RTEMS Project Ecosystem

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Ecosystem Background

- Objectives:
  - provide a fully repeatable build from source to a tested, working application base.
  - lower entry barrier and increase host support
  - consistent user interface
- Definition:
  - framework that provides a collection of tools to complete this process
- Status:
  - ongoing and active work, evolving to meet needs

Environment Reproducibility

- User produce and test RTEMS and tools from source
  - complete source
  - RTEMS Source Builder
  - RTEMS Tester
- Same infrastructure used by
  - developers for developmental testing
  - project for Continuous Integration Testing
- Plan to publish results so user can compare their results against official results from RTEMS Project

Ecosystem Deliverables

- Host tools
  - development tools, simulators, etc. with source, patches, and locally built binaries
- Target libraries
  - RTEMS and third party add-on libraries source, patches, and locally built BSP specific binaries
- Reports
  - configuration, build, and test

- Support smooth integration of RTEMS into project specific configuration management

Hosting and Infrastructure Refresh

- Half-rack of new hardware purchased with donations for GSoC and GCI participation
- Hosting now at Oregon State University Open Source Laboratory (https://osuosl.org/)
  - couple of hops off Internet2 backbone, very fast
- Multiple single purpose VMs versus multi-purpose single host
  - this did cause some URLs to break
- Conversion from Bugzilla and Mediawiki to Trac
  - Trac provides release status tracking and reports
  - commit closes ticket, sends email to list, updates github, and sends message to IRC
- Future Plans
  - need another build machine dedicated to building tools
  - need more RAM and storage for machines (purchased with space to grow)
  - Mac for testing as host

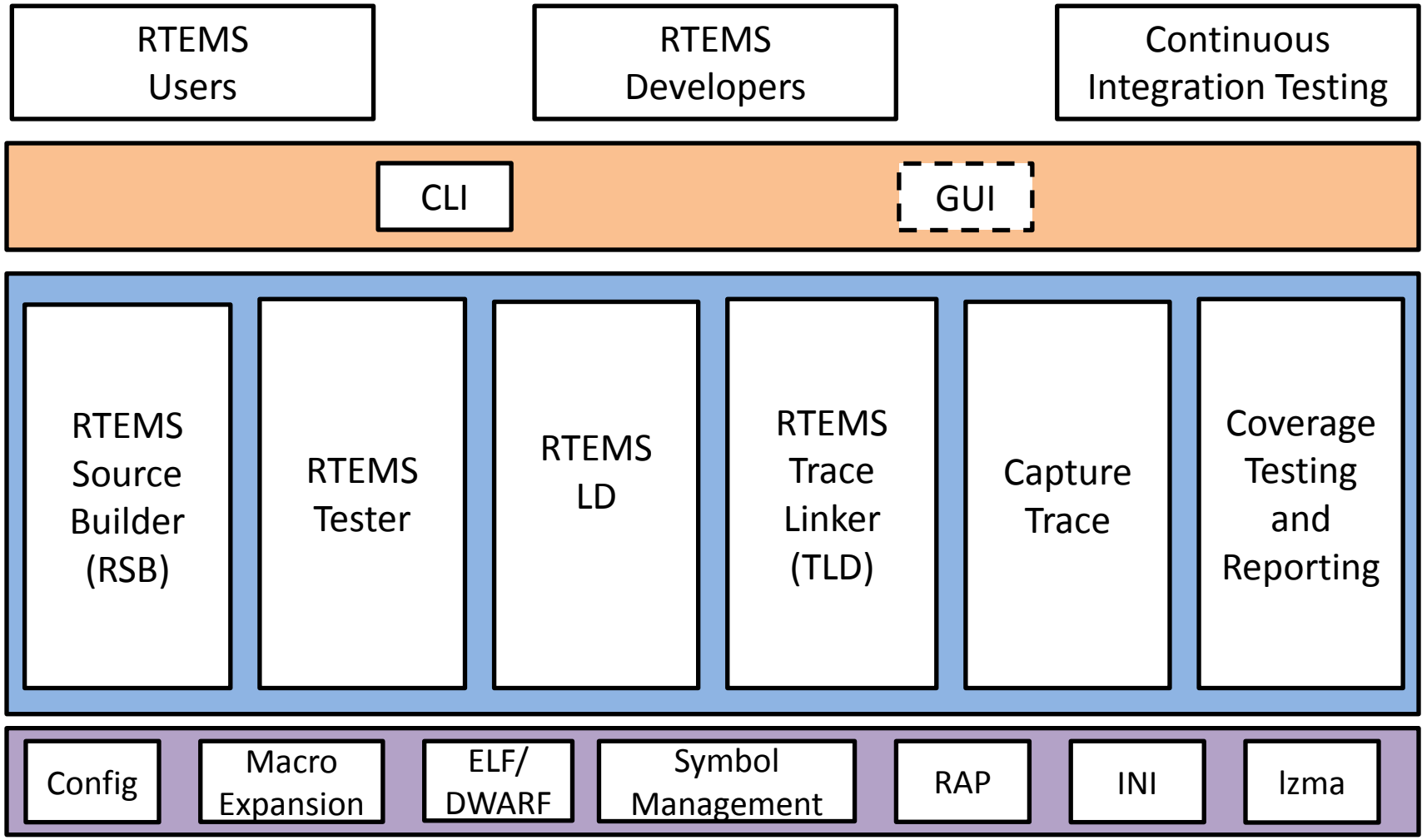
All volunteer effort! Please pitch in!

Process Refresh

- New infrastructure enables new capabilities
- Future plans
  - incorporate web based patch review and submission system
    - eventually a patch will be tested before a human sees it
  - establish continuous integration and testing so every commit results in an appropriate test sweep
  - provide database of test results
  - refresh user documentation in modern tools
    - current effort to review content in Wiki

Anything else we use computers to help with

RTEMS Tools Project



RTEMS Source Builder (RSB)

- RSB contains “recipes” for building host tools and target packages from source
  - enables configuration management of source and patches
- Host independent way to obtain environment
- Full source and patches
- Use RSB to fetch source and build
  - RTEMS tools
  - cross development environment
  - RTEMS (or by hand)
  - simulators if desired
  - third Party Packages for target system

RSB Example

- Obtain RTEMS RSB from git or release
  - `git clone git://git.rtems.org/rtems-source-builder.git`
- Check basic host environment
  - `cd rtems-source-builder`
  - `source-builder/sb-check`
- Build SPARC toolset
  - `cd rtems`
  - `../source-builder/sb-set-builder --log=l-sparc.txt \`
    `--prefix=$HOME/development/rtems/4.11 4.11/rtems-sparc`
- Takes approximately 17 minutes on a (modest) quad-core machine

RTEMS Tester

- Automates testing on simulators and hardware using GDB Machine Interface (MI)
  - direct execution using various simulators
  - takes advantage of multiple cores to parallelize simulator testing
- Execute RTEMS Test Suite

```
~/development/rtems/test/rtems-tools.git/tester/rtems-test \
    --log=log_sis_run  --rtems-bsp=sis-run \
    --rtems-tools=$HOME/development/rtems/4.11 \
    sparc-rtems4.11/c/sis/testsuites
```

- Takes ~24 minutes single threaded but 11.3 minutes with tester on modest 2.4Ghz quad code
  - Note: end up waiting for longest to complete or timeout

- Future plans
  - reduce run-time of longest running tests
  - automatically calibrate performance of simulators and scale the timeouts
  - execute GCC Test Suite
  - execute tests on other components
  - compare results with RTEMS Project
    - requires RTEMS Project to provide a populated test results database

RTEMS Coverage Testing

- Tools to analyze and report RTEMS Test Coverage
  - primary tool is *covoar*
- Test coverage itself is in good shape
  - Improved reporting and integration into framework is needed
- Current status
  - original scripts not in framework. ESA SOCIS student rewrote initial version for framework
  - original scripts had rigid reporting that was not granular enough. New version addresses that
- Future plans
  - bring framework version up to production standards so they can be integrated
  - finer grained (e.g. by directory) coverage reports

RTEMS and Tools Milestone

- Tested RTEMS Environment in place
- Provides fully tested application base with
  - full source and binaries
  - configuration reports
  - test reports including coverage
  - build reports

- RTEMS user can use ecosystem to support their project

RTEMS Continuous Integration Testing

- RSB provides uniform way to build tools, infrastructure, RTEMS and add-on packages
- Eases integration into a Continuous Integration Framework
- Prototype *buildbot* instance demonstration

- Future Plans
  - web based interface for submitting patches
  - patches tested BEFORE seen by reviewers
  - full test results available to entire community

Target Focused Tools

- Event tracing and recording
  - capture engine
  - trace wrapper generation
- Run-Time Loader
- GDB Pretty Printers

- Most of these capabilities require combination of target and host side software

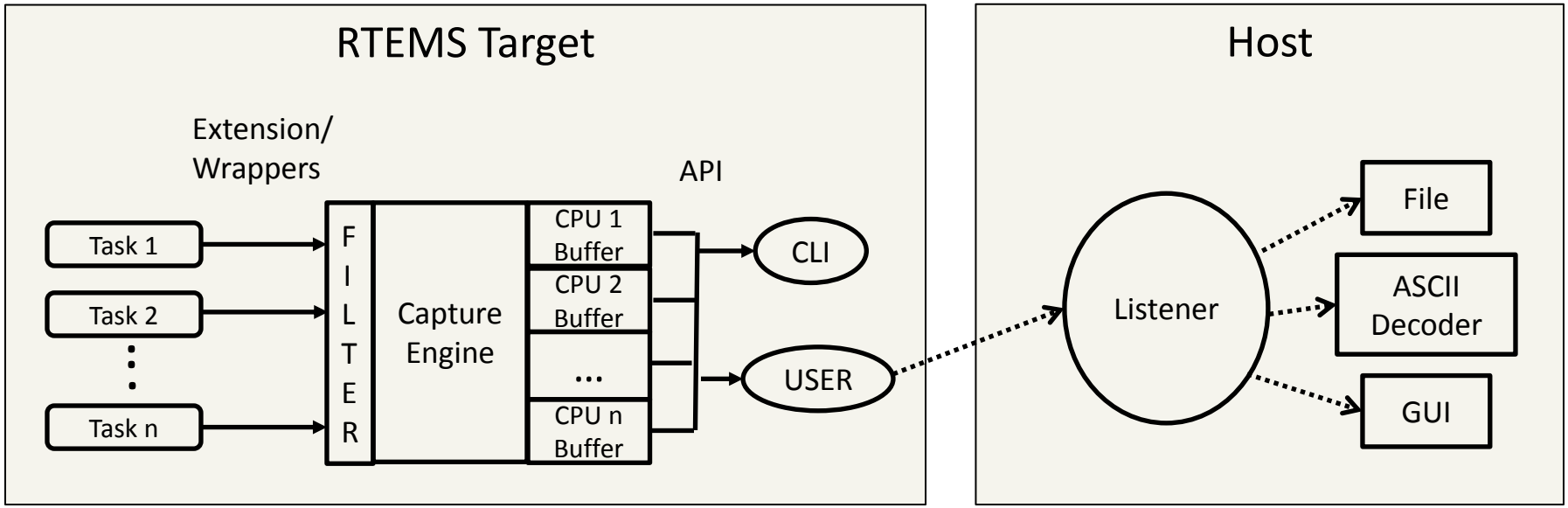
Capture Engine

- Capture trace data from
  - user extensions: thread create, start, restart, delete, switch, begin, exit, and terminate
  - any method invocation with trace wrapper generation
- Trace information is buffered on a per CPU basis to avoid locking during recording
- Can be printed via CLI or transmitted to host computer for further analysis

- Future plans
  - improve trace filtering and triggering

Capture Engine Usage

- Requires host and target support
- Run-time captures and buffers trace records
- Target has API and CLI to manage trace records
- If buffers transferred to host, other tools can be used to examine records



Thread Migration Capture Example

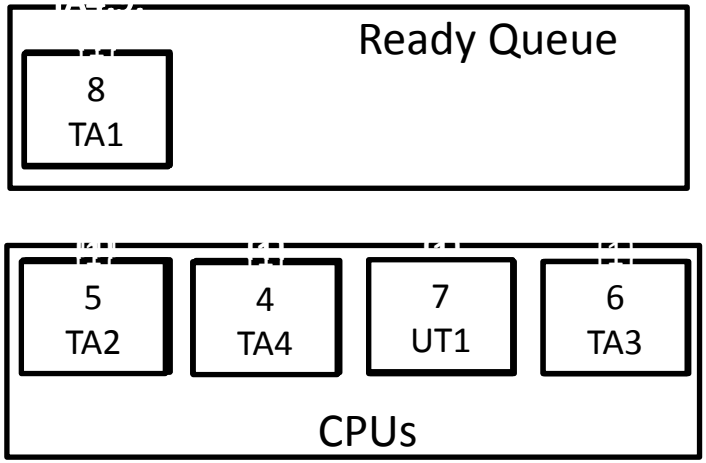
TaskName:Priority:*affinity*
affinity = {cpu,cpu}

(1) UT1:7:{2,3}

(2) TA1:8:{2,3} *(3)* TA2:5:{0,1}

(4) TA3:6:{0,3} *(5)* TA4:9:{1}

(6) Raise priority of TA4:4:{1} & trigger series of migrations

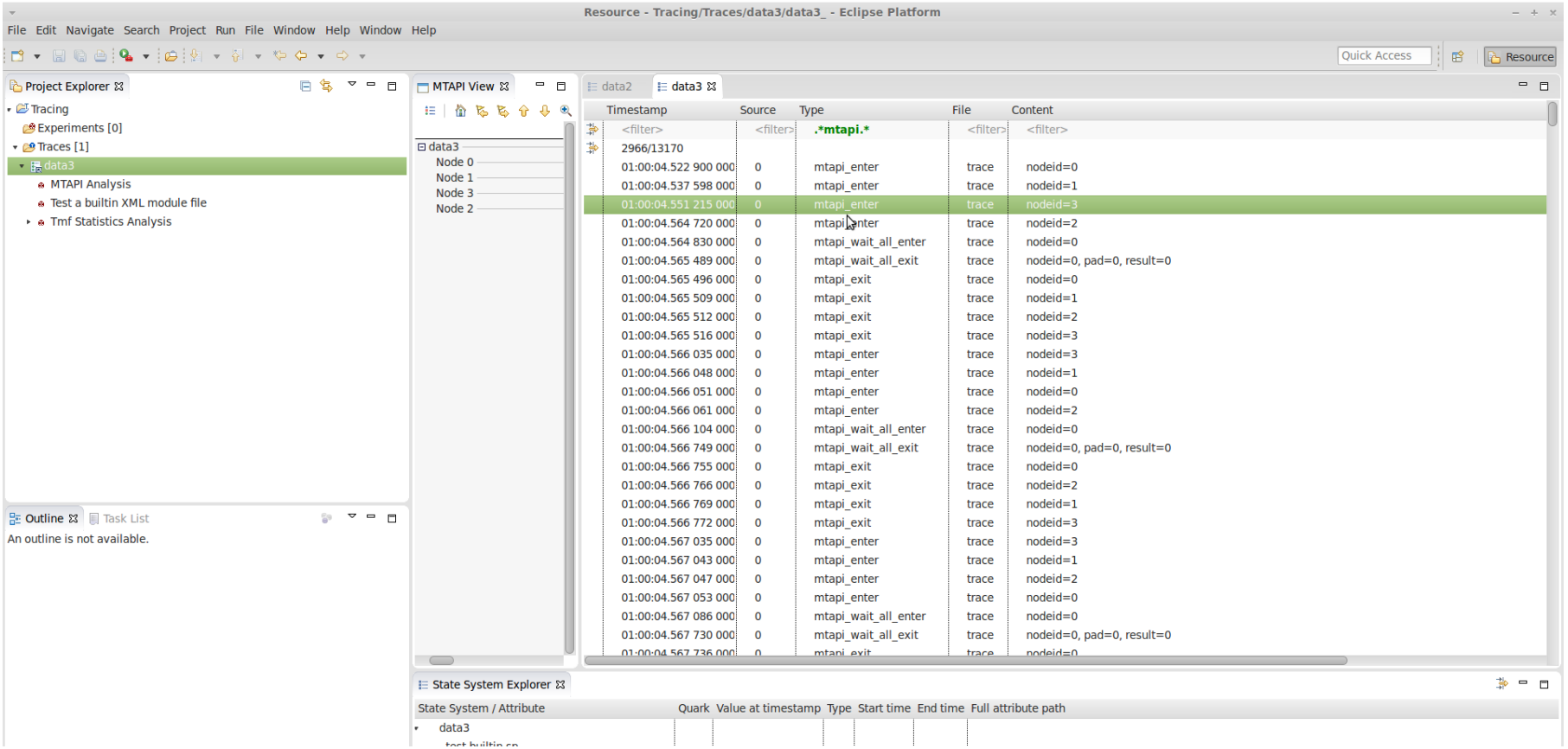


Capture Engine Output

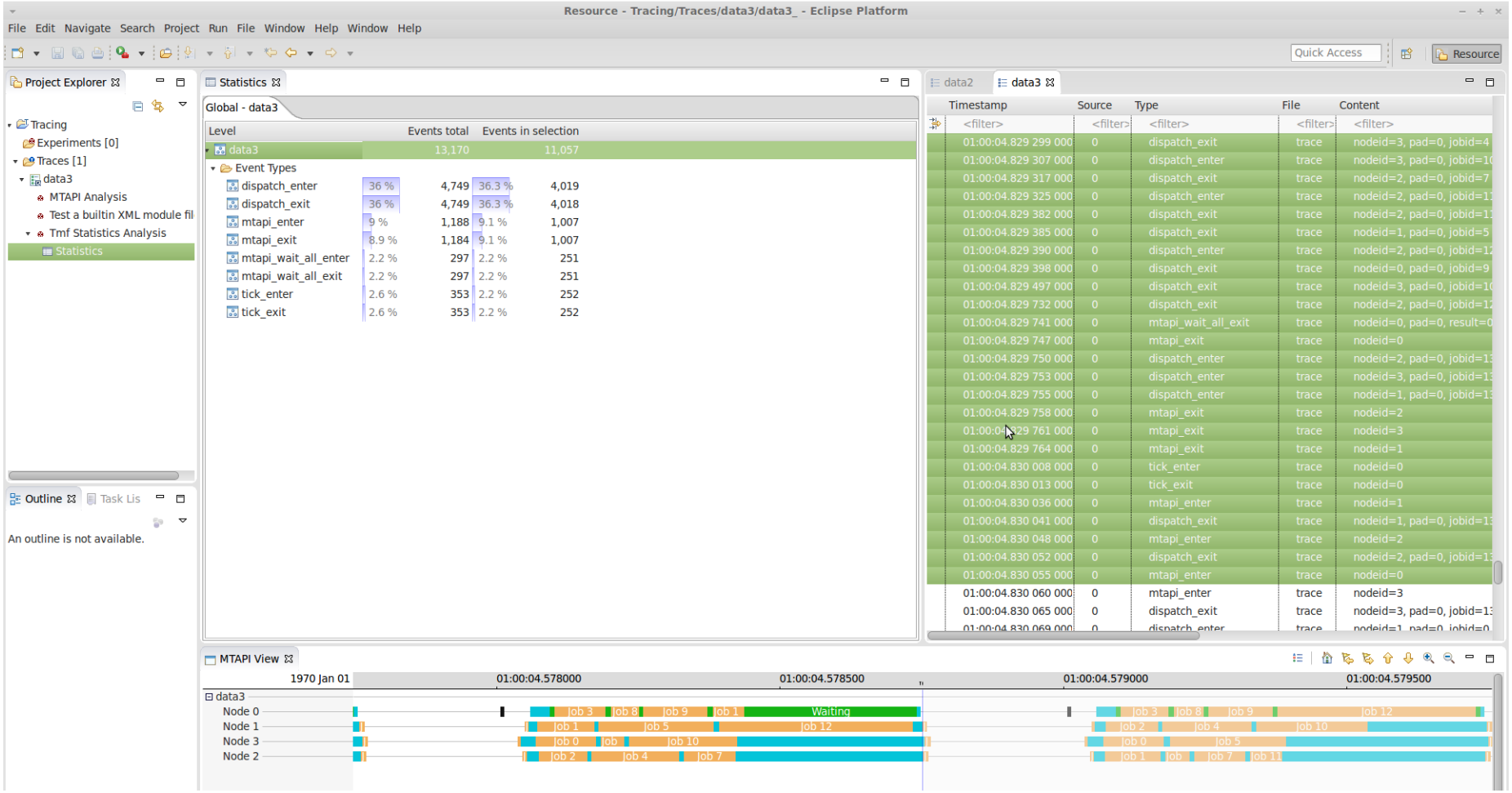
1	0:00:00.008653000		0a010003	TA02	5	5	5 4096	TASK_RECORD
0	0:00:00.008659000		0a010004	TA03	6	6	6 4096	TASK_RECORD
2	0:00:00.008663000		0a010002	TA01	8	8	8 4096	TASK_RECORD
1	0:00:00.008681000	0	0a010003		5	5		SWITCHED_IN
0	0:00:00.008686000	0	0a010004		6	6		SWITCHED_IN
2	0:00:00.008691000	0	0a010002		8	8		SWITCHED_IN
1	0:00:00.008734000	53000	0a010003		5	5		BEGIN
0	0:00:00.008738000	52000	0a010004		6	6		BEGIN
2	0:00:00.008743000	52000	0a010002		8	8		BEGIN
3	0:00:00.008914000		0a010001	UI1	7	7	7 4096	TASK_RECORD
3	0:00:00.008943000	0	0a010001		7	7		CREATED_BY
3	0:00:00.009015000		0a010005	TA04	9	9	9 4096	TASK_RECORD
3	0:00:00.009041000	98000	0a010005		9	9		CREATED
3	0:00:00.009298000	257000	0a010001		7	7		STARTED_BY
3	0:00:00.009326000	28000	0a010005		9	9		STARTED
3	0:00:01.000432000	991106000	0a010001		7	7		SWITCHED_OUT
1	0:00:01.000452000	991718000	0a010003		5	5		SWITCHED_OUT
3	0:00:01.000456000	24000	0a010004		6	6		SWITCHED_IN
0	0:00:01.000473000	991735000	0a010004		6	6		SWITCHED_OUT
1	0:00:01.000476000	24000	0a010005		4	4		SWITCHED_IN
2	0:00:01.000491000	991748000	0a010002		8	8		SWITCHED_OUT
0	0:00:01.000496000	23000	0a010003		5	5		SWITCHED_IN
2	0:00:01.000514000	0	0a010001		7	7		SWITCHED_IN

LTTng/RTEMS Proof of Concept #1

- Aeroflex/Gaisler PoC of MTAPI Demo on NGMP



LTTng/RTEMS Proof of Concept #2



RTEMS Trace Linker

- Eases linking RTEMS applications
- Automated generation of method wrappers
  - user specifies methods to wrap and trace
  - user specifies pattern for wrapper methods
- Proof of concept has pattern which uses *printk()* to display method invocation and return values
- Future plans
  - wrapper pattern for method trace to capture logs
  - extend filter/trace for arbitrary sets of user traces

Trace Visualization

- GUI visualization of event timeline
- Current status
  - identified existing FOSS tools focused on this
  - discussed with Linux Trace Toolkit developers how to add support for RTEMS trace visualization
- Future Plans
  - framework for mechanism to get trace to host
  - support Common Trace Format (CTF)
  - provide mapping of RTEMS events/objects to visual representation

RTEMS Run-time Loader

- Base image plus RTEMS Application (RAP) modules loaded and linked at run-time
  - uses host-based tool and the run-time link editor to perform a similar function to static linking
- Designed for modest target hardware
- File Formats supported by
  - ELF - normal ELF objects and executable
  - RAP - LZ77 compressed modules
  - AR – Object libraries with GNU extensions

- Future Plans
  - Support for most architectures is in place testing and feedback are needed

GDB Pretty Printers

- GDB now supports Python plugins
- Plugins can examine and analyze program variables and data structures
- Initial prototype to demonstrate feasibility
- Future Plans
  - user useful views of internal RTEMS information
  - methods to check consistency
  - replace RTEMS GDB macros with better versions written in a more capable language

Conclusion

- Work is ongoing and evolving
- Evolution is driven by feedback
- Help us make these tools make your job easier

Contacts and Acknowledgements

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Backup Slides

Ecosystem Framework (figure)

- Bottom bar is framework
  - Features: configuration, macro expansions, ELF, symbol management, execute for parallelization, RAP (RTEMS Application Package) format, INI file, lzma
- Top bar is user interface, CLI and GUI dashed
- Above top bar: User, Continuous Integration Tester
- Vertical bars: RSB, RTEMS Tester, RTEMS LD, RTEMS Trace Linker (TLD)

Capture Engine API Example

- Set capture engine to capture and print tasks with priority 0-20 related to TA00 while the application “run_program” is executing.

```
sc = rtems_capture_open (5000, NULL);
sc = rtems_capture_watch_ceiling (0);
sc = rtems_capture_watch_floor (20);
sc = rtems_capture_watch_global (true);
sc = rtems_capture_set_trigger (
  0,
  0,
  rtems_build_name('T', 'A', '0', '0'),
  0,
  rtems_capture_from_any,
  rtems_capture_switch
);
sc = rtems_capture_control (true);
run_program();
sc = rtems_capture_control (false);
rtems_capture_print_trace_records ( 22, false );
```