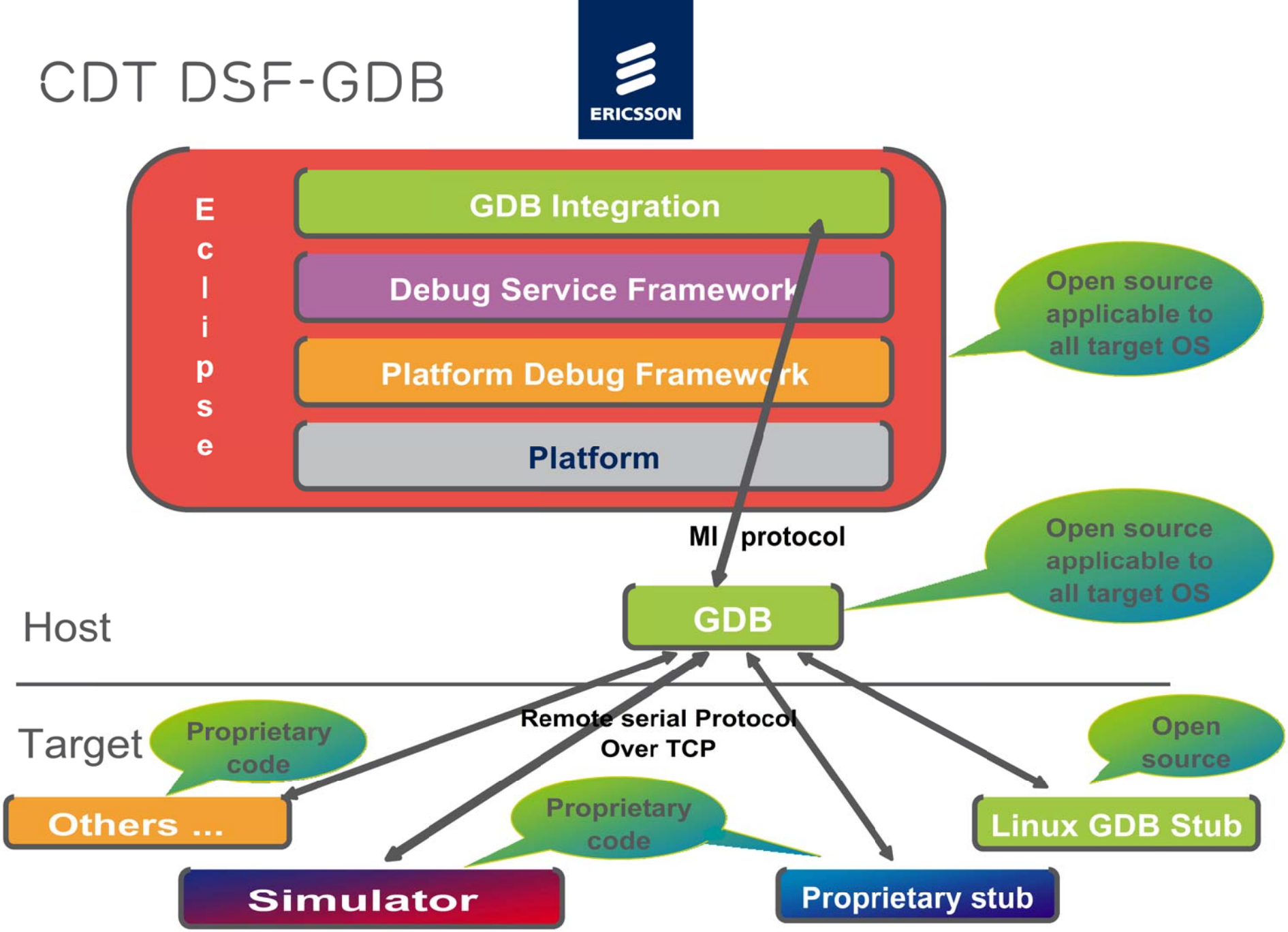
ADVANCED C/C++ DEBUGGING (CDT PROJECT) TRACING (LINUX TOOLS PROJECT)

DOMINIQUE DOT TOUPIN AT ERICSSON DOT COM

FULL OPEN SOURCE SOLUTION

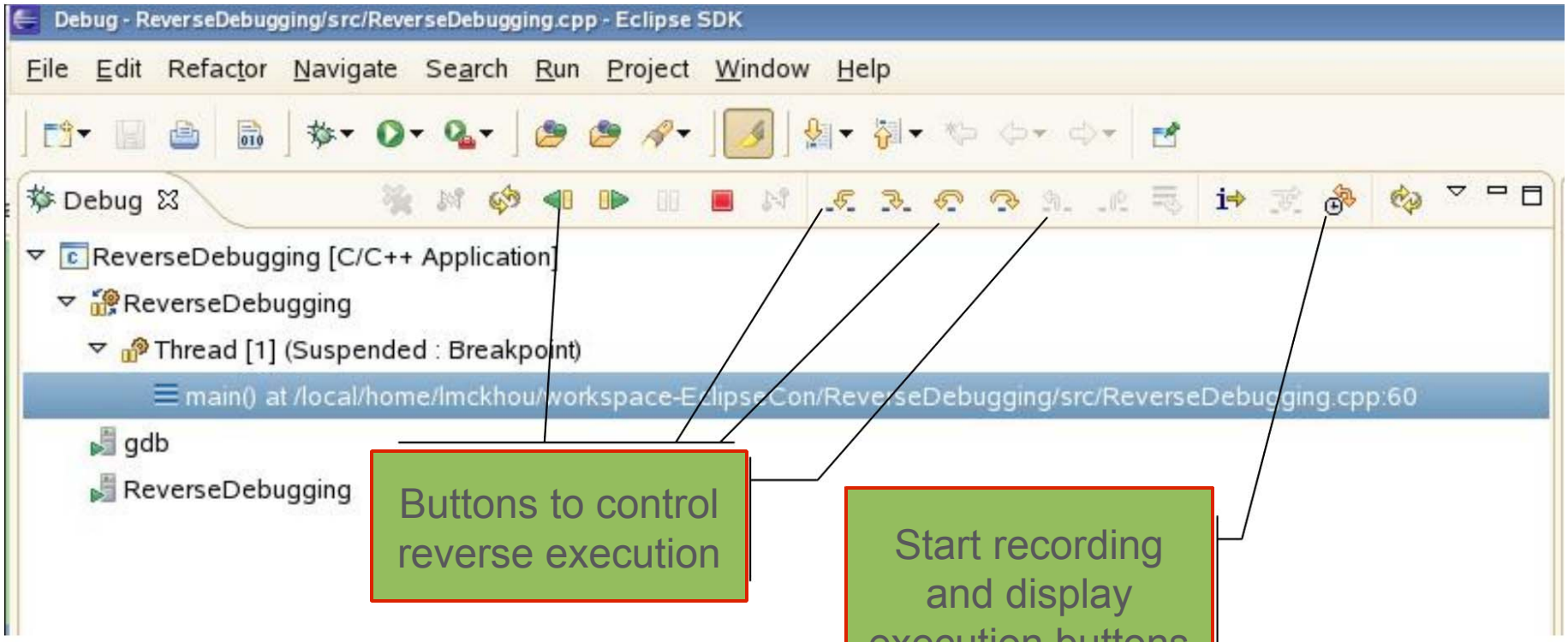
- ECLIPSE CDT
- ECLIPSE LINUX TOOLS
- GDB
- LTTNG
- LINUX

CDT DSF-GDB


ERICSSON
Eclipse
GDB Integration
Debug Service Framework
Platform Debug Framework
Platform
Open source applicable to all target OS
MI protocol
Open source applicable to all target OS
GDB
Host
Target
Proprietary code
Remote serial Protocol Over TCP
Open source
Others ...
Proprietary code
Linux GDB Stub
Simulator
Proprietary stub

REVERSE DEBUGGING

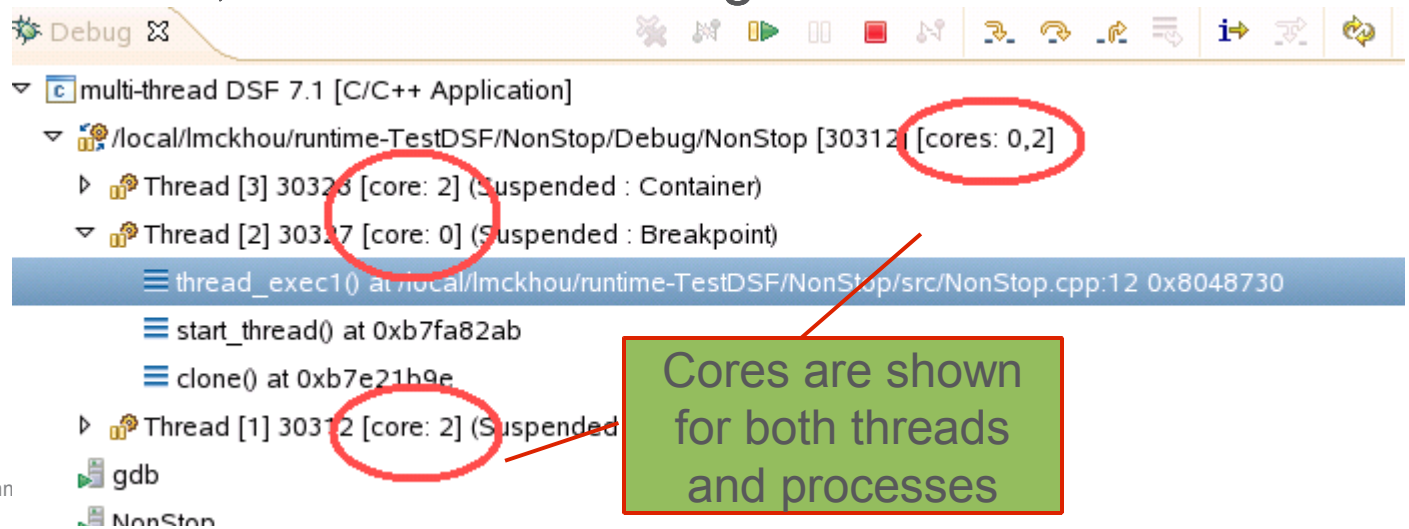
- Allows to undo register and memory changes so as to move the execution backwards
- Uses recording and playback



MULTI CORE-PROCESS-CONTEXT

HTTP://WIKI.ECLIPSE.ORG/CDT/MULTICOREDEBUGWORKINGGROUP

- More execution in parallel in many processes
- Debugging related processes at the same time
- Dynamically attach and detach from processes
- Follow child process created with a fork, exec,
- Global Breakpoint, many processes can execute the same code, auto attached to the process only when the breakpoint is hit, also usefull for short lived-process
- Core awareness, threads are running on which cores



2.4) View where users can see the cores and what is running on each core, in many cases users will use core affinity to put thread on specific core for execution locality. The threads don't move much between cores.

2.5) Define what are the process/threads for an application, attach to all of them;

2.6) Select one core and stop it or put a breakpoint on all the threads running on it; or a global breakpoint for the first process or thread hitting the breakpoint;

2.7) Continue/step for all thread running on a core;

2.8) Understand the interaction between process/threads of different cores, e.g. signal breakpoint;

2.9) A few use cases/features are almost the same as the one in PTP (process set, operations on set, etc.)
http://www.eclipse.org/ptp/documentation/2.1/org.eclipse.ptp.help/html/06parDebugging.html

- **3) Systems with multiple cores (On Chip Debugging)**

3.1) Hardware bring-up debugging

User attaches a debugger to a multi-core system for purpose of hardware configuration, such as configuring registers, IO devices, etc. (no OS, no symbol data, no executable image)

3.2) No-OS debugging

User attaches to a multi-core system and downloads simple executable image to each core and debugs them.

3.3) Debugging with OS-awareness

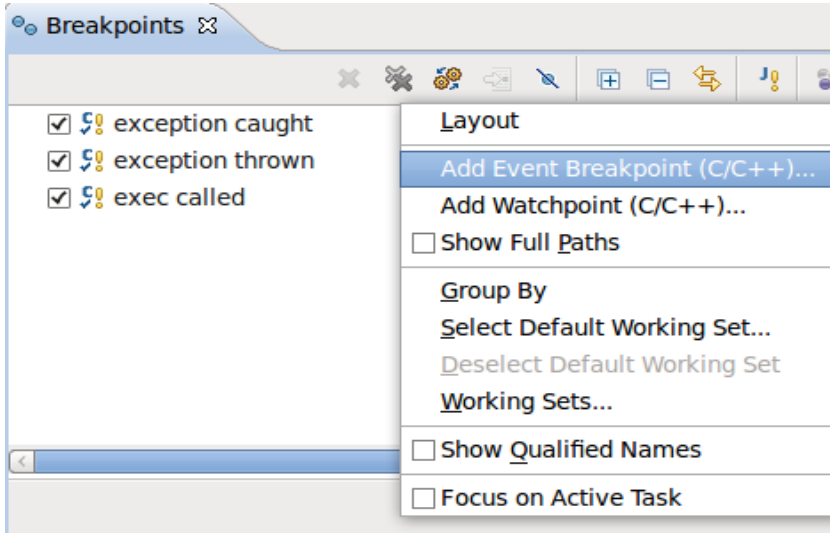
User attaches to a multi-core system, downloads an OS image to each, starts debugging the entire OS on each board, or specific tasks/processes running on specific cores.

3.4) Synchronized run control operations

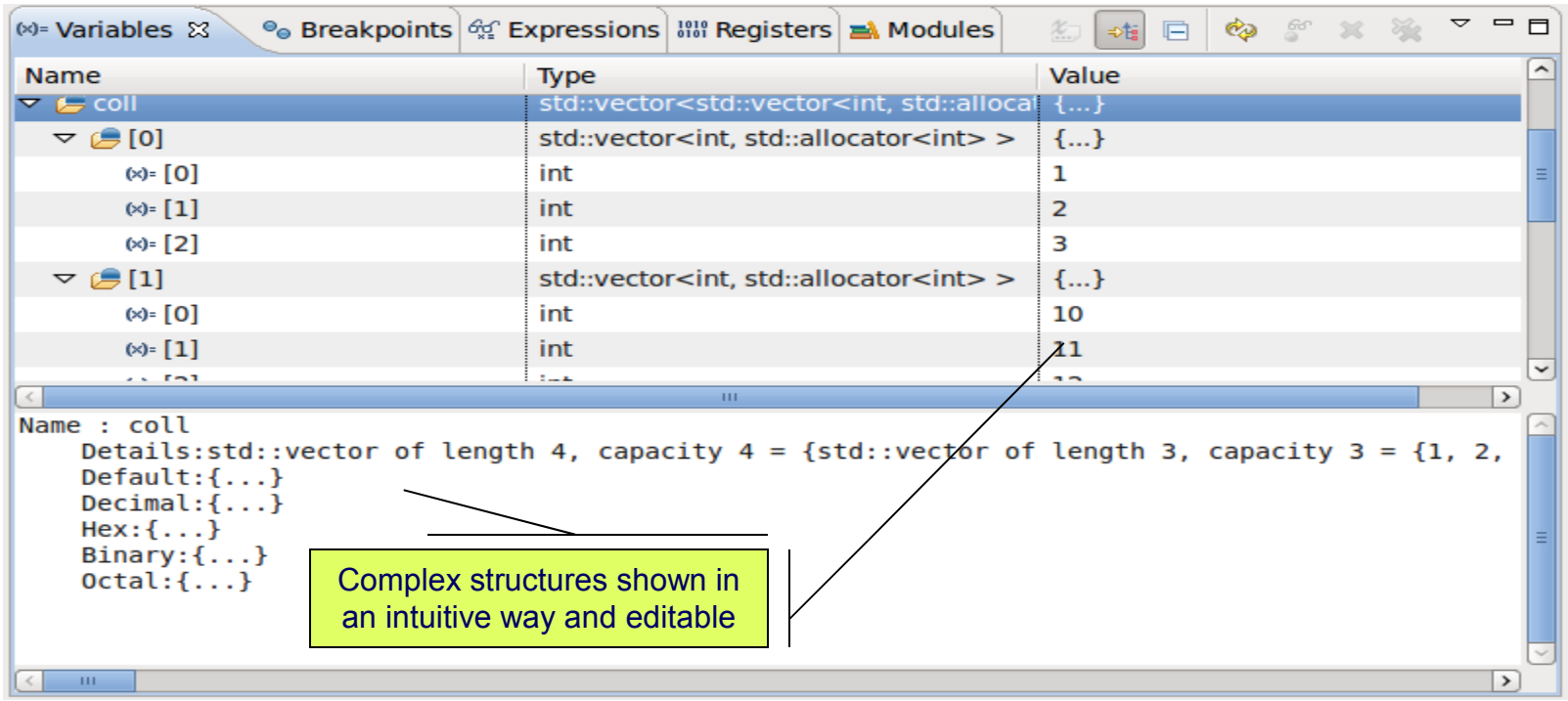
Some multi-core debuggers allow for performing synchronized operations on multiple cores. Allowing the debugger or the hardware to operate on multiple cores minimizes the skid, or the time lag, in when the operations are carried out on the different cores. There needs to be dedicated UI and APIs to exercise these debugger features.

SPECIAL BREAKPOINTS

- Conditional Breakpoint
  - Stop only if the condition is true.
  - C assert condition, break when assertion is false
- Data Breakpoint or Watchpoint
  - Stop whenever the value of an expression change
  - Don't have to predict where this may happen
  - Can be a complex expression or just a single variable
- Program event breakpoint
  - Stop when a special event occurs
  - Throwing/catching C++ exception,
  - unhandled exception
  - call to exec, fork, syscal



- Display and editing of complex objects like Lists, Maps, Vectors



- Some programs have a deep interaction with OS resources DSF-GDB can show: process groups, file descriptors, internet-domain sockets, shared memory segments, semaphore, message queues, loaded kernel modules, etc.

NON-STOP

- Debugging a process by stopping its execution might cause the program to change its behavior drastically, or perhaps fail, even when the code itself is correct.
  - Troubleshooting in the lab
  - Chasing a race condition
  - Debugging problems happening only under heavy load
  - Investigating user interface issues

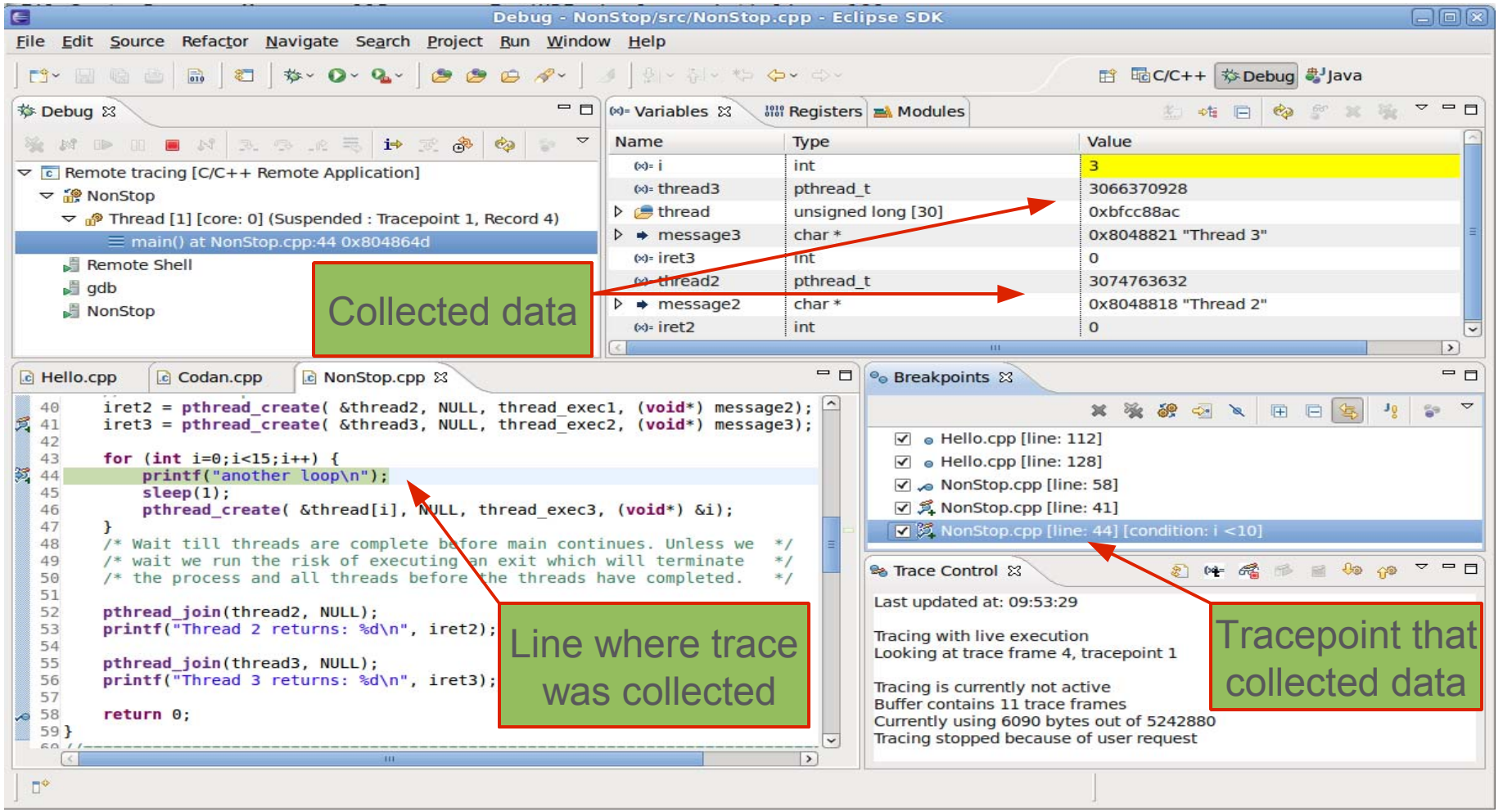
- Non-Stop allows to stop and examine one or more thread in the debugger *while other threads continue to execute freely*

DYNAMIC TRACEPOINTS

- Tracepoint collects user-specified info and continues execution without stopping any thread, essential for live sites
- Dynamic i.e. inserted with a jump (in process) or a trap
- Data collection can be conditional to a user specified expression
- Tracepoint actions:
  - collect state trace data e.g. timestamp, and program data e.g. variables, register
  - evaluate expressions , e.g. modify trace variables
  - step (similar to breakpoint step) and collect data in each step
- A trace experiment can be stopped after the n'th hit
- Static tracepoint (LTTng UST) can be stored in the debug tracepoint buffer
- Debug tracepoint are good when no static tracepoint are available and for small quantity of data

DYNAMIC TRACEPOINTS VISUALIZATION

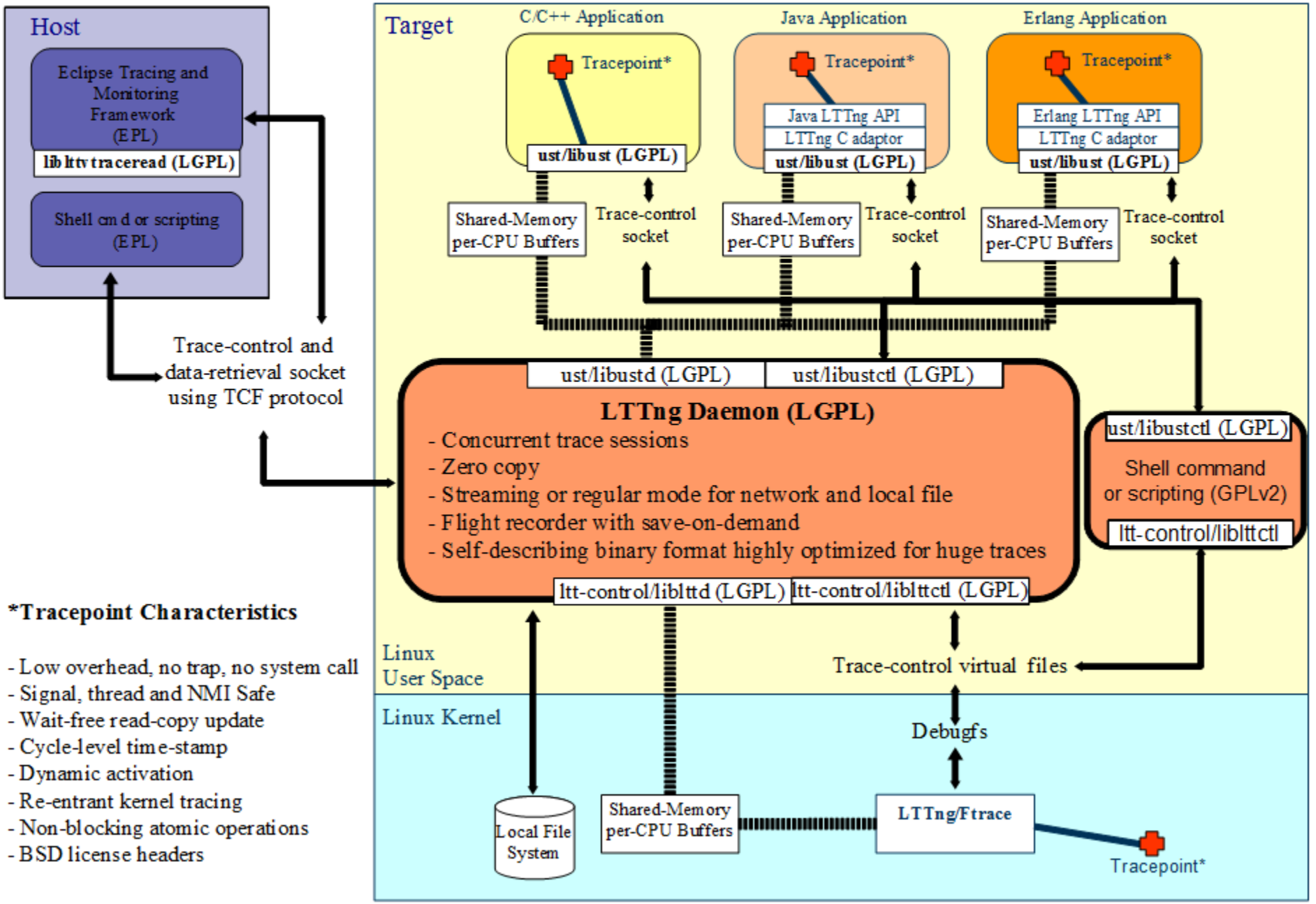
- Intuitive display using debugger views



TRACING

- Need to understand what is going on in a system without causing disturbance? → Tracing is for you
- Compared to logging, tracing typically records lower-level events that occurs much more frequently
- Tracers are therefore optimized to handle a lot of data while having a small impact on the system
- Static Tracepoint
  - created by designer before compilation
  - represent wisdom of developers who are most familiar with the code
  - The rest of the world can use static tracepoint to extract a great deal of useful information without having to know the code

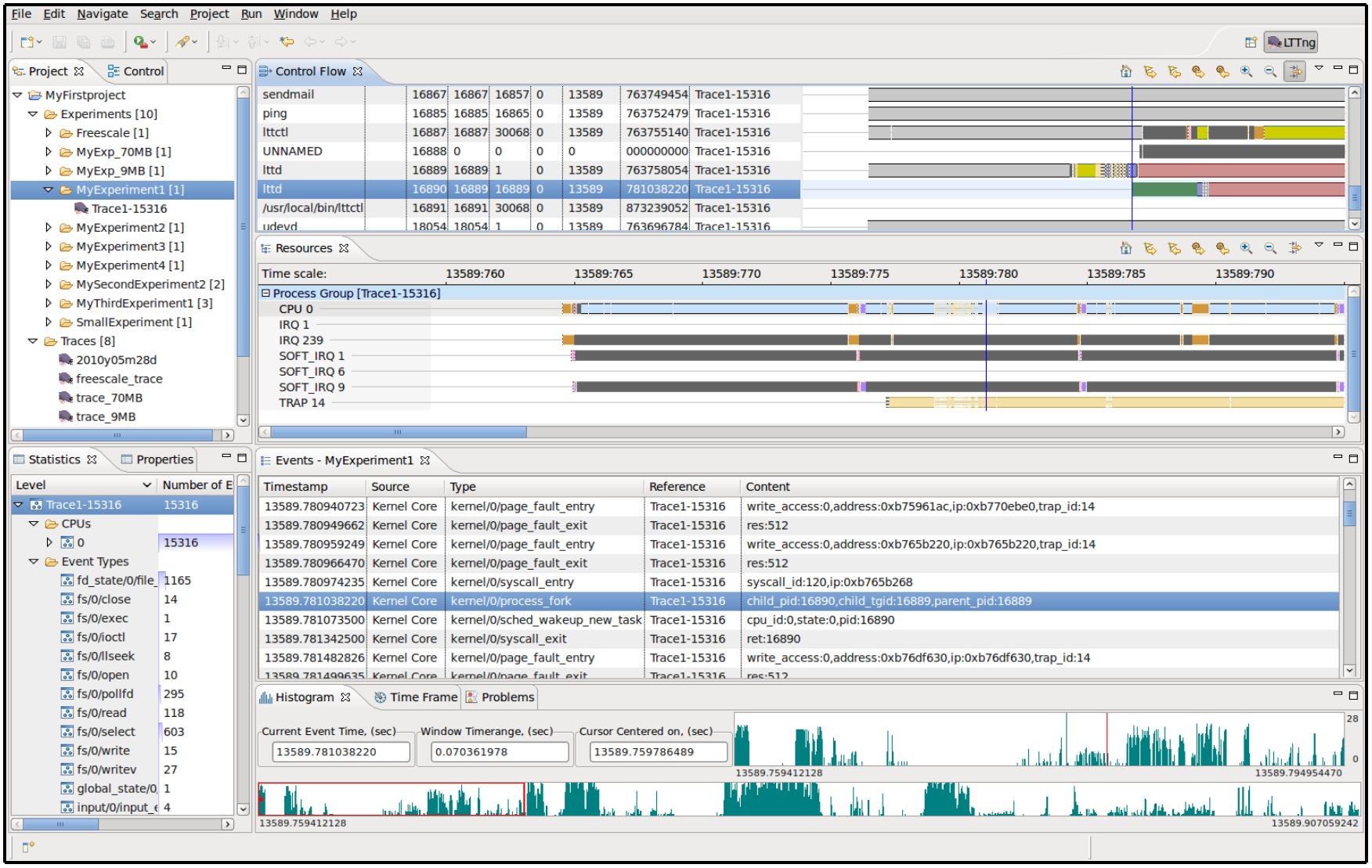
LTTng Low-Overhead Tracing Architecture



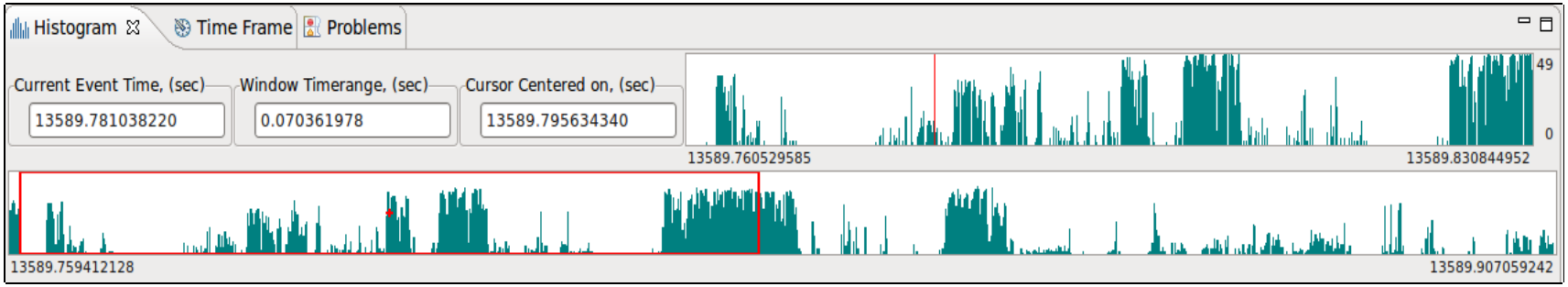
***Tracepoint Characteristics**

- Low overhead, no trap, no system call
- Signal, thread and NMI Safe
- Wait-free read-copy update
- Cycle-level time-stamp
- Dynamic activation
- Re-entrant kernel tracing
- Non-blocking atomic operations
- BSD license headers

LTTNG PERSPECTIVE



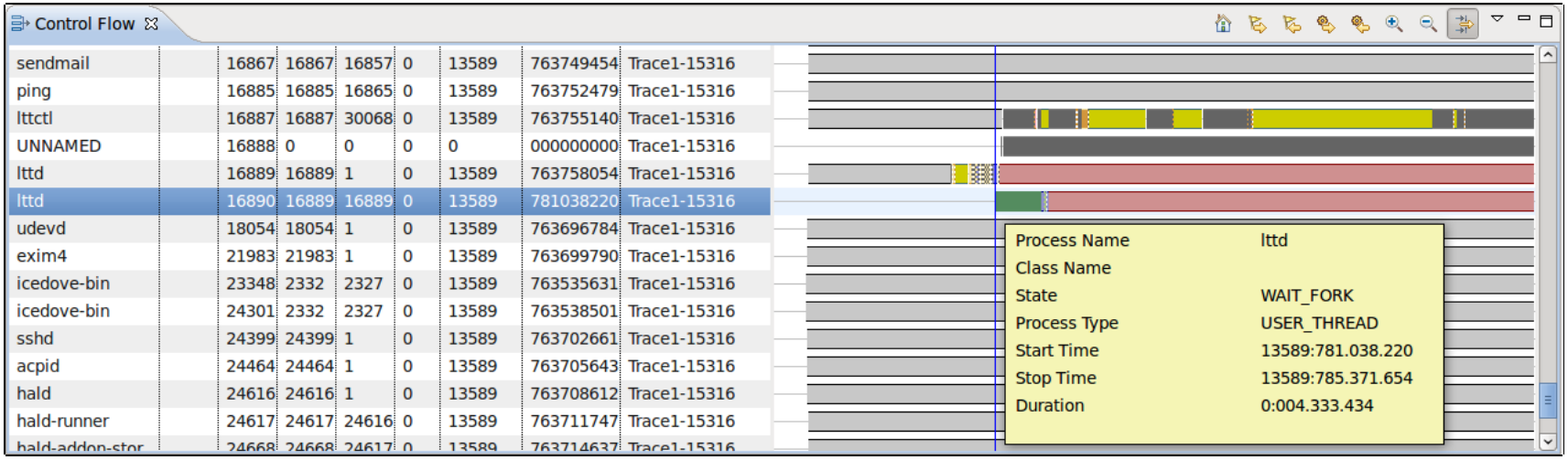
LTTNG HISTOGRAM, STATISTICS

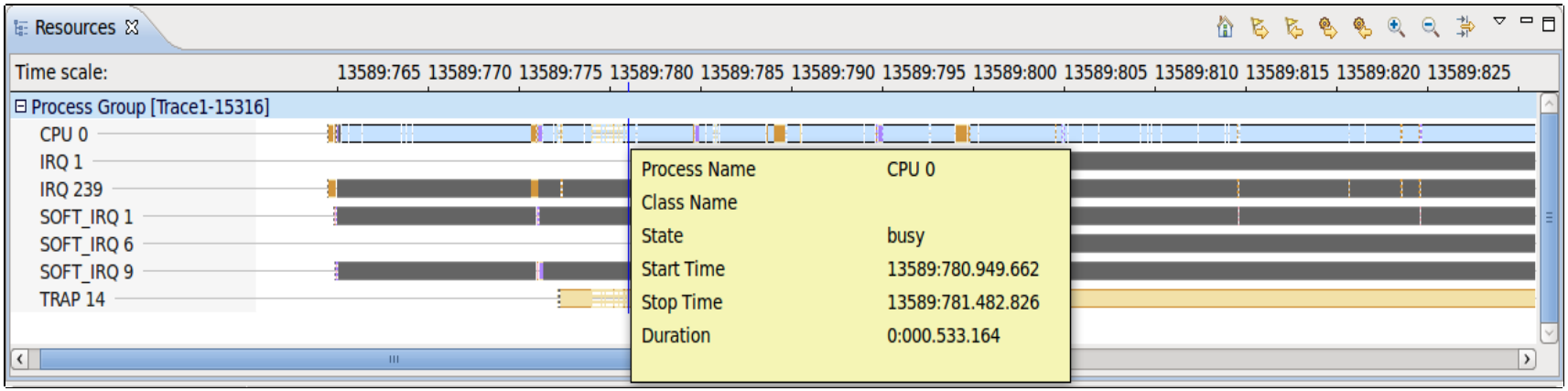


Statistics

Level	Number of Events	CPU Time	Cumulative CPU Time	Elapsed Time
Trace1-15316	15316	0.060617118	0.876353906	0.762141301
CPUs				
0	15316	0.060617118	8.497766916	0.762141301
Event Types				
Modes				
IRQ	99	0.003638321	0.008165658	0.004082829
MODE_UNKNOWN	12432	0	0	0
SOFTIRQ	89	0.001467848	0.00309494	0.00154747
SYSCALL	1890	0.030586202	1.595780335	0.748304729
TRAP	319	0.006543252	0.031454274	0.008206273
USER_MODE	487	0.018381495	0	0

LTTNG CONTROL FLOW, RESOURCES

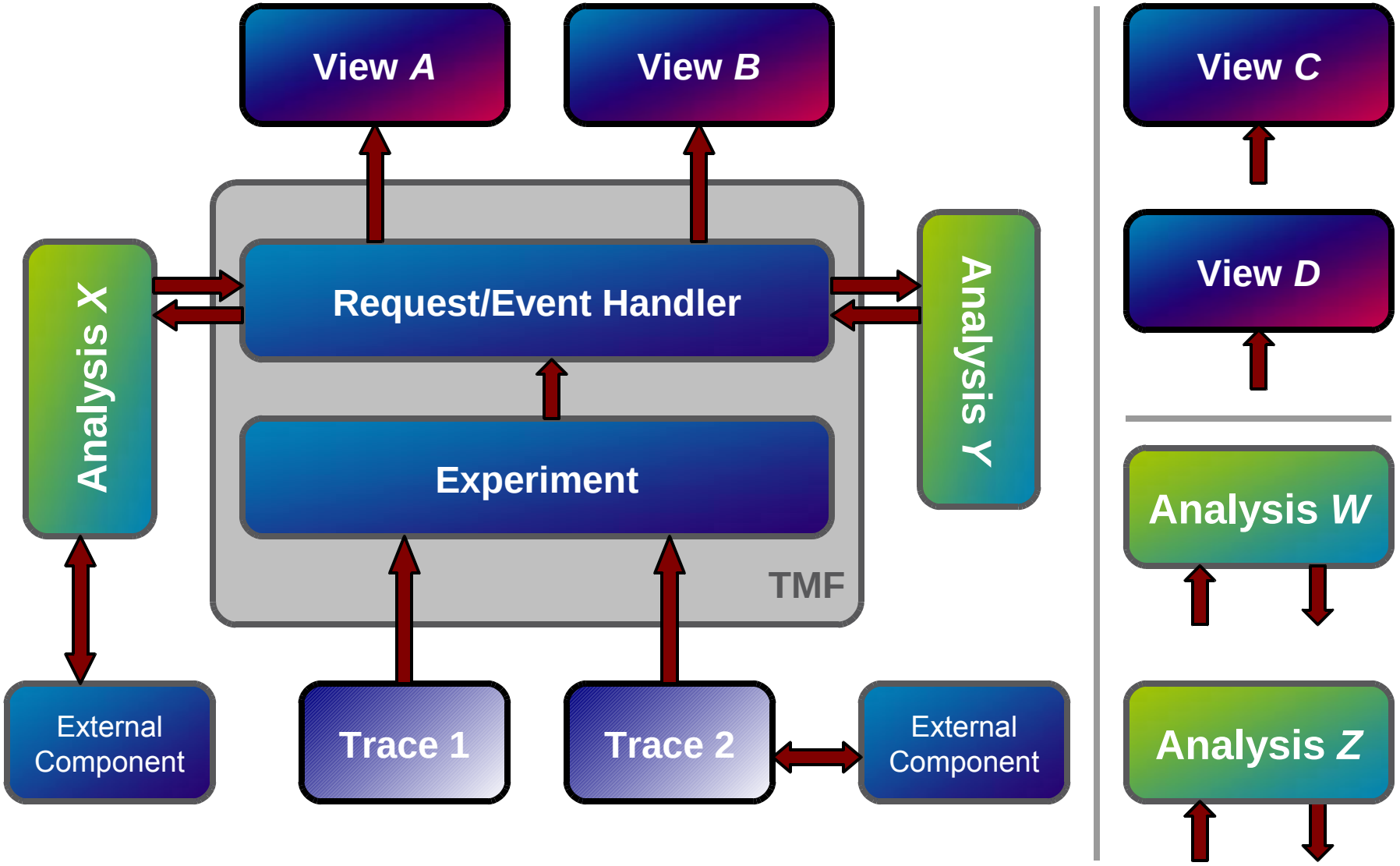




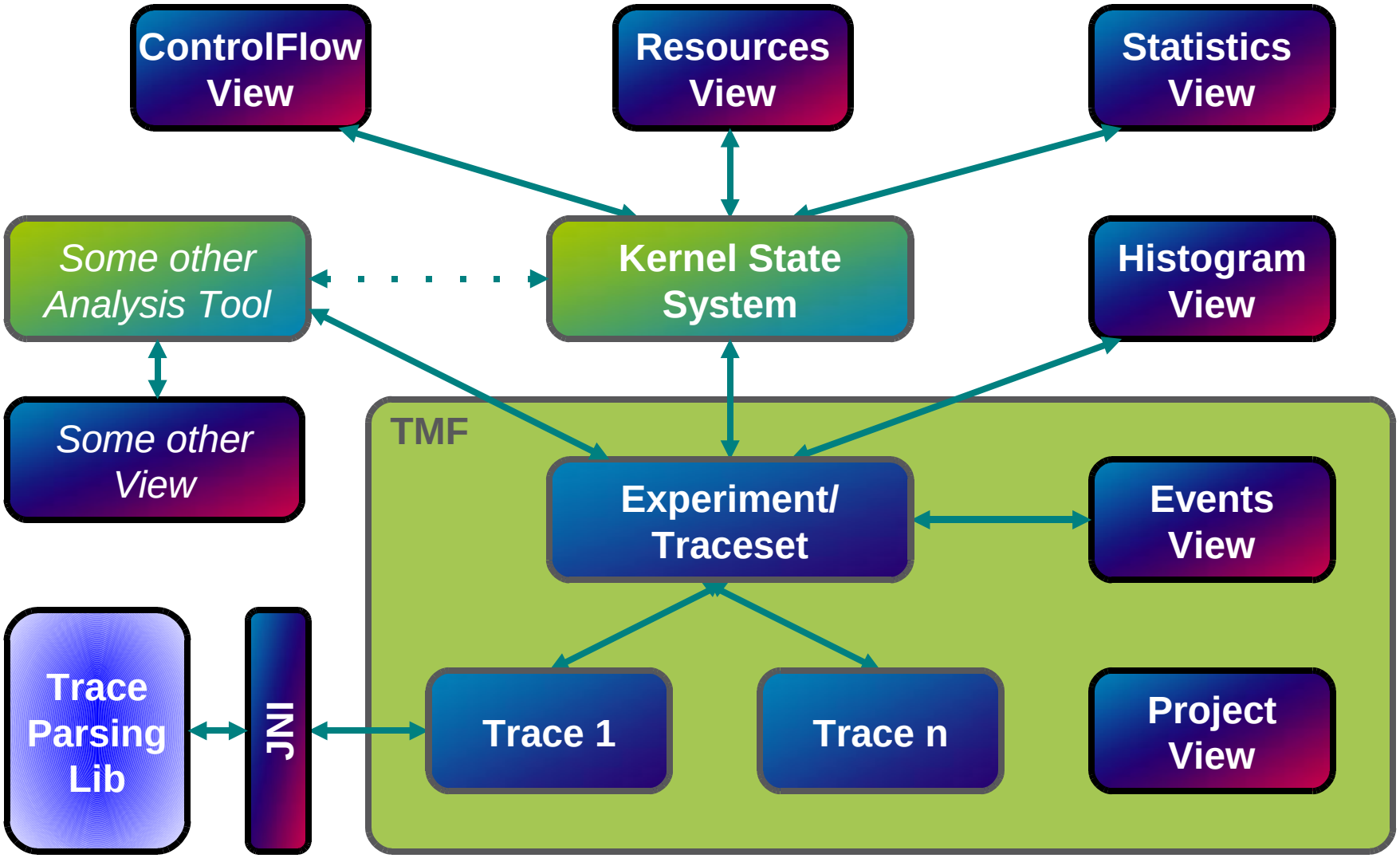
UPCOMING FEATURES

- General
  - Tracing tool control
  - Trace streaming
  - Heterogeneous traces
  - GDB Tracepoints
  - Source lookup
  - Performance tuning
- Analyses
  - Time correction (traces synchronization)
    - Multi-core, multi-level, multi-node
  - Timing dependencies (between processes)
  - Latency Analysis
  - Pattern matching (security e.g. intrusion detection)
- Other trace format
  - Linux User Space Tracing
  - Text format
  - De-facto standard format Multi-core association, Embedded Linux Forum, Samsung, Ericsson, Mentor Graphic, WindRiver, IBM, Freescale, TI, Nokia-Siemens Network, National Instruments, etc.
    www.multicore-association.org/workgroup/tiwg.php
    Common Trace Format Requirement:
    http://lwn.net/Articles/408824/
    Common Trace Format Implementation:
    http://lwn.net/Articles/408825/

TMF – ARCHITECTURE



LTTNG – TMF INTEGRATION



ADDITIONAL ONLINE RESOURCES

- Eclipse CDT DSF-GBD lead: **marc DOT khouzam AT ericsson DOT com**
  cdt-dev@eclipse.org
- CDT Multi-core debugging http://wiki.eclipse.org/CDT/designs/MultiCoreDebug, http://wiki.eclipse.org/CDT/MultiCoreDebugWorkingGroup, http://wiki.eclipse.org/PinAndClone
- http://gcc.gnu.org/wiki/summit2010
- Advanced Tracing Features using GDB and LTTng, Real-time debugging using GDB Tracepoints, GDB Tracepoints: From Prototype to Production
- http://gcc.gnu.org/wiki/HomePage?action=AttachFile&do=get&target=2009-GCC-Summ

  Using Eclipse for Reverse, Multi-Process and Non-Stop Debugging with GDB p.65, GDB Tracepoints, Redux p.105, Hybrid multi-architecture debugging with GDB p.137
- http://www.gccsummit.org/2008/gcc-2008-proceedings.pdf Non-stop Multi-Threaded Debugging in GDB p.117
- Eclipse LTTng plug-in lead: **francois DOT chouinard AT ericsson DOT com**
  linuxtools-dev@eclipse.org
- http://www.eclipse.org/linuxtools/projectPages/lttng
- http://www.lttng.org, http://lttng.org/content/success-stories

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