



# Technologies for Measuring Software Performance

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## Executive Summary

In today's increasingly competitive software marketplace, companies that produce software products need every advantage they can get. One issue that can be difficult to deal with is improving application performance. A number of performance tools are available, but they all seem to focus on just one type of problem. Often they also affect the performance of the software they are intended to measure.

Three broad performance problems that developers face include:

- Where is the performance bottleneck in my code and how can it be reduced?
- What is the function calling sequence that leads to the bottleneck location?
- What system resources are reducing the performance of the application?

### Where is the performance bottleneck and how can it be reduced?

Perhaps the most fundamental part of performance tuning involves identifying the location of performance bottlenecks and determining how to fix them. For this task, the best solution requires access to a profiling technology that does not change the performance of the software, so that the measured performance accurately reflects what the application really does. Ideally, a tool not only finds performance bottlenecks, it also helps the developer generate ideas about what can be done to address bottlenecks. The most difficult part of performance tuning — probably even more difficult than finding bottlenecks — involves determining how to make those bottlenecks go away.

### What is the function calling sequence that leads to the bottleneck location?

Frequently, the best way to improve application performance is to improve the algorithm. Most profilers offer the ability to look at a program's control flow to determine how the program arrives at the bottleneck location. Some profilers offer the ability to view blocked time to help the developer identify whether a thread (or function) spends too much time waiting for an external activity to complete. While all this information can be valuable and provide a higher-level look at program

execution, obtaining this information normally involves some type of instrumentation or extra code to help the profiler gather the performance data.

### Which system resources are reducing performance?

Inadequate system resources, not just an overloaded CPU, can sometimes limit application performance. Many commercially available operating systems provide performance counters that developers can inspect to determine if inadequate system resources limit performance. A good performance tool that references these counters provides the developer with timely data indicating whether reduced available memory or performance issues associated with file I/O slow down the application.

## Intel® VTune™ Performance Analyzer

The VTune™ Performance Analyzer provides all of these capabilities for both Windows\* and Linux\* on Intel 32-bit and 64-bit processors. This tool uses occasional hardware interrupts to identify performance bottlenecks in a low-intrusive technology called Sampling (Figure 1). With this technology, samples of the CPU's execution context are taken in real time while using post-execution analysis to identify the locations of CPU bottlenecks. This allows the developer to drill down all the way to the source code for specific bottleneck locations. The VTune Performance Analyzer provides two types of sampling technologies:

- Time-based Sampling, based on operating system timer interrupts
- Event-based Sampling, based on processor events

The Intel® Tuning Assistant provides a related capability, comparing the resulting performance data with a database of representative results, alerting the developer when the results are exceptional. This helps identify cases in which cache misses, mispredicted branches, or cache aliasing effects cause the performance bottleneck.

The VTune Performance Analyzer also has a technology known as Call Graph (Figure 2). This technology

instruments binary executable files, and then executes those files to gather and produce function calling sequence data that is presented in graphical and spreadsheet views. Blocked time is displayed for individual functions and for threads as a whole. This allows the developer to get a high-level, algorithmic view of program execution.

In terms of system resources, the VTune Performance Analyzer samples native operating system counters and shows their values in real time and in post-execution analysis. With this technology, the user can select a specific time slice of the overall execution in which a particular counter's value becomes unusual, and then drill down to source code during that time slice to determine what the application was doing to cause the counter's value to change.

## Summary

The VTune Performance Analyzer uses a number of technologies for gathering and analyzing performance

data associated with applications and device drivers. These technologies not only identify performance issues but, in some cases, help the software developer to discover solutions. The flexibility these technologies provide enables developers to select the best way to attack the performance problems they face.

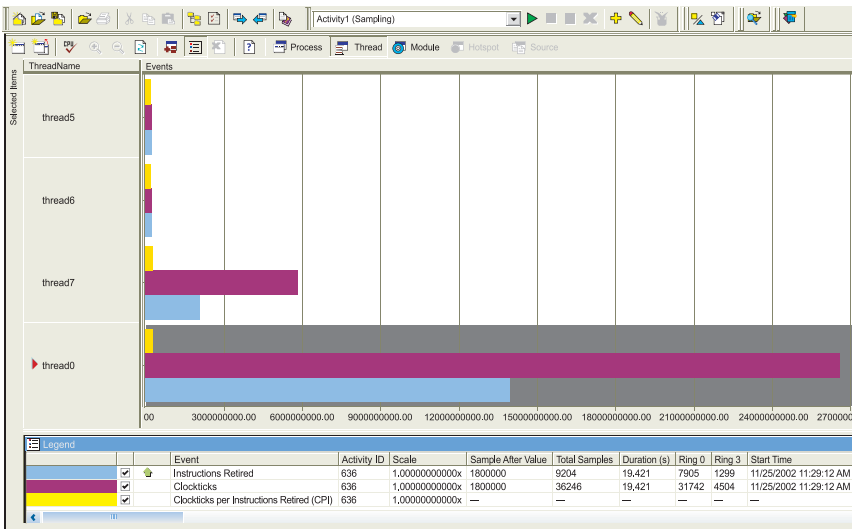
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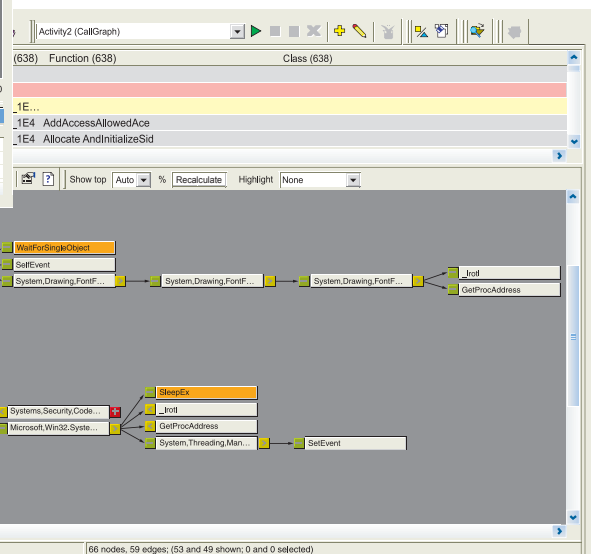
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**Figure 1. Time and Event Sampling**  
 View performance by time or processor events (cache misses, branch mispredictions, and so on)



**Figure 2. Call Graph Profiling**  
 View call paths, the number of times a function is called, time spent in each function, and more



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