Measuring WCET for MATLAB® Simulink® models with RapiTime

Determination of the worst-case execution time (WCET) of embedded software is highly beneficial for real-time applications, especially in the case of high integrity or safety critical systems. ISO 26262 (for automotive) and DO-178B/C (for aerospace) both recommend the use of WCET.

One popular use case of MATLAB® Simulink® is to generate real-time applications. To support this, Simulink offers some basic profiling tools, although these do not aim to support the determination of WCET. It is possible to find WCET of code generated by Simulink Embedded Coder using RapiTime. This will generate reports at the source level, which needs to be manually related back to the Simulink model.

Clearly, for developers adopting a model-based development approach, it is advantageous to understand detailed timing and WCET at the model level, rather than the source level. This technical note describes how RapiTime can be integrated with MATLAB Simulink to achieve this level of reporting.

Introducing RapiTime and RVS

RapiTime is a performance measurement and timing analysis tool. Working on your target system, RapiTime measures performance, determines WCET, and guides your optimization efforts.

RapiTime is part of the Rapita **Verification Suite** (R**VS**), which also includes RapiCover (low-overhead code coverage up to MC/DC) and RapiTask (RTOS/event visualization).

A detailed overview of how RapiTime works can be found in the White Paper *Automating WCET analysis for DO-178B/C* available at www.rapitasystems.com/downloads.

RapiTime reports a wide range of timing data at many levels of detail in a system. Data that RapiTime can report includes:

- Execution Time Profiles that show the distribution of execution times for functions and their children.

- High water mark, which shows the path of the longest observed execution time.

- Worst-case execution time, which can also be shown as a path through the code.

- Contribution reports, which shows what percentage of the worst-case or high water mark path a specific piece of code is responsible for.

- Which code has been tested and which is untested.

Integrating with MATLAB Simulink

Under our Early Access Program, we have developed custom integrations of RapiTime and RapiCover with MATLAB Simulink which allows timing information and code coverage to be reported at the model level.

Through the RapiTime integration, any of the above timing data can be reported.
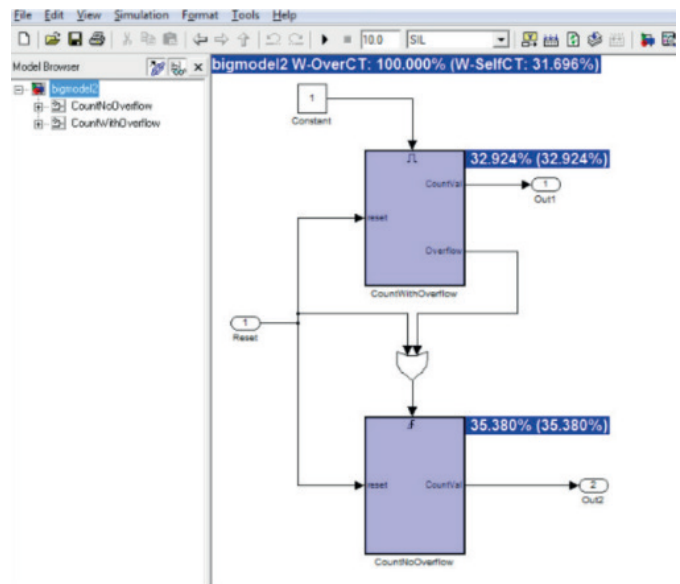
One particularly useful report is the worst-case contribution. As shown on the screen shot, Simulink blocks that appear on the worst-case path are colored in blue. The contribution of the block is shown on the model.

This information is especially helpful if you need to optimize the WCET of the code that comes from your model. You can rapidly identify which block has the largest contribution on WCET and focus optimization efforts on that.

An integration between RapiTime and MATLAB Simulink can also provide code coverage metrics via RapiCover, which could also be reported at the model level.

The integration can work with both PIL (processor in the loop) and HIL (hardware in the loop) configurations. Coverage can be measured at the SIL (software in the loop) level, although timing measurements collected on a PC could vary considerably from

measurements for a specific embedded target.

The integration of R**VS** with MATLAB and Simulink allows timing and code coverage information to be obtained throughout model-driven development, starting with early stages.

Timing information can be used to provide assurance that models (and source code derived from them) satisfy timing requirements. As we've seen, the integration also provides information that can be used to refine and optimize models during early stages of development, allowing the model to more accurately reflect the final system.

Coverage information can be used to provide early evidence that the simulation input vectors adequately test the model.

Rapi**Time** and Rapi**Cover** both have qualification kits available for ISO 26262 or DO-178B/C, and have already been qualified on a number of projects.

Find out more

For more information about the integration of Rapi**Time** or Rapi**Cover** with MATLAB Simulink, contact us.

About Rapita Systems

Founded in 2004, Rapita Systems develops on-target embedded verification software solutions for customers in the avionics and automotive electronics industries. Our tools help to reduce the cost of measuring, optimizing and verifying the timing performance and test effectiveness of their critical real-time embedded systems.

The Rapi**Time** integration with MATLAB Simulink was developed using research performed within the CRAFTERS project (ARTEMIS 295371-2), a research project co-funded by the European Commission under the ARTEMIS Joint Undertaking Programme.

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