RTEMS 4.10 and Beyond

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December 2010
Outline

- Highlights of RTEMS history
- RTEMS features
- What’s new in RTEMS 4.10 releases
- Wish List for 4.11 releases and beyond
History – Part I

- 1988 – OAR initiates development under contact to U.S. Army Missile Command (now U.S. AMCOM)
- 1992 – Superconducting Super Collider (SSC) is first non-Army organization to receive RTEMS. Evaluated easily and favorably against pSOS+.
- 1992 – Project begins using GNU tools
- 1994 – ESA sponsors OAR development of SPARC port
- 1994 – Publicly available via anonymous ftp from U.S. Army
- 1995 – Oldest date in RTEMS CVS 11 May 1995
- 1996 – rtems.com domain registered
- 1997 – GNAT/RTEMS passes Ada95 ACVC
- 1999 – First GNU/Linux RPMs
History – Part II

- 2001 – Steering Committee formed
- 2001 – Public problem tracking database available
- 2001 – Ported to NASA space hardened MIPS
- 2004 – Wiki started
- 2006 – Circles Venus and Mars
- 2007 – Launched to the asteroid belt with Dawn
- 2008 – Launched with Herschel/Plank missions
- 2008 – First year as Google Summer of Code project
- 2010 – Launched with Solar Dynamic Observatory
- 2010 – RTEMS Filesystem added
- 2010 – One of 20 organizations in Google Code In
RTEMS vs Other OSes

- Designed and supported to be open source
  - we can answer “Why was it done this way?”
  - openness includes test suite and documentation

- Single process, multi-threaded
  - comparable to VxWorks, Nucleus, pSOS+, ThreadX

- POSIX Profiles PSE51 and PSE52
  - no processes or MMU means no exec(), shm*(), etc.
  - lighter than LynxOS or real-time GNU/Linux
Graph of RTEMS vs other Oses (Order of Magnitude)

- RTEMS
- VxWorks
- GNU/Linux
- Solaris
- LynxOS
- MS-Windows

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RTEMS Features

- RTEMS is a Commercial Grade Real-Time Operating System
- Truly free in price, liberty, and end user requirements
  - All source code for OS, support components, tests, documentation, development environment, and project website is provided
- High performance with deterministic behavior
- Low overhead with predictable resource consumption
  - Full executables currently as small as 16K
- Highly configurable with unused features left out by linker
RTEMS Features

- Multitasking
- Highly Portable
- Standards Based
- Multiprocessing
- User Configurable
- Object-oriented
- Interrupt Processing/Management
- Development Environment
- Remote Debug Server
- Shell
- Eclipse plugin available

- Communication/Synchronization
- Memory Management
- I/O Drivers
- Various File Systems
  - FAT, RFS, RAM, NFS, YAFFS, etc.
- User Extensible
- Networking with Servers
- File System Infrastructure
- C, C++, Ada, Go, and Java
- Libchip – Peripheral Controller Library
RTEMS Architecture

BSD TCP/IP Stack

Add-on Libraries
- zlib
- libxml
- readline
- ncurses
- Tcl

GUIs
- MicroWindows
- OpenGUI
- FLTK
- picoTk
- NanoX

Ada95
- GNAT
- Classic API Bindings

POSIX Compliant Filesystem
- IMFS
- DEVFS
- RFS
- TARFS
- FAT
- TFTP client
- NFS client

Remote Debugging

SAPI

Classic API

POSIX Threads

Performance Monitoring API

µ ITRON API

SuperCore

Board Support Package

SuperCore CPU

LibCPU

LibCHIP

Hardware

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## Processors Supported by RTEMS

<table>
<thead>
<tr>
<th>Architecture</th>
<th>4.6</th>
<th>4.7</th>
<th>4.8</th>
<th>4.9</th>
<th>4.10</th>
<th>CVS</th>
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<th>4.10</th>
<th>CVS</th>
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<tbody>
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What’s New in 4.10? Updated Tools

- Latest version of all tools in the RTEMS Development Environment
  - autoconf 2.68
  - automake 1.11.1
  - binutils 2.20.1
  - gcc 4.4.5 for C/C++ with newlib 1.18.0
  - gdb 7.1

- Tool repositories are mirrored at three sites
What’s New in 4.10?

File System Related

- POSIX pipe support
- RTEMS File System (RFS)
- libblock now supports variable sized buffers
- Miscellaneous improvements
  - more compliant chmod() behavior
  - statvfs() support added
- Mount operation now appears more like UNIX
- New “device only file system” which is very light
What’s New in 4.10?
Code and Data Space Reduction

- Configurable maximum number of priorities
- Configurable minimum task stack size
- File system support can be disabled completely
- Idle task can be used to perform system initialization
What’s New in 4.10?
Coverage Analysis

- Significant improvements over the past few releases
- Profile tracked is “RTEMS proper” at –Os
  - RTEMS proper: score, rtems, posix, and sapi
- Coverage is tracked for 10 BSPs across 6 architectures

<table>
<thead>
<tr>
<th>Release</th>
<th>% Covered</th>
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<th>Uncovered Bytes</th>
<th>Total Bytes</th>
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</table>

http://www.rtems.org/ftp/pub/rtems/people/joel/coverage/
What’s New in 4.10?
New Ports and BSPs

- New target architectures
  - Lattice Micro 32 (LM32)
- New Board Support Packages
  - ARM Ipc24xx with variants
  - ARM Ipc32xx with variants
  - ARM Gumstix
  - ARM GDB simulator with variants
  - ARM CSB637 and Kit637
  - Coldfire Cobra5475
  - LM32 LM32_EVR
  - PowerPC Beatnik
  - PowerPC gwlcfm (MPC55xx variant)
  - PowerPC QEMU Simulator
- Many BSPs updated and enhanced
What’s New in 4.10?
Important Odds and Ends

- Configure separate or unified RTEMS Workspace and C Program Heap (e.g. malloc)
  - Separate: historical behavior – used in hard resource apps
  - Unified: similar to VxWorks – used by more dynamic apps
- More use of C99 types
- Optional use of 64-bit nanoseconds since epoch as internal time representation
- Warnings across all BSPs reduced
- BSP command line argument support added
4.10 and Beyond – The RTEMS Roadmap
RTEMS Requirements Sources

- Standards
  - The OpenGroup Single UNIX Specification
  - ISO/ANSI language and library standards
  - GNU Standards
- Space community
  - NASA, ESA, and their contractors
- Scientific Community
  - EPICS is most visible organization
- Commercial users
- Academic Community
- Good ideas
  - Research
  - User suggestions
Already in CVS for 4.11

- Changes for issues identified by static analyzers
  - Coverity Scan
  - clang scan-build

- Coverage improvements
  - Thanks to GSOC student, development profile coverage improved from ~83% in March 2010 to ~98%

- Initial support for POSIX Threading Timing Tests
Already in CVS for 4.11

- SuperCore Scheduler Refactoring
  - User can configure alternative scheduler
  - Prerequisite for SMP aware scheduler

- Per CPU Data Structure
  - Heir, executing, etc. tracked on per-CPU core basis
  - Prerequisite for SMP

- RTEMS Scheduler Simulator (close)
  - Allows one to evaluate new scheduling algorithms on host system
Community Interaction Wish List

- User application requirements
  - Please sponsor improvements which make RTEMS the perfect RTOS for your applications

- User testing and V&V
  - RTEMS artifacts and procedures should eventually dovetail into those of users
  - Make sure WE do want you need in this area

- Tell us about your application
  - Project needs more flyers on your success stories
Community Interaction Wish List – continued

- **User configuration management requirements**
  - Would periodic DVDs of tools and matching RTEMS tools be useful?
  - What else would help make RTEMS easier for your CM?

- **Legacy support requirements**
  - Free project maintains 2 branches
  - OAR provides support for versions as long as required
  - What does the space community need in this area?
Feature Wish List

- **USB support**
  - Port BSD USB stack to RTEMS
  - Refactor TCP/IP port to have shared “BSD porting layer”
  - Working port in community; requires effort to merge

- **TCP/IP stack update**
  - Update TCP/IP stack code to a late model FreeBSD version
  - Key Goal: IPV6 and ensure future updates are easy
  - No active work in this area

**Tasks are inter-related and will require sponsorship to complete!!**
Feature Wish List – continued

- Symmetric Multiprocessing Support (SMP)
  - some infrastructure and refactoring work done
  - scheduling, locks, and testing are primary activities left
  - needs engineering hands-on to finish

- Enhanced Eclipse support
  - RTEMS Eclipse plug-in available
  - Need Eclipse expertise to highlight more capabilities
Feature Wish List – continued

- Event Capturing and Visualization
  - Log events from RTEMS target and analyze on host
  - Chris Johns’ capture engine is a baseline
  - GSOC students have worked on target side of this

- Free CANbus Stack
  - There are open source implementations
  - No active work in this area
Why Does RTEMS Exist?

For YOU!

Because of YOU!

YOU are the Community!

YOU are the Source For Improvements!
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RTEMS Project URL
http://www.rtems.org

RTEMS Wiki
http://www.rtems.org/wiki