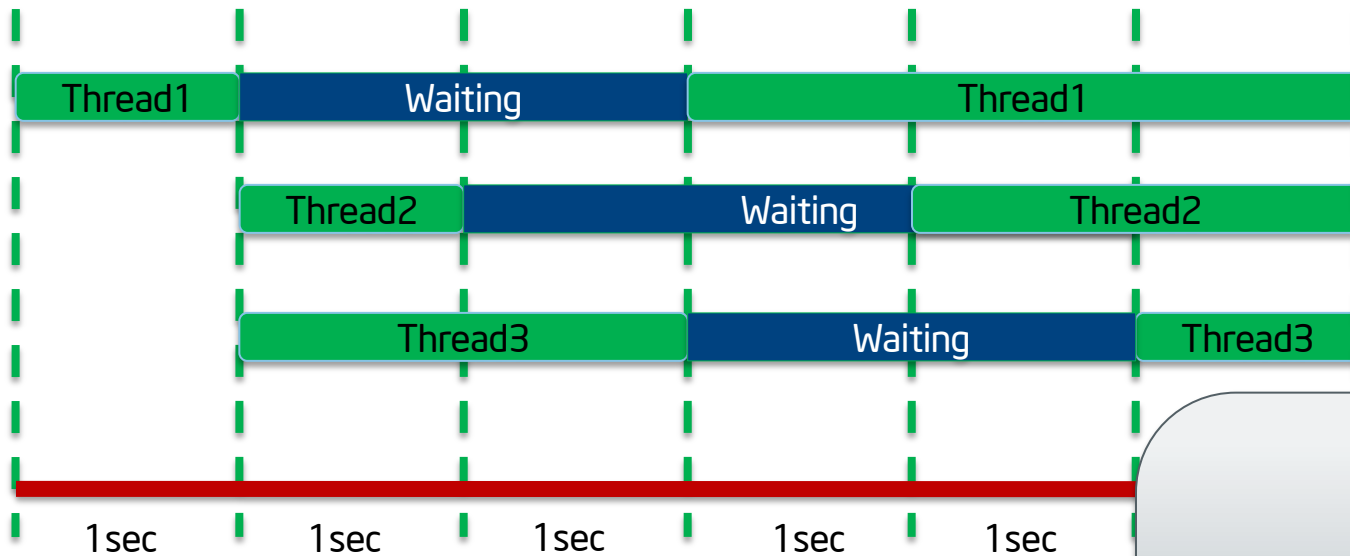
The amount of time a thread spends executing on a logical processor. For multiple threads, the CPU time of the threads is summed.

Wait Time

The amount of time that a given thread waited for some event to occur, such as: synchronization waits and I/O waits

Performance profiling

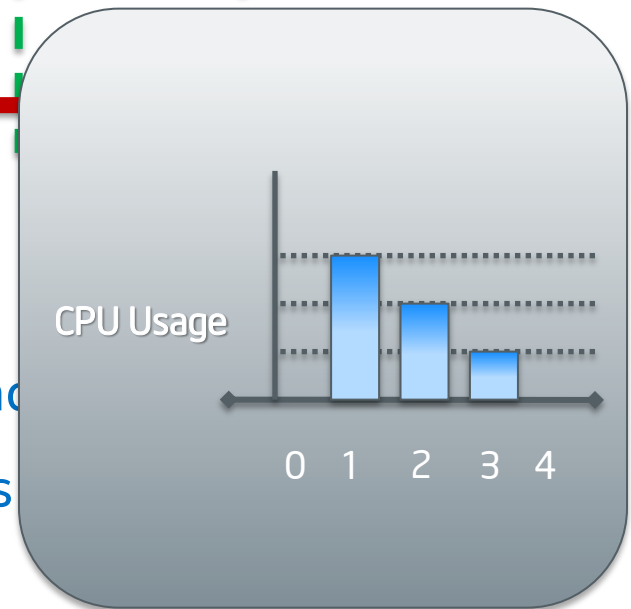
CPU Usage



Elapsed Time: 6 seconds

CPU Time: $T1 (4s) + T2 (3s) + T3 (3s) = 10 \text{ seconds}$

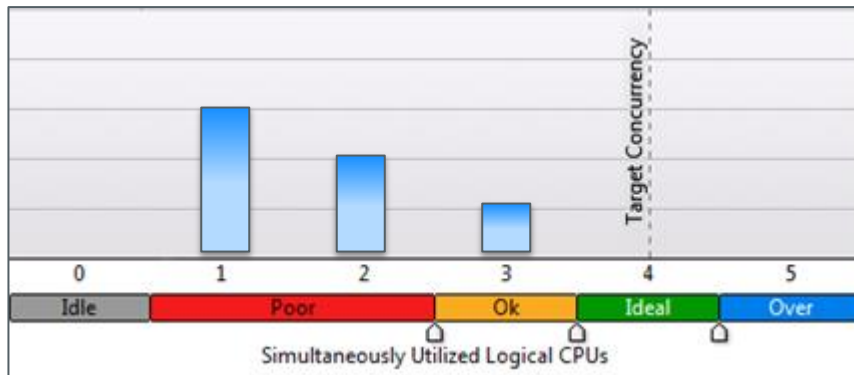
Wait Time: $T1(2s) + T2(2s) + T3 (2s) = 6 \text{ seconds}$



CPU Usage

How it's presented by VTune Amplifier

Summary View: CPU Usage Histogram



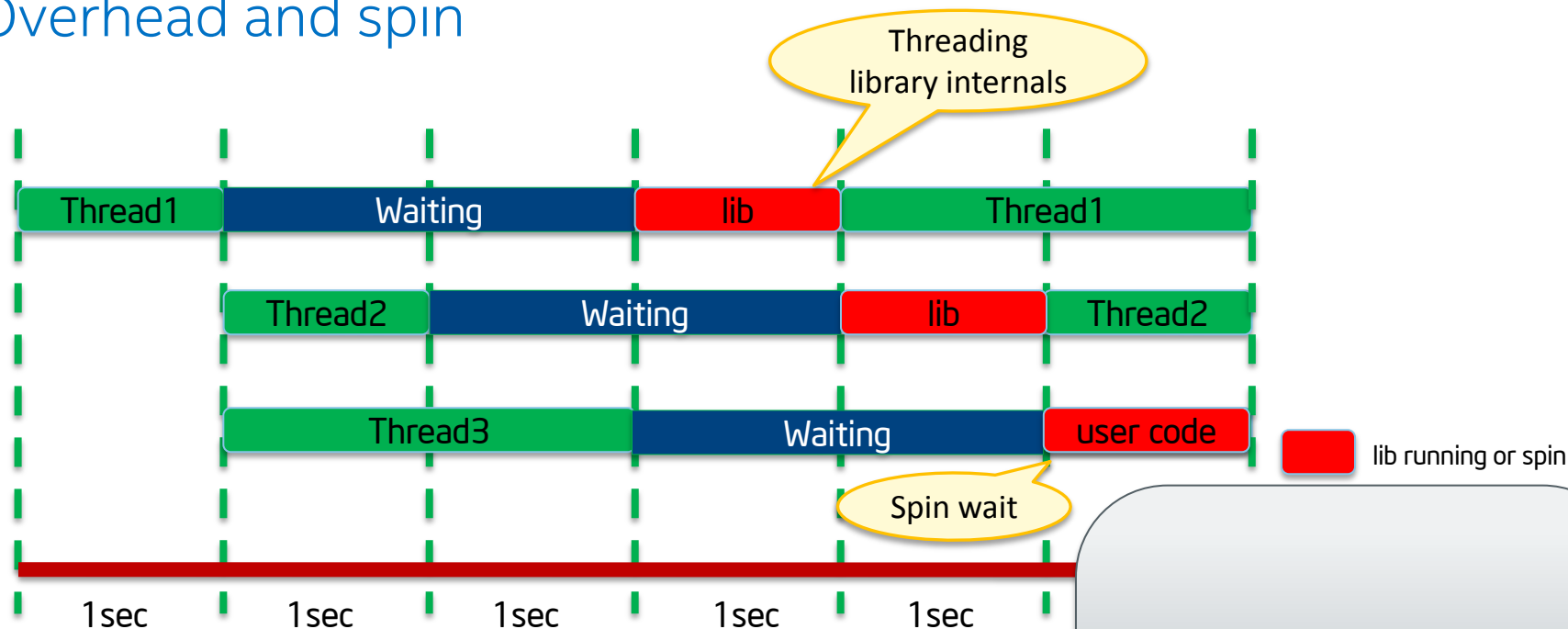
Only CPU Time measured
Wait Time is not counted
in Hotspots

Bottom-Up View: CPU Time

Function	CPU Time	By CPU Utilization
My_Func()	10 s	<div><div></div></div>

Performance profiling

Overhead and spin



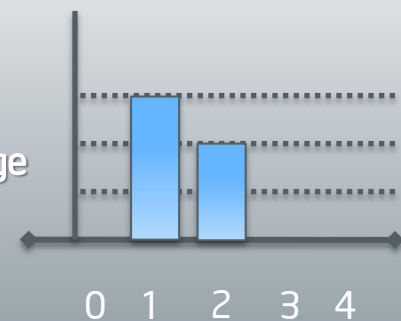
Elapsed Time: 6 seconds

CPU Time: $T1 (4s) + T2 (3s) + T3 (3s) = 10$ seconds

Wait Time: $T1(2s) + T2(2s) + T3 (2s) = 6$ seconds

Overhead and spin Time: $T1(1s) + T2(1s) + T2(1s)$

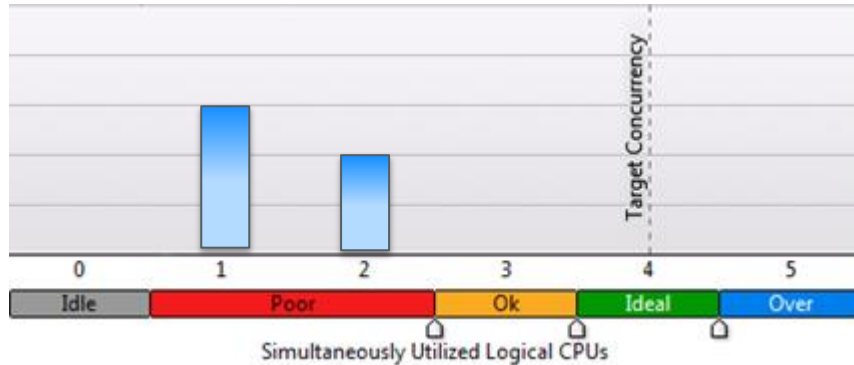
CPU Usage



CPU Usage

How it's presented by VTune Amplifier

Summary View: CPU Usage Histogram



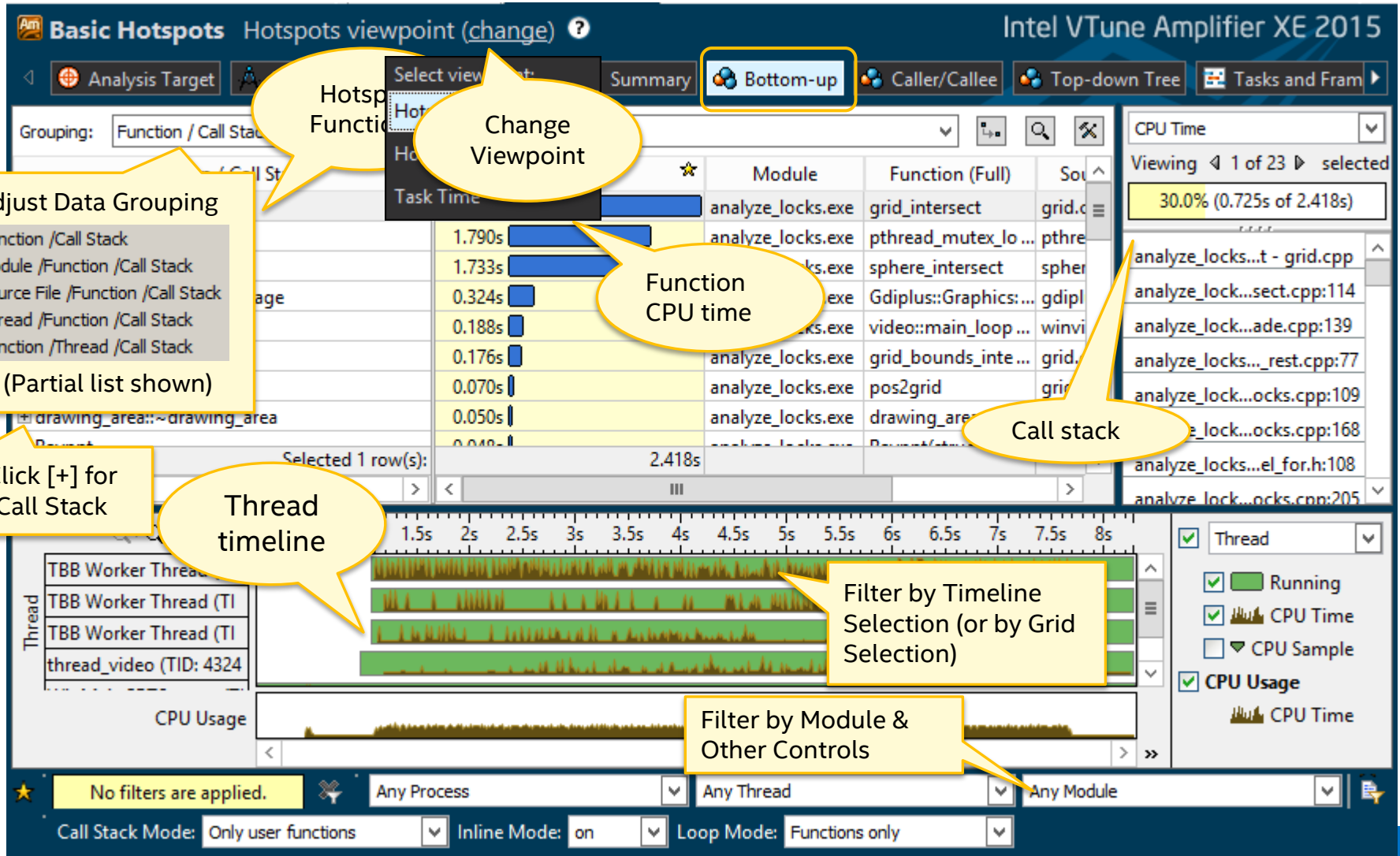
Overhead and Spin Time is not counted for CPU Usage

Bottom-Up View: CPU Time

Function	CPU Time	By CPU Utilization	Overhead and Spin Time
My_Func()	10 s	<div></div>	3 s

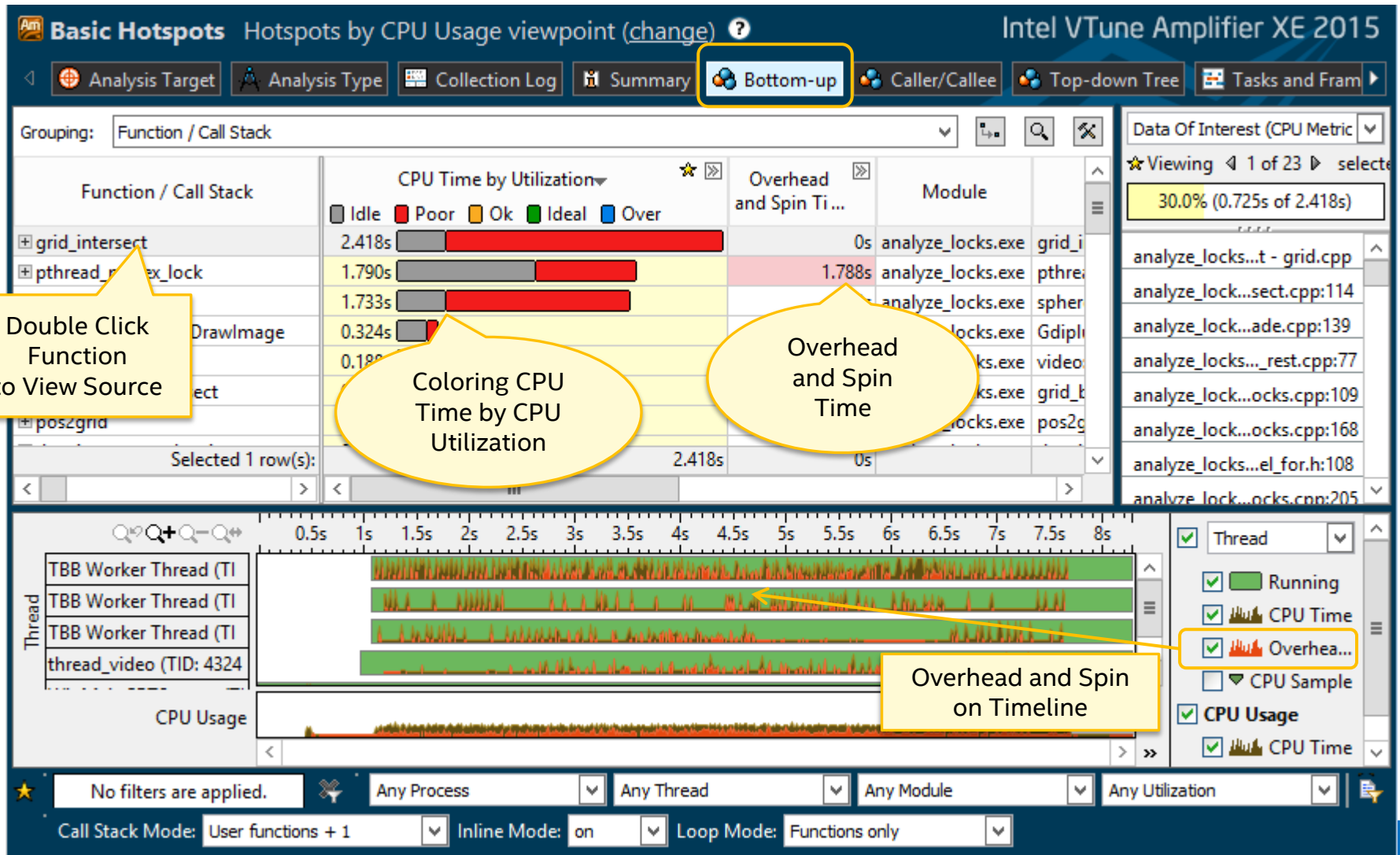
Hotspots analysis

Hotspot functions



Hotspots analysis

Hotspot functions by CPU usage



Hotspots analysis

Source View

The screenshot displays the Intel VTune Source View and Assembly View side-by-side. The Source View on the left shows C++ code with CPU time metrics. The Assembly View on the right shows the corresponding assembly instructions. Annotations highlight key features for hotspot analysis.

Source View

So. ▲	Source	CPU Time: Total
572	tmax.x += tdelta.x;	
573	curpos = nXp;	
574	nXp.x += pdeltaX.x;	
575	nXp.y += pdeltaX.y;	
576	nXp.z += pdeltaX.z;	
577	}	
578	else if (tmax.z < tmax.x) {	
579	cur = g->cells[voxindex];	
580	while (cur != NULL) {	
581	if (ry->mbox[cur->obj->id] != ry->mbox[cur->obj->id]) {	863.901ms
582	ry->mbox[cur->obj->id] = ry->mbox[cur->obj->id];	470.596ms
583	cur->obj->methods->intersect(cur->obj->methods->intersect);	344.992ms
584	}	
585	}	365.913ms
586	}	
587	curvox.z += step.z;	11.005ms
588	if (ry->maxdist < tmax.z curvox.z > tmax.z) {	20.980ms
589	break;	
590	voxindex += step.z;	
591	tmax.z += tdelta.z;	

Assembly View

Address ▲	Sour...	Assembly	CPU Time: Total
0x40e0f1	581	cmp dword ptr [eax+edx*4], ecx	542.360ms
0x40e0f4	581	jz 0x40e10d <Block 49>	
0x40e0f6		Block 47:	
0x40e0f6	582	mov edx, dword ptr [esi+0x4]	375.228ms
0x40e0f9	582	mov edx, dword ptr [edx]	52.595ms
0x40e0fb	582	mov dword ptr [eax+edx*4], ecx	42.774ms
0x40e0fe	583	mov dword ptr [esi+0x4], ecx	54.972ms
0x40e101	583	mov dword ptr [eax+edx*4], ecx	37.383ms
0x40e104	583	mov dword ptr [eax+edx*4], ecx	6.785ms
0x40e106	583	push edi	32.718ms
0x40e107	583	push eax	31.020ms
0x40e108	583	call edx	204.404ms
0x40e10a		Block 48:	
0x40e10a	583	add esp, 0x8	
0x40e10d		Block 49:	
0x40e10d	585	mov dword ptr [eax+edx*4], ecx	69.080ms
0x40e10f	585	mov dword ptr [eax+edx*4], ecx	96.833ms
0x40e111	585	jnz 0x40e0e6 <Block 46>	
0x40e113		Block 50:	
0x40e113	580	moved xmm0, qword ptr [esp+0x4]	9.909ms

Annotations:

- Source View:**
 - Self and Total Time on Source / Asm:** Points to the CPU Time: Total column.
 - Quick Asm navigation:** Select source to highlight Asm. Points to the Source View.
 - Quickly scroll to hot spots:** Scroll Bar "Heat Map" is an overview of hot spots. Points to the scroll bar.
- Assembly View:**
 - Right click for instruction reference manual:** Points to the Assembly View.
 - Click jump to scroll Asm:** Points to the jump instruction in the Assembly View.

Intel® VTune™ Amplifier XE

User APIs

User APIs

- Collection Control API
- Thread Naming API
- User-Defined Synchronization API
- Task API
- User Event API
- Frame API
- JIT Profiling API

User API

Enable you to

- control collection
- set marks during the execution of the specific code
- specify custom synchronization primitives implemented without standard system APIs

To use the user APIs, do the following:

- Include **ittnotify.h**, located at <install_dir>/include
- Insert **__itt_*** notifications in your code
- Link to the **libittnotify.lib** file located at <install_dir>/lib

User API

Collection control and threads naming

Collection Control APIs

`void __itt_pause (void)`

Run the application without collecting data. VTune™ Amplifier XE reduces the overhead of collection, by collecting only critical information, such as thread and process creation.

`void __itt_resume (void)`

Resume data collection. VTune™ Amplifier XE resumes collecting all data.

Thread naming APIs

`void __itt_thread_set_name (const __itt_char *name)`

Set thread name using char or Unicode string, where *name* is the thread name.

`void __itt_thread_ignore (void)`

Indicate that this thread should be ignored from analysis. It will not affect the concurrency of the application. It will not be visible in the Timeline pane.

User API

Collection Control Example

```
int main(int argc, char* argv[])
{
    doSomeInitializationWork();

    __itt_resume();
    while(gRunning) {
        doSomeDataParallelWork();
    }
    __itt_pause();

    doSomeFinalizationWork();
    return 0;
}
```

User API

User defined synchronization API example

```
long spin = 1;
. . . .
. . . .
__itt_sync_prepare((void *) &spin );
while(ResourceBusy);
    // spin wait;
__itt_sync_acquired((void *) &spin );
    // Use shared resource
__itt_sync_releasing((void *) &spin );
    // Code here should free the resource
```


User API

User Event APIs

- Useful to observe when certain events occur in your application or identify how long certain regions of code take to execute
- Event APIs enables you to annotate an application when certain events occur

```
__itt_event __itt_event_create(char *, int);  
__itt_event_start(__itt_event);  
__itt_event_end(__itt_event);
```

User API

User Event APIs reference

```
__itt_event __itt_event_create(const  
__itt_char *name, int namelen );
```

Create a user event type with the specified name. This API returns a handle to the user event type that should be passed into the following APIs as a parameter. The `namelen` parameter refers to the number of characters, not the number of bytes.

```
int __itt_event_start( __itt_event event );
```

Call this API with an already created user event handle to register an instance of that event. This event appears in the Timeline pane display as a tick mark.

```
int __itt_event_end( __itt_event event );
```

Call this API following a call to `__itt_event_start()` to show the user event as a tick mark with a duration line from start to end. If this API is not called, the user event appears in the Timeline pane as a single tick mark.

User API

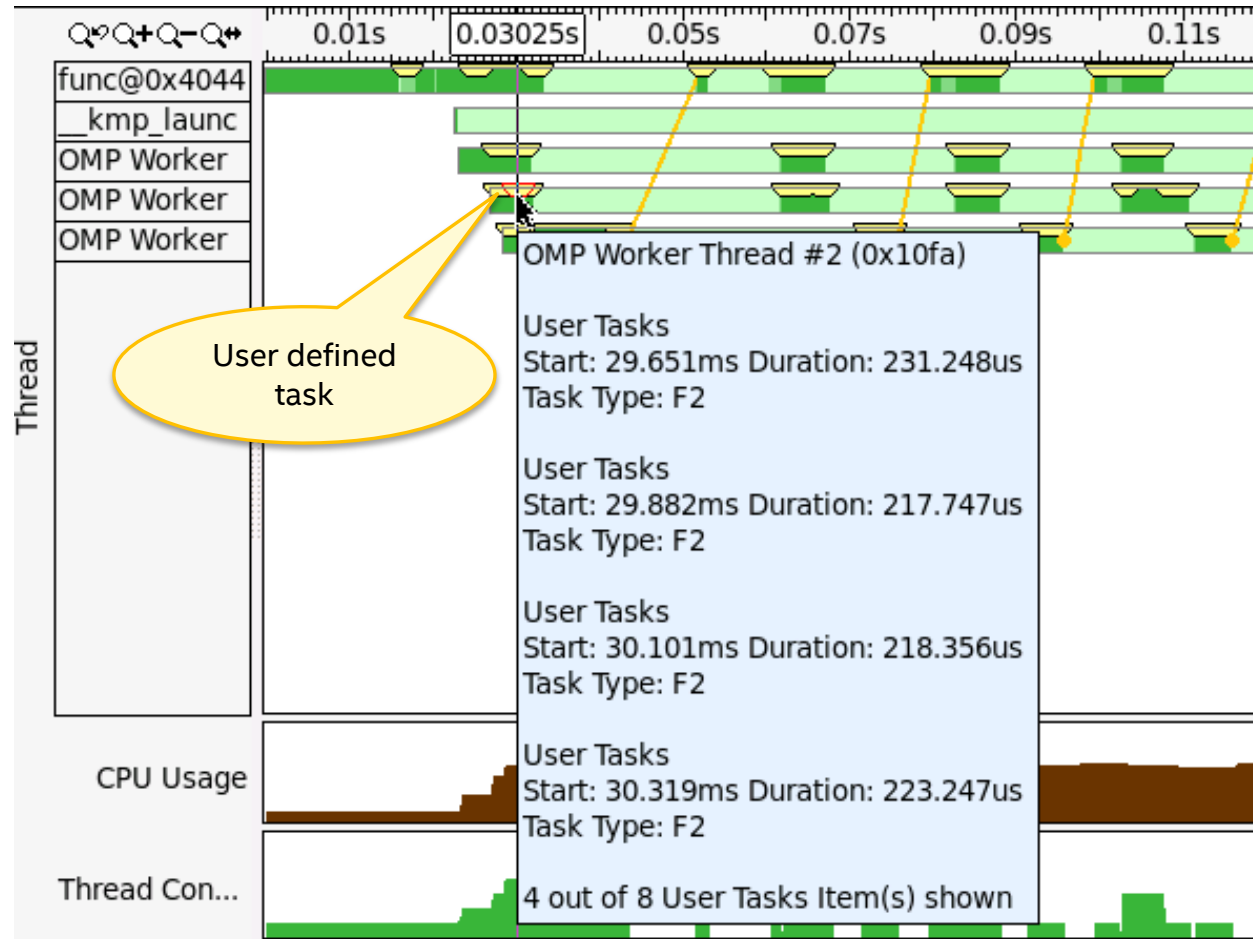
User Event APIs example

```
DWORD WINAPI aiWork(LPVOID lpArg)
{
    int tid = *((int*)lpArg);
    __itt_event aiEvent;
    aiEvent = __itt_event_create("AI Thread Work",14);

    while(gRunning) {
        WaitForSingleObject(bSignal[tid], INFINITE);
        __itt_event_start(aiEvent);
        doSomeDataParallelWork();
        __itt_event_end(aiEvent);
        SetEvent(eSignal[tid]);
    }
    return 0;
}
```

User API

Visualizing Events in the Timeline View



Performance Profiling

Frame Analysis

Frame Analysis – Analyze Long Latency Activity

Frame: a region executed repeatedly (non-overlapping)

- API marks start and finish
- Auto detect DirectX frames

Examples:

- Game – Compute next graphics frame
- Simulator – Time step loop
- Computation – Convergence loop

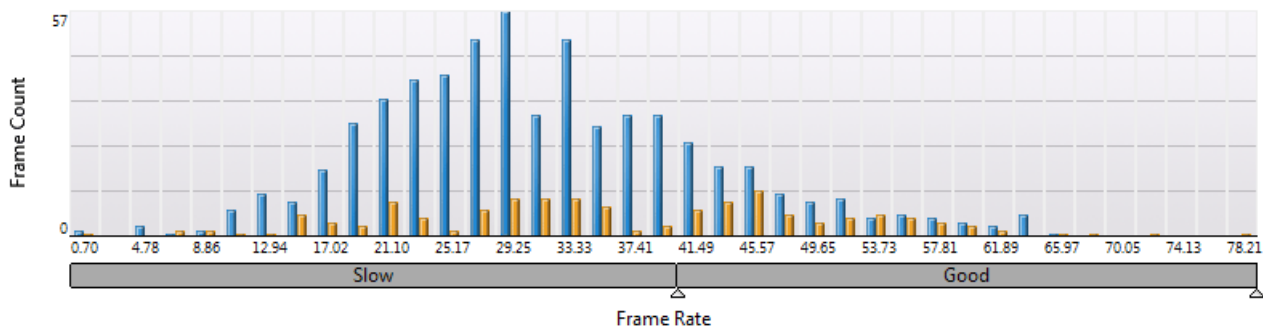
Application

```
voidalgorithm_1();  
voidalgorithm_2(int myid);  
doubleGetSeconds();  
DWORD WINAPI do_xform (void * lpmyid);  
bool checkResults();  
__itt_domain* pD = __itt_domain_create ("myDomain");
```

Region (Frame)

```
while( gRunning ) {  
    __itt_frame_begin_v3(pD, NULL);  
    ...  
    //Do Work  
    ...  
    __itt_frame_end_v3(pD, NULL);  
}
```

```
for (int k = 0; k < N; ++k) {  
    int ik = i*N + k;  
    int kj = k*N + j;  
    c2[ij] += a[ik]*b[kj];  
}
```



User API

Frame APIs reference

```
__itt_domain* __itt_domain_create(  
const __itt_char *name );
```

Create a domain with a domain name.

Since the domain is expected to be static over the application's execution time, there is no mechanism to destroy a domain. Any domain can be accessed by any thread in the process, regardless of which thread created the domain. This call is thread-safe.

```
void __itt_frame_begin_v3(const  
__itt_domain *domain, __itt_id *id);
```

Define the beginning of the frame instance.

A `__itt_frame_begin_v3` call must be paired with a `__itt_frame_end_v3` call.

Successive calls to `__itt_frame_begin_v3` with the same ID are ignored until a call to `__itt_frame_end_v3` with the same ID.

- domain is the domain for this frame instance.
- id is the instance ID for this frame instance, or NULL.

```
void __itt_frame_end_v3(const  
__itt_domain *domain, __itt_id *id);
```

Define the end of the frame instance.

A `__itt_frame_end_v3` call must be paired with a `__itt_frame_begin_v3` call. The first call to `__itt_frame_end_v3` with a given ID ends the frame. Successive calls with the same ID are ignored, as are calls that do not have a matching `__itt_frame_begin_v3` call.

- domain - The domain for this frame instance
- id - The instance ID for this frame instance, or NULL for the current instance.

User API

Frame APIs example

```
__itt_domain* pD = __itt_domain_create ("SimDomain");

while(gRunning) {
    __itt_frame_begin_v3(pD, NULL);

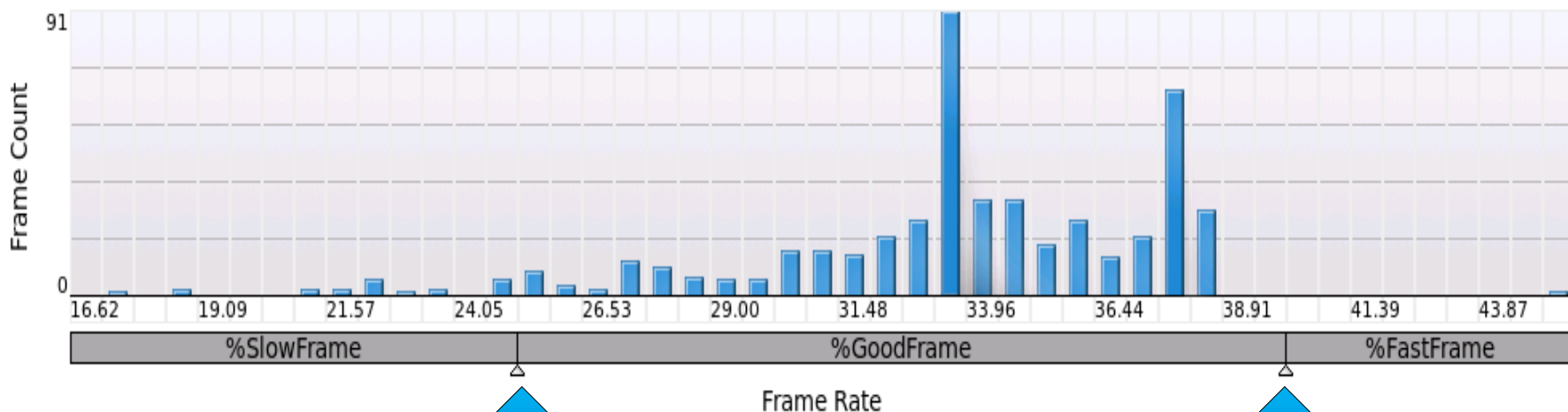
    start = clock();
    //Wait all threads before moving into the next frame
    WaitForMultipleObjects(FUNCTIONAL_DOMAINS, eSignal, TRUE,
INFINITE);
    stop = clock();
    //Give all threads the "go" signal
    for (int i = 0; i < FUNCTIONAL_DOMAINS; i++)
        SetEvent(bSignal[i]);
    if (frame % NETWORKCONNECTION_FREQ == 0) {
        //Start network thread
        SetEvent(bNetSignal);
    }
    __itt_frame_end_v3(pD, NULL);
}
```

Frame Analysis

Summary View / Frame Rate Chart

Frame Rate Chart

This histogram shows the total number of frames in your application executed with a specific frame rate. High number of slow or fast frames signals a performance bottleneck. Explore the data provided in the Bottom-up, Top-down Tree, and Timeline panes to identify code regions with the high/slow frame rate. Try to optimize your code to keep the frame rate constant (for example, from 30 to 60 frames per second).



Adjust the frame rate then changes

Frame Analysis

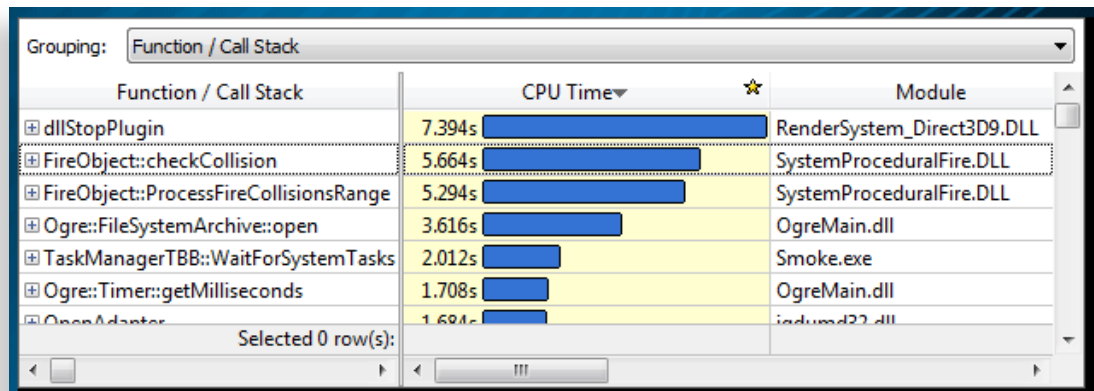
Find Slow Frames With One Click

(1) Regroup Data

Function - Call Stack
Module - Function - Call Stack
Source File - Function - Call Stack
Thread - Function - Call Stack
Function - Thread - Call Stack
OpenMP Region - Function - Call Stack
Task Type - Function - Call Stack
Frame Domain - Frame - Function - Call Stack
Frame Domain - Frame Type - Function - Call Stack

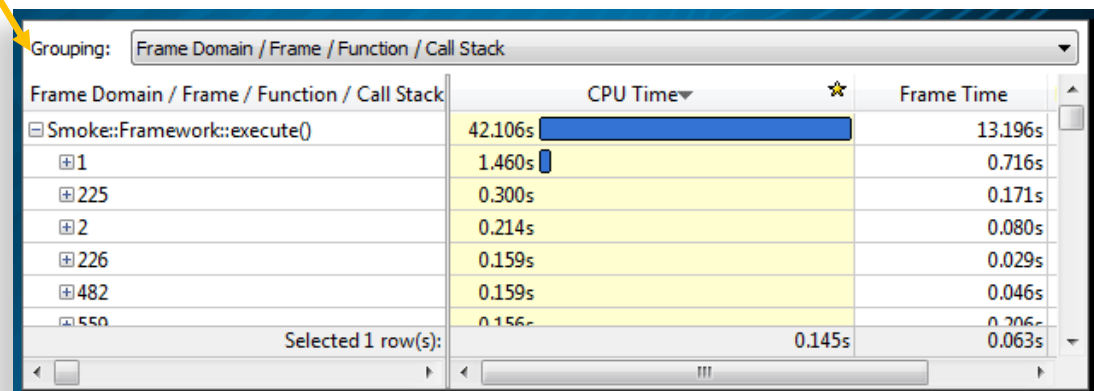
... (Partial list shown)

Before: List of Functions Taking Time



Function / Call Stack	CPU Time	Module
dllStopPlugin	7.394s	RenderSystem_Direct3D9.DLL
FireObject::checkCollision	5.664s	SystemProceduralFire.DLL
FireObject::ProcessFireCollisionsRange	5.294s	SystemProceduralFire.DLL
Ogre::FileSystemArchive::open	3.616s	OgreMain.dll
TaskManagerTBB::WaitForSystemTasks	2.012s	Smoke.exe
Ogre::Timer::getMilliseconds	1.708s	OgreMain.dll
OpenAdapter	1.694s	indum22.dll

After: List of Slow Frames



Frame Domain / Frame / Function / Call Stack	CPU Time	Frame Time
Smoke::Framework::execute()	42.106s	13.196s
1	1.460s	0.716s
225	0.300s	0.171s
2	0.214s	0.080s
226	0.159s	0.029s
482	0.159s	0.046s
550	0.156s	0.063s

Frame Analysis

Find Slow functions in slow frames

(1) Only show slow frames

Grouping: Frame Domain / Frame / Function / Call Stack

Frame Domain / Frame / Function / Call Stack	CPU Time	Frame Time
Smoke::Framework::execute()	42.106s	13.196s
#1	1.460s	0.716s
#225	0.300s	0.171s
#2	0.214s	0.080s
#226	0.159s	0.029s
#482	0.159s	0.046s
#550	0.155s	0.206s
		1.420s

Context Menu Options:

- Show Data as
- Hide Column
- Show All Columns
- ★ Set Column as Data of Interest
- Copy to Clipboard (Ctrl+C)
- Filter In by Selection**
- Filter Out by Selection
- Highlight Selection in Other Panes

Result:

Functions taking a lot of time in slow frames

Hotspots - Hotspots Intel VTune Amplifier XE 2013

Analysis Target Analysis Type Summary Bottom-up Top-down Tree Tasks

Grouping: Function / Call Stack

Function / Call Stack	CPU Time	Module
OpenAdapter	532.759ms	igdumd32.dll
FireObject::checkCollision	300.169ms	SystemProceduralFire.DLL
dllStopPlugin	222.407ms	RenderSystem_Direct3D9.DLL
Scheduler::Execute	159.260ms	Smoke.exe
FireObject::ProcessFireCollisionsRange	96.050ms	SystemProceduralFire.DLL
Ogre::Timer::getMilliseconds	66.979ms	OgreMain.dll
AnimalsUpdateFire	58.261ms	System.dll

Selected 1 row(s): 717.802ms

(2) Regroup: Show functions

Function - Call Stack

Module - Function - Call Stack

Source File - Function - Call Stack

Thread - Function - Call Stack

User API

Task APIs

- A **task** is a logical **unit of work** performed by a particular thread
- Tasks can be **nested**
- You can use task APIs to **assign tasks** to threads
- **One thread** executes **one task** at a given time
- Tasks may correspond to **functions**, **scopes**, or a **case block** in a switch statement

User API

Task APIs reference

Use This Primitive	To Do This
<code>void __itt_task_begin (const __itt_domain *domain, __itt_id taskid, __itt_id parentid, __itt_string_handle *name)</code>	Create a task instance on a thread. This becomes the current task instance for that thread. A call to <code>__itt_task_end()</code> on the same thread ends the current task instance.
<code>void __itt_task_end (const __itt_domain *domain)</code>	End a task instance on a thread.

Parameter	Description
<code>__itt_domain</code>	The domain of the task.
<code>__itt_id taskid</code>	This is a reserved parameter.
<code>__itt_id parentid</code>	This is a reserved parameter.
<code>__itt_string_handle</code>	The task string handle.

User API

Task APIs example

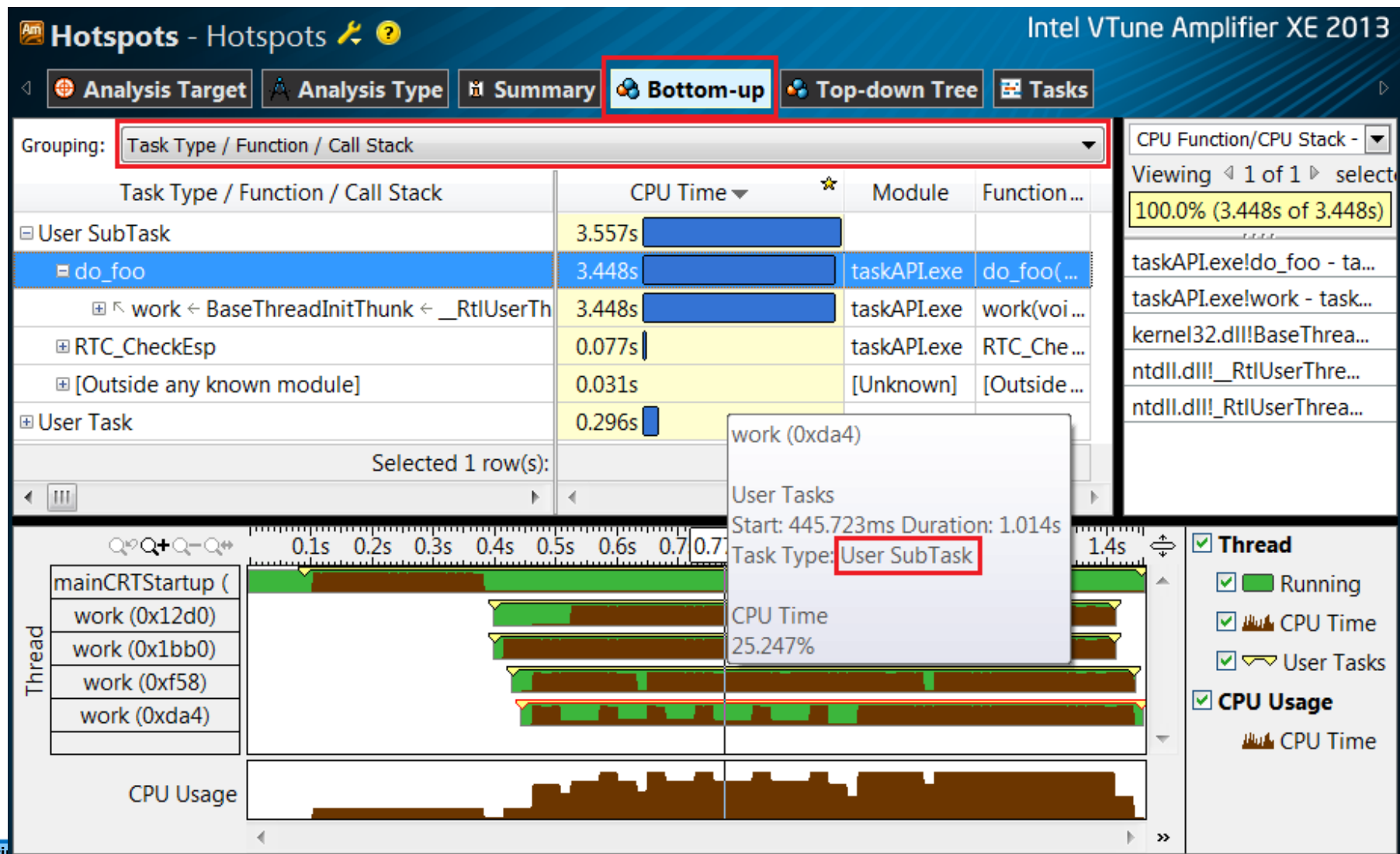
```
__itt_domain* domain = __itt_domain_create(L"Task Domain");
__itt_string_handle* UserTask = __itt_string_handle_create(L"UserTask");
__itt_string_handle* UserSubTask = __itt_string_handle_create(L"UserSubTask");

int main(int argc, char* argv[])
{
    ...
    __itt_task_begin (domain, __itt_null, __itt_null, UserTask);
    //create many threads to call work()
    __itt_task_end (domain);
    ...
}

work()
{
    __itt_task_begin (domain, __itt_null, __itt_null, UserSubTask);
    do_foo();
    __itt_task_end (domain);
    return 0;
}
```

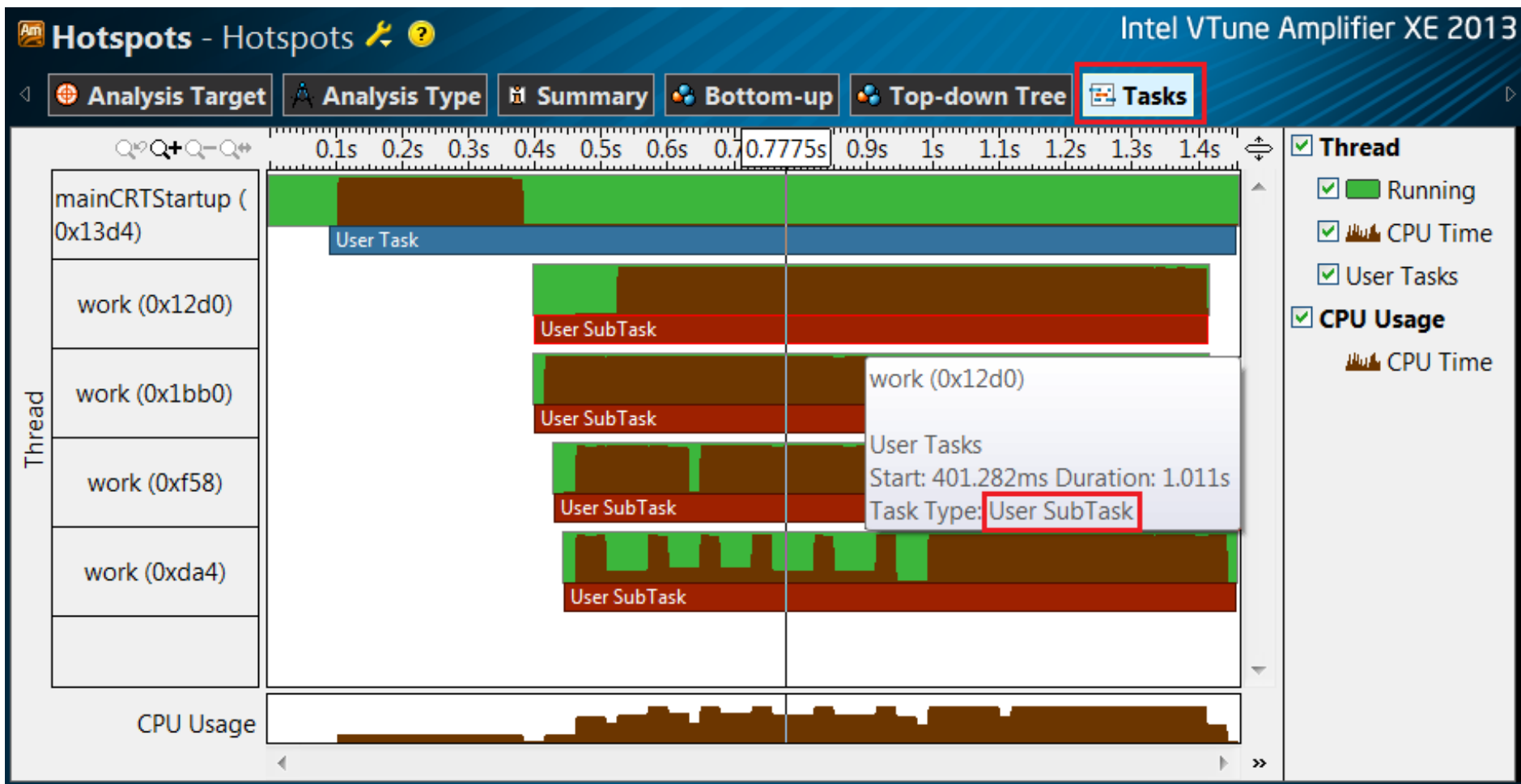
Using Task API

Hotspots analysis – Bottom-up view



Using Task API

Hotspots analysis – Task view



Command Line Interface

Command line (CLI) versions exist on Linux* and Windows*

- **CLI use cases:**

- Test code changes for performance regressions
- Automate execution of performance analyses

- **CLI features:**

- Fine-grained control of all analysis types and options
- Text-based analysis reports
- Analysis results can be opened in the graphical user interface

Command Line Interface

Examples

Display a list of available analysis types and preset configuration levels

```
amplxe-cl -collect-list
```

Run Hot Spot analysis on target *myApp* and store result in default-named directory, such as *r000hs*

```
amplxe-cl -c hotspots -- myApp
```

Run the Cuncurrency analysis, store the result in directory *r001par*

```
amplxe-cl -c concurrency -result-dir r001par -- myApp
```

Command Line Interface

Reporting

```
$> ampxe-cl -report summary -r  
/home/user1/examples/lab2/r003cc
```

Summary

Average Concurrency:	9.762
Elapsed Time:	158.749
CPU Time:	561.030
Wait Time:	190.342
CPU Usage:	3.636
Executing actions	100 % done

Command Line Interface

Gropof-like output

```
[levent@hlnasnb AXE_lab3]$ ampxe-cl -report gprof-cc -r /home/levent/examples/cern/labs/AXE_lab3/r003cc
Using result path ^/home/levent/examples/cern/labs/AXE_lab3/r003cc'
Executing actions 50 % Generating a report
```

Index	% Wait	Time:Total	Wait Time:Self	Children	Name	Index

[0]	99.88		190.104	190.104	G4RunManager::BeamOn	[23]
			190.104	0.0	ParRunManager::DoEventLoop	[0]
[1]	0.1		0.162	0.162	operator<<	[17]
			0.025	0.025	G4RunManagerKernel::G4RunManagerKernel	[11]
			0	0.001	RunAction::EndOfRunAction	[30]
			0.186	0.001	G4strstreambuf::sync	[1]
			0.001	0.001	G4MycoutDestination::ReceiveG4cout	[5]
			0.033	158.141	func@0x416c28	[7]
[2]	83.08		0.033	158.108	main	[2]
			0	158.108	G4_main	[18]
			0.002	0.002	CLHEP::HepRandom::showEngineStatus	[22]
[3]	0.0		0.002	0.0	CLHEP::RanecuEngine::showStatus	[3]
			0.001	0.001	G4_main	[18]
[4]	0.0		0.001	0.0	G4MycoutDestination::G4MycoutDestination	[4]
			0.001	0.001	G4strstreambuf::sync	[1]
[5]	0.0		0.001	0.0	G4MycoutDestination::ReceiveG4cout	[5]
			0	0	G4UImanager::ExecuteMacroFile <cycle 1>	[28]
[6]	0.0		0.0	0.0	G4UIbatch::G4UIbatch	[6]
			0.0	158.141	func@0x416c28	[7]
[7]	83.08		0.033	158.141	main	[2]
			0	190.107	G4_main	[18]
[8]	99.88		0.0	190.107	<cycle 1 as a whole>	[8]

Command Line Interface

CSV output

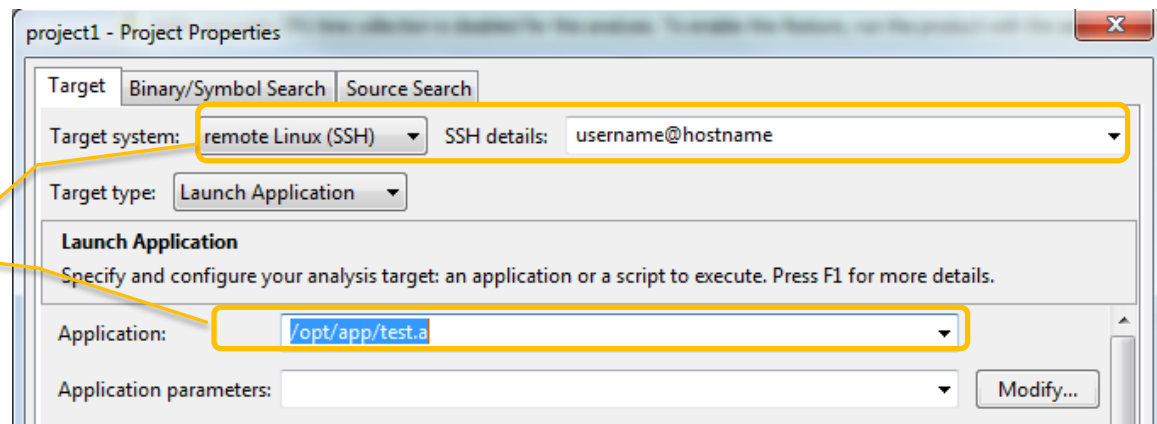
```
$> amplxe-cl -report hotspots -csv-delimiter=comma -format=csv -  
report-out=testing111 -r r003cc
```

```
Function,Module,CPU Time,Idle:CPU Time,Poor:CPU Time,Ok:CPU  
Time,Ideal:CPU Time,Over:CPU Time  
CLHEP::RanecuEngine::flat,test40,50.751,0,0.050,0.081,0.080,50.541  
G4UniversalFluctuation::SampleFluctuations,test40,32.730,0,0.030,0.  
070,0.010,32.620  
sqrt,test40,19.060,0,0.010,0.070,0.030,18.951  
G4Track::GetVelocity,test40,15.330,0,0.030,0.030,0.040,15.230  
G4VoxelNavigation::LevelLocate,test40,14.460,0,0.020,0.010,0.040,14  
.390  
G4Step::UpdateTrack,test40,14.090,0,0,0.030,0.020,14.040  
G4NavigationLevelRep::G4NavigationLevelRep,test40,13.721,0,0.030,0.  
020,0.040,13.631  
exp,test40,13.438,0,0.038,0.010,0.060,13.330  
log,test40,13.340,0,0.180,0.020,0.110,13.030  
G4PhysicsVector::GetValue,test40,11.970,0,0.020,0.020,0.050,11.880
```

Remote Data Collection



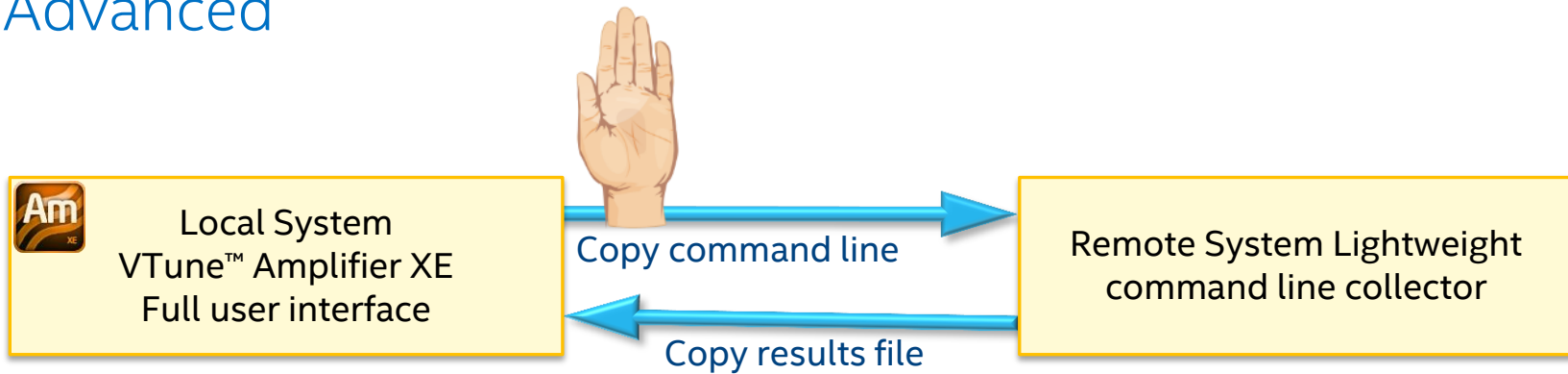
1. Setup the experiment using GUI locally
2. Configure remote target connection*
3. Specify application to run
4. Run analysis and get results copied to the Host automatically.



*Need to establish a passwordless ssh-connection

Remote Data Collection

Advanced



1. Setup the experiment using GUI locally
2. Copy command line instructions to paste buffer
3. Open remote shell on the target system
4. Paste command line, run collection
5. Copy result to your system
6. Open file using local GUI

One typical model

- Collect on Linux, analyze and display on Windows
 - The Linux machine is target
- Collect data on Linux system using command line tool
 - Doesn't require a license
- Copy the resulting performance data files to a Windows* system
- Analyze and display results on the Windows* system
 - Requires a license

Summary

The Intel® VTune Amplifier XE can be used to find:

- Source code for performance bottlenecks
- Characterize the amount of parallelism in an application
- Determine which synchronization locks or APIs are limiting the parallelism in an application
- Understand problems limiting CPU instruction level parallelism
- Instrument user code for better understanding of execution flow defined by threading runtimes

Questions?



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