SPACE STATION
OPERATING SYSTEM STUDY

SUMMARY REPORT

PREPARED FOR NASA
UNDER CONTRACT
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SPACE STATION OPERATING SYSTEM STUDY

SUMMARY REPORT

I. OVERVIEW AND SUMMARY ........................................ 1
   A. Purpose and Methodology .................................... 1
   B. Systems Tested ............................................. 1
   C. Structure of Report ....................................... 4
   D. Benchmark Summary ........................................ 4
   E. Source Code Conventions .................................. 11
   F. Conclusions ................................................ 13
      1. Ada ..................................................... 13
      2. Operating Systems ...................................... 14

II. BENCHMARK SOFTWARE ....................................... 16
   A. Prime Number ............................................. 16
   B. Floating Point .......................................... 16
   C. Matrix Manipulation ...................................... 19
   D. Disk Write Timing ....................................... 20
   E. Ada Tasking ............................................. 21
      1. Ada Rendezvous Response ............................... 21
      2. Ada Two-Task Data Transfer ......................... 21
      3. Ada Two-Task Data Transfer via Shared Disk .... 23
   F. System Services .......................................... 23
      1. Send/Receive .......................................... 23
      2. Process Creation ...................................... 25
      3. Synchronization ...................................... 26

III. TEST PROGRAMS .......................................... 28
   A. Multi-Process Timing Test ............................... 28
   B. Ada Multi-tasking Scenario ............................. 28
   C. VAX High-Level Language Access to System Services . 30
   D. VAX Alarm Test .......................................... 30
   E. Ada "delay" Test ......................................... 33
   F. Ada Task Order Test .................................... 33
   G. Multi-task Time Shared Execution Test ............... 33

IV. SYSTEM AND COMPILER ANALYSIS .......................... 35
   A. Ada Terminal Input Analysis ............................ 35
   B. Foreign Routine Capability ............................ 37
   C. I/O Loading Analysis ................................... 40
   D. Multiple Process Loading Analysis .................... 41
   E. Large Array Analysis .................................. 41
   F. Ada Multiple Periodic Tasks With Calculation Tasks . 46
   G. VAX/VMS Ada Analysis .................................. 47
   H. Alsys Ada (SUN) Analysis ............................... 48
   I. Alsys Ada (PC/AT) Analysis ............................. 49

V. SOURCE LISTINGS ........................................ 56
LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table I-1</td>
<td>Systems Tested</td>
<td>3</td>
</tr>
<tr>
<td>Table I-2</td>
<td>Benchmark Summary</td>
<td>5</td>
</tr>
<tr>
<td>Table I-3</td>
<td>Source Code Conventions</td>
<td>12</td>
</tr>
<tr>
<td>Table IV-1</td>
<td>SUN Alsys Ada Benchmark Analysis</td>
<td>53</td>
</tr>
<tr>
<td>Table IV-2</td>
<td>PC/AT Alsys Ada Benchmark Analysis</td>
<td>55</td>
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</table>

LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
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<th>Page</th>
</tr>
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<tbody>
<tr>
<td>Figure II-1</td>
<td>Prime Number Benchmark Commented FORTRAN Source</td>
<td>17</td>
</tr>
<tr>
<td>Figure II-2</td>
<td>Rendezvous Response Time Flow Chart</td>
<td>22</td>
</tr>
<tr>
<td>Figure II-3</td>
<td>Send/Receive Data Transfer Flow Chart</td>
<td>24</td>
</tr>
<tr>
<td>Figure III-1</td>
<td>Ada Multi-Tasking Scenario</td>
<td>29</td>
</tr>
<tr>
<td>Figure III-2</td>
<td>VAX QIO System Service Access</td>
<td>31</td>
</tr>
<tr>
<td>Figure IV-1</td>
<td>Corrected Version of Ada LRM Example 14.7</td>
<td>36</td>
</tr>
<tr>
<td>Figure IV-2</td>
<td>Screen Copy of Foreign Routine Example</td>
<td>38</td>
</tr>
<tr>
<td>Figure IV-3</td>
<td>Multiple Process Loading on MicroVAX</td>
<td>42</td>
</tr>
<tr>
<td>Figure IV-4</td>
<td>Multiple Process Loading on SUN 3/260</td>
<td>43</td>
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<tr>
<td>Figure IV-5</td>
<td>Large Array Analysis, (Ada and FORTRAN)</td>
<td>44</td>
</tr>
<tr>
<td>Figure IV-6</td>
<td>Large Array Analysis, (FORTRAN)</td>
<td>45</td>
</tr>
<tr>
<td>Figure IV-7</td>
<td>Source for test1.ada error test program</td>
<td>50</td>
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<tr>
<td>Figure IV-8</td>
<td>Source for test2.ada error test program</td>
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<tr>
<td>Figure IV-9</td>
<td>Source for Matrix Benchmark &quot;Workaround&quot;</td>
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I. OVERVIEW AND SUMMARY

A. Purpose and Methodology

The current phase of this study has been based on the analysis, evaluation, and comparison of the operating systems implemented on the computer systems and workstations in the software development laboratory. Primary emphasis of the study has been the DEC MicroVMS operating system as implemented on the MicroVAX II computer, with comparative analysis of the SUN UNIX system on the SUN 3/260 workstation computer, and to a limited extent, the IBM PC/AT microcomputer running PC-DOS. Some benchmark development and testing was also done for the Motorola MC68010 (VM03 system) before that system was removed from the lab. These systems were studied with the objective of determining their capability to support space station software development requirements, specifically for multi-tasking and real-time applications. The methodology utilized consisted of development, execution, and analysis of benchmark programs and test software, and the experimentation and analysis of specific features of the systems or compilers in the study.

B. Systems Tested

Since the Ada programming language is the language selected for Space Station software use, the primary programming language used for test
software development on these systems was Ada. Other languages were used as a comparison where compilers were available, such as FORTRAN, "C", and Pascal. Several times during the course of the study, newer releases of compilers were received and installed on the systems. In such cases, all benchmarks and test programs were rerun to obtain new data, such that all data presented in this report is a result of the most recent releases. A table of the computer systems that were included in the study, their operating systems, languages, and software versions is presented in Table I-1.
<table>
<thead>
<tr>
<th>COMPUTER</th>
<th>OPERATING SYSTEM</th>
<th>LANGUAGES</th>
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<td>DEC MicroVAX II</td>
<td>MicroVMS 4.5</td>
<td>VAX Ada V1.3</td>
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<tr>
<td></td>
<td></td>
<td>VAX FORTRAN V4.5</td>
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<tr>
<td></td>
<td></td>
<td>VAX C V2.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>VAX/VMS Macro V04</td>
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<tr>
<td>SUN 3/260</td>
<td>SUNOS 3.2</td>
<td>SUN FORTRAN 77</td>
</tr>
<tr>
<td></td>
<td>(UNIX 4.2 BSD derived)</td>
<td>SUN C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SUN Pascal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Alsys Ada 3.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SUN Assembly</td>
</tr>
<tr>
<td>IBM PC/AT</td>
<td>PC-DOS 3.2</td>
<td>Alsys Ada 3.2</td>
</tr>
<tr>
<td>Motorola MC68010</td>
<td>UNIX System V/68 2.1</td>
<td>TeleSoft Ada 2.1</td>
</tr>
<tr>
<td>(VM03)</td>
<td></td>
<td>Sys V/68 FORTRAN 77</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sys V/68 C</td>
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<td></td>
<td></td>
<td>Sys V/68 Assembly</td>
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<td></td>
<td></td>
<td>VERSAdos 4.3</td>
</tr>
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<td></td>
<td></td>
<td>VERSAdos Pascal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>M68000 Assembly</td>
</tr>
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</table>

Table I-1. Systems Tested
C. Structure of Report

In the following sections of this report, the study is presented in its major categories. First, benchmark programs are detailed. These programs were developed to quantify the performance of selected functional areas of the operating systems/languages and produce a measured execution time as a result. Second, test programs are documented. These programs were used to test certain features and capabilities of the operating system or language, and as such did not produce a measured result. They did produce an observable behavior from which conclusions could be made or the operating systems could be compared. Next, specific operating system/compiler analysis results are documented. For these cases, special tests to analyze a particular problem area or to test options unique to a particular Ada compiler or operating system were made. Finally, the source code listings for the software developed for the study are presented. These listings should prove valuable not only to allow comparisons to be made for other operating systems/compilers, but to serve as an example of implementation techniques for some of the features available with the systems tested, such as calling operating system services, or linking "foreign" subprograms to an Ada main program.

D. Benchmark Summary

A combined summary of benchmark timing results of all the benchmarks for all the systems tested, for each programming language used, is presented in Table I-2.
### SPACE STATION OPERATING SYSTEM STUDY BENCHMARK SUMMARY

### TIMING RESULTS (ALL TIMES IN SECONDS)

<table>
<thead>
<tr>
<th>BENCHMARK</th>
<th>MicroVAX II</th>
<th>SUN 3/260</th>
<th>IBM PC/AT</th>
<th>Motorola 68010</th>
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<tbody>
<tr>
<td>Sieve Prime Number Execution</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FORTRAN 1.1 (4 byte integers)</td>
<td>.50</td>
<td></td>
<td>13.8</td>
<td></td>
</tr>
<tr>
<td>1.7 (2 byte integers)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C 1.3</td>
<td>.67</td>
<td></td>
<td>12.3</td>
<td>5.7 (optimized)</td>
</tr>
<tr>
<td>PASCAL .62</td>
<td></td>
<td></td>
<td>6.8</td>
<td>(VERSADos)</td>
</tr>
<tr>
<td>ADA 1.5</td>
<td>.89</td>
<td>5.1</td>
<td>205.8</td>
<td></td>
</tr>
<tr>
<td>1.2 (w/suppress_all)</td>
<td>.66 (check= stack)</td>
<td>3.7 (check= stack)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASSEMBLY 1.2 (2 byte integers)</td>
<td>.39</td>
<td></td>
<td>4.5 (UNIX)</td>
<td>2.6 (VERSADos)</td>
</tr>
<tr>
<td>Sieve Prime Number Compile and Link</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FORTRAN 2.6 (compile)</td>
<td>6.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.5 (link)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C 6.1 (compile)</td>
<td>3.2</td>
<td></td>
<td>50.8</td>
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<tr>
<td>35.4 (link)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>PASCAL 5.8</td>
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<tr>
<td>ADA 14.5 (compile)</td>
<td>25.0</td>
<td></td>
<td>735.2</td>
<td></td>
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<tr>
<td>16.2 (link)</td>
<td>44.3 (link)</td>
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<td></td>
<td></td>
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<tr>
<td>ASSEMBLY 15.2</td>
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Table I-2 Benchmark Summary
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<tr>
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<th>MicroVAX II</th>
<th>SUN 3/260</th>
<th>IBM PC/AT</th>
<th>MOTOROLA 68010</th>
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### Floating Point Subroutine (no library)

**FORTRAN**

<table>
<thead>
<tr>
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<th>MOTOROLA 68010</th>
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<tbody>
<tr>
<td>Single</td>
<td>3.3</td>
<td>6.2</td>
<td>399.3</td>
<td></td>
</tr>
<tr>
<td>Double</td>
<td>4.2 (d-float)</td>
<td>15.3</td>
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<td></td>
</tr>
<tr>
<td>Quad</td>
<td>462.7</td>
<td></td>
<td></td>
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**C**

<table>
<thead>
<tr>
<th>Type</th>
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<tr>
<td>Single</td>
<td>6.0</td>
<td>18.0</td>
<td>205.7</td>
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<tr>
<td>Double</td>
<td>5.0 (d-float)</td>
<td>15.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quad</td>
<td>not supported</td>
<td></td>
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**Ada**

<table>
<thead>
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<th>MOTOROLA 68010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single</td>
<td>1.8</td>
<td>6.8 (float= M68881)</td>
<td>27.7</td>
<td>300.6</td>
</tr>
<tr>
<td>Double</td>
<td>2.7 (d-float)</td>
<td>10.0</td>
<td></td>
<td>45.5</td>
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<tr>
<td>Quad</td>
<td>553.5</td>
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### Floating Point Library Sine Function

**FORTRAN**

<table>
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<tr>
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<tr>
<td>Single</td>
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<td>7.4</td>
<td>144.9</td>
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</tr>
<tr>
<td>Double</td>
<td>3.3 (d-float)</td>
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<tr>
<td>Quad</td>
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**C**

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<td>Single</td>
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<td>12.2</td>
<td>142.6</td>
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<tr>
<td>Double</td>
<td>3.5 (d-float)</td>
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<tr>
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**Ada**

<table>
<thead>
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<td>8.7</td>
<td>no math lib</td>
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<td>3.3 (d-float)</td>
<td>9.6</td>
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Table I-2 (continued)

Page 6
## Table I-2 (continued)

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<td>6.5 (&quot;C&quot; algorithm)</td>
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<td></td>
<td>11.1 (g-float)</td>
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<td>quad</td>
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<td>6.9 (d-float)</td>
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<td>16.9</td>
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<td>quad</td>
<td>not supported</td>
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</tr>
<tr>
<td>Ada</td>
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<td>13.3 (float= M68881)</td>
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<td>16.3 (float= M68881)</td>
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<td>quad</td>
<td>403.6</td>
<td>398.6 (w/suppress_all)</td>
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* C does not support variable dimensions, a simulated algorithm was used.
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<th>SUN 3/260</th>
<th>IBM PC/AT</th>
<th>MOTOROLA 68010</th>
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<td>4.0</td>
<td>57.0</td>
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<td>blocks)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>10.0</td>
<td>2.0</td>
<td>39.0</td>
<td></td>
</tr>
<tr>
<td>(pre-allocated)</td>
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<td>2.0</td>
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<td>19.0 (VERSAdos)</td>
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<td>(buffered)</td>
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<td></td>
</tr>
<tr>
<td>Ada</td>
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<td>9.7</td>
<td>1.9</td>
<td>13.4</td>
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<td>(pre-allocated &amp; contiguous)</td>
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<td></td>
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<td>12.2</td>
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<td></td>
<td></td>
<td>(buffercount=22)</td>
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<tr>
<td>VAX/RMS</td>
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<td>12.2</td>
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<td>12.2</td>
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<td>(from FORTRAN)</td>
<td></td>
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<td></td>
<td>(block I/O,</td>
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<td></td>
<td></td>
<td></td>
<td>not buffered)</td>
</tr>
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<td>Ada Tasking</td>
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<td>1.7</td>
<td>0.6</td>
<td>1.0</td>
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<td>Rendezvous</td>
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<tr>
<td>Send/Receive</td>
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<td>3.2</td>
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<td>775.7</td>
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<td>16.9</td>
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<td>Send/Receive</td>
<td>50.0</td>
<td>7.2</td>
<td>58.3</td>
<td></td>
</tr>
<tr>
<td>(shared disk)</td>
<td></td>
<td></td>
<td></td>
<td>(buffered)</td>
</tr>
<tr>
<td>(pre-allocated &amp; contiguous)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table I-2 (continued)
Send/Receive 2-Task Data Transfer Benchmark

MicroVAX II Using VMS System Services

<table>
<thead>
<tr>
<th>Common Type</th>
<th>Method</th>
<th>Time (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installed Shareable Common</td>
<td>event flags</td>
<td>8.1</td>
</tr>
<tr>
<td></td>
<td>hiber/wake</td>
<td>8.1</td>
</tr>
<tr>
<td></td>
<td>suspend/resume</td>
<td>8.4</td>
</tr>
<tr>
<td></td>
<td>shared common flags</td>
<td>9.7</td>
</tr>
<tr>
<td></td>
<td>lock/unlock</td>
<td>12.1</td>
</tr>
<tr>
<td>Mapped Global Section Common</td>
<td>hiber/wake</td>
<td>7.5</td>
</tr>
<tr>
<td>Mailbox</td>
<td></td>
<td>13.3</td>
</tr>
<tr>
<td>Shared Disk File</td>
<td>shared common variables</td>
<td>20.7</td>
</tr>
</tbody>
</table>

*.01 second is smallest wait time available

SUN 3/260 Using UNIX System calls

<table>
<thead>
<tr>
<th>Common Type</th>
<th>Method</th>
<th>Time (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shared Memory</td>
<td>signals</td>
<td>60.1</td>
</tr>
<tr>
<td></td>
<td>semaphores</td>
<td>60.1</td>
</tr>
<tr>
<td></td>
<td>shared memory flags</td>
<td>6.2</td>
</tr>
<tr>
<td></td>
<td>shared memory flags (no delay)</td>
<td>50.5</td>
</tr>
</tbody>
</table>

*shorter delays caused loss of synchronization

Table I-2 (continued)
Process Creation Benchmark

MicroVAX II Using VMS System Services,
time in seconds per each process creation

Spawn Subprocess:
with defaults .88
with installed process image .82
with installed process image, no optional .80
data structures

Create Detached Process:
with hiber/wake synch., .07 sec wait .32
with event flag synch., .07 sec wait .32
with termination mailbox, synch. read to .31
mailbox
with termination mailbox, synch. read to .28
mailbox, installed image

Synchronization Benchmark

MicroVAX II
with hiber/wake services 1.2 seconds

Table I-2 (concluded)
E. Source Code Conventions

All source code files generated as a result of this study follow standard naming conventions with regard to file extension (file type) for each system and each language used. To form the source code file name in order to examine the source code, merely append the program name given in the benchmark program and test software descriptions with the appropriate file type. For example, the disk timing benchmark, named "timtes" is appended with the file type, ".ada" to form "timtes.ada", which is the file name of the source code for this benchmark. A table of all file extensions or file types for each of the systems studied, for each language used, is presented in Table I-3, using the benchmark program named "zprime" as an example.
<table>
<thead>
<tr>
<th>COMPUTER</th>
<th>PROGRAM NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motorola</td>
<td></td>
</tr>
<tr>
<td>FORTRAN</td>
<td>zprime.f</td>
</tr>
<tr>
<td>Pascal</td>
<td>zprime.sa</td>
</tr>
<tr>
<td>&quot;C&quot;</td>
<td>zprime.c</td>
</tr>
<tr>
<td>Ada</td>
<td>zprime.text</td>
</tr>
<tr>
<td>Assembler (UNIX)</td>
<td>zprimel.s</td>
</tr>
<tr>
<td>Assembler (VERSAdos)</td>
<td>zprimel.sa</td>
</tr>
<tr>
<td>MicroVAX II</td>
<td></td>
</tr>
<tr>
<td>Ada</td>
<td>zprime.ada</td>
</tr>
<tr>
<td>FORTRAN</td>
<td>zprime.for</td>
</tr>
<tr>
<td>Assembler</td>
<td>zprime.mar</td>
</tr>
<tr>
<td>&quot;C&quot;</td>
<td>zprime.c</td>
</tr>
<tr>
<td>IBM PC AT</td>
<td></td>
</tr>
<tr>
<td>Ada</td>
<td>zprime.ada</td>
</tr>
<tr>
<td>SUN 3/260</td>
<td></td>
</tr>
<tr>
<td>FORTRAN (F77)</td>
<td>zprime.f</td>
</tr>
<tr>
<td>&quot;C&quot;</td>
<td>zprime.c</td>
</tr>
<tr>
<td>Pascal</td>
<td>zprime.p</td>
</tr>
<tr>
<td>Assembler</td>
<td>zprime.s</td>
</tr>
<tr>
<td>Ada</td>
<td>zprime.ada</td>
</tr>
</tbody>
</table>

Table I-3 Source Code Conventions
F. Conclusions

1. Ada

The performance of the Ada compilers as used with the operating systems and computers included in the study have proven to be on a level with the other high-level languages to which they were compared, with the exception of the TeleSoft Ada compilers used on the Motorola System V/68 UNIX operating system. The TeleSoft compilers (1.5 and 2.1) were preliminary versions whose performance was so poor that they were useless as software development tools, and should now be considered obsolete. Among the remaining Ada compilers tested, the DEC VAX/VMS compiler is clearly superior. VAX/VMS Ada is very well integrated into the VMS operating system environment, having complete access to the rich set of VMS system services and system libraries. No "bugs" or anomalies were found with the VAX/VMS Ada compiler. In addition, the documentation for VAX/VMS Ada is excellent, consisting of several volumes covering the complete Ada software development system. Even DEC's version of the Ada Language Reference Manual has been enhanced with VAX/VMS-specific information.

The Alsys Ada compiler was also very good, although not quite as mature as the DEC VAX/VMS product. Some errors were found with the version of the compiler that Alsys delivered for the SUN workstation. Alsys, Inc. claims that these problems are supposed to be corrected in later releases. The problem areas are discussed in Section IV of this report. It should also be noted that version 3.2 of the Alsys Ada compiler as delivered for the PC/AT finally included a math library, but this library is a user supplied library and is not supported by Alsys, Inc.
During the course of the study, the Ada language itself has proven to be a capable language for real-time and multi-tasking applications, frequently obviating the need or supplanting the requirement for direct calls to operating system services. This is especially true for UNIX or UNIX derived time-sharing operating systems, or for operating systems with no direct capability for real-time or multi-tasking functions, such as PC-DOS. In fact, the send/receive benchmark for the MicroVAX showed that in some cases, execution time for Ada tasking and rendezvous is faster than equivalent methods using operating system services. There were, however, some problem areas uncovered with the use of Ada for these applications. For example, the capability for one task to suspend and resume the execution of another is lacking in Ada. This was demonstrated with the multi-task time-shared execution test program (task_exec) where either a complex time-checking subprogram "workaround" had to be used, or a time-slice option relied on, if available. For VAX/VMS, operating system services exist to perform this function as an alternative, while on a UNIX system, they do not. Thus, where a real-time application requires scheduling of tasks, Ada's current inability to provide task control of other tasks' execution would be a limitation to be considered.

2. Operating Systems

Of the operating systems considered in this study, the most applicable by far for real-time, multi-tasking applications is MicroVMS for the DEC MicroVAX II. VAX/VMS (or MicroVMS, which is actually the same operating systems as VMS for the larger VAX
computer systems, only tailored specifically for the MicroVAX) is DEC's standard proprietary operating system for the VAX series of computers.

An important measure by which to judge an operating system's suitability for real-time or multi-tasking use is its programming interface, as opposed to its user interface, (which is a greater factor in determining how "friendly" it is for the human user to interact with the system). The programming interface for VAX/VMS consists of an extensive repertoire of system services, standard libraries, and optional routines all callable from any of the standard VAX/VMS programming languages. The system services offer a variety of means for a VMS process to communicate with another process, control another processes' execution, control its own execution, exercise direct control over I/O devices, control system resources, and utilize system utilities.

The SUN workstation's UNIX operating system also has a considerable number of operating system services (or "system calls" as the UNIX documentation refers to them), and an extensive library. The system calls do not, however, have as extensive a process communication and control capability as VAX/VMS. For example, there is no direct SUN UNIX call for a process to suspend or resume the execution of another process. SUN UNIX system calls and libraries are a combination of those from AT&T UNIX System V and Berkeley UNIX 4.2 BSD and as such do not incorporate any real-time extensions as offered by vendors of "real-time UNIX" systems. A more complete description of the UNIX operating system capabilities can be found in the study report for Phase I of this study, titled "Space Station Operating System Study Phase I Report".
II. BENCHMARK SOFTWARE

The following subsections describe the benchmark programs.

A. Prime Number Benchmark

Typically, the first benchmark program to be applied to any system under test was the "Sieve of Eratosthenes" prime number calculation program derived from Byte magazine, September, 1981. This program is based on using only repetitive addition for its algorithm, no multiplication or division, and tests a system's high-level language capability as well as the operating system and processor performance. This program (name: zprime for all except Motorola UNIX assembly: zprimel.s, and Motorola VERSAdos assembly: zprimel.sa) was coded and executed for the widest variety of languages of any of the benchmarks. It was also used to measure compilation and linking (or binding) speed for each case tested. Both the execution and compile/link timing data is presented in the summary section of this document. A highly commented FORTRAN version of this benchmark is presented in the source listing of Figure II-1 to explain the algorithms used in the program. Although this version is correct, it was not used to obtain timing data and is included here only for documentation.

B. Floating Point Benchmarks

The floating point benchmarks were derived from floating point test programs published in DEC Professional magazine, September 1986 and December 1986, and serve the purpose of testing the floating-point capabilities of the system. These benchmarks consist of two programs. One, (fpatestsub) to repeatedly perform floating point
PROGRAM ZPRIME

C zprime.for  Eratosthenes Sieve Prime Number Program in FORTRAN.
C  Compute all primes from 3 to 16K

LOGICAL FLAGS( 8191 )  ! Array representing odd numbers starting
                      ! with the number 3 and ending with
                      ! the number 16383.
INTEGER I             ! Index for flags array.
INTEGER IPRIME        ! Used to store the actual value of a prime.
INTEGER K             ! Index in flags array for odd multiples
                      ! of a prime.
INTEGER ICNT          ! Total number of primes.
INTEGER ITER          ! Number of iterations of the program.

WRITE( 6,900 )        ! Write format for iterations
900 FORMAT( ' 10 iterations' )  \ Repeat the calculations 10 times so we can
\ measure the time.

C
C DO 92 ITER = 1,10
C ICNT = 0
C
C SET COUNT OF NUMBER OF PRIMES TO ZERO.
C
C SET 8191-ELEMENT ARRAY OF FLAGS (REPRESENTING
C ALL ODD NUMBERS STARTING WITH THE NUMBER 3 AND
C GOING THRU 16383) TO ALL TRUE (TRUE MEANING THE
C NUMBER IS A PRIME). WHEN FINISHED WITH SIEVE,
C ALL NON-PRIME ODD NUMBERS WILL HAVE THEIR FLAGS
C SET TO FALSE. WE MUST START WITH THE NUMBER 3
C BECAUSE WE KNOW THAT ONLY AFTER 2, ALL PRIMES
C ARE ODD NUMBERS!

C DO 10 I = 1,8191
10 FLAGS( I ) = .TRUE.
Loop through flags array for each odd number. The prime's index is 'i'. (Index 1 is for the number '3'.)

```
do 91 i = 1, 8191    
   if ( flags(i) .eq. .false. ) go to 91
```

Test for prime (always true for first time).

```
   iprime = i + i + 1
```

Yes, we have a prime, now do the algorithm that converts the prime's index to the actual value of the prime (for a 1-relative flag array, a 0-relative flag array uses: iprime=i+i+3).

```
k = i + iprime
```

Get index of 1st odd multiple of the prime (3 times the prime's index plus 1 for a 1-relative flag array, 3 times the prime's index plus 3 for a 0-relative flag array).

```
20   if( k .gt. 8191 ) go to 90
   flags( k ) = .false.
   k = k + iprime
   go to 20
```

Loop to set all odd multiples of iprime to false go to 90

```
90   icnt = icnt + 1
```

Increment count of number of primes found.

```
   type *,icnt,iprime
   91   continue
   92   continue
```

This is where iprime should be written out if we want to see what the primes are.

```
   write( 6,901 ) icnt
   901   format( 1x,i6,' primes')
   end
```
calculations using division and addition and another (speed_test) to repeatedly perform calculations using a sine subroutine from a math library (the programs were named fpasub and speed_te, respectively, on the PC/AT). Both of these benchmarks were performed using all floating point formats available for each system tested. For the MicroVAX, this consisted of single-precision (4-byte) format, two double-precision (8-byte) formats, and quad-precision (16-byte) format.

It should be noted that an earlier version of the "fpatestsub" floating point benchmark did not use repetitive calls of a subroutine to perform the calculations. When this program was applied to the MicroVAX II, the language compilers used such extensive optimization techniques that the loops and unused calculation results were "optimized away".

C. Matrix Manipulation Benchmark

The purpose of this benchmark (name: run5) was to test both single-precision and double-precision floating point array computations and addressing, and nested iteration constructs. This benchmark factors a square matrix into a lower and upper triangular matrix with a Gaussian elimination technique. The actual lower and upper matrix decomposition algorithm is contained in a subprogram named "ludecm". This subprogram, along with a data output subprogram named "prnary", uses a variable-sized square matrix (2-dimensional array) with the array dimensions passed to the subprogram as arguments. This technique is not supported in the "C" language so an equivalent method of calculating and using array element addresses from
subscripts was used for the "C" version of this benchmark. Results of benchmark runs showed superior performance from the "C" version, so a FORTRAN version was implemented (tstrun5.for) that used the same algorithm as the "C" language benchmark. The improved performance, as shown in the benchmark summary, indicates that this addressing algorithm is quicker in execution than using a double-subscripted array. It should also be noted that the "C" double precision version executes faster than the single precision version because "C" always internally uses double precision, thus the single precision version incurs additional time performing single-to-double and double-to-single conversions.

D. Disk Write Timing Benchmark

A test of effective I/O throughput to disk was implemented to determine the time required to write a series of large records to disk, as would be typical in a real-time data acquisition application. The timing test program (name: timtes) was designed to write 300 records of 2,048 16-bit words (4,096 bytes) per record to the disk. For the Motorola TeleSoft Ada and Motorola FORTRAN benchmark, UNIX disk limitations resulted in a maximum of only 256 records that could be written. For these cases, the time recorded in the benchmark summary was extrapolated from 250 record runs to provide an equivalent time for 300 records. In addition, a compiler error in release 3.0 of Alsys Ada for the SUN 3/260 (see a discussion of compiler problems in Section IV of this report) limited the maximum record size to only 2,047 16-bit words per record for that version of the benchmark. Therefore, times recorded for SUN Alsys Ada are based on 2,047 word records.
In addition to this benchmark series, a MicroVAX-specific disk timing analysis using VAX/VMS Record Management Services (RMS) options was also performed. This was accomplished by developing two additional versions of the disk write timing benchmark utilizing RMS system services. The first version (named timtesblok) performed block mode I/O directly to a disk file with no intermediate buffering, while the second version (named timtesblokput) used RMS "put" calls for buffered record mode I/O with large intermediate buffers. An RMS buffer count of 22 was used for this benchmark (VMS quota limits prevented greater buffering). Both versions use the "useropen" subroutine method of accessing the required RMS data structures.

E. Ada Tasking

1. Ada Rendezvous Response Benchmark

This benchmark, (name: timetask1), is an Ada two-task response time test for the purpose of determining the overhead required by the system for a rendezvous. A rendezvous is used to enable the synchronization of the two tasks in order to give an idea of how fast a task can respond to being started by another task. The design flow chart for this benchmark is presented in Figure II-2. This particular benchmark performs the rendezvous operation 1,000 times, so that the execution time listed in the benchmark summary in Section I can be divided by 1,000 to obtain the time for a single rendezvous.

2. Ada Two-Task Data Transfer Benchmark (Send/Receive)

This benchmark (name: adasend) is a send/receive data transfer test that was designed to study the throughput available in a synchronized
Figure II-2 Two-Task Response Time Flowchart
multi-task environment wherein one task generates data and transfers it in memory to another task which then processes the data. The data quantity was based on previous disk transfer tests of 300 transfers of 2,048 16-bit words (4,096 bytes) each. The design flow chart for this benchmark is presented in Figure II-3. This test was used as a comparison with similar versions of the benchmark written in other languages and using system service calls to perform similar synchronized data transfer between tasks (or processes). See Section II.F.1 for a description of these system service versions. This allowed a direct comparison of execution overhead of Ada tasking services versus that of operating system services.

3. Ada Two-Task Data Transfer via Shared Disk File Benchmark

This benchmark (name: adasend_disk) is based on the two task data transfer (send/receive) benchmark but it transfers the data via a shared disk file. This benchmark allows simultaneous, asynchronous access to a disk file by the two tasks, each of which control reading and writing with shared variables, thus testing the capabilities for sharing variables as well as sharing disk files.

F. System Services

1. Send/Receive

In order to analyze the capability of an operating system to provide multiple tasks with the means of transferring data and synchronizing their access to that data, a send/receive two-task data transfer benchmark utilizing system services was developed. This benchmark is functionally identical to the Ada two-task data transfer benchmark described under Ada tasking tests, except that separate operating
Figure II-3 Multi-task "Send/Receive" Data Transfer Design Flow Chart
system "processes" are used in place of Ada "tasks". The benchmark is designed to cause a "send" process to transfer 300 data buffers of 2,048 16-bit words each to a "receive" process, which checks the data to verify that no data was lost, insuring that synchronization was maintained. The flowchart for this benchmark is the same as for the Ada version presented in Figure II-3. For the MicroVAX II, several versions of the benchmark were developed, each testing a different method of synchronizing the two processes or testing a different method of transferring the data from one process to another. These various versions were written in VAX FORTRAN to allow easiest access to the system services and are named such that names begin with "forsend" or "forrecv" for the send and receive processes, respectively.

As a comparison, some versions were also developed for the SUN 3/260 workstation. These versions were written in "C" since that language is the "native" language of the SUN's UNIX operating system. They are named such that names begin with "csend" or "crecv" for the send and receive processes, respectively.

2. Process Creation

As part of the analysis of operating system services, a study of process (or "task") creation response timing was performed by implementing a process creation benchmark. For the MicroVAX II, versions of this benchmark were developed for both subprocesses and detached processes to determine the time required to create a process. These programs were tested with various options such as with/without error checking, with installed images, using process termination mailboxes, etc., in an attempt to determine the minimum time required.
The benchmark consists of a driver process (names beginning with "rspns1") that creates a second process (named "rspns2") that does nothing but exit. The driver process waits while the 2nd process is being created, then resumes control when the 2nd process terminates. This action is repeated for 100 iterations to obtain a representative time for a single process creation cycle. As can be seen from the benchmark summary, the results of this benchmark series indicate that the version most simple to program, but slowest executing, is creation of a subprocess using the LIB$SPAWN call. The fastest executing version, but more complex to program, was creation of a detached process with the SYS$CREPRC call using a termination mailbox, where the executable image for the detached process was made an "installed" image with the Install utility. Analysis was also performed for process images defined as foreign commands but this had no affect on timing results.

3. Synchronization

Process synchronization techniques and timing results can be seen in the send/receive benchmarks described previously. However, as a direct comparison to the Ada rendezvous response time benchmark for the MicroVAX II, a program was implemented that performed a system service equivalent of the Ada rendezvous response benchmark. The benchmark used the SYS$HIBER and SYS$WAKE service calls to accomplish the synchronization, since these services were among the most time-efficient, based on the results of the send/receive tests. It consisted of two VMS processes (named timetask1.for and timetask2.for) wherein the first process "wakes" the second and
"hibernates", then the 2nd process "wakes" the first and "hibernates". This action is then repeated for 1,000 iterations to provide a means of timing the synchronization. As can be seen from the benchmark data, this method was slightly faster than the Ada rendezvous time, .0012 seconds versus .0017 seconds (per synchronization cycle).
III. TEST PROGRAMS

A. Multi-Process Timing Test
The purpose of this test was to verify correct process scheduling when running multiple copies of a program. This was performed by creating a "parent-child" process (name: proctim) wherein a "parent" program created and initiated multiple copies of a "child" program. Each of the "child" programs then ran independently and periodically displayed a sequence number which identified each process as it executed. By observing this sequence number over a period of time, correct process scheduling could be verified. This test was implemented using Ada tasking for all Ada compilers, "C" on the SUN using UNIX system calls, and two versions using VAX/VMS system calls: one for subprocesses (named proctim_sub) and one for detached processes (named proctim_det). All tests showed correct execution with no time skew.

B. Ada Multi-Tasking Scenario
The purpose of this test (name: task1_and_task2) was to demonstrate multi-tasking concurrency via the concurrent execution of two Ada tasks. The first task starts the second task, then each task runs independently and asychronously while periodically writing a message to the terminal screen. A screen copy of the output from this program as executed on the MicroVAX II is shown in Figure III-1.
Ada Multi-tasking Scenario (No synchronization)

$ ada task1_and_task2.ada
$ acs link task1
%ACS-I-CL_LINKING, Invoking the VAX/VMS Linker
$ run task1
  task2 starting time (in seconds from midnight) = 50451.5600
  task2 running, time (in seconds from midnight) = 50451.6600
  task2 running, time (in seconds from midnight) = 50451.7400
  task2 running, time (in seconds from midnight) = 50451.8100
  task1 starting time (in seconds from midnight) = 50451.8900
  task1 running, time (in seconds from midnight) = 50451.9800
  task1 running, time (in seconds from midnight) = 50452.0500
  task1 running, time (in seconds from midnight) = 50452.2000
  task1 running, time (in seconds from midnight) = 50452.3600

Figure III-1  Page 29
C. VAX High-Level Language Access to System Services

This test was used to demonstrate the VMS operating system's capability for high-level language access to the system services. To accomplish this, a test program implementing the Queued Input/Output system service (QIO) was implemented on the MicroVAX II. This program was written in VAX Ada (ttqio.ada), VAX FORTRAN (ttqio.for), and in "C" (ttqio.c). The Ada program used the VAX Ada STARLET package which is provided for access to system services from Ada.

The system services necessary for access to an operating system's I/O devices directly through its I/O drivers are an important consideration for real-time applications and this test successfully demonstrated this capability. The design flow chart for this benchmark is presented in Figure III-2. The screen copy of the output from the Ada and "C" versions is also presented in Figure III-2.

D. VAX Alarm Test

The VAX Alarm Test was a series of programs developed to test the MicroVAX VMS timer system calls. Two basic versions of this alarm test program were implemented. One version (testalarm) causes a system event flag to be set after a specified time period. The other version (testalarm_ast) causes an AST routine to be executed after a specified time period. This version was implemented in FORTRAN (testalarm_ast.for), in "C" (testalarm_ast.c), and in Ada (testalarm_ast.ada). The implementations of the "AST" version verified that AST routines could be utilized from Ada and "C" programs as well as from FORTRAN.
VAX qio system service access

assign VAX i/o channel to terminal with assign system service

↓

output status message

↓

set up parameters for qio system service

↓

use qio system service to output buffer of characters - "this is a test" to terminal screen

↓

output status message

Command: en

# $USER1:CHECKTTOIO.ADA:6465 lines

| use ttqio
| use link ttqio sysmsg
| VAX-L-CL_LINKING, Invoking the VAX/VMS Linker

assign status:
| VAX-L-NORMAL, normal successful completion

"this is a test"

qio status:
| SYSTEM-S-NORMAL, normal successful completion

"this is a test"

qio status:
| VAX-L-NORMAL, normal successful completion

Figure III-2 (1 of 2)
assign status: SYSTEM-S-NORMAL, normal successful completion

This is a test

assign status: SYSTEM-S-NORMAL, normal successful completion

assign status: NONAME-S-NORMAL, normal successful completion

Figure III-2 (2 of 2)
E. Ada "delay" Test

The purpose of this test was to simulate periodic processing at a fixed time interval in Ada. This was accomplished by implementing a program (name: adadelay) to use the Ada "delay" statement and the "calendar" package. Results of this test showed accurate timing for the MicroVAX system, but inaccurate timing for the Motorola VM03 system. This was determined to be because the TeleSoft Ada compiler does not use the system clock for the delay, but instead uses simulated timing via software. The Alsys Ada compilers also produced programs that executed with accurate timing.

F. Ada Task Order Test

The Ada Task Order test was used to determine the order of task activation when multiple task declarations were made in Ada. This test was devised such that four independent tasks were declared in an Ada main program (name: task_order), then each task would identify itself on the operator's terminal when it was activated. Results from this test showed that for all Ada compilers tested except VAX Ada, the tasks were activated in the order declared. For the MicroVAX, tasks were activated in the reverse order of their declaration.

G. Multi-Task Time-shared Execution Test

This test was developed to determine if there were deficiencies in a real-time Ada application where one task must control the execution
of another task. This test (name: task_exec, for the PC/AT: tsk_exec) was devised where a master task attempts to schedule execution of 3 sub-tasks such that each sub-task executes for a specified time interval (5 seconds in the test case). The master task accomplishes this with a reentrant "check" subprogram for checking execution time. This test was run on the MicroVAX II, the SUN 3/260, and the IBM PC/AT. Results of this test for the MicroVAX showed an actual allocation of 5 seconds of execution time for each task, using a 5 second delay in the check subprogram. For the PC/AT, execution time was 5.0 to 5.1 seconds, while for the SUN, execution time was 5.0 to 5.2 seconds. In addition, some anomalies were encountered during the execution of this test for the SUN. These were: 1) Task 2 and Task 3 of the 3-task set would terminate if screen output was held; 2) the test would only run in non-window mode, it would not run with windows (SUNTOOLS) active.

Also, as a comparison, a version was developed for the PC/AT using the Alsys Ada compiler's "time-slice" option. This version (name: tstslicex) resulted in an execution allocation of varying amounts from 5.6 seconds to 13.9 seconds for the test case timed. Since the time-slice feature was not available for SUN Alsys Ada, this test could not be run on that system.
IV. SYSTEM AND COMPILER ANALYSIS

A. Ada Terminal Input Analysis

Some problems developing Ada programs that performed input from the terminal keyboard led to an investigation of the details of Ada terminal input on the MicroVAX and SUN systems. These problems occurred when using the various forms of Ada GET and GET_LINE procedures in certain combinations. The Ada Language Reference Manual and other reference material contain little information on this subject, therefore a series of experiments were performed to determine the behavior of these procedures for each of the data types. It was found that using GET for numeric (integer, float, etc.) or enumerated types returned the valid input, but left the line terminator as the next character in the "read" buffer, so that if a GET_LINE of a string followed, the terminator caused the input to immediately complete with no characters read. It is necessary to use a SKIP_LINE call after the GET to bypass the line terminator. The same problem occurs if invalid input is entered. The invalid input characters remain in the "read" buffer after the exception generated by the invalid input, and must be bypassed with a SKIP_LINE call to prevent re-reading this invalid input during a retry attempt. An example of the lack of information in this area is the fact that Example 14.7 of the Ada Language Reference Manual has such an error in its exception handling code. This example neglects to include a SKIP_LINE call after a data error. If this example is implemented as written, an endless loop will occur after a data error generated by the input of leading non-alpha characters. A corrected version of this example is shown in Figure IV-1.
-- dialogue.ada  -- This is the example program given in 14.7 of the Ada LRM.

with text_io; use text_io;
procedure dialogue is
  type color is (white, red, orange, yellow, green, blue, brown);
  package color_io is new enumeration_io(enum => color);
  package number_io is new integer_io(integer);
  use color_io, number_io;
  inventory : array (color) of integer := (20, 17, 43, 10, 28, 173, 87);
  choice : color;

  procedure enter_color (selection : out color) is
    begin
      loop
        begin
          put("color selected: "); -- prompts user
          get (selection); -- accepts color typed, or
          return; -- raises exception
        exception
          when data_error =>
            put("Invalid color, try again. ");
            new_line(2);
        end;
      end loop; -- completes execution of the block statement
    end enter_color;

loop
  enter_color(choice); -- user types color and new line
  set_col(5); put(choice); put(" items available:");
  set_col(40); put(inventory(choice)); -- default width is 5
  new_line;
end loop;
end dialogue;

-- Note: The following line must be added to the example given in 14.7 of
-- the Ada LRM in order to correctly handle data errors generated by
-- the input of leading non-alpha characters.

skip_line;

-- completes execution of the block statement
-- repeats the block statement until color accepted
begin
  number_io.default_width := 5;
  loop
    enter_color(choice); -- user types color and new line
    set_col(5); put(choice); put(" items available:");
    set_col(40); put(inventory(choice)); -- default width is 5
    new_line;
  end loop;
end dialogue;
B. Foreign Routine Capability

The ability to call "foreign" routines from within MicroVAX Ada and to call Ada routines from main programs in other VAX languages was demonstrated by implementing VAX software to call both a FORTRAN subroutine (innerprod1.for) and a FORTRAN function (innerprod.for) from an Ada main program (main1.ada and main.ada respectively), and to call Ada functions from FORTRAN main programs (formain.for). Also implemented was an Ada main program (main2.ada) that calls a FORTRAN subroutine (sysmsg.for) which in turn calls a VAX system routine. A VAX terminal screen copy of the results of the above is shown in Figure IV-2.

The ability to call foreign routines from within Alsys Ada on the SUN was demonstrated by implementing test cases similar to those used on the DEC MicroVAX. The following cases were demonstrated:

- Calling a FORTRAN subroutine (innerprod1.f) from an Ada procedure (main1.ada).
- Calling a FORTRAN function (innerprod.f) from an Ada procedure (main2.ada).
- Calling a UNIX system routine (fork) from an Ada procedure (adafork.ada).

It should be noted that to accomplish the above mentioned cases, special Alsys Ada "binder" options were required in addition to the Ada source code pragmas. These binder options are documented in the appropriate source code listings.
CALLING FORTRAN SUBROUTINE FROM ADA

$ ada mainl
$ for innerprod
$ acs link mainl innerprod
%ACS-I-CL_LINKING, Invoking the VAX/VMS Linker
$ run mainl
returned value = 1.00000E+02

CALLING FORTRAN FUNCTION FROM ADA

$ ada main
$ for innerprod
$ acs link main innerprod
%ACS-I-CL_LINKING, Invoking the VAX/VMS Linker
$ run main
returned value = 1.00000E+02

CALLING ADA SUBROUTINE FROM FORTRAN

$ for formain
$ ada nfind
$ acs link/nomain nfind formain
%ACS-I-CL_LINKING, Invoking the VAX/VMS Linker
$ run nfind
5

$ link formain, [horne.adalib]nfind
run formain
5

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Figure IV-2 (1 of 2)

Page 38
Example of Using Ada to Call Fortran Subroutine That Calls a System Service

$ ada main2
$ for sysmsg
$ acs link main2 sysmsg
ZACS-I-CL_LINKING, Invoking the VAX/VMS Linker
$ run main2
  Please enter system error number: 10820

%SYSTEM-E-EXENQLM, exceeded enqueue quota
$
$ run main2
  Please enter system error number: -1

%NONAME-?-NOMSG, Message number FFFFFFFF
$
$ run main2
  Please enter system error number: 1

%SYSTEM-S-NORMAL, normal successful completion
$
$

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C. I/O Loading Analysis

The effects of the "priority" pragma and the "time slice" pragma on the order and frequency of the I/O from I/O-bound Ada tasks was studied. This was implemented by having an Ada main program (char.ada) declare two separate tasks (tasks pra and prb) which would each output a single character to the terminal screen. For a proper demonstration of the test, these two tasks need to alternate execution. This test was implemented on the MicroVAX II, the SUN 3/260 and the IBM PC/AT. The test was first run without any pragmas, in which case, the first task to be activated would output to the screen continuously without ever allowing the other task to run. This result was the same on all three systems. Then the test was run with the "priority" pragma. Again, only the first task to be activated would run, but in this case, the "priority" pragma allows the programmer to select the task to be activated first, i.e., the task with the higher priority would be activated first. This result was also the same on all systems. Finally the test was run with the "time slice" pragma. This allowed the output to the terminal to be alternated. On the PC/AT the two tasks alternated execution approximately in accordance to the time slice value. When run on the MicroVAX, the execution was alternated on a byte by byte basis, i.e., the first task would output one character, then the other task would output one character, then the first task would output again, etc. Since the "time slice" pragma is not yet implemented on the SUN 3/260 system, this option could not be tested on that system.
D. Multiple Process Loading Analysis

An analysis of the effects of loading and of different process priority on compute-bound processes for the DEC MicroVAX II and the SUN 3/260 was performed. This was accomplished by timing the execution of the Ada prime number benchmark while varying the number of computational processes running in the "background". The series was repeated with the benchmark running at a high operating system priority level. Graphs of the loading degradation are shown in Figures IV-3 and IV-4 for the MicroVAX and the SUN, respectively. This analysis was performed on the SUN both with and without the SUN Window environment present. There was no detectable difference in the time.

Also, an investigation of the loading effects of the SUN window environment using the SUN Ada 2-task data transfer benchmark was performed. No degradation was observed for 1, 2 or 3 windows (with no processes active in the window).

E. Large Array Analysis

This analysis studied the MicroVMS operating systems support of very large data arrays, both for size limitations and for loading degradation, using Ada and FORTRAN. A graphic representation of system loading (execution time) versus array size was generated that showed points of discontinuity where loading increased dramatically for a small increase in array size. This data is presented in Figures IV-5 and IV-6. The large size of the executable image file for the Ada version of this test was also noted.
MUltiple Process Loading on MicroVAX
(Computational Processes)

Benchmark Times, seconds

default VMS priority of 4

VMS priority of 10

Number of "Background" Processes

Benchmark used was Ada prime number program with suppress_all pragma.

"Background" processes were FORTRAN versions of prime number program with increased iteration count.

Figure IV-3
Page 42
MULTIPLE PROCESS LOADING ON SUN 3/260
(computational processes)

Benchmark Times, seconds

Number of "Background" Processes

Notes:

Benchmark used was Ada prime number program (Alsys Ada) with "checks=stack" option.

"Background" processes were FORTRAN versions of prime number program with increased iteration count.

This test was run without the SUN Window environment.
Note: 512 K array resulted in 2055 block executable image file for Ada vs. 5 blocks for FORTRAN.
F. Ada Multiple Periodic Tasks with Calculation Task

To resolve questions concerning CPU usage during multi-tasking, an Ada test program (procload.ada) consisting of multiple periodic tasks interrupted by a calculation-intensive task was implemented. This program (procload.ada) was constructed by inserting the code of the prime number benchmark program (zprime.ada) into the body of the multiple process timing test program (proctim.ada). The purpose of this analysis was to determine if the time-slice mechanism would allow the calculations of the prime number program to be performed during the delays (idle time) of the multiple periodic tasks program. The results of this analysis are presented as follows:

Ada Test Scenario - Multiple Periodic Tasks with Calculation Task

Alsys Ada - PC/AT
- with timeslice=10 msec - 322 sec.
- without timeslice - 507 sec., tasks out of order after calculation task runs
- calculation task alone - 213 sec.

MicroVAX Ada
- with timeslice=10 msec - 322 sec.
- without timeslice - 355 sec., tasks stayed in order after calculation task runs
- calculation task alone - 55 sec.

This shows the need for a time-slice scheduling mechanism for all Ada compilation systems.
G. VAX/VMS Ada Analysis

While performing the benchmark study, it was found that the VMS Ada compiler defaults to the g_float format when performing calculations involving 64-bit (long_float) real numbers. However, if this is changed with "pragma long_float (d_float)", the system then uses the d_float format from that point on until it is changed back with "pragma long_float (g_float)". It should also be noted that when using the g_float format in conjunction with the math library this format is implemented with software rather than hardware and therefore executes much more slowly. Also, it was discovered that d_float is incompatible with the VAX predefined instantiation of the long_float math library (long_float_math_lib). This predefined instantiation of the library is expecting g_float, therefore, in order to use d_float a user instantiation of the library must be made.

While performing the I/O loading analysis (see Section IV.C) it was noted that the "priority" pragma and the "time slice" pragma exhibited behavior that was not expected. The VAX allows priority values in the range from 0 to 15 with a default priority value of 7. The data gathered during the I/O loading analysis (char.ads) indicates that although the VAX allows a priority value range of 0-15, the priority value chosen has no bearing on the actual scheduling of the tasks. It appears that any priority values above 7 (8-15) or any values below 7 (0-6) are treated as equal values, i.e., a priority of 14 is the same as a priority of 8 or a priority
of 6 is the same as a priority of 0. A task with the default priority of 7 will be scheduled before any task with any priority less than 7 and after any task with any priority greater than 7.

It was observed that the VAX time-slice pragma apparently causes round robin scheduling to occur once the time specified in the pragma has elapsed. This observation was based on the execution of char.ada which has two Ada tasks, each of which have an infinite loop in which a single character is output to the terminal screen. Without any pragmas, the first task to run will run continuously without allowing the second task to execute. With the time-slice pragma set to 5 seconds, the first task to execute will run for approximately 5 seconds, then the two tasks will alternate execution with each task transmitting a single character to the terminal screen. It would seem that each task should run for 5 seconds and then release the CPU to the other task, instead of the much faster scheduling behavior actually observed.

H. Alsys Ada (SUN) Analysis

During the performance of the benchmark study for the SUN workstation, two Alsys Ada compiler anomalies were encountered. These two problems were observed while implementing the disk write timing benchmark (timtes) and the matrix manipulation benchmark (run5). The error that occurred with the disk write timing benchmark was that the maximum record size that could be successfully compiled was only 2,047 16-bit words. Any larger record size (this benchmark was designed for 2048-word records) would generate a fatal compiler error. For the matrix manipulation benchmark, a run-time error would
be generated when attempting to execute the long_float version of the program. Test cases with minimum code were developed to demonstrate the two anomalies, and these two test cases were presented to Alsys, Inc. who acknowledged that they were indeed compiler errors. According to Alsys, both are to be corrected in later compiler releases. The test programs to demonstrate the errors that occurred in the disk write timing benchmark and the matrix manipulation benchmark are presented in Figures IV-7 and IV-8, respectively. (The program names are test1.ada and test2.ada, respectively). Figure IV-9 presents an intermediate step that is a "work around" to the problem that occurred in the matrix manipulation benchmark.

In addition to the analysis of the compiler anomalies for the SUN Alsys Ada compiler, an analysis of several compiler/binder options were performed on a representative set of the benchmark programs for the SUN. Table IV-1 presents the results of this analysis.

It should be noted that the Alsys Ada compiler for the SUN does not provide any form of a time-slice mechanism.

I. Alsys Ada (PC/AT) Analysis

During the course of the study, release 3.2 of the Alsys Ada compiler for the PC/AT was received and analysis performed. This version (3.2) of the compiler for the IBM PC/AT contains a math library, but this math library is user supplied and is not supported by Alsys Inc. To access this library the user must perform the following steps:
-- test1 ada - SUN 3/260 version. ALSYS Ada compiler. Demonstrates the
  compiler error found in timtes.ada.

with sequential_io;

procedure test1 is

  type buffer is array( integer range 1..2048 ) of integer;

  package buffer_io is new sequential_io( buffer );
  use buffer_io;

  data_file : buffer_io.file_type;

begin

  create( file => data_file, -- create a file.
            name => "timetest.dat" );

end test1;
-- test2.ada -- SUN 3/260 version. ALSYS Ada compiler. Demonstrates the
-- "PROGRAM_ERROR" found in run5.ada.

procedure test2 is
  type buf is array( integer range 1..2, integer range 1..2 ) of long_float;
  b : buf := (( 1.0, 1.0 ),
              ( 2.0, 3.0 ));
  mult : long_float;
  diag : integer := 1;
  row : integer := 2;
begin  -- beginning of test2.
  mult := b( diag, row ) / b( diag, diag );
  end test2;  -- end of test2.
test3.ada -- SUN 3/260 version. ALSYS Ada compiler. Demonstrates the "work-around" for the "PROGRAM_ERROR" found in run5.ada.

procedure test3 is

  type buf is array( integer range 1..2, integer range 1..2 ) of long_float;

  b : buf := (( 1.0, 1.0 ),
             ( 2.0, 3.0 ));

  mult : long_float;
  diag : integer := 1;
  row : integer := 2;
  temp1 : long_float;
  temp2 : long_float;

begin
  -- beginning of test3.

  temp1 := b( diag, row );
  temp2 := b( diag, diag );
  mult := temp1 / temp2;

end test3;

  -- end of test3.
### SUN Alsys Ada benchmark analysis (Execution Time in Seconds)

<table>
<thead>
<tr>
<th>Benchmark</th>
<th>All Defaults</th>
<th>68881</th>
<th>Improve =&gt; extensive</th>
<th>checks =&gt; stack w/68881</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sieve Prime Number</td>
<td>.89</td>
<td>-</td>
<td>.84</td>
<td>.66</td>
</tr>
<tr>
<td>Floating point, sine function</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>float</td>
<td>4.4</td>
<td>4.0</td>
<td>4.0</td>
<td>3.9</td>
</tr>
<tr>
<td>long-float</td>
<td>9.6</td>
<td>7.0</td>
<td>9.4</td>
<td>8.8</td>
</tr>
<tr>
<td>Floating point, subroutine (no math lib.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>float</td>
<td>6.8</td>
<td>6.8</td>
<td>6.8</td>
<td>7.4</td>
</tr>
<tr>
<td>long-float</td>
<td>10.0</td>
<td>8.0</td>
<td>10.0</td>
<td>10.8</td>
</tr>
<tr>
<td>Matrix</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>float</td>
<td>13.9</td>
<td>13.3</td>
<td>12.5</td>
<td>12.3</td>
</tr>
<tr>
<td>long-float</td>
<td>15.8</td>
<td>16.3</td>
<td>14.4</td>
<td>13.9</td>
</tr>
<tr>
<td>2-task data transfer</td>
<td>3.2</td>
<td>-</td>
<td>2.7</td>
<td>2.6</td>
</tr>
</tbody>
</table>

Table IV-1

Page 53
1. copy the math library package specification
   (mathl.ads) and the math library package body
   (mathl.adb) into the user directory. (note: these
   reside in \alsys\math)

2. compile both of the above into the user library,
   and

3. use the "bind" option
   interface=(search=\alsys\math\math.lib)
   when building the executable.

Additional study of the PC/AT Alsys Ada compiler consisted of an
analysis of several compiler/binder options that were performed on a
representative set of the benchmark programs for the PC/AT. The
results of this analysis is presented in Table IV-2. This table also
presents the times obtained using the previous version (3.1) of the
Alsys Ada compiler. These times were obtained using all default
values.
<table>
<thead>
<tr>
<th>Benchmark</th>
<th>All Defaults</th>
<th>Tasking = No</th>
<th>Checks = Stack</th>
<th>Reduction = Partial</th>
<th>Previous Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sieve Prime Number, execute</td>
<td>5.1</td>
<td>5.1</td>
<td>3.7</td>
<td>4.9</td>
<td>6.2</td>
</tr>
<tr>
<td>compile, bind</td>
<td>101.0</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>89.1</td>
</tr>
<tr>
<td>Floating point, sine function</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>float</td>
<td>8.7</td>
<td>8.7</td>
<td>8.7</td>
<td>8.7</td>
<td>N/A</td>
</tr>
<tr>
<td>long-float</td>
<td>9.9</td>
<td>9.9</td>
<td>9.9</td>
<td>9.9</td>
<td>N/A</td>
</tr>
<tr>
<td>Floating point, subroutine</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(no math lib.) float</td>
<td>27.7</td>
<td>27.7</td>
<td>27.7</td>
<td>27.6</td>
<td>28.0</td>
</tr>
<tr>
<td>long-float</td>
<td>45.5</td>
<td>45.5</td>
<td>45.4</td>
<td>45.3</td>
<td>N/A</td>
</tr>
<tr>
<td>Matrix</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>float</td>
<td>71.2</td>
<td>71.2</td>
<td>61.0</td>
<td>62.8</td>
<td>76.9</td>
</tr>
<tr>
<td>long-float</td>
<td>76.8</td>
<td>76.9</td>
<td>67.0</td>
<td>68.8</td>
<td>N/A</td>
</tr>
<tr>
<td>2-task data transfer</td>
<td>19.1</td>
<td>N/A</td>
<td>16.9</td>
<td>16.9</td>
<td>29.2</td>
</tr>
<tr>
<td>Rendezvous response</td>
<td>1.0</td>
<td>N/A</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Disk write timing</td>
<td>13.4</td>
<td>13.4</td>
<td>13.4</td>
<td>13.4</td>
<td>15.5</td>
</tr>
</tbody>
</table>

Table IV-2
V. SOURCE LISTINGS

This section contains program source file listings of the software developed during the course of the study. Unless otherwise noted in the comments at the beginning of the program or in the following list, the programs listed are the versions of benchmarks and test programs that were developed for, and executed on, the DEC MicroVAX II system. The following source listings are included in this section:

1. zprime.ada
2. zprime.for
3. zprime.c
4. zprime.mar
5. zprime.p (SUN)
6. zprime.s (SUN)
7. fpatestsub.ada
8. fpatestsub.for
9. fpatestsub.c
10. speed_test.ada
11. speed_testsav.ada (long_float)
12. speed_test.for
13. speed_test.c
14. run5.ada & subprograms ludecm & prnary
15. run5.for & subroutines ludecm & prnary
16. run5.c & functions ludecm & prnary
17. tstrun5.for & subroutines ludecum & prnary
18. timtes.ada
19. timtes.for
20. timtes.c
21. timtes.p (SUN)
22. timtesblok.for
23. timtesblokput.for
24. timetask1.ada
25. adasend.ada
26. adasend_disk.ada
27. forsendl.for/forrecv.for
28. forsendsavelfil.for/forrecvsavel1.for
29. forsendsave6.for/forrecvsave6.for
30. csend1.c/crecv1.c (SUN)
31. csend2.c/crecv2.c (SUN)
32. csend3.c/crecv3.c (SUN)
33. rspns1sav1.for/rspns2.for
34. rspns1sav6qio.for
35. timetask1.for/timetask2.for
36. proctime.c (SUN)
37. proctime_sub.for
38. proctime_det.for
39. proctime1.for
40. proctim.ada
41. task1_and_task2.ada
42. ttqio.ada
43. ttqio.for
44. ttqio.c
45. testalarm.for
46. testalarm_ast.for
47. testalarm_ast.ada
48. testalarm_ast.c
49. adadelay.ada
50. task_order.ada
51. task_exec.ada
52. tstslice.ada (PC/AT)
53. main.ada
54. innerprod.for
55. main1.ada
56. innerprod1.for
57. formain.for
58. nfind.ada
59. main2.ada
60. sysmsg.for
61. main1.ada (SUN)
62. innerprod1.f (SUN)
63. main2.ada (SUN)
64. innerprod.f (SUN)
65. adafork.ada (SUN)
66. char.ada
67. procload.ada
-- zprime.ada  Eratosthenes Sieve Prime Number Program in VAX Ada.

with text_io;
with integer_text_io;
use text_io, integer_text_io;

procedure zprime is
  flags:array (integer range 0..8190) of boolean;
i,prime,k,count,iter:integer;

  -- pragma optimize( time );

begin

  put("10 iterations"); new_line;

  for iter in 1..10 loop
    count := 0;

    flags := ( 0..8190 => TRUE );

    for i in 0..8190 loop
      if flags(i) then
        prime := i + i + 3;
        k := i + prime;

        while k <= 8190 loop
          flags(k) := FALSE;
          k := k + prime;
        end loop;

        count := count + 1;

        --
        put(count);put(prime); new_line;

      end if;
    end loop;

  end loop;

  put(count);put(" primes"); new_line;

end zprime;

--pragma suppress_all;
PROGRAM ZPRIME

C zprime.for Eratosthenes Sieve Prime Number Program in VAX FORTRAN.

logical flags( 8191 )
integer i, iprime, k, icnt, iter

write( 6,900 )
900 format( 'I0 iterations' )

do 92 iter = 1,10
   icnt = 0
   do 10 i = 1,8191
   10 flags( i ) = .true.
   do 91 i = 1,8191
      if ( flags(i) .eq. .false. ) go to 91
      iprime = i + i + 1
      k = i + iprime
      20 if( k .gt. 8191 ) go to 90
         flags( k ) = .false.
         k = k + iprime
         go to 20
      90 icnt = icnt + 1
   91 continue
   92 continue
write( 6,901 ) icnt
901 format( 'Ix,i6,' primes' )
end
```c
/* zprime.c  Eratosthenes Sieve Prime Number Program in C for MicroVAX II. */

#define TRUE 1
#define FALSE 0
#define SIZE 8191

char flags[SIZE];

main()
{
    int i,prime,k,count,iter;

    printf("10 iterations\n");
    for (iter =1;iter <= 10; iter++)
    {
        count=0;
        for(i = 0;i < SIZE; i++)
            flags[i] = TRUE;

        for(i = 0;i < SIZE; i++)
        {
            if(flags[i])
            {
                prime = i + i + 3;
                k = i + prime;
                while( k < SIZE )
                {
                    flags[k] = FALSE;
                    k += prime;
                }
                ++count;
            }
        }
        printf("%d primes\n",count);
    }
}
```
; zprime.mar  - Eratosthenes Sieve Prime Number Program in VAX Macro.

.TITLE  ZPRIME

.psect  data,noexe
FLAGS:  .BLKW  8192
DUMMY:  .BLKW  1    ; THIS IS USED WITH THE MOVC5 INSTRUCTION

ttchan:  .blkw  1
ttdesc:  .long  20$-10$
          .long  10$
10$:  .ascii /tt/
20$:  
iostat:  .blkq  1

strmsg:  .ascii "10 iterations "<13><10>
stpmmsg:  .ascii "___ primes"<13><10>
prmmsg:  .ascii "prime= ___"<13><10>

quot:  .long  0
rem:  .long  0

.psect  code,nowrt,exe
.ENTRY  ZPRIME,^M<R2,R3,R4,R5,R6,R7,R8,R9,R11>  ; set entry mask

$assign_s  devnam=ttdesc,-
    chan=ttchan

;** write out the number of iterations (in R2) here

$qiow_s  chan=ttchan,-
    func=#io$_writevblk,-
    iosb=iostat,-
    pl=strmsg,-
    p2=#16

MOVW  #1,R3  ; initialize iteration counter
MOVZBL  #10,R2  ; set number of iterations
MOVZWL  #8191,R4  ; set size of FLAGS array
CLRL  R7  ; clear "k" index for FLAGS array

; do for R2 iterations
L1:
CLRW  R11  ; clear count of number of primes found
pushr  "^m<r2,r3,r4>"  ; Save registers that MOVC5 uses
MOVC5  #0,DUMMY,"^XFF,#16384,FLAGS
popr  "^m<r2,r3,r4>"  ; restore registers

L3:
MOVL  #1,R5  ; reset array index and loop counter
TSTW  FLAGS[R5]  ; test FLAGS for prime (true for first time)
BEQL  S91
ADDW3  R5,R5,R6  ; calculate the value of the prime from
                     its index, put in R6
ADDW3  R6,R5,R7  ; calculate the prime's first odd multiple

S20:
CMPW R7,#8191
BGTR S90

CLRW FLAGS[R7] ; set the odd multiple’s flag value false
ADDW2 R6,R7 ; calculate next odd multiple of the prime
BRB S20

S90:
INCW R11 ; increment count of primes found

;**
; write out the value of the prime (in R6) here (for debug)
; cvtwl r6,r0
; movab prmmgs+7,r8
; bsbw convert
; $qiow_s chan=ttchan,-
; func=#io$ _writevblk,-
; iosb=iostat,-
; p1=prmmgs,-
; p2=#14

S91:
ACBW R4,#1,R5,L3 ; all through FLAGS array?
ACBW R2,#1,R3,L1 ; all through with number of iterations?

;**
; write out the number of primes found (in R11) here
; cvtwl r11,r0
movab stpmgs,r8
bsbw convert

$qiow_s chan=ttchan,-
func=#io$_writevblk,-
iosb=iostat,-
pl=stpmgs,-
p2=#14

MOVL #1,R0 ; set successful completion (VAX requires)
RET
; Convert binary integer to ascii string, 5 digits, right-justified, zero-filled
; assume binary value is in work register r0
; and address of ascii string to receive converted integer is in register r8

convert:
; msg+0 byte
  clrl  r1 ;this instruction needs to be here,
           ;(it can't go after the ediv ; instruction either).
  ediv   #10000,r0,quot,rem
  addl2  #48,quot
  cvt lb quot,r0
  movb   r0,(r8)+

; msg+1 byte
  movl   rem,r0
  ediv   #1000,r0,quot,rem
  addl2  #48,quot
  cvt lb quot,r0
  movb   r0,(r8)+

; msg+2 byte
  movl   rem,r0
  ediv   #100,r0,quot,rem
  addl2  #48,quot
  cvt lb quot,r0
  movb   r0,(r8)+

; msg+3 byte
  movl   rem,r0
  ediv   #10,r0,quot,rem
  addl2  #48,quot
  cvt lb quot,r0
  movb   r0,(r8)+

; msg+4 byte
  addl2  #48,rem
  cvt lb rem,r0
  movb   r0,(r8)+
rsb

.END ZPRIME
(* zprime.p *)
(* Eratosthenes Sieve Prime Number Program in PASCAL for the SUN. *)

program zprime(output);
const
    size = 8190;
var
    flags : array[0..size] of boolean;
    i, prime, k, count, iter : integer;

begin  (* ZPRIME *)
    writeln(output,'10 iterations');
    for iter := 1 to 10 do
    begin
        count := 0;
        for i := 0 to size do
            flags[i] := true;
        for i := 0 to size do
            if flags[i] then
            begin
                prime := i + i + 3;
                k := i + prime;
                while k <= size do
                    begin
                        flags[k] := false;
                        k := k + prime;
                    end;
                count := count + 1;  (* Count of number of prime numbers *)
            end;
        end;
        writeln(output, count, ' primes');
    end.  (* ZPRIME *)
I Erathosthenes sieve prime number program in Motorola 68000 assembly.
I This is the version for the SUN.

.data

rem: .word 0
quotient: .word 0

| Build output messages. |

msg1: .asciz "10 iterations\12"
msg2: .asciz " primes\12"

.text

pea msg1
jsr _printf

lea flags,a2
clr dl
movw # 10, d5
clrl d6
movw #8191, d2

J Load beginning address of flags.
J Clear register d6.
J Upper loop counter for 1-10 loop.
J Lower loop counter for 1-10 loop.
J Upper loop counter for array flags.

11:
addw #1, d1
clr dl
lea flags, a1

| Increment lower loop ctr for 1-10 loop
| Count.
| Lower loop ctr. for array flags.

| Set all 8191 cells of array flags to true ( i.e. = 1 ). |

lea flags, a1

12:
addw #1, d3
movw #1, a1[+]
cmpw d3, d2
bgt 12

J Increment lower loop counter.
J Set to true. Point to next cell.
J See if the loop is complete.
J Loop until d2=d3 (8191).

| Array flags has been set to true. Continue. |

crl dl
lea flags, a1

| Clear register d3. ( set to zero ).
| load beginning address of flags.

| Begin 1-8191 loop. Check each cell to see if = true (=1). |

13:
addw #1, d3
cmpw #1, a1[+]
blt 15

J Increment lower loop counter.
J See if this cell = true.
J Not true, check the next cell.

| This cell of flags array is true. |

movw d3, d6
addw d3, d6
addw #1, d6

| d3 contains i.
| d6 now contains i + i.
| d6 now contains i + i + 1.

| d6 contains PRIME and d4 contains K. |

movw d3, d4
addw d6, d4

| k = i + prime.
| Loop while k lt or = 8191.
14:  cmpw d4, d2  | d2 contains the value 8191.
     blt 17  | k is now gt 8191.
     movw d4, d0
     aslw #1, d0  | Shift contents of d0 left 1 bit.
     subw #2, d0  | Subtract 2 from contents of d0.
     movw #0x00, a28(0, d0: w)
     addw d6, d4  | k = k + prime.
     bra 14  | Check the next location.

| K has become gt 8191. Increment count.

17:  addw #1, d7  | Increment prime number counter.

15:  cmpw d3, d2  | Compare lower loop ctr. to 8191.
     bgt 13  | Continue loop. See if next cell true.
| Have looped 8191 times. See if outer loop has looped 10 times.

16:  cmpw d1, d5  | Compare lower loop counter to 10.
     bgt 11  | Execute next iteration of 1-10 loop.
| All 10 iterations of the outer loop have been completed, finished.
| Output the number of primes (count) that were found.

    lea msg2, a4  | Load addr. of the return buffer.
    jmp convert  | Convert to the ASCII equivalent.

back:
    pea msg2  | Print out the number of ASCII equivalent.
    jsr _printf  | Jump to the print routine.

return:
    jsr _exit  | Exit the program.

| This routine converts a binary value to its ASCII equivalent.
| This routine assumes a maximum of five (5) characters.
| On entry to this routine, register d7 contains the binary
| value to be converted and register a4 contains the address
| of the buffer where the ASCII equivalent is to be placed.

convert:
    divs #10000, d7  | Save the remainder from the division.
    movl d7, rem  | See if this digit is zero.
    cmpw #0x00, d7  | If so, skip to the next digit.
    ble next  | Add an ASCII zero to the answer.
    addw #060, quotient
    movb quotient+1, a4@

next:
    clrl d7  | d7
    movw rem, d7
    divs #1000, d7  | d7
    movl d7, rem
    addw #060, quotient
    movb quotient+1, a4@
    clrl d7
    movw rem, d7
    divs #100, d7  | d7
    movl d7, rem
    addw #060, quotient
    movb quotient+1, a4@
    clrl d7
    movw rem, d7
divs    #10,d7
movl    d7,rem
addw    #060,quotient
movb    quotient+1,a4@+
addw    #060,rem
movb    rem+1,a4@+
jmp     back       | Return to the caller.
-- fpatestsub.ada  floating point test benchmark (w/subroutine), MicroVAX Ada.
with text_io;  use text_io;
procedure fpatestsub is
  package realnum is new float_io( float );
  use realnum;
  x : float := 100.0;
  y : float := 100.0;
  z : float := 100.0;
  pragma optimize( time );
  __***************************
  procedure fpa(x: in out float;
      y: in out float;
      z: in out float) is
    begin
      y := x / x;
      z := (y/x) + 1.0;
    end fpa;
  __***************************
  begin
    put("start"); new_line;
    for i in 1..100000 loop
      fpa(x,y,z);
    end loop;
    put("z ="); put( z,4,30,0 ); new_line;
  end fpatestsub;
  pragma suppress_all;
program fpatest
   real*4 x, y, z
   data x /100./, y /100./, z /100./
   type *, 'start'
   do i = 1, 100000
      call fpa(x, y, z)
   enddo
   type 900, z
690   format(' z = ', f34.30)
end

subroutine fpa(x, y, z)
   real*4 x, y, z
   y = x / x
   z = y / x + 1.
   return
end
main()
{
    float x = 100.;
    float y = 100.;
    float z = 100.;

    int i;
    printf("start\n");
    for( i = 0; i < 100000; i++ )
        fpa( &x, &y, &z);
    printf(" z = %34.30f\n", z );
}

fpa(x,y,z)
float *x, *y, *z;
{
    *y = *x / *x;
    *z = ( *y / *x ) + 1.0;
}
-- speed_test.ada - floating point test benchmark (w/sine),
-- VAX Ada.

with text_io; use text_io;
with float_math_lib; use float_math_lib;

procedure speed_test is

  package debug_io is new float_io( float );
  use debug_io;

  sum : float := 0.0;
  x : float := 0.0;

begin

  put("10000 iterations"); new_line;

  for i in 1..10000 loop
    x := float( i );
    sum := sum + 1.0 / ( x + sin(x) );
  end loop;

  put("done"); new_line;

  put(" sum = "); put( sum, 2, 6, 0 ); new_line; -- for debug

end speed_test;

-- pragma suppress_all;
-- speed_testsav.ada

-- speed_test.ada  -  floating point test benchmark ( w/sine ), VAX
    Ada; special version for long_float d_float.

-- The VAX/VMS predefined instantiation of math_lib for long_float
-- is not compatible with the d_float pragma and requires user
-- instantiation of math_lib for long_float types.

pragma long_float( d_float );
with text_io; use text_io;
with math_lib;
procedure speed_testsav is
    -- user instantiation of math_lib.
    package my_math_lib is new math_lib( long_float );
    use my_math_lib;
    package debug_io is new float_io( long_float );
    use debug_io;
    sum : long_float := 0.0;
    x : long_float := 0.0;
begin
    put("10000 iterations"); new_line;
    for i in 1..10000 loop
        x := long_float( i );
        sum := sum + 1.0 / ( x + sin( x ) );
    end loop;
    put("done"); new_line;
    put(" sum = "); put( sum, 2, 6, 0 ); new_line;  -- for debug
end speed_testsav;

-- pragma suppress_all;
c speed_test.for - floating point test benchmark (w/sine), MicroVAX II.

program speed_test
real*4 x, sum

write(5,700)
700 format(' 10000 iterations')

do 10 i = 1,10000
  x = i
  sum = sum + 1.0 / ( x + sin(x) )
10

write(6,800)
800 format(' done')

for debug
write(5,900)sum
900 format(' sum=',f9.6)
end
/* speed_test.c - floating point test benchmark (w/sine), MicroVAX II. */
#include math

main()
{
    int i;
    float sum = 0., x = 0.;
    printf(" 10000 iterations\n");
    for( i = 1; i <= 10000; i++ )
    {
        x = i;
        sum = sum + 1. / ( x + sin(x) );
    }
    printf("done\n");
    printf("sum = %f
",sum);
}
-- run5.ada - Matrix manipulation test benchmark, MicroVAX II.
-- This version uses separate compilation of subprograms
   ludecm and prnary.

with text_io; use text_io;

procedure run5 is

   type buf is array( integer range <> , integer range <> ) of float;

   n : integer := 4;
n2 : integer := 2;

   a : buf(1..n,1..n) := (( -2.0,-4.0,-6.0,-8.0 ),
                           ( 2.0,5.0,8.0,11.0 ),
                           ( 1.0,5.0,10.0,15.0 ),
                           ( 5.0,6.0,5.0,5.0 ));
   al : buf(1..n,1..n);
   b : buf(1..n2,1..n2) := (( 1.0,1.0 ),
                            ( 2.0,3.0 ));
   b1 : buf(1..n2,1..n2);

   procedure ludecm( array1 : buf;
                      number : integer;
                      array2 : in out buf ) is separate;

   procedure prnary( array2 : in out buf;
                    num : integer ) is separate;

begin
    -- beginning of run5.

    put(" 10,000 iterations"); new_line;

    for i in 1..10000 loop
        ludecm( a,n,al );
        ludecm( b,n2,b1 );
    end loop;

    put(" done!"); new_line;

    prnary( a,n );
    prnary( b,n2 );
    prnary( al,n );
    prnary( b1,n2 );

    end run5;

    -- end of run5.

    --pragma suppress_all;
procedure ludecm( array1 : buf; number : integer; array2 : in out buf ) is
begin
    array2 := array1;
    for diag in 1..number-1 loop
        for row in diag+1..number loop
            mult := array2( diag,row ) / array2( diag,diag );
            array2( diag,row ) := mult;
            for col in diag+1..number loop
                array2( col,row ) := array2( col,row ) - mult*array2( col,diag );
            end loop;
        end loop;
    end loop;
end ludecm;
-- prnary.ada

with text_io; use text_io;

separate( run5 )

procedure prnary( array2 : in out buf; num : integer ) is

    package buffer_io is new float_io( float );
    use buffer_io;

    package new_integer_io is new integer_io( integer );
    use new_integer_io;

begin

    new_line; new_line;

    for i in 1..num loop
        for j in 1..num loop
            put("array("); put(i,1); put(",",);
            put(j,1); put("="); put( array2(i,j),3,0,O );
            new_line;
        end loop;
    end loop;

    new_line;

end prnary;

--pragma suppress_all;
c run5.for - Matrix manipulation test benchmark, MicroVAX II.

program run5

    real*4 a(4,4), b(2,2)
    real*4 a1(4,4), b1(2,2)

    data a/-2.,-4.,-6.,-8.,
       1  2.,  5.,  8.,11.,
       2  1.,  5.,10.,15.,
       3  5.,  6.,  5., 5./

    data b/1.,1.,
       1  2.,3. /

    write(6,900)
    format(’10,000 iterations’)

    do 10 i=1,10000
        call ludecm(a,4,a1)
        call ludecm(b,2,b1)
    10 continue

    write(6,901)
    format(’done!’)

    call prnary(a,4)
    call prnary(a1,4)
    call prnary(b,2)
    call prnary(b1,2)

end
subroutine ludecm(array1,n,array2)
  c Lower and upper decomposition of square matrix
  c with Gaussian elimination.
  c Tests floating point computation, array addressing,
  c and nested iteration constructs.
  real*4 array1(n,n),mult,array2(n,n)
  integer*2 diag,row,col
  c
  copy input array to the working array
  do 9 row= 1,n
    do 10 col=1,n
      array2(col,row)=array1(col,row)
    continue
  continue

  do 39 diag= 1,n-1
    do 29 row= diag+1,n
      mult=array2(row,diag)/array2(diag,diag)
      array2(row,diag)=mult
      do 19 col= diag+1,n
        array2(row,col)=array2(row,col)-mult*array2(diag,col)
      continue
    continue
  continue

  return
end
subroutine prnary(array,n)
  c subroutine to print out the array.

  real*4 array(n,n)
  integer*2  row,col

  do 20 row= 1,n
     do 10 col=1,n
        write(6,900)col,row,array(col,row)
   900    format(’ array(’,i1,’,’),i1,’)=’,f4.0)
   10    continue
   20   continue

    write(6,901)
   901   format(’ ’)

    return
  end
/* run5.c - Matrix manipulation test benchmark, MicroVAX II. */

float a[4][4] =
{    
{-2.,-4.,-6.,-8.},
{ 2., 5., 8.,11.},
{ 1., 5.,10.,15.},
{ 5., 6., 5., 5.},
};
float b[2][2] =
{    
{ 1., 1.},
{ 2., 3.},
};
float a1[4][4], b1[2][2];

main()
{
    int iter;
    printf("10000 iterations\n");
    for ( iter=1; iter<=10000; ++iter )
    {
        ludecm( a,4,a1 );
        ludecm( b,2,b1 );
    }
    printf("done! \n");
    prnary(a,4);
    prnary(b,2);
    prnary(a1,4);
    prnary(b1,2);
}

ludecm(array,n,arrayl)
/* Lower and upper decomposition of square matrix */
/* with Gaussian elimination */
/* tests floating point computation, array addressing, */
/* and nested iteration constructs. */

int n;
/* Treat arrays as single dimensioned because "C" */
/* does not support variable 2-dimensional arrays. */

float array[],arrayl[];
{    
    int diag,row,col,i;
    float mult;
    for( i=0; i<=((n-1)*n+(n-1)); i++)
        arrayl[i] = array[i];
    for(diag=0; diag<(n-1); ++diag )
    {
        for( row=diag+1; row<n; ++row )
        {
            /* Use algorithm to compute array element */
            /* to simulate 2-dimensional array */
            mult = arrayl[diag*n+row]/arrayl[diag*n+diag];
array1[diag*n+row]=mult;
    for( col=diag+1; col<n; ++col )
        array1[col*n+row]=array1[col*n+row]-mult*array1[col*n+diag];
}

print(array,n)

/* Routine to print out the array. */

int n;
float array[];
{
    int i,j;
    for( j=0; j<n; ++j )
    {
        for( i=0; i<n; ++i )
            printf("array[%d][%d]= %5.1f\n",j,i,array[j*n+i]);
        printf("\n");
    }
}
program tstrun5

real*4  a(4,4), b(2,2)
real*4  al(4,4), bl(2,2)

data a/-2.,-4.,-6.,-8.,
   1  2., 5., 8., 11.,
   2  1., 5., 10., 15.,
   3  5., 6., 5., 5./

data b/1.,1.,
   1  2., 3./

write(6,900)
format(' 10,000 iterations')

do 10 i=1,10000
   call ludecm(a,4,al)
   call ludecm(b,2,b1)
10 continue

write(6,901)
format(' done!')

call prnary(a,4)
call prnary(al,4)
call prnary(b,2)
call prnary(b1,2)
end
subroutine ludecm(array1,n,array2)

   c  Lower and upper decomposition of square matrix
   c  with Gaussian elimination.
   c  Tests floating point computation, array addressing,
   c  and nested iteration constructs.

   real*4 array1(1),mult,array2(1)
   integer*2 diag,row,col

   c  copy input array to the working array
   do 9 i = 1,n*n
      array2( i )=array1( i )
   continue

   do 39 diag = 1,n-1
      do 29 row= diag+1,n
         mult=array2( row+n*(diag-1))/array2( diag+n*(diag-1) )
         array2( row+n*(diag-1) )=mult
      continue
      do 19 col= diag+1,n
         array2( row+n*(col-1) )=array2( row+n*(col-1) )
         mult*array2( diag+n*(col-1) )
      continue
      continue
      continue

   return
   end
subroutine primary(array,n)

c subroutine to print out the array.

real*4 array(n,n)
integer*2 row, col

do 20 row= 1,n
    do 10 col=1,n
        write(6,900) col,row, array(col,row)
        format(900) array('array(',il,',',il,')=','f4.0)
        10        continue
    20        continue

write(6,901)
format(901) ' '

return
end
-- timtes.ada - Disk write timing benchmark, MicroVAX II.

with text_io; use text_io;
with calendar; use calendar;
with sequential_io;

procedure timtes is

  type buffer is array( short_integer range 1..2048 ) of short_integer;

package buffer_io is new sequential_io( buffer );
use buffer_io;

package duration_text_io is new fixed_io( duration );
use duration_text_io;

  data_file : buffer_io.file_type;
  ibuf : buffer;
  i : short_integer;
  t1 : duration;
  t2 : duration;
  deltime : duration;
  date : time;

pragma optimize( time );

begin -- start of the Ada program timtes.

  new_line;
  put( " Program TIMTES - MicroVAX ADA version ");
  new_line;

  for i in short_integer range 1..2048 loop
    ibuf( i ) := i;
  end loop;

  create( file => data_file,
         name => "timetest.dat",
         form => "file;"
          & "best_try_contiguous yes;" &
          "allocation 2500;" );

  date := clock;
  t1 := seconds( date );

  for i in 1..300 loop
    write( data_file, ibuf );
  end loop;

  date := clock;
  t2 := seconds( date );

  deltime := t2 - t1; -- calculate the delta time in seconds.

  close( data_file );

  put( " time difference = " );
  put( deltime );
  new_line;

end timtes;
program timtes

integer*2 ibuf( 2048 )
integer i
real t1, delta

output the program header to crt.

write( 6,100 )
100 format( '/,' Program TIMTES - MicroVAX II FORTRAN version ',/ )

load the buffer "ibuf".

do 10 i = 1,2048
   ibuf( i ) = i
10 continue

open the disk file "timetest".

open( unit=4,file='timetest.dat',
1 status='unknown',form='unformatted',access='direct',
1 organization='sequential',
1 initialsize=2500,recordsize=1024 )

t1 = secnds( 0.0 ) ! get the start time.

write 300 records to "timetest".

do 20 i = 1,300
   write( 4, rec=i ) ibuf
20 continue

delta = secnds( t1 ) ! get the delta time (in seconds).

output the delta time to the crt.

write( 6,200 ) delta
200 format( 'x, time difference = ', f10.3,'/ )

! close the disk file "timetest".

! exit the program.
/* timtes.c - Disk write timing benchmark, MicroVAX II */

#define NREC 300           /* Number of records to write. */
#define N 4096             /* Number of bytes per record. */
#define NW 2048            /* Number of words per record. */
#define PMODE 0777         /* Mode with which to open file */

#include <error>

short int ibuf[NW], fd;
long tl, t2, delta, time();

main()
{
    int i, nwritten;

    for (i = 0; i < NW; ++i)                  /* Initialize the write buffer. */
        ibuf[i] = i + 1;

    fd = creat("timetest.dat", PMODE,"mrs=4096","rfm=fix","alq=2400","fop=ctg");

    if (fd != -1)
    {
        tl = time((long *)0);              /* get starting time, seconds. */

        for (i = 1; i <= NREC; ++i)        /* write NREC records. */
            nwritten = write(fd, ibuf, sizeof(ibuf));

        t2 = time((long *)0);             /* Get ending time, seconds. */
        delta = t2 - tl;                 /* Calculate the delta time. */
        printf(" nwritten= %d time diff= %ld \n", nwritten, delta);
    }
    else
    {
        printf(" error creating the file \n");
        perror("timtes");
    }
}
(* timtes.p -- Disk write benchmark for SUN Pascal *)

program timtes ( output, testdat );

(* A PASCAL program to test writing to a disk file *)

const
  nrec = 300;                (* Number of records to write *)
  nw  = 1024;                (* Number of (32 bit) words per record *)

type
  ibuf = record
    data : array[1..nw] of integer;
  end;

var
  newdata : ibuf;
  testdat : file of ibuf;    (* File for the test data *)
  i     : integer;          (* Loop counter *)
  btime : integer;          (* Begin time *)
  etime : integer;          (* End time *)
  delta : real;             (* Delta time in seconds *)

procedure sync; external c;

begin (* TIMTES *)

  (* Create the file for the test data *)
  rewrite( testdat,'testdat.tf' );

  (* Get the current system time *)
  btime := wallclock;

  (* Put the test data in the file *)
  testdat^ := newdata;

  (* Write output buffered for the PASCAL file testdat into the UNIX file *)
  (* Call the "C" function "sync" *)
  sync;

  (* Get the current system time *)
  etime := wallclock;

  (* Calculate delta time in seconds *)
  delta := etime - btime;

  (* Output the time to the screen *)
  writeln( output, ' Time for write = ',delta:7:3,' seconds' );
end.    (* TIMTES *)
Fortran program to time writing to the disk.

```
integer*2 ibuf(2048)
integer*4 i
real*4 t1, delta
integer*4 rabadr, for$rab, rmssts, rmsstv, sys$write, sys$put
integer*4 uopen
external uopen

output the program header to crt.

write(6,100)
100 format(/,' Program TIMTESFOR - MicroVAX II FORTRAN version ',/)

load the buffer "ibuf".

do 10 i = 1,2048
   ibuf(i) = i
10 continue

open the disk file "testfile".

open( unit=4, file='timetest.dat',
   status='new', form='unformatted',
   organization='sequential',
   recordtype='fixed',
   initialsize=2500, recl=1024, useropen=uopen,
   access='sequential',
   err=99)

t1 = secnds(0.0) ! get the start time.

write 300 records to "testfile".

rabadr = for$rab(4)
call setrab(%val(rabadr), ibuf)
do 20 i = 1,300
   ids = sys$write(%val(rabadr))
20 continue

delta = secnds(t1) ! get the delta time (in seconds).

output the delta time to the crt.

write(6,200) delta
200 format(1x,' time difference = ', f10.3,/)
close(unit=4)
call exit ! exit the program.
call errsns(rmssts, rmsstv,)
call sysmsg(rmssts)
call sysmsg(rmsstv)
end```

c uopen.for - user-open routine. Called in 'open' statement

integer*4 function uopen(fab,rab,lun)

include '($fabdef)'
include '($rabdef)'

record /fabdef/fab
record /rabdef/rab

integer*4 lun,chan,sys$create,sys$connect

fab.fab$b_fac = fab.fab$b_fac .or. fab$m_bio !set user-open bit
uopen = sys$create(fab)
if( .not. uopen ) return !open the file
uopen = sys$connect(rab)
if( .not. uopen ) return

return
end

subroutine setrab(rab,ibuf)

include '($rabdef)'

record /rabdef/rab

integer*2 ibuf(1)

rab.rab$w_rsz = 4096
rab.rab$1_rbf = %loc(ibuf)

return
end
program timtesblok

integer*2 ibuf( 2048 )
integer*4 i
real*4 t1, delta

integer*4 rabadr, for$rab, rmssts, rmsstv, sys$put

integer*4 uopen
external uopen

write( 6,100 )
100 format( /*, 'Program TIMTESFOR - MicroVAX II FORTRAN version ',/ )

do 10 i = 1, 2048
ibuf( i ) = i
10 continue

open( unit=4, file='timetest.dat', status='new', form='unformatted',
organization='sequential',
recordtype='fixed', buffercount=22,
initialize=2500, recl=1024, useropen=uopen,
access='sequential', err=99 )
t1 = secnds( 0.0 ) ! get the start time.

rabadr = for$rab(4)
call setrab(%val(rabadr), ibuf)
do 20 i = 1, 300
ids = sys$put(%val(rabadr))
20 continue

delta = secnds( t1 ) ! get the delta time (in seconds).

write( 6,200 ) delta
200 format( 1x, 'time difference = ', f10.3,/ )

type *, 'records written: ', i, ' status:'
call sysmsg(ids)
close(unit=4)
call exit
99 call errsns(), rmssts, rmsstv,
call sysmsg(rmssts)
call sysmsg(rmsstv)
end
c uopen.for - user-open routine. Called in 'open' statement

integer*4 function uopen(fab, rab, lun)
include '($fabdef)'
include '($rabdef)'
record /fabdef/fab
record /rabdef/rab
integer*4 lun, chan, sys$create, sys$connect

fab.fab$b_fac = fab.fab$b_fac
!set user-open bits
uopen = sys$create(fab)
if( .not. uopen ) return
!open the file
uopen = sys$connect(rab)
if( .not. uopen ) return
return
end

subroutine setrab(rab, ibuf)
include '($rabdef)'
record /rabdef/rab
integer*2 ibuf(1)
rab.rab$w_rsz = 4096
rab.rab$l_rbf = %loc(ibuf)
return
end
This is a two-task response time test for the purpose of determining the overhead required by the system for a rendezvous. A rendezvous is used to enable the synchronization of the two tasks in order to give an idea of how fast a task can respond to being started by another task.

with text_io; use text_io;

procedure timetask1 is
  i : integer;
  task timetask2 is
    entry start;
  end timetask2;
  task body timetask2 is
    begin
      loop
        select
          accept start;
        or
          terminate;
        end select;
      end loop;
    end timetask2;
    begin
      put("start"); new_line;
      for i in 1..1000 loop
        timetask2.start; -- start timetask2.
      end loop;
      put("stop"); new_line;
    end timetask1;
-- adasend.ada - Two-task synchronized data transfer (send/receive)
-- benchmark, MicroVAX-II.

with text_io; use text_io;

procedure adasend is
    type buffer is array( short_integer range 1..2048 ) of short_integer;
    package debug_io is new integer_io( short_integer );
    use debug_io;
    i     : short_integer;
    k     : short_integer;
    j     : short_integer := 0;
    l     : short_integer;
    ibuf  : buffer;

    task adarecv is
        entry start;
        end adarecv;

    task body adarecv is
        begin -- beginning of adarecv.
            loop -- loop forever.
                j := j + 1; -- increment loop counter.
                select
                    accept start do
                        for l in short_integer range 1..2048 loop
                            if ibuf( l ) /= j then
                                put( "data is incorrect for loop = " );
                                put( j ); new_line;
                            end if;
                        end loop;
                        end start;
                    or
                        terminate; -- terminate adarecv.
                    end select;
                end loop;
            end start;
        or
            terminate;
        end loop;
    end adarecv; -- end of the receive task.

    --*********************************************************************
    begin -- beginning of adasend.
        put(" The send task (Program ADASEND) is starting"); new_line; new_line;
for k in short_integer range 1..300 loop
    for i in short_integer range 1..2048 loop
        ibuf( i ) := k;
        end loop;
        adarecv.start;
    end loop;
    put(" Program ADARECV is exiting");
end adasend;
-- adasend_disk.ada - Two-task data transfer (send/receive)
-- via shared disk file, MicroVAX-II.

with text_io; use text_io;
with direct_io;

procedure adasend_disk is

  type buffer is array( short_integer range 1..2048 ) of short_integer;

  package buffer_io is new direct_io( buffer );
  use buffer_io;

  package debug_io is new integer_io( short_integer );
  use debug_io;

  data_file : buffer_io.file_type;
  ibuf      : buffer;
  i         : short_integer;
  k         : buffer_io.positive_count;
  j         : short_integer := 0;
  l         : short_integer;
  recno     : buffer_io.positive_count;
  numrec    : short_integer := 0;

  pragma volatile( numrec);
  pragma volatile( j );

-- task adarecv_disk:

task body adarecv_disk is

  ibuf : buffer;

  begin -- beginning of adarecv.

    loop -- loop forever.

      j := j + 1; -- increment loop counter.

      while numrec < j loop
        delay 0.01;
      end loop;

      read( data_file, ibuf, buffer_io.positive_count( j ) );

      for l in short_integer range 1..2048 loop
        if ibuf( l ) /= j then
          put(" data is incorrect for loop = ");
          put( j ); new_line;
        end if;
      end loop;

  end loop;

  exception

    when buffer_io.end_error =>
      put(" adarecv_disk: end_error"); new_line( 2 );

    when buffer_io.use_error =>
      put(" adarecv_disk: use_error"); new_line( 2 );
when buffer_io.data_error =>
  put("adarecv_disk: data_error"); new_line(2);

when others =>
  put("adarecv_disk: unknown error"); new_line(2);
end adarecv_disk; -- end of the receive task.

begin -- beginning of adasend.

create(file => data_file,
       name => "dua2:[user.horne]test.dat",
       form => "file;" &
              "best_try_contiguous yes;" &
              "allocation 2500;"
       );

new_line;
put("ADASEND_DISK is starting"); new_line(2);

for k in buffer_io.positive_count range 1..300 loop
  recno := k;
  for i in short_integer range 1..2048 loop
    ibuf(i) := short_integer(k);
  end loop;
  write(data_file, ibuf, recno);
  numrec := short_integer(k);
end loop;

while j <= numrec loop
  delay 0.01;
  if adarecv_disk'terminated then
    new_line(2);
    put("ADARECV_DISK task terminated abnormally");
    new_line;
    put("read error on record number "); put(j); new_line;
    exit;
  end if;
end loop;

if j > numrec then
  put("ADARECV_DISK task terminated normally"); new_line;
  put(numrec); put(" records were read"); new_line(2);
  abort adarecv_disk;
end if;

end adasend_disk;
program forsend

integer*2 ibuf, iflag
integer*2 i, k
integer*4 ispawn, ids, sys$ascefc, sys$setef, sys$waitfr, sys$clref
external cli$m_nowait
common/comglb/ibuf(2048), iflag
ids = sys$ascefc(%val(64), 'efcluster', ,) ! assign ef cluster

ispawn=%loc(cli$m_nowait)
call lib$spawn('run forrecv', , , ispawn, 'forrecv', ipid)
call wait('0 ::3.0', ids)

-- beginning of forsend
type *, ' The send task (Program FORSEND) is starting'
do 30 k=1,300

  fill buffer
    do 20 i=1,2048
      ibuf(i)=k
    continue

  resume the receive task to process the data in ibuf
  (resume forrecv)
  ids = sys$setef(%val(64))

  suspend this task while forrecv processes
  (suspend forsend)
  ids = sys$waitfr(%val(65))
  ids = sys$clref(%val(65))

continuous

type *, ' Program FORSEND is exiting'
type *, ibuf, k
call sys$delprc(ipid, )
end
c wait.for

subroutine wait(itim, ids)
  integer*4 sys$waitfr, sys$setimr, sys$bintim
  integer*4 ids, ibintim
  character*(*) itim

  ids=sys$bintim(itim, ibintim)
  if(.not. ids) go to 1000

  ids=sys$setimr(%val(1), ibintim, ,)
  if(.not. ids) go to 1000

  ids=sys$waitfr(%val(1))
  if(.not. ids) go to 1000

1000 return

end
c comglb.for -- Used to define the installed shareable image
  for the global common in some send/receive tests.

block data

integer*2 ibuf,iflag
common/comglb/ibuf(2048),iflag
data ibuf/2048*0/,iflag/0/
end
! comglb.opt
! Options file for linking comglb global common
!
dua0:[sys0.syslib]comglb/share
! comglbins.com -- Command file to install 'comglb' global common.
! set noverify
! Modules using this common should be linked thus:
!    $ link module,comglb/opt
! where file comglb.opt contains:
!    comglb/share
! set verify
! install delete dua0:[sys0.syslib]comglb
! install create dua0:[sys0.syslib]comglb.exe;I/share/write
! finished installing comglb
! set noverify
$! comglbbld.com -- Command file to compile, link, install 'comglb' global common.
$ set noverify
$! Modules using this common should be linked thus:
$!
$! $ link module, comglb/opt
$! where file comglb.opt contains:
$!
$! comglb/share
$ set verify
$ for comglb
$ link/share comglb
$ purge comglb.obj, comglb.exe
$ install delete dua0:[sys0.syslib]comglb
$ delete dua0:[sys0.syslib]comglb.exe;
$ copy comglb.exe dua0:[sys0.syslib]comglb.exe;
$ install create dua0:[sys0.syslib]comglb.exe;1/share/write
$! WARNING! Programs using comglb must now be re-linked!
$! finished building comglb
$ set noverify
c forrecv.for - Receive task for 2-task synchronized data transfer.
    -- event flag/installed shareable common version

    program forrecv
        integer*2 ibuf, iflag
        integer*2 j, l
        integer*4 ids, sys$ascefc, sys$waitfr, sys$clref, sys$setef

        common/comglb/ibuf(2048), iflag

        ids = sys$ascefc(%val(64), 'efcluster', ,)
           ! assign ef cluster
        j = 0

        continue  loop forever
                  j = j + 1

        suspend this task until send task has some data
        (suspend forrecv)

        ids = sys$waitfr(%val(64))
        ids = sys$clref(%val(64))

        check data to see if correct
        do 20 l = 1, 2048
           if( ibuf(l) .ne. j )then
              type *, 'data is incorrect for loop = ', j
           end if
        20 continue

        resume the send task to send more data
        (resume forsend)
        ids = sys$setef(%val(65))

        go to 10

        continue

        c end

    continue
c forsendsavelfil.for

program forsend

integer*2 ibuf,iflag
integer*2 i,k

integer*4 ispawn,ids
integer*4 sys$crmpsc,ipid,chan
integer*4 inadr(2),retadr(2),secflags

include '($secdef)'

external cli$m_nowait

common/comglb/ibuf(2048),iflag

common/ufo/chan
integer*4 ufo_create
external ufo_create

iflag=0

c open the section file

open( unit=4, file='comglb.tmp',
    status='new', initialsize=9,
    useropen=ufo_create,err=30)
close(4)

secflags = sec$m_gbl .or. sec$m_dzro .or. sec$m_wrt

inadr(1) = %loc(ibuf(1) )
inadr(2) = %loc(iflag )

c create and map to global section

ids=sys$crmpsc(inadr,retadr,,
    %val(secflags),
    'glbsec',,,%val(chan)
    ,,,)

c start up the receive task to run concurrently

ispawn=%loc(cli$m_nowait)
call lib$spawn('run forrecvsavel',,,ispawn,'forrecv',ipid)

c -- beginning of forsend

type *, 'The send task (Program FORSEND) is starting'
do 30 k=1,300

c fill buffer

do 20 i=1,2048
    ibuf(i)=k
    continue

20

c resume the receive task to process the data in ibuf

c (resume forrecv)
call sys$wake(ipid, )
suspend this task while forrecv processes
(suspend forsend)
call sys$hiber()

30 continue

type *,’ Program FORSEND is exiting’
call sys$delprc(ipid, )

end
c ufo_create.for - user-open routine. Called in 'open' statement

integer function ufo_create(fab,rab,lun)
include '($fabdef)'
include '($rabdef)'
record /fabdef/fab
record /rabdef/rab
integer*4 lun,chan,ids,sys$create
common /ufo/chan       !common for passing the channel

fab.fab$l_fop = fab.fab$l_fop .or. fab$m_ufo       !set user-open bit
ids = sys$create(fab)                                     !open the file
chan = fab.fab$l_stv                                      !get channel from fab
ufo_create = ids                                          !set status
end
glbsec.opt -- options file for linking the 'mapping' programs

this is used to page-align the common block 'comglb'

psect_attr = comglb,PAGE
c forrecvsavel.for

program forrecv

integer*2 ibuf, iflag
integer*2 j,l
integer*4 ids
integer*4 sys$hiber, sys$wake, sys$crmpsc, sys$mgblsc
integer*4 inadr(2), retadr(2), secflags

include '($secdef)'

common/comglb/ibuf(2048), iflag

secflags = sec$m_wrt
inadr(1) = %loc(ibuf(1))
inadr(2) = %loc(iflag )

map to the global section called 'glbsec'

ids=sys$mgblsc(inadr, retadr,,
1   %val(secflags),
1   'glbsec',,)

j=0

loop forever (we'll stop it with ctrl-y)

j=j+1

suspend this task until send task has some data

(suspend forrecv)
call sys$hiber()

c check data to see if correct

do 20 l=1,2048
   if( ibuf(1) .ne. j )then
      type *, 'data is incorrect for loop = ', j
   end if
20 continue

(resume forsend)
call sys$wake('HORNE')
go to 10

continue

end
program forsend

integer*2 ibuf(2048)
integer*2 i,k
integer*4 ispawn,ids
integer*4 ipid

integer*2 irecno 
integer*2 j !loop counter for receive task

external cli$m_nowait

common/comglb/irecno,j

irecno = 0

create and open file

open(unit=4,file='timetest.dat;1',status='new',
form='unformatted',access='direct',
orGANIZATION='sequential',recordsize=1024,
initialsize=2800,shared,err=99)

start up the receive task to run concurrently

ispawn=%loc(cli$m_nowait)
call libSspawn('run forrecvsave6,,,ispawn,'forrecv',ipid)

let receive task start
call libSwait(%ref(l.0))

-- beginning of forsend

!The send task (Program FORSEND) is starting'

!write 300 records to disk file

fill buffer

ibuf(i)=k
continue

write to file

write(4,rec=k,err=98)ibuf
update record number in common

irecno = irecno+1
continue

!wait for recv task to finish

if( j .gt. 300)go to 50
call libSwait(%ref(0.01))
go to 40

Program FORSEND is exiting'
call sysSdelprc(ipid, )
go to 60

forsend: write error on file'
go to 60

99 type *, 'forsend: open error on file'

60 continue
end
program forrecv

integer*2 ibuf(2048)
integer*2 j, l
integer*4 ids
integer*2 irecno
integer*2 itest

common/comglb/irecno, j
j=0

open file
open(unit=4, file='timetest.dat:1', status='old',
form='unformatted', access='direct',
organization='sequential',
recordsize=1024, shared, err=99)

continue
j=j+1
! set j to next record to read

wait for a record to be written
if ( irecno .ge. j ) then
  go to 16
else
  call lib$wait(%ref(0.01))
endif
  go to 15

read file
read(4, rec=j, err=98) ibuf

check data to see if correct

20 do l=1, 2048
  if ( ibuf(l) .ne. j ) then
    type *, 'data is incorrect for loop = ', j
  end if
continue
  go to 10

30 continue
  go to 40

98 type *, 'recv: read error, record no. ', j
  go to 40

99 type *, 'recv: open error'

40 continue

end
#include <errno.h>
#include <sys/types.h>
#include <sys/ipc.h>
#include <sys/shm.h>
#include <sys/signal.h>

key_t keyshm=200;
char *shmaddr=0;
char *shmat();
int shmid;

char crecv[7] = "crecv1";
char *argv;
int func();

int sig2flag=0;

main()
{
  int i, k, pid;
  char *shmbuf;
  short int *ibuf;
  extern int errno;

  printf("create shm seg\n");
      /* create shared memory segment  */
  if( (shmid = shmget(keyshm, 4096,IPC_CREAT|0666)) == -1)
    perror("shmget");

  printf("attach shm seg\n");
      /* attach shared memory segment  */
  if( (shmbuf = shmat(shmid, shmaddr, 0666)) == (char *) (-1))
    perror("shmat");

  ibuf = (short int *)(shmbuf);

  /* start up the receive task to run concurrently */
  printf("fork the recv process\n");
  if( (pid = fork()) == 0)
    execv(crecv, argv);

  printf("pid= %d\n", pid);
  perror("execv");
  signal(SIGUSR2, func); /* set up to catch resume signal from recv*/
  sleep(5);

  /* -- beginning of csend */
  printf( "The send task (Program CSEND) is starting\n");
  for( k=1; k<=300; ++k)
  {
    /* fill buffer */
    for(i=0; i<2048; ++i)
      ibuf[i] = k;

    /*resume the receive task to process the data in ibuf*/
    /*(resume crecv)*/
    usleep(100000);   /* delay to make sure recv is paused */
    kill(pid,SIGUSR1);

    /*suspend this task while crecv processes */
/*(suspend csend)*/

/*
  printf("send: suspending waiting for recv to check loop %d\n",k); */
  if( sig2flag != 1 )
    pause();
  sig2flag = 0;
/*
  printf("send: resumed, fill buffer for loop %d\n",(k+1)); */
}
printf("program CSEND is exiting\n");
kill(pid,9);
}

func(signum, sig_code, scp)
  int signum,sig_code;
  struct sigcontext *scp;
{
  sig2flag = 1;
/*
  printf("sigusr2 caught, sig2flag */
  return;
}
/* crecvl.c  send/receive benchmark for UNIX "C" on the Sun */
/* This version uses shared memory and signals */

#include <sys/types.h>
#include <sys/ipc.h>
#include <sys/shm.h>
#include <sys/signal.h>

key_t keyshm=200;
char *shmaddr=0;
char *shmat();
int shmid;

int siglflag=0;

main()
{
    int j, m, pid, func();
    char *shmbuf;
    short int *ibuf;

    /* get shared memory segment */
    if( (shmid = shmget(keyshm, 4096,0666)) == -1)
        perror("shmget");

    /* attach shared memory segment */
    if( (shmbuf = shmat(shmid, shmaddr,0666)) == (char *)(-1))
        perror("shmat");

    ibuf = (short int *)(shmbuf);
    pid = getppid();

    /* loop forever (we'll stop it externally) */
    signal(SIGUSR1,func);  /* set up to catch resume signal from send */
    for(j=1; ; ++j)
    {
        /* suspend this task until send task has some data*/
        /*(suspend crecv)*/
        /* printf("recv: now suspending waiting for loop %d\n",j); */
        if( siglflag != 1 )
            pause();
        siglflag = 0;
        /* printf("recv: resumed, check data for loop %d\n",j); */
        for(m=0; m<2048; ++m)
        {
            if( ibuf[m] != j)
            {
                printf("data is incorrect for loop = %d\n",j);
                printf(" ibuf[%d] = %d\n",m,ibuf[m]);
            }
        }
        /*(resume csend)*/
        usleep(100000);      /* delay to make sure send is paused */
        kill(pid,SIGUSR2);
    }
    /* terminate */
}
func(signum, sig_code, scp)
    int signum, sig_code;
    struct sigcontext *scp;
    
    siglflag = 1;
    return;

/* csend2.c send/receive benchmark for UNIX "C" on the Sun */
/* This version uses shared memory and semaphores */

#include <stdio.h>
#include <errno.h>
#include <sys/types.h>
#include <sys/ipc.h>
#include <sys/shm.h>
#include <sys/sem.h>

key_t keyshm=200, keysem=300;
char *shmaddr=0;
char *shmat();
int shmid, semid, semval;
struct sembuf lock0={0,-1,SEM_UNDO};
struct sembuf unlock0={0, 1,SEM_UNDO};
struct sembuf lock1={0,-1,SEM_UNDO};
struct sembuf unlock1={0, 1,SEM_UNDO};

char crecv[7] = "crecv2";
char *argv;

main()
{
    int i, k, pid;
    char *shmbuf;
    short int *ibuf;
    extern int errno;

    printf("create shm seg\n");
    /* create shared memory segment */
    if( (shmid = shmget(keyshm, 4096,IPC_CREAT|0666)) == -1)
        perror("send:shmget");

    printf("attach shm seg\n");
    /* attach shared memory segment */
    if( (shmbuf = shmat(shmid, shmaddr,0666)) == (char *)(-1))
        perror("send:shmat");

    ibuf = (short int *)(shmbuf);
    if( (semid = semget(keysem, 2,0666|IPC_CREAT|IPC_EXCL)) == -1)
        perror("send:semget");

    if( (semval = semctl(semid,0,GETVAL)) == -1)
        perror("send:semctl");
    printf("semval=%d\n",semval);

    /* start up the receive task to run concurrently */
    printf("fork the recv process\n");
    if( (pid = fork()) == 0)
        execv(crecv, argv);

    printf("pid= %d\n", pid);
    perror("send:execv");

    sleep(5);

    /* -- beginning of csend */
    printf( "The send task (Program CSEND) is starting\n");
    for( k=1; k<=300; ++k)
    {
        /* fill buffer */
        for(i=0; i<2048; ++i)
ibuf[i] = k;
  /* resume the receive task to process the data in ibuf */
  usleep(100000);
  /* (resume crecv) */
  if( semop(semid, &unlock1, 1) == -1)
    perror("send: semop");
  if( (semval = semctl(semid, 1, GETVAL)) == -1)
    perror("send: semctl");
  /*
   * printf("send: semval after unlock=%d\n",semval);
  */

  /* suspend this task while crecv processes */
  /* (suspend csend) */
  /* printf("send: suspending waiting for recv to check loop %d\n",k); */
  if( semop(semid, &lock0, 1) == -1)
    perror("send: semop");
  /* printf("send: resumed, fill buffer for loop %d\n",(k+1)); */
  if( (semval = semctl(semid, 0, GETVAL)) == -1)
    perror("send: semctl");
  /*
   * printf("send: semval after lock=%d\n",semval);
  */

}
printf( "program CSEND is exiting\n");
kil(pid, 9);
semctl(semid, 0, IPC_RMID);
/ * crecv2.c send/receive benchmark for UNIX "C" on the Sun */

#include <stdio.h>
#include <sys/types.h>
#include <sys/ipc.h>
#include <sys/shm.h>
#include <sys/sem.h>

key_t keyshm=200, keysem=300;
char *shmaddr=0;
char *shmat();
int shmid, semid, semval;

struct sembuf lock0={0,-1,SEM_UNDO};
struct sembuf unlock0={0, 1,SEM_UNDO};
struct sembuf lock1={0,-1,SEM_UNDO};
struct sembuf unlock1={0, 1,SEM_UNDO};

main()
{
    int j, m, pid;
    char *shmbuf;
    short int *ibuf;

    printf("recv: starting recv\n");
    /* get shared memory segment */
    if( (shmid = shmget(keyshm, 4096, 0666)) == -1)
        perror("shmget");
    /* attach shared memory segment */
    if( (shmbuf = shmat(shmid, shmaddr, 0666)) == (char *) (-1))
        perror("shmat");
    ibuf = (short int *) (shmbuf);
    pid = getppid();
    semid=semget(keysem,2,0);
    semval = semctl(semid,0,GETVAL);
    printf("recv: semval = %d\n",semval);
    /* loop forever (we'll stop it externally) */
    printf("recv: start recv loop\n");
    for(j=1; ; ++j)
    {
        /* suspend this task until send task has some data*/
        /*(suspend crecv)*/
        /* print("recv: now suspending waiting for loop %d\n",j); */
        semop(semid,&lock1,1);
        semval = semctl(semid,1,GETVAL);
        /* print("recv: resumed, check data for loop %d\n",j);*/
        printf("recv: semvall after lock = %d\n",semval);
        /* check data to see if correct */
        for(m=0; m<2048; ++m) /* check each word of array */
        {
            if( ibuf[m] != j)
            {
                printf("data is incorrect for loop = %d\n",j);
                printf("ibuf[%d] = %d\n",m,ibuf[m]);
            }
        }
        if( m < 3 || m > 2045)
/*
    printf("m = %d, ibuf[m] = %d\n",m,ibuf[m]); */
}

    /* resume the send task to send more data */
    usleep(100000);
    /*(resume csend)*/
    semop(semid,&unlock0,1);
    semval = semctl(semid,0,GETVAL);  
    printf("recv: semval after unlock=%d\n",semval); */
}

    /* terminate */
}
/* csend3.c  send/receive benchmark for UNIX "C" on the Sun */
/*
* This version uses shared memory for data and
* a shared memory flag for synchronization */

#include <errno.h>
#include <sys/types.h>
#include <sys/ipc.h>
#include <sys/shm.h>

key_t keyshm=200;
char *shmaddr=0;
char *shmat();
int shmid;

char ccrecv[7] = "ccrecv3";
char *argv;

main()
{
    int i, k, pid;
    char *shmbuf;
    short int *ibuf;
    extern int errno;

    printf("create shm seg\n");
    /* create shared memory segment */
    if( (shmid = shmget(keyshm, 8192,IPC_CREAT|0666)) == -1)
        perror("send:shmget");

    printf("attach shm seg\n");
    /* attach shared memory segment */
    if( (shmbuf = shmat(shmid, shmaddr, 0666)) == (char *)(-1))
        perror("send:shmat");

    ibuf = (short int *) (shmbuf);
    ibuf[2048] = 0; /* initialize flag for synchronization*/

    /* start up the receive task to run concurrently */
    printf("fork the recv process\n");
    if( (pid = fork()) == 0)
        execv(ccrecv, argv);

    printf("pid= %d\n", pid);
    perror("send:execv");

    sleep(5);

    /* -- beginning of csend */
    printf("The send task (Program CSEND) is starting\n");

    for( k=1; k<=300; ++k)
    {
        /* fill buffer */
        for(i=0; i<2048; ++i)
            ibuf[i] = k;

        /*resume the receive task to process the data in ibuf*/
        /*(resume ccrecv)*/
        /*
        printf("send: resume recv to process loop %d\n",k); */
        ibuf[2048] = 1;

        /*suspend this task while ccrecv processes */
/* (suspend csend) */
/*
printf("send: suspending waiting for recv to check loop %d\n",k); */
while( ibuf[2048] != 0)
    usleep(10000);    /* delay a minimum amount */
    /* NOTE: takes the same time for 1 to 10000 usec. */
/*
printf("send: resumed, fill buffer for loop %d\n",k); */

} printf( "program CSEND is exiting\n" );
kill(pid, 9);
/ * crecv3.c  send/receive benchmark for UNIX "C" on the Sun  */
/ * This version uses shared memory for data and
a shared memory flag for synchronization */

#include <sys/types.h>
#include <sys/ipc.h>
#include <sys/shm.h>

key_t keyshm=200;
char *shmaddr=0;
char *shmat();
int shmid;

main()
{
    int j, m, pid;
    char *shmbuf;
    short int *ibuf;

    printf("recv: starting recv\n");

    /* get shared memory segment */
    if( (shmid = shmget(keyshm, 8192, 0666)) == -1)
        perror("shmget");

    /* attach shared memory segment */
    if( (shmbuf = shmat(shmid, shmaddr, 0666)) == (char *) (-1))
        perror("shmat");

    ibuf = (short int *) (shmbuf);

    pid = getppid();

    /* loop forever (we'll stop it externally) */
    printf("recv: start recv loop\n");
    for(j=1; ; ++j)
    {
        /* suspend this task until send task has some data*/
        /*(suspend crecy)*/
        /* print("recv: now suspending waiting for loop %d\n",j); */
        while( ibuf[2048] != 1 )
            usleep(10000); /* delay a minimum amount */
            /* NOTE: takes the same time for 1 to 10000 usec.*/
        /* print("recv: resumed, check data for loop %d\n",j); */

        /* check data to see if correct */
        for(m=0; m<2048; ++m) /* check each word of array */
        {
            if( ibuf[m] != j)
                {
                    printf("data is incorrect for loop = %d\n",j);
                    printf(" ibuf[%d] = %d\n",m,ibuf[m]);
                }
        }

        /* resume the send task to send more data */
        /* print("recv: now resume the send process\n"); */
        /*(resume csend)*/
        ibuf[2048] = 0;
    }
} */
program rspns1

integer*4 ids, lib$spawn
character*6 name
data name/'rspns2'/

write(6,900)
format(’ start response time test ’)

do 10 i=1,100
   spawn subprocess and wait for completion
   ids = lib$spawn(’run rspns2’,,,,name) ! spawn w/run
   ids = lib$spawn(’rspns2’,,,,name) ! spawn as command
   call lib$spawn(’run rspns2’,,,,name) ! spawn w/run
   if(.not. ids) call sysmsg(ids) ! This code for debug
   continue

write(6,910)
format(’ end response time test ’)
end
c rspns2.for

    program rspns2
    end
This version uses the termination mailbox method to wait for completion of the created process. The created process is the original version of rspns2.

The termination mailbox is read with a QIO call.

```fortran
program rspns1

include '($prcdef)'
include '($dvidef)'
include '($iodef)'

integer*4 ids,sys$creprc,sys$crembx,lib$getdvi,sys$qiow
integer*4 pid, ichan, mbxunt
integer*2 itrmsg(512)
integer*2 iostat(4)
character*6 name

data name/'rspns2'/

create termination mailbox
ids = sys$crembx( ,ichan,,,'mbx')
if(.not. ids) go to 99

get device unit no. for mbx
ids = lib$getdvi(dvi$ unit,ichan,,mbxunt,,)
if(.not. ids) go to 99

write (6,900)
format(' start response time test ')

do 10 i=1,100
create detached process with term. mailbox
ids = sys$creprc( pid,'dual:[user.horne]rspns2.exe',
  1 ',
  1 ',name,%val(4),,
  1 %val(mbxunt),%val(prc$m_detach) )
if(.not. ids) go to 99
!read to wait for termination
ids = sys$qiow( , %val(ichan), %val(io$_readvblk),
  1 iostat,,,itrmsg,%val(8),,,)

10 continue

!!!! type 901,(itrmsg(k),k=1,42)
!901 format(4(x,10z6.4/),(x,2z6.4))

write(6,910)
format(' end response time test ')
if(.not. itrmsg(3))call sysmsg(itrmsg(3))
go to 100

99 call sysmsg(ids) ! This code for debug
100 continue
end
```
c timetask1.for -- hiber/wake version

program timetask1

integer*2 i
integer*4 ispawn, ids
integer*4 ipid

integer*4 sys$hiber, sys$wake

external cli$m_nowait

c start up task2 to run concurrently
ispawn=%loc(cli$m_nowait)
call lib$spawn('run timetask2', ispawn, 'timtk2', ipid)

c wait while task2 loads
call lib$wait(%ref(2.0))
type *, ' task1 is starting'
do 30 i=1,1000

(c resume task2
(c (resume task2)
call sys$wake(ipid, )

(c suspend this task while task2 runs
(c (suspend task1)
call sys$hiber( )

30 continue

type *, ' task1 is exiting'
call sys$delprc(ipid, )
go to 40

40 continue

end
program timetask2
integer*4 ids
integer*4 sys$hiber,sys$wake

loop forever
continue
suspend this task until send task1 starts it
(suspend task2)
call sys$hiber()
resume task1
(resume task1)
call sys$wake(,'HORNE')
go to 10
continue
end
/* proctim.c -- parent-child process timing test */

#define DELAY 30
int i;
int j;

main()
{
  for(i=1; i<=20; ++i)
  {
    sleep(1);
    if(fork() == 0)
    {
      for(;;)
      {
        printf("i'm task no. %d \n",i);
        sleep(Delay);
      }
      exit();
    }
  }
}
program proctim

integer*4 ids

include '($prcdef)'
integer*4 pid,sys$creprc,lib$spawn
character*6 prcnam /'prcn__'/
external cli$m_nowait

do 50 i=1,20
    if( i .lt. 10 )then
        prcnam(5:5) = '0'
        prcnam(6:6) = char(48+i)
    else
        if( i .lt. 20)then
            prcnam(5:5) = '1'
            prcnam(6:6) = char(48+i-10)
        else
            prcnam(5:5) = '2'
            prcnam(6:6) = char(48+i-20)
        endif
    endif
    ids = lib$spawn('run dual:[user.horne]proctiml',',,
    %loc(cli$m_nowait),prcnam)

    call lib$wait(%ref(1.0))

50 continue

call lib$wait(%ref(200.0))
end
c proctim_det.for

c proctim.for -- process timing test, detached process version.
c    This is the "parent" process, the "child" processes are copies of proctiml.for.

program proctim

integer*4    ids

include    '($dvidef)'
character*16    devnam
integer*2    ilen
integer*4    lib$getdvi

include    '($prcdef)'
integer*4    pid,sys$creprc
character*6    prcnam  /*'prcn__'*/

!get equivalence name for sys$input device
ids = lib$getdvi(dvi$_devnam,,'sys$input',,devnam,ilen)

!start off 24 "child" processes

do 50 i=1,24

    if( i .lt. 10 )then
        prcnam(5:5) = '0'
        prcnam(6:6) = char(48+i)
    else
        if( i .lt. 20)then
            prcnam(5:5) = '1'
            prcnam(6:6) = char(48+i-10)
        else
            prcnam(5:5) = '2'
            prcnam(6:6) = char(48+i-20)
        endif
    endif

    !create process as detached process
    ids = sys$creprc(pid,'dual:[user.horne]proctiml',
                      devnam(1:ilen),devnam(1:ilen),devnam(1:ilen),
                      prcnam,%val(10),,,%val(prc$m_detach))

    call lib$wait(%ref(1.0))

50    continue

end
program proctiml

integer*4 ids

include '(jpi_def)'
integer*4 lib$getjpi, jlen
character*15 prcnam

ids = lib$getjpi(jpi$_prcnam,,,prcnam,jlen)

do 100 i=1,10
   type *, 'I’m task no. ',prcnam(5:6)
   call lib$wait(%ref(60.0))
100 continue

end
--- proctim.ada --- Parent-Child Process timing test, program to start
--- 20 "child" processes, letting them run independently.
--- Ada version for the MicroVAX II, uses Ada tasks
--- instead of operating system processes.

with text_io; use text_io;

procedure proctim is

    idum : integer;

    package my_io is new integer_io( integer );
    use my_io;

    -- This is the "child" task. Multiple copies will be started.

    task type test_run is
        entry start;
    end test_run;

    bunch_of_runs : array(1..20) of test_run; -- declare 20 tasks.

    task body test_run is

        iname : integer := 0;

        begin

            accept start;
            iname := idum;
            for j in 1..5 loop
                put("I'm task "); put( iname );
                new_line;
                delay 30.0;
            end loop;
        end test_run;

    -- This is the "parent" task.

    begin

        for i in 1..20 loop
            idum := i;
            bunch_of_runs(i).start;
            delay 1.0;
        end loop;

    end proctim;
-- task1_and_task2.ada - an Ada program to test multi-tasking.

-- This program alternates execution between two
tasks. There is no synchronization between the
two tasks, only delay statements to test
alternating execution.

with text_io, calendar;
use text_io, calendar;

procedure task1 is

    package duration_text_io is new fixed_io( duration );
    use duration_text_io;

    t0 : duration; -- time for task1.
    t1 : duration; -- time for task2.

    task task2;

    task body task2 is

        begin -- beginning of task2.

            t1 := seconds( clock );
            put(" task2 starting time ( in seconds from midnight ) = ");
            put( t1 ); new_line;
            delay 5.0; -- delay for 5 seconds.

            t1 := seconds( clock );
            put(" task2 running, time ( in seconds from midnight ) = ");
            put( t1 ); new_line;
            delay 5.0; -- delay for 5 seconds.

            t1 := seconds( clock );
            put(" task2 running, time ( in seconds from midnight ) = ");
            put( t1 ); new_line;
            delay 5.0; -- delay for 5 seconds.

            t1 := seconds( clock );
            put(" task2 running, time ( in seconds from midnight ) = ");
            put( t1 ); new_line;
            delay 5.0; -- delay for 5 seconds.

            t1 := seconds( clock );
            put(" task2 running, time ( in seconds from midnight ) = ");
            put( t1 ); new_line;
            delay 5.0; -- delay for 5 seconds.

        end task2;

        begin -- beginning of task1.

            t0 := seconds( clock );
            put(" task1 starting time ( in seconds from midnight ) = ");
            put( t0 ); new_line;
            delay 5.0; -- delay for 5 seconds.

            t0 := seconds( clock );
            put(" task1 running, time ( in seconds from midnight ) = ");
            put( t0 ); new_line;
            delay 5.0; -- delay for 5 seconds.

            t0 := seconds( clock );
            put(" task1 running, time ( in seconds from midnight ) = ");
            put( t0 ); new_line;
            delay 5.0; -- delay for 5 seconds.

            t0 := seconds( clock );
            put(" task1 running, time ( in seconds from midnight ) = ");
            put( t0 ); new_line;
            delay 5.0; -- delay for 5 seconds.

            t0 := seconds( clock );
            put(" task1 running, time ( in seconds from midnight ) = ");
            put( t0 ); new_line;
            delay 5.0; -- delay for 5 seconds.
        end task1;
delay 5.0; -- delay for 5 seconds.

t0 := seconds( clock );
put(" task1 running, time ( in seconds from midnight ) = ");
put( t0 ); new_line; -- print out the current time.
delay 5.0; -- delay for 5 seconds.

t0 := seconds( clock );
put(" task1 running, time ( in seconds from midnight ) = ");
put( t0 ); new_line; -- print out the current time.

end task1;
ttqio.ada — program to test QIO system service from Ada for terminal output, MicroVAX II.

with text_io; use text_io;

with starlet; use starlet; -- used for system calls.
with system; use system; -- used by starlet.
with condition_handling; use condition_handling; -- used for status returns.
with unchecked_conversion; -- used for type conversion.

procedure ttqio is

    -- The purpose of this function is to convert a value
    -- from the type of "address" to the type of
    -- "unsigned_longword" so that the value can be used
    -- by the QIO system service routine.

    function convert_addr_to_longword is new unchecked_conversion (address, unsigned_longword);

    -- The purpose of this function is to convert a value
    -- from the type of "iosb_type" to the type of
    -- "cond_value_type" so that it can be used by the
    -- routine sysmsg.

    function convert_status is new unchecked_conversion (iosb_type, cond_value_type);

    -- make declarations necessary
    -- to access FORTRAN routine to
    -- output system messages.

    procedure sysmsg( ids : cond_value_type);
    pragma interface( fortran, sysmsg );
    pragma import_procedure( sysmsg, mechanism=>reference );

    -- declare variables.
    buffer : constant string := "this is a test";
    adrbuf : address;
    ttchan : channel_type; -- I/O channel.
    ids : cond_value_type; -- system service status.
    iostat : iosb_type; -- QIO returned status.
    cond_stat : cond_value_type; -- QIO function code.
    ifunc : function_code_type := io_writepblk;
    qio_pl : unsigned_longword; -- QIO buffer address.
    qio_p2 : unsigned_longword := 14; -- QIO byte count.

    begin
        assign( ids,"tt:",ttchan);
        new_line(2);
        put_line( "assign status:" );
        sysmsg( ids );
        new_line(2);
        adrbuf := buffer'address;
        qio_pl := convert_addr_to_longword ( adrbuf );

        qiw( status=>ids, chan=>ttchan, func=>ifunc,
             iosb=>iostat, pl=>qio_pl, p2=>qio_p2);

        new_line;
put_line(" qio status:");
sysmsg( ids );
new_line;

put_line(" i/o status:");
cond_stat := convert_status ( iostat );
sysmsg( cond_stat );

end ttqio;
program ttqio
character*20 buffer
integer*4 ids,sys$assign,sys$qiow,lib$getjpi,lib$getdvi
integer*2 iosb(4),ttchan
character*15 prcnam
character*16 devnam
integer*2 ilen
integer*4 jlen

data buffer/'this is a test: no.1'/
include '($iodef)'
include '($ssdef)'
include '($jpidef)'
include '($dvidef)'

write(5,900)

format( ' ttqio performs 2 qio writes to terminal',/)  
ids=lib$getjpi(jpi$_prcnam,,,,prcnam,jlen)  
type *,'process name = ','prcnam(1:jlen)  
ids=lib$getdvi(dvi$_devnam,'sys$input',,devnam,ilen)  
type *,'sys$input name = ','devnam(1:len)  
call lib$wait(%ref(4.0))  
ids=sys$assign('tt:',ttchan,,)  
type *,' ttchan= ',ttchan,' assign status:'  
    !"type" tests write
    call sysmsg(ids)  
type *,''
ids=sys$qiow(, %val(ttchan), %val(IO$_WRITEPBLK),iosb,,  
    1   %ref(buffer), %val(20),,,,)  
    type *,' qio status:'  
call sysmsg(ids)  
    type *,'i/o status:'  
call sysmsg(iosb(1))  
call lib$wait(%ref(30.0))  

ids=sys$assign('tt:',ttchan,,)  
type *,' ttchan= ',ttchan,' assign status:'  
call sysmsg(ids)  
type *,''
buffer(20:20)=2'  
ids=sys$qiow(, %val(ttchan), %val(IO$_WRITEPBLK),iosb,,  
    1   %ref(buffer), %val(20),,,,)  
    type *,' qio status:'  
call sysmsg(ids)  
    type *,'i/o status:'
call sysmsg(iosb(1))

type *, 'ttqio exiting!'
type 901

901 format(' $ ',$

end
/ttqio.c - Program to test QIO system services from "C" for terminal output. NOTE: To link, use the following command:
  link ttqio,sysmsg
where sysmsg is a FORTRAN subroutine to output system messages.

#include stdio /* UNIX 'Standard I/O' Definitions. */
#include iodef /* I/O Functions Codes Definitions. */
#include descrip /* VMS Descriptor Definitions. */

char buffer[15] = "this is a test"; /* test output message. */

int SYS$ASSIGN(),SYS$QIOW(); /* declaration of the system services (not required). */

main()
{
  short ttchan,iosb[4];
  int ids,p2=14;

  struct dsc$descriptor_s name_desc; /* Name the descriptor */
  char *name = "tt:"; /* Define device name. */

  /* length of name WITHOUT null terminator. */
  name_desc.dsc$w_length = strlen( name );

  name_desc.dsc$a_pointer = name; /* Put address of shortened string in descriptor. */

  /* String descriptor class */
  name_desc.dsc$b_dtype = DSC$K_CLASS_S;

  /* Data type: ASCII string */
  name_desc.dsc$b_dtype = DSC$K_DTYPE_T;

  /* Call assign system service */
  ids=SYS$ASSIGN( &name_desc,&ttchan,0,0);

  putchar( '\n' );
  putchar( '\n' );

  printf( "assign status:\n" );
  sysmsg( &ids );

  putchar( '\n' );
  putchar( '\n' );

  /* Call QIO system service. */
  ids=SYS$QIOW( 0,ttchan,IO$_WRITEPBLK,&iosb,0,0,
                 &buffer,p2,0,0,0,0 );
```c
putchar(\n');
printf("qio status:\n");
sysmsg( &ids );
putchar(\n');

ids=iosb[0];
printf("i/o status:\n");
sysmsg( iosb );
```
c testalarm.for -- program to test alarm call, MicroVAX II.
c
This program uses an event flag to signal an alarm after a specified period of time.

program testalarm

real*4 dtime
integer*4 delta(2)
integer*4 istat, ival, iflag, itimr, sys$redef

include '(ssdef)'

iflag = 1
itimr = 1

type *, 'enter alarm delay time, in seconds (real number)'
accept *, dtime

type *, 'calling alarm routine'

! Convert delay time to VMS quadword format.
call rtimsysbin(dtime, delta)
call sys$setimr(%val(iflag), delta, %val(itimr))

type *, 'waiting for event flag'

10 istat = sys$redef(%val(iflag), ival)
if( istat .eq. SS$ WASSET ) go to 20
call lib$wait(%ref(0.01))
go to 10

20 continue

type *, 'ALARM!'

end
This program uses an AST routine to interrupt the main program and signal an alarm after a specified period of time.

Program `testalarm`

```fortran
program testalarm
  real*4    dtime
  integer*4 delta(2)
  integer*4 istat,ival,itimr
  external  alarmast !must use else a reserved opcode fault occurs
  common/astcom/istat
  include    '($ssdef)'
  itimr = 1
  istat = 0
  type *,'enter alarm delay time, in seconds (real number)'
  accept *,dtime
  call rtimsysbin(dtime,delta) !Convert delay time to VMS quadword format.
  call sys$setimr(delta,alarmast,%val(itimr)) !call system routine to set timer and specify !the AST routine.
  type *,'waiting for alarm AST'
10 continue
  if( istat .eq. SS$_WASSET )go to 20
  call lib$wait(%ref(0.01))
  go to 10
20 continue
  type *,'ALARM!'
end

subroutine alarmast !this is the AST routine.
  include    '($ssdef)'
  integer*4   istat
  common/astcom/istat
  istat = SS$_WASSET
  return
end
```
c rtimsysbin.for -- will convert an amount of time (in seconds, to a resolution of 0.01 sec), to system quadword format.

c subroutine rtimsysbin(tim,deltim)

real*4 tim !time, in seconds, real number
integer*4 itics,idays,ihrs,imin,isec,ihsec,irem
character*16 string
integer*4 deltim(2) !time, in vax system quadword format

***convert "tim" to integer number of 0.01 sec. ticks***

itics = tim*100. !convert "tim" to integer number of 0.01 sec. ticks
idays = itics/8640000 !(100*60*60*24) ticks/day
irem = jmod(itics,8640000)
ihrs = irem/360000 !(100*60*60) ticks/hour
irem = jmod(irem,360000)
imin = irem/6000 !(100*60) ticks/min
irem = jmod(irem,6000)
isec = irem/100 !(100) ticks/sec
ihsec = jmod(irem,100) !ticks

write(string,900)idays,ihrs,imin,isec,ihsec
format(i4,' ',i2.2(':',i2.2,':',i2.2,'.',i2.2),i2.2)

type 900,idays,ihrs,imin,isec,ihsec !DEBUG
call sys$bigint(string,deltim) !convert from string to system delta format

return
end
This program uses an AST routine to interrupt the main program and signal an alarm after a specified period of time.

NOTE: The link command for this program is as follows:
acs link testalarm_ast rtimsysbin

with text_io; use text_io; -- used for system calls.
with starlet; use starlet; -- used by starlet.
with system; use system; -- used for status returns.
with condition_handling; use condition_handling; -- used for status returns.

procedure testalarm_ast is

package my_io is new float_io( float );
use my_io;

procedure rtimsysbin( dtime : float; delta_tim : date_time_type );
pragma interface( fortran,rtimsysbin );
pragma import_procedure( rtimsysbin, mechanism=>reference );

dtime : float := 0.0; -- input delay time.
delta_tim : date_time_type; -- delay time (VMS quadword).
ids : cond_value_type; -- system service status.

--*********************************************************************
task handler is -- THIS IS THE AST ROUTINE.
    entry receive_ast;
    pragma ast_entry( receive_ast );
end handler;

begin
    task body handler is
        begin
            accept receive_ast;
            istat := SS_WASSET;
        end handler;
    --*********************************************************************

begin
    loop
        begin
            put_line("enter alarm delay time, in seconds (real number)");
            get( dtime ); -- get the input delay time.
            exit; -- exit loop if no error.
        exception
            when data_error =>
                skip_line; put("input error - try again");
        end;
    end loop;

    -- call fortran subroutine to
    -- convert delay time to VMS
    -- quadword format.
rtimsysbin( dtime,delta_tim );

-- call system routine to
-- set the timer and to
-- specify the AST routine.

setimr( status=>ids, daytim=>delta_tim,
    astadr=>handler.receive_ast'ast_entry,
    reqidt=>itimr );

put_line("waiting for alarm AST"); new_line;

loop
    delay 0.01;
    if istat = SS_WASSET then
        exit;
    end if;
end loop;

put( "ALARM!" ); new_line;

end testalarm_ast;
/* testalarm_ast.c -- program to test alarm call, MicroVAX II. */
/*
This program uses an AST routine to interrupt the main program and signal an alarm after a specified period of time. */

#include ssdef /* used for system services */

int istat;

main()
{
    extern alarmast();
    float dtime;
    int delta[2],ival,itimr;
    itimr =1;
    istat = 0;
    printf("enter alarm delay time, in seconds (real number)\n");
    scanf("%f", &dtime);
    rtimsysbin(&dtime,delta);
    /* call system routine to set */
    /* the timer and to specify */
    /* the AST routine. */
    sys$setimr(0,delta,alarmast, itimr);
    printf("waiting for alarm AST\n");
    while( istat != SS$_WASSET )
    {
        lib$wait(0.01);
    }
    printf("ALARM\n");
}

/* alarmast() */
/* This is the AST routine. */

istat = SS$_WASSET;
*/
-- adadelay.ada  - An Ada program to test the Ada "delay" statment,  
       MicroVAX II.

with calendar, text_io;
use calendar, text_io;

procedure adadelay is

    package duration_io is new fixed_io( duration );
    use duration_io;

    interval : constant duration := 10.0;
    tl       : duration;
    t2       : duration;
    dtime    : duration;
    ptime    : duration;

    begin

        tl := seconds( clock );

        loop

            t2 := seconds( clock );

            ptime := t2 - tl;
            dtime := (interval - ( ptime ) );
            delay dtime;

            tl := seconds( clock );

            put(" proc. time = "); put ( ptime ); new_line;
            put(" delay time = "); put( dtime ); new_line;
            put(" total time = "); put( dtime+ptime ); new_line; new_line;

        end loop;

    end;

-- task_order.ada  -- An Ada program used to determine the order of
activation of multiple tasks, MicroVAX-II.

with text_io; use text_io;

procedure task_order is

------------------------------

    task task4;
    task task3;
    task task2;
    task task1;

------------------------------

    task body task2 is
        begin -- beginning of task2.
            put(" Task2 is starting"); new_line;
        end task2;

------------------------------

    task body task3 is
        begin -- beginning of task3.
            put(" Task3 is starting"); new_line;
        end task3;

------------------------------

    task body task4 is
        begin -- beginning of task4.
            put(" Task4 is starting"); new_line;
        end task4;

------------------------------

    task body task1 is
        begin -- beginning of task1.
            put(" Task1 is starting"); new_line;
        end task1;

------------------------------

begin -- beginning of task_order.
    put(" The driver (task_order) is starting"); new_line;
end task_order;
-- task_exec.ada - Ada multi-task time-shared execution test.
--
-- This is a test program to run three tasks
-- by alternating their execution, letting
-- each one run for a specified time interval.
-- (MicroVAX-II version.)
--
-- NOTE: This program is designed to run without
"time-slicing" of any kind.

with text_io; use text_io;
with calendar; use calendar;

procedure task_exec is

package duration_io is new fixed_io( duration );
use duration_io;

package my_io is new integer_io( integer );
use my_io;

--*****************
-- procedure check -- reentrant procedure to let calling task
-- control its own execution.
--
-- This procedure checks to see if the process time has expired.
-- THIS PROCEDURE IS USED INSTEAD OF A TIME_SLICE MECHANISM.

procedure check( interval : in duration; tl : in out duration ) is

  t2 : duration;          -- current time (seconds).
  dtime : duration;       -- delta time (seconds).

begin
  t2 := seconds( clock ); -- get current time (seconds).
  dtime := t2 - tl;      -- calculate how long the calling
                         -- task has been running.
  if dtime >= interval then
    delay 0.01;           -- delay just enough to schedule
    -- another task.
    tl := seconds( clock ); -- get new start time (seconds).
  end if;
  end check;

--********

--********

-- declare tasks such that taskl starts first.

task task3;      -- declare tasks such that taskl starts first.
task task2;
task task1;

--********

task body taskl is

  tl : duration;          -- process start time (seconds).
  interval : constant duration := 5.0; -- desired process time.
  icnt : integer := 0;

begin
  -- beginning of taskl.
put(" Task1 is starting"); new_line;
tl := seconds( clock ); -- set starting time.
loop -- loop forever.
check( interval,tl ); -- see if time has elapsed.
icnt := icnt + 1;
put("Task1 = "); put(icnt);
put(" "); new_line;
end loop;
end task1;

-- beginning of task1.
-- beginning of task2.

task body task2 is

tl : duration; -- process start time (seconds).
interval : constant duration := 5.0; -- desired process time.
icnt : integer := 0;

begin -- beginning of task2.
put(" Task2 is starting"); new_line;
tl := seconds( clock ); -- set starting time.
loop
check( interval,tl ); -- see if time has elapsed.
icnt := icnt + 1;
put(" Task2 = "); put(icnt);
put(" "); new_line;
end loop;
end task2;

-- beginning of task2.
-- beginning of task3.

task body task3 is

tl : duration; -- process start time (seconds).
interval : constant duration := 5.0; -- desired process time.
icnt : integer := 0;

begin -- beginning of task3.
put(" Task3 is starting"); new_line;
tl := seconds( clock ); -- set starting time.
loop -- loop forever.
check( interval,tl ); -- see if time has elapsed.
icnt := icnt + 1;
put(" Task3 = "); put(icnt);
new_line;
end loop;
end task3;

-- beginning of task3.
-- beginning of task_exec.

begin -- beginning of task_exec.

put(" task_exec is starting"); new_line;

end task_exec;
tstslice.ada - Multi-task time-shared execution program using
time-slicing, IBM PC AT version.

This program is designed to perform the same functions as tsk_exec.ada except using 5-second time-slicing
instead of the reentrant check subprogram.

To bind with 5-second time-slicing, use the following command:

bind tstslice, adalib, options=(slice=5000)

with text_io; use text_io;

procedure tstslice is

----------
task task1;
task task2;
task task3;
----------
task body task1 is

begin
  put("task1 is starting"); new_line;
  loop -- loop forever.
    put("Task1"); new_line;
  end loop;
end task1;

----------
task body task2 is

begin
  put("Task2 is starting"); new_line;
  loop
    put(" Task2"); new_line;
  end loop;
end task2;

----------
task body task3 is

begin
  put("Task3"); new_line;
  loop
    put(" Task3"); new_line;
  end loop;
end task3;

----------
begin
  put(" tstdelay is starting"); new_line;
end tstslice;
with text_io; use text_io;

procedure main is

   package new_float is new float_io( float );
   use new_float;

   type arrayl is array( integer range <> ) of float;

   function innerprod( a,b : arrayl; n : integer ) return float;
   pragma interface( fortran,innerprod );
   pragma import_function( innerprod, mechanism => reference );

   q : arrayl( 1..100 ) := ( i..I00 => 1.0 );
   t : arrayl( 1..100 ) := ( i..i00 => 1.0 );
   p : float;

begin

   p := innerprod( q, t, q'length );
   put( "returned value = " ); put( p ); new_line;

end main;
function innerprod(a, b, n)

c This routine multiples two one-dimensional arrays. 
c element-by-element, then sums the products.

c Declare A and B as arrays of real numbers.

real innerprod, a(n), b(n)

sum = 0.0

do 100 i = 1, n
   sum = sum + a(i) * b(i)
100 continue

innerprod = sum

return
end
-- mainl.ada - program to test calling a Fortran subroutine (innerprodl)
-- from an Ada program, MicroVAX II.

-- NOTE: Use the following command to link:
    acs link mainl innerprodl

with text_io; use text_io;

procedure mainl is

    package new_float is new float_io( float );
    use new_float;

    type arrayl is array( integer range <> ) of float;

    procedure innerprodl( a,b : arrayl; n : integer; sum : in out float );
    pragma interface( fortran,innerprodl );
    pragma import_procedure( fortran,innerprodl, mechanism => reference );

    q : arrayl( 1..100 ) := ( 1..100 => 1.0 );
    t : arrayl( 1..100 ) := ( 1..100 => 1.0 );
    p : float;

begin

    innerprodl( q, t, q'length, p );
    put( "returned value = " ); put( p ); new_line;

end mainl;
subroutine innerprodl( a, b, n, sum )

This routine multiples two one-dimensional arrays.

declare A and B as arrays of real numbers.

real a( n ), b( n )

sum = 0.0

do 100 i = 1, n
   sum = sum + a( i ) * b( i )
100 continue

return
end
formain.for - program to test calling an Ada function (nfind) from a FORTRAN subroutine, MicroVAX II.

NOTE: Use one of the following commands to link:
acs link/nomain nfind formain, OR
link formain,[xxx]nfind
where [xxx] is the directory of the ada library that contains the object file for "nfind".

program formain
character*12 x
character*1 b
x = '1234 6789'
b = '

n = nfind( x, %ref( b ) )

The %ref mechanism specifier causes b to be passed by reference.

type *, b, n
end
-- nfind.ada -- An Ada function, called by a FORTRAN program
--             (formain), MicroVAX II.

function nfind( str : string;
c              c : character ) return integer is
begin

    for i in str'range   loop
        if str( i ) = c then -- a match was found.
            return i;
        end if;
    end loop;

    return 0; -- there was no match.

end:

pragma export_function( nfind );
-- main2.ada -- program to test calling a FORTRAN subroutine, which
--- then calls a VAX system service, from an Ada program.
--- MicroVAX II.

with text_io; use text_io;

procedure main2 is
  package new_integer is new integer_io( integer );
  use new_integer;

  procedure sysmsg( msgnum : integer );
  pragma interface( fortran, sysmsg );
  pragma import_procedure( sysmsg, mechanism => reference );

  imsg : integer;

begin
  put(" Please enter system error number: ");
  get( imsg );
  new_line; new_line;
  sysmsg( imsg );

end main2;
This routine writes out the appropriate system message, then returns to the caller instead of killing the program like lib$signal does.

```
subroutine sysmsg(ids)
    integer*4 ids, sys$getmsg
    integer*2 msglen
    character*256 msgbuf

        !call system service to get system error message from status value.
        istat=sys$getmsg(%val(ids), msglen, msgbuf, %val(15), )
        if(.not. istat) go to 100

        type 900, msgbuf(1:msglen)
    900 format(x,a<msglen>)

    100 return
end
```
procedure mainl is
  package new_float is new float_io( float );
  use new_float;

  type arrayl is array( integer range <> ) of float;
  procedure innerprodl(a,b : arrayl; n : in out integer; sum : in out float);
  pragma interface( fortran,innerprodl );
  pragma interface_name( innerprodl, "innerprodl_" );

  q : arrayl( 1..100 ) := ( 1..100 => 1.0 );
  t : arrayl( 1..100 ) := ( 1..100 => 1.0 );
  p : float;
  r : integer;

begin
  r := q’length;
  innerprodl( q, t, r, p );
  put( " returned value = " ); put( p ); new_line;

end mainl;
c innerprodl.f - Version for the SUN 3/260.

subroutine innerprodl( a,b,n,sum )

*This routine multiples two one-dimensional arrays, element-by-element, then sums the products.*

*Declare A and B as arrays of real numbers.*

integer*2 n
real a( n ), b( n )

sum = 0.0

do 100 i = 1,n
sum = sum + a( i ) * b( i )
100 continue

return
end
-- main2.ada - Version for the SUN 3/260.
-- NOTE: To link, use the following command:
-- bind main2, adalib, interface=(modules="innerprod.o", search="/lib/libc.a")
with system;
with text_io; use text_io;

procedure main2 is

package new_float is new float_io( float );
use new_float;

type array1 is array( integer range <> ) of float;

function innerprod( a,b : array1; n : system.address ) return float;
pragma interface( fortran, innerprod );
pragma interface_name( innerprod, "innerprod" );

val_n : integer;
q : array1( 1..100 ) := ( 1..100 => 1.0 );
t : array1( 1..100 ) := ( 1..100 => 1.0 );
p : float;

begin
val_n := q'length;
p := innerprod( q, t, val_n'address );
put( " returned value = " ); put( p ); new_line;
end main2;
function innerprod( a,b,n )

This routine multiples two one-dimensional arrays, element-by-element, then sums the products. Declare A and B as arrays of real numbers.

integer*2 n
real innerprod, a( n ), b( n )

sum = 0.0

do 100 i = 1,n
   sum = sum + a( i ) * b( i )
100 continue

innerprod = sum

return
end
-- adafork.ada -- This version is for the SUN 3/260.

-- Note: Use the following command to link:
--    bind adafork,adalib,interface=(search="/lib/libc.a")

with system;
with calendar; use calendar;
with text_io; use text_io;

procedure adafork is
    package my_io is new integer_io( integer );
    use my_io;

    function fork return integer;
    pragma interface( c,fork );

    function sleep (param1: integer) return integer;
    pragma interface( c, sleep);

    i  : integer;
    stat : integer := 1;
    dtime : duration := 30.0;

begin --adafork

    fork_loop: for i in 1..20 loop
        delay 1.0;
        stat := sleep(1);
        stat := fork;
        if stat = 0 then
            for j in 1..5 loop
                put(" i'm task no. "); put( i ); new_line;
                delay dtime;
            end loop;
            exit fork_loop;
        end if;
    end loop fork_loop;

end adafork;
-- char.ada - Ada program used to perform an asynchronous, two-task
-- I/O loading analysis, MicroVAX II version.

with text_io; use text_io;
with calendar; use calendar;

procedure char is -- char is the driver for the two tasks.

    pragma time_slice ( 5.0 );

    task pra is
        entry a;
    end pra;

    task prb is
        entry b;
    end prb;

    task body pra is
        begin
            accept a do
                loop
                    put( "A" );
                    end loop;
            end a;
        end pra;

    task body prb is
        begin
            accept b do
                delay 1.0;
                loop
                    put( "B" );
                    end loop;
            end b;
        end prb;

    begin
        prb.b;
        pra.a;
    end char;
-- procload.ada  - An Ada program used to perform a multiple process loading analysis, MicroVAX II.

with text_io; use text_io;

procedure procload is
  pragma time_slice ( 0.01 ); -- 10 milliseconds.
  idum : integer;

package my_io is new integer_io( integer );
use my_io;

flags : array ( integer range 0..8190 ) of boolean;

i, prime, k, count, iter : integer;

--***************************************************************

task type test_run;

type run_name is access test_run;
run1 : run_name;
task body test_run is
  iname : integer := 0;

begin
  iname := idum;
  for j in 1..10 loop
    put("I'm task "); put( iname );
    new_line;
    delay 30.0;
  end loop;
end test_run;

--***************************************************************

begin
  for i in 1..20 loop
    idum := i;
    run1 := new test_run;
    delay 1.0;
  end loop;
  delay 60.0;

  -- code to cause a computational load on the system (zprime.ada code).

  put("1550 iterations"); new_line;

  for iter in 1..1550 loop
    count := 0;
    flags := ( 0..8190 => TRUE );
    for i in 0..8190 loop
      if flags(i) then
        prime := i + i + 3;
        k := i + prime;
      end if;
      k := i + prime;
    end loop;
  end loop;

--***************************************************************
while k <= 8190 loop
    flags(k) := FALSE;
    k := k + prime;
    end loop;

    count := count + 1;
    end if;
    end loop;
end loop;

    put(count);put(" primes"); new_line;
    "---------------------------------------------------------------------"
end procload;