Solving the Endianness Problem with GNAT

Porting applications across hardware with different endianness (byte order conventions), or processing personal data, requires a solution through Ada. Big-endian and little-endian data can peacefully coexist in the same program, and applications can be written to be endian-independent. Byte swapping may be required, but the necessary code will be generated automatically by the compiler.

Ada’s Bit order attribute is not in itself sufficient. It only defines how bits are numbered within multi-byte values stored in memory (known as “machine scales”), but how these successive bytes in memory are assembled into a machine scalar if the endianness change occurs, a component that starts in one byte and ends in another will have a noncontiguous representation, which cannot be described using any standard representation clause.

The new implementation-defined attribute ‘T:Scalar_Storage_Order, available for all platforms in GNAT Pro 71, overcomes this limitation. Its effect is to override the byte order in machine scalars for a given record type.

For example:

```ada
type Packet is record
  A : Boolean;
  B : range 0..7;
end record;
```

On a big-endian machine a Packet value would be laid out as follows:

<table>
<thead>
<tr>
<th>Byte 0</th>
<th>Byte 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>7</td>
</tr>
</tbody>
</table>

In a little-endian machine the bytes would be laid out as follows:

<table>
<thead>
<tr>
<th>Byte 0</th>
<th>Byte 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
</tr>
</tbody>
</table>

However, if this code is compiled on a little-endian machine, the low-byte order would precede the high-byte order, resulting in a nontransparent representation for $A$. Adding a Scalar_Storage_Order clause solves this problem:

```ada
for Packet use record
  A at range 0..7;
  B at range 1..8;
end record;
```

Conference / Events ▪ April – November 2013

For up-to-date information on conferences where AdaCore is participating, please visit www.adacore.com/category/press-center/events/

Tech Corner ▪ April 2013

New tools and initiatives for the industry

Since our last briefing on the progress of CodePeer 2.2, the advanced static analysis tool that helps detect run-time and logic errors in Ada programs, was released on leading platforms during Q4 2012, CodePeer is fully integrated into the GNAT Pro development environment and can also be used with other Ada compilers. The product comes with a coding standard verification tool (GNACheck), a source code metrics plugin, and more. The latest codePeer messages and analysis have been updated for GNAT Pro 2013.

Pat Rogers has been given Ada Community Contribution Award

At ACM SIGAda’s High Integrity Language Technology (HILT) conference in Boston in December 2012, Pat Rogers received the “Outstanding Ada Community Contributions” award. Dr. Rogers, a member of AdaCore’s senior technical staff, was acknowledged for his longstanding work in Ada real-time and fault-tolerant technology and his efforts in promoting Ada usage at NASA.

Termas selects CodePeer for Space Monitor Project

Termas A/S has selected the GNAT Pro Safety-Critical development environment to implement onboard software for the Atmosphere-Space Interactions Monitor (ASIM) that will be mounted on the Columbus module of the International Space Station. Termas will use GNAT Safety-Critical together with the GNATToolsuite and GNAToverage dynamic testing tools to develop and perform comprehensive tests for the application prior to deployment on the actual LEON 3 embedded processor.

Rockwell Collins uses AdaCore’s Traceability Analysis Package for DO-178B certification

Rockwell Collins has successfully used AdaCore’s source-to-object code Traceability Analysis Package for DO-178B in the certification of the Integrated Display System (IDS) for a large, remotely operated, commercial aircraft. The Traceability Analysis Package is part of the evidence needed to satisfy the DO-178B objective of strong code coverage at Level A, the highest (most stringent) level for avionic software safety.

The GNAT Pro Safety-Critical product is now available for the bareboard ARM Cortex M3, M4, and M7 microprocessors, as well as those that need to meet safety standards in domains such as avionics, transportation, and space-based systems, can thus take advantage of the rich support ecosystem and the growing popularity of these low-power processors.

The ARM implementation extends the range of bareboard platforms targeted by GNAT Pro Safety-Critical, which already includes the PowerPC and LEON processors. The technology does not require an underlying operating system, and it includes a Radarenc xtra implementation that is efficient from both a memory usage and a performance perspective.

The product suite includes the following:

• Support for Ada 2012 (including the important “contract-based programming” features that make it easier to formalize the program’s intent) and all earlier versions of the Ada language.
• Support for the Ravenmark targeting profile.

GNAT Pro is a major release of CodePeer 2.2, which is fully integrated into the GNAT Pro development environment; it can also be used with other Ada compilers. The product comes with a coding standard verification tool (GNACheck), a source code metrics plugin, and more. The latest CodePeer messages and analysis have been updated for GNAT Pro 2013.

1st Tool Qualification Symposium April 8-10, 2013 / Munich, Germany
Matthieu Borderi and Roberto Vinther are presenting “Open-Object Programming for High-Value-Adding Software: Local Type Consistency Verification without Trust,” at www.cc-tc.org/1sttoolqualification2013.html

STC 2013 - Software Technology Conference April 8-11, 2013 / Soft Lake City, UT, USA
Ben Brosgol is presenting “Object- Oriented Programming for High-Value-Adding Software: Local Type Consistency Verification without Trust,” at www.cc-tc.org/1sttoolqualification2013.html

Design West April 22-25, 2013 / San Jose CA, USA
AdaCore is exhibiting at this conference, and there are presentations from Ben Brosgol (“Object-Oriented Programming for High-Value-Adding Software: Local Type Consistency Verification without Trust”), and Thomas Quint (“System High Order First: ‘big-endian’”), at www.cc-tc.org/1sttoolqualification2013.html

Ada Europe 2013 April 10–14, 2013 / Berlin, Germany
AdaCore is a major sponsor and is exhibiting at this event. Thomas Quint is presenting “Last Acts of Peace in Endianness War,” at www.adacore.eu.org/2013-access.html

ARM-Embedded System Design June 25, 2013 / Sindelfingen, Germany

Sae Aerotech 2013 September 24–26, 2013 / Montreuil C, Canada
Turker T double-T is presenting “Integrating Test and Prototyping in the Next Generation Verifiable SPARK Language, Using Contact-Based Programming Features and SMT Solvers.” at www.org/gravitee/innovus/2013conf.html

GNAT Pro User Day September 25, 2013 / Paris, France
Please use the companion article on Page 3 of this issue to find more information.

IEEE Systems Safety October 14–17, 2013 / Cardiff, UK
AdaCore is a sponsor of this event and is exhibiting.

IfYou Systems Safety Conference October 14–17, 2013 / Paris, France
Please see the companion article on Page 3 of this issue to find more information.

RTEC - Real-Time & Embedded Computing Conference May 7, 2013 / Nashville TN, USA
AdaCore is exhibiting at this event. www.rtecconference.com/viewer117

DASIA 2013 May 14–16, 2013 / Porto, Portugal
AdaCore and David Levins (Airbus Space Transportation) are presenting “Formal Validation of Aerospace Software” at www.eurospan.org/dasia-2013.aspx

ACM SIGAda’s HILT 2013
High Integrity Language Technology November 10–13, 2013 / Pittsburgh, PA
AdaCore is a Platinum Sponsor of this conference. Turker T is Program Chair, and Evgeni Gligo is Publicity Chair.

AdaCore is exhibiting at this conference, and there are presentations from Ben Brosgol (“Object-Oriented Programming for High-Value-Adding Software: Local Type Consistency Verification without Trust”), and Thomas Quint (“System High Order First: ‘big-endian’”), at www.cc-tc.org/1sttoolqualification2013.html

The Traceability Analysis Package is part of the evidence needed to satisfy the DO-178B objective of strong code coverage at Level A, the highest (most stringent) level for avionic software safety.

The Traceability Analysis Package is available online at www.adacore.com/knowledge/demos/codepeer-2-2/.

More accurate analysis of mathematical functions and floating point computations

Export of message to spreadsheets

CodePeer is able to find errors by systematically analyzing every possible input and path through the program. The tool can be employed very early in the development cycle to identify defects when they are the least costly to repair, and it can also be used retrospectively on existing code bases to obviate latent vulnerabilities.

In light of its broad applicability, CodePeer directs the requirements of Section 9.33 (“Improvements in Assurance of Computer Software Processed by the Department Of Defense”) of the United States National Defense Authorization Act for Fiscal Year 2013. This provision of this section “require use of appropriate automated vulnerability analysis tools in computer software code during the entire lifecycle of a covered system, including during development, operational testing, operations and sustainment, and retirement.”

A demo of CodePeer 2.2 is currently available online. In addition to highlighting the new product features, the demo shows how to use Ada 2012 and CodePeer together to identify potential issues, and more generally explains how the tool can improve code quality. Please visit www.adacore.com/knowledge/demos/codepeer-2-2/.

GNAT Pro Safety-Critical for ARM

The GNAT Pro Ada Safety-Critical product is now available for the bareboard ARM Cortex M3, M4, and M7 microprocessors, as well as those that need to meet safety standards in domains such as avionics, transportation, and space-based systems, can thus take advantage of the rich support ecosystem and the growing popularity of these low-power processors.

The ARM implementation extends the range of bareboard platforms targeted by GNAT Pro Safety-Critical, which already includes the PowerPC and LEON processors. The technology does not require an underlying operating system, and it includes a Radarenc xtra implementation that is efficient from both a memory usage and a performance perspective.

The product suite includes the following:

• A set of static analysis tools
• GNAStack for stack analysis
• GNAMetrics for code metrics computation
• GNACheck for coding standard verification
• The GNATTools test harness generator
• The GDB visual debugger
• A native integrated Development Environment (IDE) as well as an Eclipse plug-in

GNAT Pro Safety-Critical for ARM supplies a fully configurable and customizable run-time library and includes High-integrity profiles that are especially useful in safety-critical systems. The Zero-Footprint Profile (ZFP) in particular defines an Ada subset that does not require any run-time routines, thus reducing the memory footprint to a code-only product.

In addition to the new bareboard ARM targets for GNAT Pro Safety-Critical, the standard GNAT Pro package is also available. A pre-release of GNAT Pro for ARM Android is available now, and GNAT Pro for ARM WiiBox is 6.0 on the roadmap for further development. For further information please contact info@adacore.com.

GNAT Pro Insider Spring/Summer 2013

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GNAT Pro Insider Spring/Spring 2013

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Hi-Lite Project Completed

The Hi-Lite project, a French government-sponsored effort to combine formal methods with traditional software development and verification techniques for High-Integrity systems in Ada and C, was successfully completed in May 2013. Hi-Lite’s main goal was to make formal verification faster and easier to use for software subject to certification standards such as DO-178C for airborne systems, and the project has met this objective. Hi-Lite started in 2010 and was led by AdaCore, and has produced a variety of Open Source tools as well as new methodologies for applying formal methods in conjunction with unit testing. The Hi-Lite work has also led to a major upgrade to the SPARK language, known as SPARK 2014, and its toolset (see the pipeline section, on this page). The tools and other products developed under Hi-Lite will be made available on the/libre.adacore.com website. For more information, please visit www.open-do.org/projects/hi-lite/

Professional Courses from AdaCore

AdaCore offers a wide range of live training, available for delivery at customer site. The courses span a variety of topics, and many are tailorable in duration and content to fit the customer’s schedule and application requirements.

Ada Language (including Ada 2012)
- Ada Fundamentals (4 or 5 days)
- Ada Advanced Topics (4 or 5 days)
- Multi-Language Programming (1 to 4 days)
- Hard Real-Time & Embedded Systems Programming (4 days)

SPARK Language
- Software Engineering with SPARK (4 days)
- Advanced SPARK (1 to 5 days)
- Secure Software Development with SPARK (1 day)
- SPARK Overview (2 days)
- Refresh Your SPARK (1 day)

Software Safety Certification
- DO-178B and DO-178C for Software Professionals (1 to 3 days)
- Tools and Technology
  - Static Analysis Tools (1 day)
  - Dynamic Analysis Tools (1 day)
  - CodePher (1 day)
  - GNAT Pro with GPS (3 days)
  - GNAT Pro with GNATbench (2 days)
  - GtkAda (3 days)

Joint Product Training with Wind River
- GNAT Pro Safety-Critical for VxWorks 653 (4 days)
- GNAT Pro Safety-Critical for VxWorks Cert (4 days)
- GNAT Pro for VxWorks General Purpose Platform (GPP) (4 days)

For details on these courses please visit www.adacore.com/training/

GNAT Pro 7.1
This latest version of the GNAT Pro development environment and toolset was released on all supported platforms during Q1 2013. A summary of the major new functionality appeared in the in the pipeline section of the Autumn/Winter 2012-2013 issue of GNAT Pro Insider; available at www.adacore.com/newsletter/, and an updated list of new features is located at www.adacore.com/developers/product-update/gnatt-pro-7.11

GNATcoverage 1.1
GNATcoverage 1.1, the latest release of AdaCore’s tool that provides complete code coverage analysis without requiring instrumentation or specialized hardware, includes a number of new features and enhancements:
- Support for GNAT project files to locate Source Coverage Obligations, so that users no longer need to compute the list of ALI files
- Improved GPS integration
- Support for full Ada run-time constructs such as task entries and select statements
- Support for analysis of optimized code (C-0) on all targets

In the pipeline

GNAT Pro for Android
A GNAT Pro release for Android-based ARM targets is planned for Q2 2013, and a pre-release is available now, supporting applications that are completely in Ada or that combine Ada and Java (for example using Java for the GUI and Ada for the computational logic). Extensive support is currently available in GNATbench 2.7 for this mixed language approach, including automatic Java binding code generation via JAI, the Ada Interface Suite.

GNAT Tracker 3.0
AdaCore is currently working on a new version of the GNAT Tracker customer server. Based on customer feedback the new version (available later in 2013) will offer an improved and more customizable interface. It will also take advantage of modern design capabilities and support tablets and mobile devices.

Reminder: GNAT Tracker is an essential support portal for customers, giving access to a wealth of information. GNAT Pro users can log in to GNAT Tracker to download products, obtain wavefronts, ask questions about Ada or AdaCore products, and check their account status and details. GNAT Tracker can also be used to learn about product version numbering, licensing terms, AdaCore services, and more.

SPARK Technology
As part of the Hi-Lite project, major enhancements have been made to the SPARK language and toolset. The new SPARK 2014 language is both richer and more flexible, and exploits the Ada 2012 contract-based programming features. This will enable greater verification automation and also simplify the development of SPARK 2014 applications. The new toolset that will rely on SPARK 2014 will also provide innovative ways of combining formal verification with testing and will allow SPARK 2014 to be used incrementally in legacy projects. The first commercial release is expected in Q1 2014. For more information please visit www.spark-2014.org/

Submit your application to the 4th Open-Do Program in Abu Dhabi!

Spring/Summer 2013

GNAT Pro Insider

This year’s GNAT Pro User Day will be held on Wednesday, September 25, in Paris. Attendees will hear news about the latest tools and toolset features, product roadmaps, and practical tips from technology experts. Updates on Open-DO projects and the SPARK 2014 language evolution will also be presented, and AdaCore staff will be on hand to answer questions. For registration details and further information, please contact events@adacore.com or visit www.adacore.com/gnatt-pro-day/
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- Refresh Your SPARK (1 day)
- SPARK: Safety-Critical Software and Tools (4 days)
- SPARK: Tools and Technology (4 days)
- SPARK: Complete Toolset (4 days)
- SPARK: Advanced Toolset (4 days)
- SPARK: Tools and Technology (3 days)

Tools and Technology
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- Dynamic Analysis Tools (1 day)
- CodePeer (1 day)
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- GNAT Pro with GNATbench (2 days)
- GitAda (3 days)

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- current releases -

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- Support for GNAT project files to locate Source Coverage Obligations, so that users no longer need to compute the list of ALI files
- Improved GPS integration
- Support for full Ada run-time constructs such as task entries and select statements
- Support for analysis of optimized code -C101 on all targets
- Support for source coverage analysis per generic instance, instead of merged for all instances.

GtkAda 3
GtkAda 3 is available with GNAT Pro 7.1. This new major release marks the switch to version 3 of the underlying Gtk+ toolkit, bringing new widgets, a CSS-based theming framework, and an improved and simplified API that incorporates a more homogenous naming scheme.

- in the pipeline -

GNAT Pro for Android
A GNAT Pro release for Android-based ARM targets is planned for Q3 2013, and a pre-release is available now, supporting applications that are completely in Ada or that combine Ada and Java for example using Java as the GUI and Ada for the computational logic. Extensive support is currently available in GNATbench 2.7 for this mixed language approach, including automatic Java binding code generation via A4J, the Ada Java Interface Suite.

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AdaCore is currently working on a new version of the GNAT Tracker customer server. Based on customer feedback the new version (available later in 2013) will offer an improved and more customizable interface. It will also take advantage of modern design capabilities and support tablets and mobile devices.

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As part of the Hi-Lite project, major enhancements have been made to the SPARK language and toolset. The new SPARK 2014 language is both richer and more flexible, and exploits the Ada 2012 contract-based programming features. This will enable greater verification automation and also simplify the development of SPARK 2014 applications. The new toolset that will rely on SPARK 2014 will also provide innovative ways of combining formal verification with testing and will allow SPARK 2014 to be used incrementally in legacy projects. The first commercial release is expected in Q1 2014. For more information please visit www.spark-2014.org/
### Newsflash

**Pat Rogers given Ada Community award**

At ACM SIGAda's High Integrity Language Technology (HILT) conference in Boston in December 2012, Pat Rogers received the “Outstanding Ada Community Contributions” award. Dr. Rogers, a member of AdaCore's senior technical staff, was acknowledged for his longstanding work in Ada real-time and fault-tolerant technology and his efforts in promoting Ada usage at NASA.

### Major New Release of CodePeer

CodePeer 2.2, the advanced static analysis tool that helps detect run-time and logic errors in Ada programs, was released for Ada toolsets platforms during Q1 2013. CodePeer is fully integrated into the GNAT Pro development environments and can also be used with other Ada compilers. The product comes with a coding standard verification tool (GNATcheck), a source code analytics tool (CodePeer), and a diagnostic tool (CodePeer). Based on customer feedback, a number of enhancements have been incorporated into CodePeer 2.2. These include:

- Integration into GNATbench, the GNAT Pro Ada plug-in for Eclipse and Wind River Workbench
- Full support for GNAT project files
- Message review from HTML reports
- New “code view” supporting CodePeer messages and analysis
- More accurate analysis of mathematical functions and floating point computations
- Export of message to spreadsheets

CodePeer is able to find errors by systematically analyzing every possible input and path through the program. The tool can be employed very early in the development cycle to identify defects when they are the least costly to repair, and it can also be used retrospectively on existing code bases to debug latent vulnerabilities.

In light of its broad applicability, CodePeer directly satisfies the requirements in Section 933 (“Improvements in Assurance of Computer Software Procured by the Department Of Defense”) of the United States’ National Defense Authorization Act for Fiscal Year 2013. The provision of this section “require use of appropriate automated vulnerability analysis tools in computer software code during the entire lifecycle of a covered system, including during development, operational testing, and sustainment activities, and retirement.”

A demo of CodePeer 2.2 is currently available online. In addition to highlighting the new product features, the demo shows how to use Ada 2012 and CodePeer together to identify potential issues, and more generally explains how the tool can improve code quality. Please visit www.adacore.com/knowledge/demos/codepeer-2-2.html

### GNAT Pro Safety-Critical for ARM

The GNAT Pro Ada Safety-Critical product is now available for the bareboard ARM Cortex M3, M4, and M7 microprocessors. Ada projects, especially those that need to meet safety standards in domains such as avionics, transportation, and space-based systems, can thus take advantage of the rich support ecosystem and the growing popularities of these low-power processors.

The ARM implementation extends the range of board-level platforms targeted by GNAT Pro Safety-Critical, which already includes the PowerPC and LEON processors. The technology does not require an underlying operating system, and it includes a Raspberry PI tasking implementation that is efficient from both a memory usage and a performance perspective.

The product suite includes the following:

- Support for Ada 2012 (including important “contract-based programming” features that make it easier to formalize the program’s intent) and Ada 2008 versions of the Ada language
- Support for the Ravenclaw tasking profile

The GNAT Pro Safety-Critical product includes:

- A set of static analysis tools
- GNATcheck for stack analysis
- GNATMetix for code metrics computation
- GNATcheck for coding standard verification
- The GNATtest unit test harness generator
- The GBD visual debugger
- A native Integrated Development Environment (IDE) as well as an Eclipse plug-in

GNAT Pro Safety-Critical for ARM supplies a fully configurable and customisable runtime library and includes high-integrity profiles that are especially useful in safety-critical systems. The Zero Footprint Profile (ZFP) in particular defines an Ada subset that does not require any run-time routines, thus reducing the memory footprint to a code only.

In addition to the new bareboard ARM targets for GNAT Pro Safety-Critical, the standard GNAT Pro toolsets for Ada 2008 and Ada 2012 can now be used. A pre-release of GNAT Pro for ARM Android is now available, and GNAT Pro for ARM WebWorks 6 is on the roadmap for future releases. For further information please contact info@adacore.com.