ERC32 SOFTWARE TOOLS EVALUATION

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Evaluation Objectives

- Port SOHO AOCS software to ERC32.
- Simulate I/O Interfaces.
- Introduce tasking instead of cyclic scheduler.
- Use Normal mode software.
- Carry out timing analysis.

Rationale

For:

- a significant system (6000 lines of Ada).
- a working system, concentrate on tools.
- real time properties important.

Against:

- problems of porting code.

Timescales

Planned:

- Start September
- Finish December

Actual:

- September
- illness ♥
  - missed training day
- January

Planned Activities

- Assess SOHO application.
- Identify needed files.
- Copy to Sun Workstation.
- Compile (functional).
- Bind.
- Extract WCET information.
- Apply HRT tools.
- Link (ESTEC).
- Functional simulation.

SOHO AOCS

- Multiple modes.
- Each mode self contained.
- Frequency/phase scheduler.
- Mode change by table change.
- Choose Normal mode.
- Follow WITH chains to identify needed files (70 out of 120).
- FTP all needed files (VAX -> Sun)

Compilation

- Tools installed, set up in ½ day.
- Simple program compiled and bound.
- Started at lowest level software.
- Stubbed out assembler routines.
- New Tasks package added.
- Some general problems:
  - System.Unsigned | Created special
  - Package Machine_Code | ERC32 packages
  - Package Bitops

Compilation (cont)

- Some particular problems:
  - Address calculations (e.g. TM buffers)
  - Unchecked Conversions not allowed as assignment targets.
  - Integer to/from Enumerated type conversions.
    - Implementation restriction - why?
  - Integer to/from Boolean type conversions.
  - Long_Integer, Storage size.
  - Unchecked Conversions with size differences.

Examples 1

```
Formatted_Torque
            := System.Unsigned(abs(Fix(Wheel_Torque(n) * Scale_Factor)));

         declare -- local block to perform bit manipulation on
                                                  Formatted_Torque

            subtype Bit_Index is Integer range 0..15;
            MSB : constant Bit_Index := 0;
            type Boolean_Array_Type is Array (Bit_Index) of Boolean;
            Pragma Pack (Boolean_Array_Type); -- pack into one word
            function CUB is new Unchecked_Conversion
               (Source => System.Unsigned, Target => Boolean_Array_Type);

         begin -- set bit 7 of Formatted_Torque to sign of Wheel_Torque(n)

            CUB(Formatted_Torque)(7) := (Wheel_Torque(n) < 0.0);

         end; -- local block
```

Examples 2

```
   type FPSS_Data_Error_Type is
      (OK, Bad_Ap, Bad_Ay, Bad_Angle_P, Bad_Angle_Y,
No_Sun_P, No_Sun_Y);
--
   for FPSS_Data_Error_Type use (0, 1, 2, 4, 8, 16, 32);
--
   function CFI is new Unchecked_Conversion
      (Source => FPSS_Data_Error_Type,
       Target => Integer);
--
   function CIF is new Unchecked_Conversion
      (Source => Integer,
       Target => FPSS_Data_Error_Type);
```

Use of these functions flagged as an error

Tool Observations

- Error messages usually good, with LRM references.
- Deletion of obsoleted units from library listing surprising (initially).
- Unable to print from Library Manager (Motif).
- It would help if a successful compilation produced a message in the AdaWorld window.
- Colour change in icon only after browsing.
- Locked library caused Library Open to hang.
- AdaMake worked well.

Timing Data Extraction

- Achieved successful Bind at functional level.
- Turned on WCET data in compiler options.
- Recompiled complete application.
- WCETE warnings in 8 files.
  - compound assignments.
  - pointers (access).
  - ‘pos attribute.
  - loops with parameter for upper limit.
  - Raise statements (but there are none).
  - task declaration location.

Examples 3

```
352        MACS_Error_Data := (Counter => 0, Time => 0,
               First_Error => True);
353
354        On_Time_Increment := (others => 0);  (array (1..8) of natural)
           1
 1    *COD WCETE subset warning: This construct is not permitted
in the WCET Ada HRT Restrictions. The containing subprogram must
not be called within the main body of a critical task.

2220    type Address_Pointer is Access ERC32_System.Address;
                                                    <--1-->
 1    *EXP WCETE subset warning: This construct is not permitted
in the WCET Ada HRT Restrictions. The containing subprogram must
not be called within the main body of a critical task.
```

Examples 4

```
102 -- function Arctan(X : in Float) return Float is
103
104    begin
105
106       if abs(X) < X_Small then
107
108          return X;
                    1
                    2
 1    *COD WCETE warning: Block containing explicit raise
statement has been excluded from worst case path analysis.

 2    *COD WCETE warning: Block containing explicit raise
statement has been excluded from worst case path analysis.
```

Execution Profile generation

- Enabled HRT processing in Binder.
- First bind flagged errors in 3 procedures.
  - Issue_RD in MACS object, undefined loop counts.
    Had to hard code - no PRAGMA Loop_Count.
  - Read_FPSS in AOCS_Units, a compound assignment.
    Rewrote as set of individual assignments.
    WHY IS THIS NOT DETERMINABLE BY COMPILER?
  - Process_FPSS_Data in Sensor_Processing, a ‘pos attribute.
    Replaced by Fixed value. ALL ATTRIBUTES?
- Obtained bindable system with 10 tasks, giving execution profile with 10 threads.

Timing comparison

Comparison between execution profile times and original SOHO calculated times:

Task	ERC32	SOHO
FPSS_Task	5157	955
Mode7_Ctl	1134	400
Control laws	1989	4411
Control laws HK	2124	568
Mode7 roll	473	153
SSU7	2280	2103
SSU Data	2408	3063
SSU8	119	42
RSL	202	107
Wheel	2530	2160
Total	18416	13962

NB: ERC32 1MHz, SOHO MAS281 15MHz, 3 wait states

HRT tools

- Tools easily installed.
- Straightforward to run.
- UCF file generated from original scheduler table data.
- ESF file from compiler used.
- DEMO run time file used.
- Analyser shows thread set schedulable.
- GANTT chart generated from Simulator.

Conclusions

- Evaluation has been useful, given time constraints.
- Tools acceptable.
- Future directions:
  - ERC32? Yes
  - Ada Compiler? Probably
  - WCET extraction? Yes (standalone table of times?)
  - Functional simulation Yes
  - HRT tools? ? (tasking vs frequency/phase)