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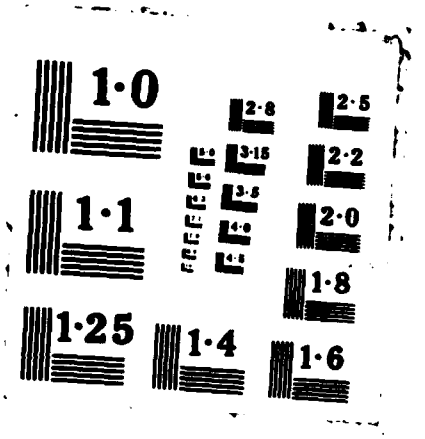
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Technical Report
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Carnegie-Mellon University
Software Engineering Institute

Prototype Real-Time Monitor: Executive Summary

Roger Van Scoy

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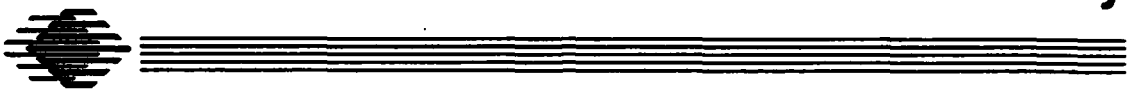

Roger Van Scoy

Dissemination of Ada Software Engineering Technology

Software Engineering Institute
Carnegie Mellon University
Pittsburgh, Pennsylvania 15213

This technical report was prepared for the

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The ideas and findings in this report should not be construed as an official DoD position. It is published in the interest of scientific and technical information exchange.

Review and Approval

This report has been reviewed and is approved for publication.

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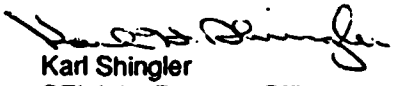

Karl Shingler
SEI Joint Program Office

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Prototype Real-Time Monitor: Executive Summary

Context

The task to study implementing a real-time monitor (RTM) resulted from the Software Engineering Institute's (SEI) involvement with the Ada® Simulator Validation Program (ASVP). The ASVP introduced us to the needs and constraints of real-time flight simulators. One of the goals of the ASVP is to produce well-engineered designs that exhibit modularity, abstraction, information hiding, and that are well-documented, reliable, extensible, modular, and maintainable. The embodiment of these attributes in the resulting Ada system introduces new problems to the flight simulator world, problems which do not exist in the traditional FORTRAN environment.

One problem is the ability to monitor the software of an executing simulator and to tune its performance dynamically at run time without interfering unduly with the timing and control structure of the application. To do that requires knowledge of the organization of simulator memory and the ability to traverse this organization. Because FORTRAN common blocks are traditionally used in flight simulators, this knowledge is readily available. But when one attempts to impose abstraction and information hiding on top of Ada's control of the application's address space, the process of seeing inside an executing application becomes difficult. Add to this the dynamic nature of Ada's run time memory management, Ada type constraints, and the need to operate in a distributed environment, and the problem is compounded.

The problem, then, is no longer one of simply looking at a static address map and locating the parameters of interest. Indeed, with the size of current flight simulators, even the old FORTRAN solutions are being stretched to their limits. But as we shall see, this problem is not unique to the flight simulator world (see *Prototype Real-Time Monitor Requirements* [1] for additional information on the constraints imposed by a flight simulator on a monitor); rather, it is one specific instance of a more general problem: monitoring any system where the data to be studied are not known ahead of time.

The real-time monitor task was undertaken to address two specific technical questions raised by the ASVP contractors:

1. How can user tools find, access, and display data hidden in the bodies of Ada applications?
2. How can user tools be layered on top of Ada applications?

The real-time monitor task resulted in the prototype documented by these reports because the ASVP contractors needed a monitor tool, but did not have the contract resources to develop one.

Results

The major result of this task was a working prototype real-time monitor, built (using reusable parts) to test our technical solutions. The prototype was delivered to the ASVP contractors to use as they saw fit. A full set of documentation was developed to support their use of the prototype. These documents include:

- *Prototype Real-Time Monitor: Requirements [1]*
- *Prototype Real-Time Monitor: User's Manual [3]*
- *Prototype Real-Time Monitor: Design [2]*
- *Prototype Real-Time Monitor: Ada Code [4]*

Again, the primary purpose of the prototype was to test technical solutions, specifically, solutions to the questions raised above:

1. How can user tools find, access, and display data hidden in the bodies of Ada applications?

   We found that we could treat data addresses as abstractions and still use them to access memory (once an address was computed, discussed below). Once the data was acquired, it was easily converted into displayable form using (text_io).

2. How can user tools be layered on top of Ada applications?

   For tools that require address information about Ada objects, certain limited address information is available within the language (if one is willing to tolerate a large amount of hand crafting). However, automation of these tools requires access to compiler and linker generated information on memory allocation. Currently no compiler makes this information available. This problem is not peculiar to software monitors, but comes up again on other tools that need address information (such as performance analyzers, hardware monitoring devices, and program partition tools).

Other Issues

During the development of the prototype RTM, several significant side issues were uncovered, but which were beyond the scope of the RTM task to pursue:

1. The role of reusable components (which were extensively used in the RTM development process) and their impact on design and implementation (to be discussed in a future paper).
2. The use of object oriented requirements analysis and its impact on software design.
3. The buffering scheme developed for the prototype RTM has potential utility in other applications (to be discussed in a future paper).

Nature of the Prototype

The prototype real-time monitor is just that: a prototype. To bring the prototype up to a fully capable RTM would require:

- Complete implementation of all requirements documented in the *Prototype Real-Time Monitor: Requirements* [1].
- Comprehensive testing and evaluation of the RTM.
- Integration into a real-time application for performance tuning.

The prototype RTM is intended to be a simple tool that can easily be rehosted and extended. It is not intended to be an example of what a well-documented system should include. Since it was a prototyping effort, no standard documentation or development methods were applied, nor did we attempt to solve all the traditional "monitor" problems (determinism, predictability, interference, etc.).

Bibliography

[1] D'Ippolito, R., K. Lee, C. Plinta, M. Rissman and R. Van Scoy.
Prototype Real-Time Monitor: Requirements.
Technical Report CMU/SEI-87-TR-36, Software Engineering Institute,
November, 1987.
Summary: This document is the set of requirements developed at the SEI to address the needs for monitoring flight simulator software on the ASVP.

[2] Van Scoy, R., C. Plinta, T. Coddington, R. D'Ippolito, K. Lee, and M. Rissman.
Prototype Real-Time Monitor: Design.
Technical Report CMU/SEI-87-TR-38, Software Engineering Institute,
November, 1987.
Summary: This document contains the full description of the design and implementation of the prototype real-time monitor.

[3] Van Scoy, R., C. Plinta, T. Coddington, R. D'Ippolito, K. Lee, and M. Rissman.
Prototype Real-Time Monitor: User's Manual.
Technical Report SEI-CMU/SEI-87-TR-37, Software Engineering Institute,
November, 1987.
Summary: This document contains the full description of the user interface for the prototype real-time monitor.

[4] Van Scoy, R.
Prototype Real-Time Monitor: Ada Code.
Technical Report CMU/SEI-87-TR-39, Software Engineering Institute,
November, 1987.
Summary: This is the actual Ada code developed at the SEI for the real-time monitor.

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THE TASK TO STUDY IMPLEMENTING A REAL-TIME MONITOR (RTM) RESULTED FROM THE SOFTWARE ENGINEERING INSTITUTE'S (SEI) INVOLVEMENT WITH THE ADA SIMULATOR VALIDATION PROGRAM (ASVP). THE ASVP INTRODUCED US TO THE NEEDS AND CONSTRAINTS OF REAL-TIME FLIGHT SIMULATORS. ONE OF THE GOALS OF THE ASVP IS TO PRODUCE WELL-ENGINEERED DESIGNS THAT EXHIBIT MODULARITY, ABSTRACTION, INFORMATION HIDING, AND THAT ARE WELL-DOCUMENTED, RELIABLE, EXTENSIBLE, MODULAR, AND MAINTAINABLE. THE EMBODIMENT OF THESE ATTRIBUTES IN THE RESULTING ADA SYSTEM INTRODUCES NEW PROBLEMS TO THE FLIGHT SIMULATOR WORLD, PROBLEMS WHICH DO NOT EXIST IN THE TRADITIONAL FORTRAN ENVIRONMENT.

THIS REPORT SUMMARIZES THE HISTORY, GOALS, AND CONCLUSIONS OF THE PROTOTYPE REAL-TIME MONITOR DEVELOPMENT EFFORT. THIS EFFORT WAS UNDERTAKEN TO ADDRESS TWO SPECIFIC TECHNICAL QUESTIONS: 1) HOW CAN USER TOOLS FIND, ACCESS, AND DISPLAY DATA HIDDEN IN THE BODIES OF ADA APPLICATIONS? AND 2) HOW CAN USER TOOLS BE LAYERED ON TOP OF ADA APPLICATIONS?

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