RapiTime Experience Report

RapiTime Worst-Case Execution Time Optimisation
BAE Systems Hawk Mission Computer

In November 2006, Rapita Systems Ltd was awarded a contract by BAE Systems to identify opportunities for worst-case execution time reduction in the Operational Flight Program software of the Hawk Mission Computer. Hawk is the world's most successful advanced training aircraft, outperforming and outselling all other aircraft in its class. Over 900 Hawks are in operational service, or have been ordered, by 19 customers world-wide.

+ **Hundreds of thousands of lines of Ada**
+ **Worst-case hot spots identified using RapiTime**
+ **Targeted optimisation effort**
+ **Examined just 1.2% of the code**
+ **Achieved 23% reduction in execution time**
+ **Significant cost saving**

Hundreds of thousands of lines of Ada code

The Hawk Mission Computer Operational Flight Program (OFP) software comprises hundreds of thousands of lines of Ada source code, executing on a PowerPC (MPC7410) as 25 separate software partitions.

The key objective of the project is to reduce the overall execution time of the OFP Software by 10%. Phase 1 of the project focused on 4 partitions that make up approximately 25% of the schedule. The RapiTime worst-case execution time analysis tool set was used to identify opportunities for reducing the overall execution time of code in these partitions.

Worst-case hotspots

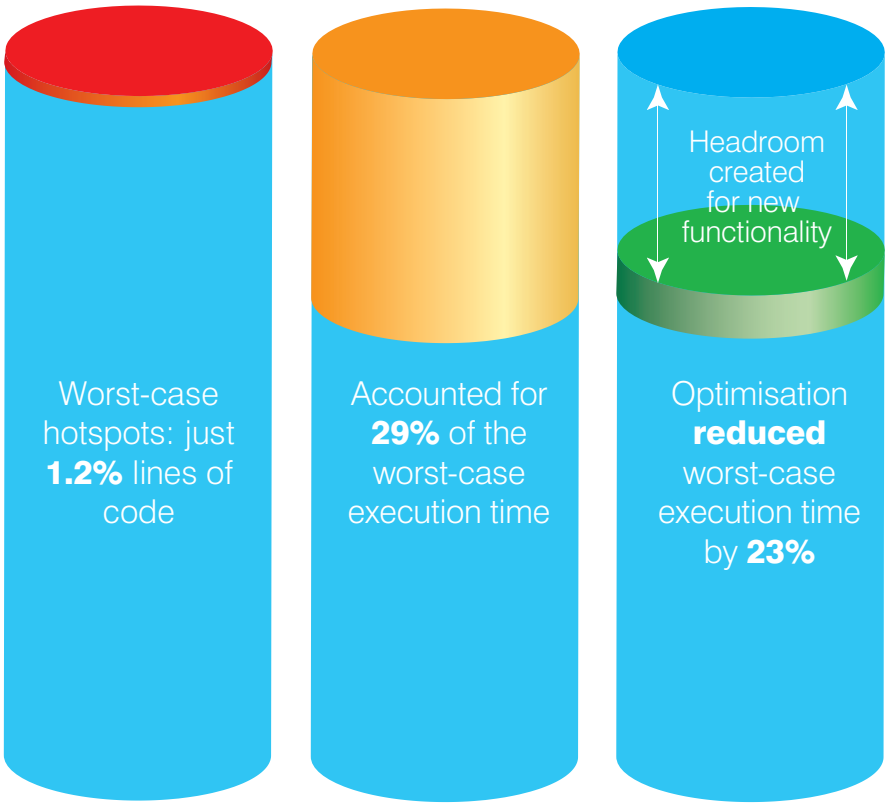
Unlike conventional code profiling techniques, RapiTime identifies worst-case hotspots from the point of view of worst-case execution time. That is the Ada sub-programs and lines of source code that contribute most to the overall worst-case execution time. Conventional profiling techniques identify the lines of code that execute the most on average, which is very different.

Execution time contribution

By combining static analysis of the program structure with timing trace information generated via extensive testing, RapiTime was able to provide information about the contribution of every sub-program to the overall worst-case execution time thus identifying candidate sub-programs for optimisation.

What if?

Next RapiTime **was used to answer what-if questions about the effects of potential reductions in the execution time of these sub-programs. This showed that optimising some candidate sub-programs would result in a commensurate reduction in the overall worst-case execution time; whilst for other sub-programs, optimisation would bring little benefit as the worst-case path shifted to other code.**



The best candidates for optimisation were inspected. This involved studying both the Ada source code and in some cases the object code produced by the compiler. A variety of code constructs were found to be contributing heavily to the worst-case execution time. Where possible, these constructs were optimised.

Code optimisations

Optimisations included: removing code that created redundant copies of large data structures; re-writing bit unpacking code, enabling the compiler to produce much more efficient object code (in a sub-program that was called over 700 times on the worst-case path); and re-writing case statements using look-up tables (called over 450 times on the worst-case path).

23% reduction in worst-case execution time

Overall, RapiTime accurately identified worst-case hotspots enabling a 23% reduction in the worst-case execution time of the analysed partitions. This reduction was achieved via a targeted and highly focused optimisation effort. This minimised the software development and validation/ verification effort required whilst ensuring that the improvements had the maximum possible impact.

By examining 1.2% of the code

The sub-programs that needed to be examined to achieve this reduction represented just over 1% of the code in the selected partitions.

The reductions in worst-case execution time achieved in phase 1 mean that the project is well on track to meet its objectives. Successful conclusion of the project will enable significant extra functionality to be added to the Mission Computer without the need for an extremely costly hardware upgrade.

"We are delighted with the schedule reductions achieved in phase 1" said Dean Armstrong, Software Engineering Manager at BAE Systems Brough. *"The integration team are now looking at how RapiTime can be used as an integral part of the software development process for future Hawk developments".*

BAE Systems Chairman's award winners

Rapita Systems Ltd has won a BAE Systems Chairman's Award for Innovation in the Transferring Best Practice category. The Bronze Award, made jointly to Rapita Systems and BAE Systems Brough was presented at the prestigious Chairman's Awards dinner.

The award was for deployment of RapiTime worst-case execution time analysis technology on the Hawk Advanced Jet Trainer project. The Rapita Systems / Hawk team successfully demonstrated application of this ground breaking technology to analyse components of the new Open Architecture Mission Computer.

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