Using RapiTime with VxWorks® to verify real-time performance

To show that your application meets hard real-time requirements, you need to know the **worst-case response time** of time-critical threads within the application. To establish this, you need to satisfy two conditions: use an RTOS with deterministic scheduling behavior and know the **worst-case execution time (WCET)** for each thread. The first condition is met by VxWorks with real-time processes (RTPs). The second can be met by Rapi**Time** WCET analysis of individual threads.

Part of RVS (Rapita Verification Suite), Rapi**Time** goes beyond the capabilities of conventional performance profilers in several ways. Specifically, Rapi**Time**:

- Collects distributions of execution time measurements taken directly from the target.
- Allows the level of detail for measurements to be configured on the level of lines or blocks of code, functions or entire subsystems.
- Combines measurements with a structural model of the application's source code to determine predicted WCET.
- Displays the predicted worst case path through the code.
- Shows which lines of code have the biggest impact on WCET.

How RapiTime works

Figure 1 shows how RVS fits into the build process. The *instrumenter* embeds instrumentation points (Ipoints) into code between pre-processing and compiling the code. Using data from the instrumenter, the structural analysis generates a complete structural model of the application. During testing, trace data in the form of **instrumentation point identifiers** and timestamps are collected. Once the trace data has been collected, it is combined with the structural model in the Rapi**Time** Database, which can be examined in the Report Viewer.

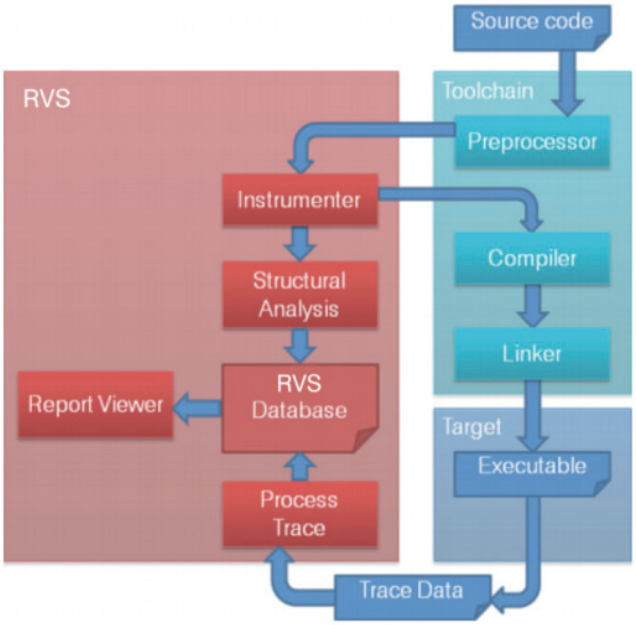

Figure 1: RVS tool chain integration

RVS's trace collection is via an open interface. This allows the trace to be captured in a variety of ways. Two common options are external hardware capture and software capture. In the case of hardware capture, the instrumentation point identifier is written to an I/O port, where it is captured by a logic analyzer or Rapita's data logger, **RTBx**. For software capture, an on-target buffer is used. At each instrumentation point, the identifier and timestamp are recorded in the buffer. A VxWorks thread can spool trace data off the target for later analysis.

Target integration kits can be provided to support different trace interfaces.

Eliminating Context Switches and Interrupts from Execution Time

Collecting the execution time from a specific thread within VxWorks means eliminating the time spent executing other (pre-empting) threads and interrupts from any time measurements.

For interrupts, this is achieved with a modified VxWorks

board support package featuring specific Ipoints embedded into an interrupt service routine. These Ipoints identify the start, interrupt vector and end of the interrupt.

Eliminating time in other threads requires an instrumented context switch. This is achieved by instrumenting the task context switch via the API call `taskSwitchHookAdd()` to insert two Ipoints representing the start and end of the context switch. Another Ipoint identifying the task appears between these two.

In situations where you are interested in the execution time of several tasks, Rapi**Time** can collect a trace of many tasks concurrently and demultiplex it into reports on separate tasks.

About Rapita Systems

Rapita Systems provides customized on-target verification solutions which reduce the cost of measuring and optimizing the timing performance of large, real-time software systems in the avionics and automotive electronics markets.

Rapita Verification Suite (RVS), which includes Rapi**Time** and Rapi**Cover**, is the essential collection of on-target timing verification, optimization and code coverage measurement tools for real-time embedded systems. It is the only product on the market that can tell users exactly where to focus optimization effort to minimize worst-case execution time.

Using RVS, customers have cut the worst-case execution time of large scale, legacy applications by up to 50% with only a few days effort, and significantly reduced unnecessary testing and instrumentation overheads. Our software supports Windows and Linux.

For information about Rapi**Time** and the timing information it can provide, visit www.rapitasystems.com.

Glossary

Execution time:

The time spent executing a specific thread between two points. This time excludes time spent executing any pre-empting threads or interrupts.

Instrumentation point identifiers (Ipoint Ids):

Constant values that allow an external view of the application's progress to be made. Under Rapi**Time**, Ipoint Ids do not need to be unique.

Response time:

The elapsed time between some initial stimulus to a system and that system's response. In the case of a multi-threaded application, this may include the time spent executing several tasks and/or interrupts.

Worst-case execution time (WCET):

The longest possible execution time for a given thread.

Worst-case response time (WCRT):

The longest possible response time that can occur for a given system. Note for non real-time applications this can be unbounded.

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About Pebble Bay Consulting Ltd

Pebble Bay is an independent, privately-owned company that specializes in providing embedded software consultancy and bespoke development services. When it comes to technology, we have experience and knowledge across the board. Our areas of expertise lie in the building blocks of your product – the low-level software that ensures that the rest of the application works to its full potential. Whether you need us to deliver a board support package, port your real time operating system or ensure your communication protocols are working their hardest for you, we can help.

We have many years of experience in developing Board Support Packages (BSPs) for real-time operating systems and kernels that are targeted to embedded systems.

Further details can be found at: www.pebblebay.com

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