Real-time Debugging using GDB Tracepoints and other Eclipse features

GCC Summit 2010

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Summary

- Introduction
- Advanced debugging features
  - Non-stop multi-threaded debugging
  - Pretty-printing of complex structures
  - Multi-process debugging
  - Reverse debugging
  - Multi-core debugging
- GDB Tracepoints

Introduction

- Many companies deal with embedded systems
- Linux is widely used in the embedded space
- Applications are complex and have complex interactions
- Use of different targets
  - Different OS: Linux, Real-time OS, proprietary OS
  - Different architectures
  - Different environments: design, test, integration, live site
  - Different setups : Simulator, Real hardware, Lab, JTAG

Introduction

- Need for a debugging tool to address those situations

- Same tool for design, test, integration, live sites
- Same tool for simulator, real-target
- Same tool for different archs, OS
- Same tool for different types of users

- GDB provides the advanced debugging features
- Eclipse Integration provides the ease-of-use and efficiency

Features

Now

- Non-Stop multi-threading
- Partial Pretty-printing
- Single space multi-process
- Reverse
- Any binary debugging
- Tracepoints

Next

- Full Pretty-printing
- Full Multi-process
- Multi-core debugging
- Global breakpoints
- Tracepoints improvements
  - Fast tracepoints
  - Static tracepoints
  - Observer-mode
  - Intelligent trace visualization

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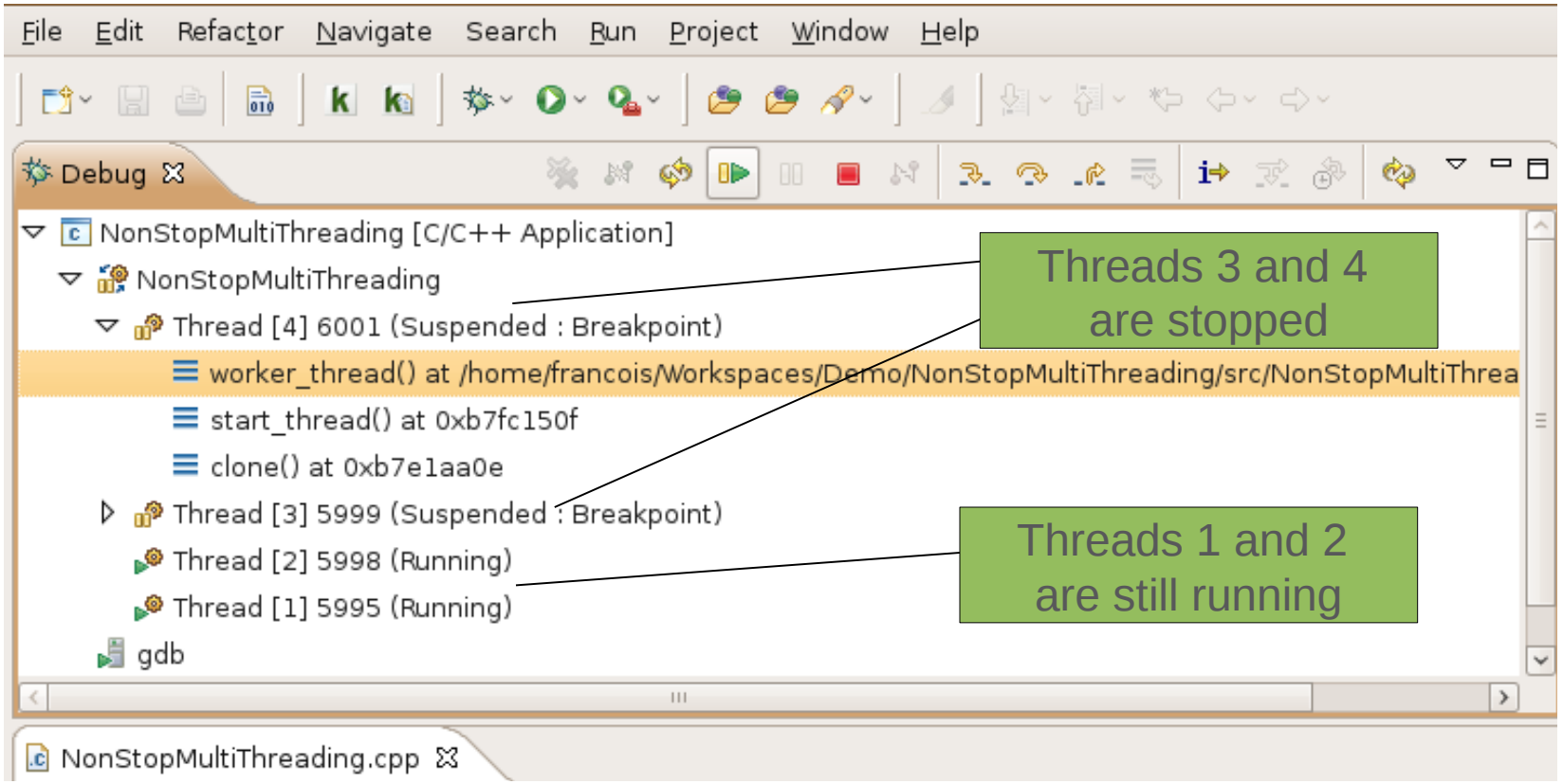
Non-Stop multi-threading

- Debugging a process by stopping its execution might cause the program to change its behavior drastically
- Some threads should not be interrupted for proper program execution
  - Heartbeat threads
  - Monitoring threads
  - Server threads
- Non-stop allows to stop and examine a subset of threads, while other threads continue to run freely.

Non-Stop multi-threading

- Allows to individually control treads
  - Step, Resume, Suspend



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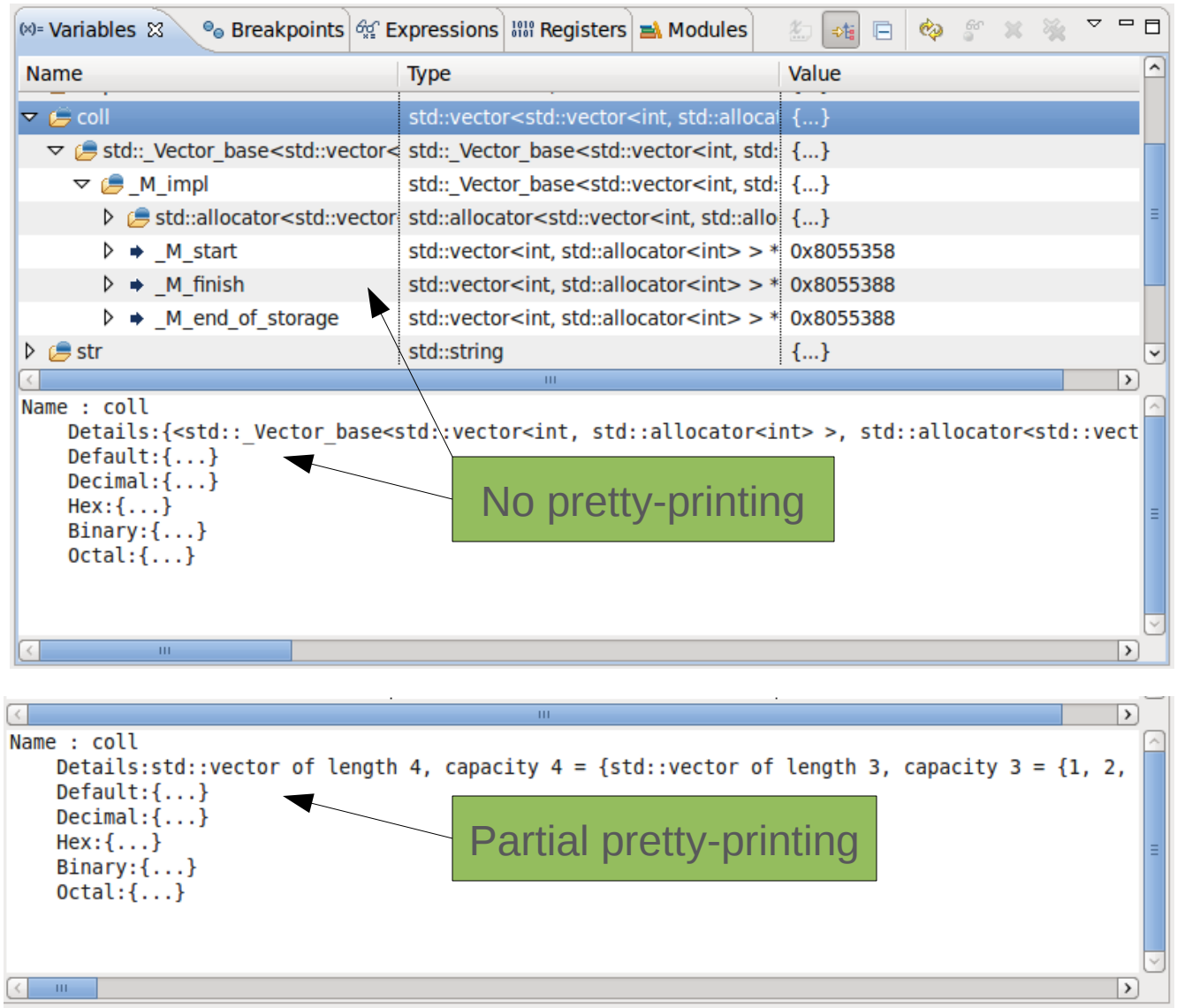
Pretty-printing

- Content of complex abstract data structures should be presented to the user while keeping the abstraction.
  - Vectors
  - List
  - Maps
  - User-defined structure

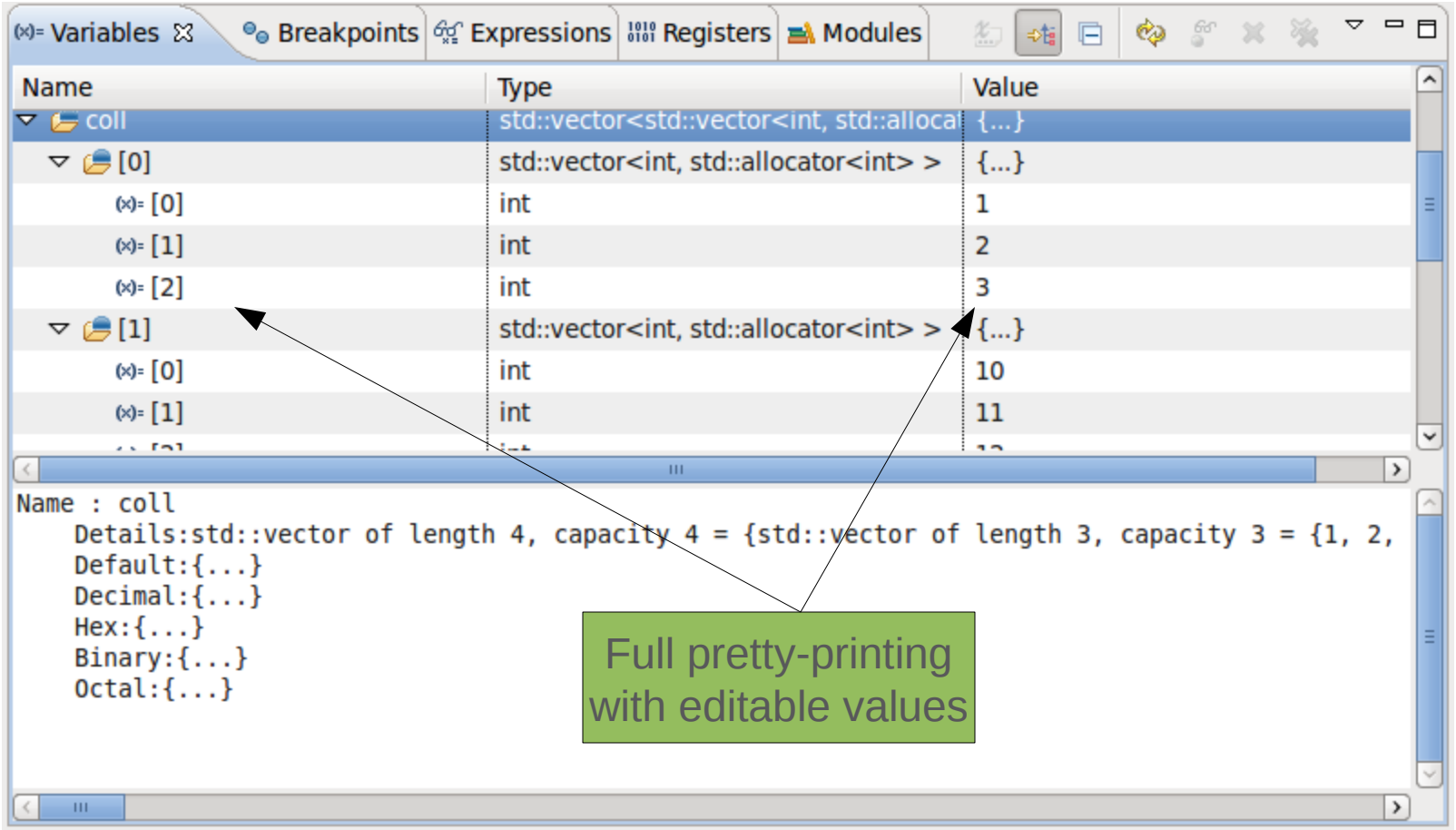
- GDB provides Python pretty-printing feature which is STL-ready

Pretty-printing (Now)



Pretty-printing (Next)

- Display content in user-friendly fashion
- Allows to modify content directly!



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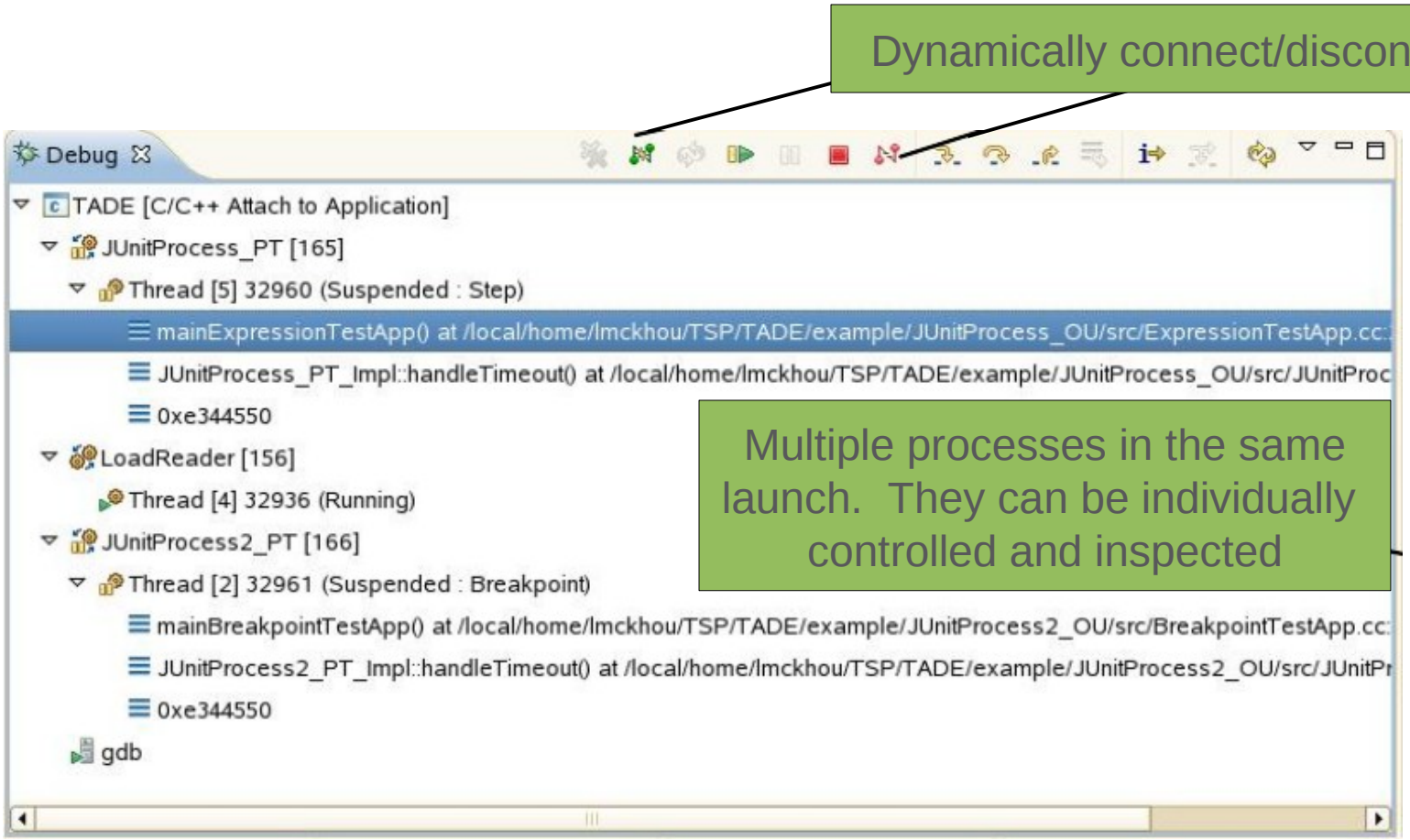
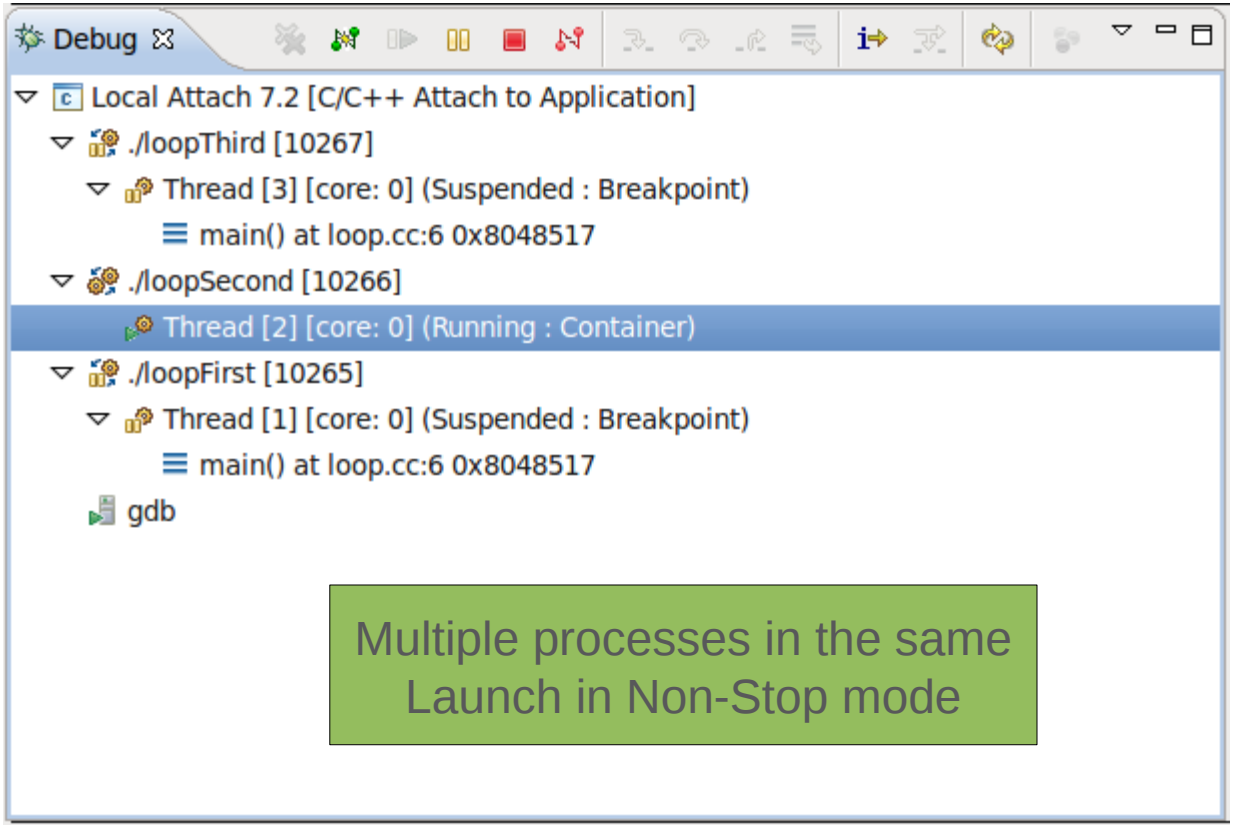
Multi-process (Now)

- Currently available for targets that have a single memory space for all processes



Multi-process (Next)

- Current work to bring this to Linux using GDB 7.2 for next release



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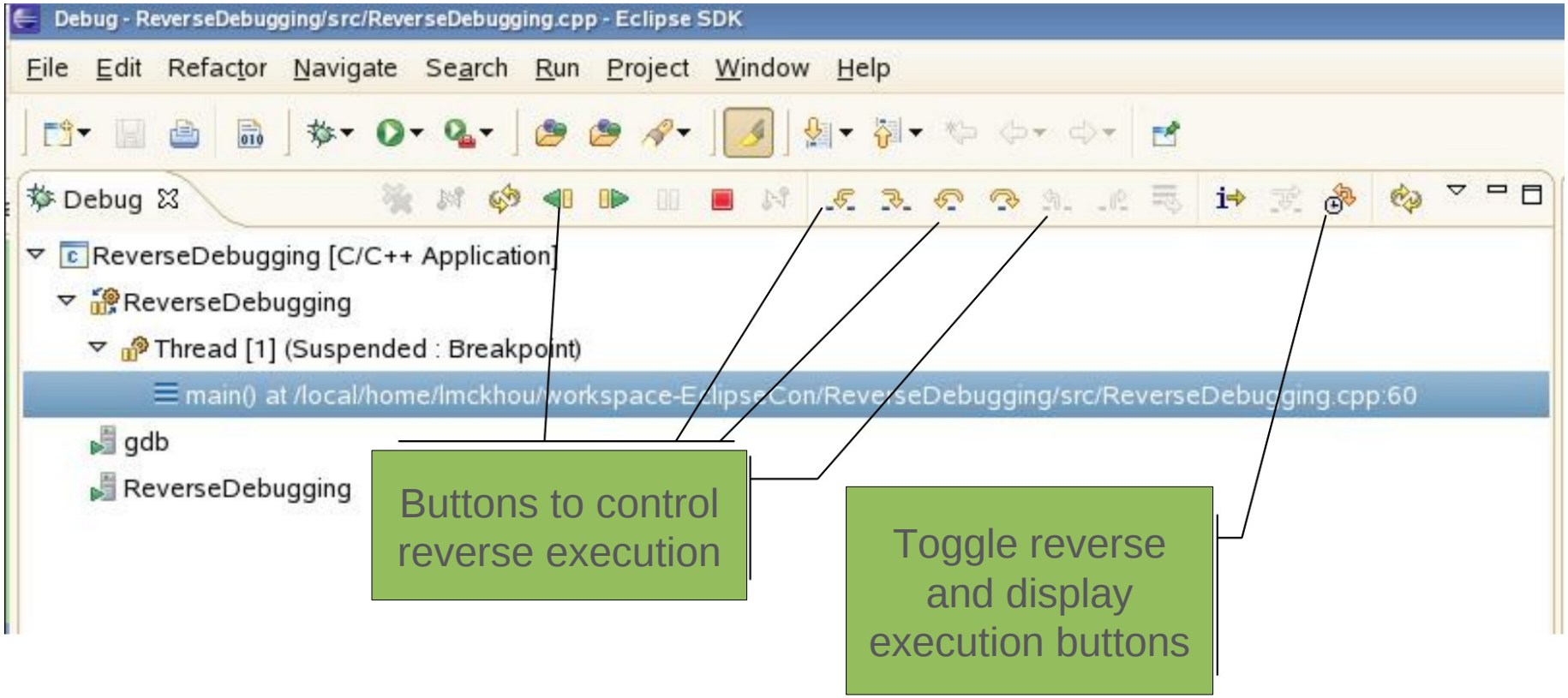
Reverse debugging

- Often, when debugging, you realize that you have gone too far and some event of interest has already happened.
- Restarting execution to reach that same failure can be tedious and time consuming
- Why not simply *go backwards?*
- Undo the changes in machine state that have taken place as the program was executing normally i.e., revert registers and memory to previous values
- GDB provides Process Record and Replay for Linux
- Allows to go backwards, modify memory/registers, then resume execution on a new path!

Reverse debugging



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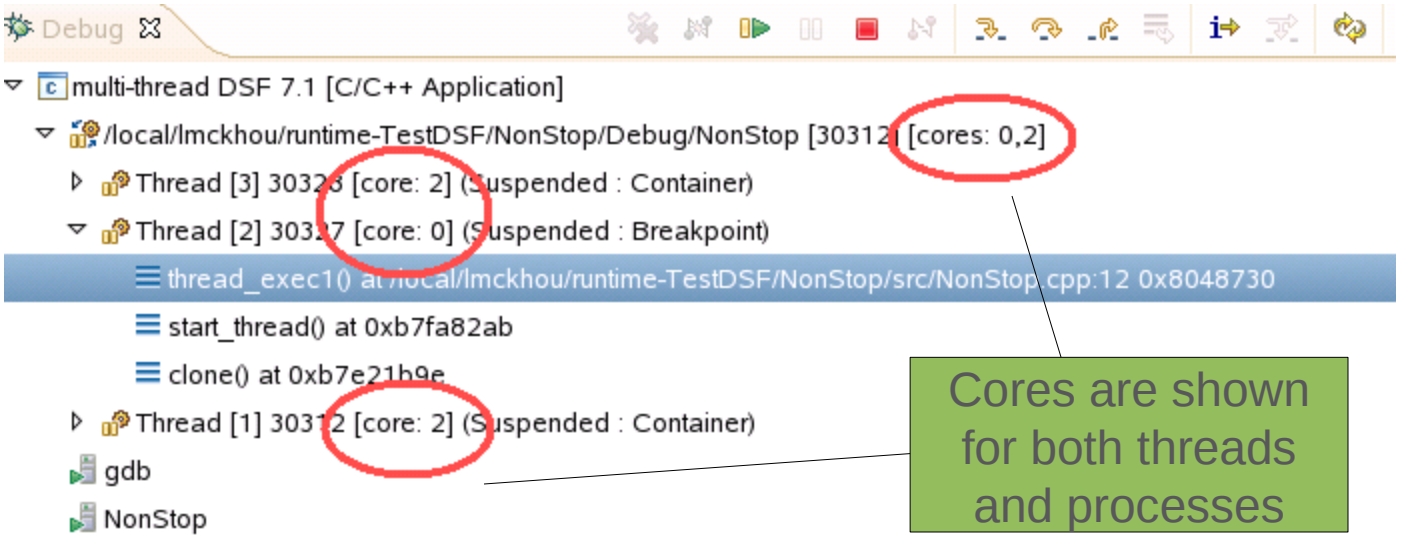
Multi-core debugging

- As systems get more complex, so does the software running on them
- Debugging tools must provide more information to describe these complex systems
- Multi-core systems are the default now
- Troubleshooting requires having knowledge of what is running where

Multi-core debugging

- First step in upcoming broader multi-core debugging support
- Indicates core information to the user



Others

- Any binary debugging (Now)
  - Allows to debug any binary without having to build it in Eclipse
  - Almost immediate debugging of GDB or GCC!
- Automatic remote launching (Next)
  - Will automatically start gdbserver on your target
- Global breakpoints (Next)
  - Allows to stop processes that don't have the debugger attached to it
  - Essential for short-lived processes
  - Essential for startup-sequence debugging on a real target

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  - **Observer-mode**
  - **Intelligent trace visualization**

Dynamic Tracing

- Using a debugger drastically changes execution
- In some cases, a debugger is too intrusive :
  - Debugging a race condition
  - Investigating user-interface issues
  - Live sites
  - Real-time systems
- Low-overhead tracing is the answer: LTTng, UST

- What if existing static traces don’t give info needed?
- What about systems that are not instrumented?

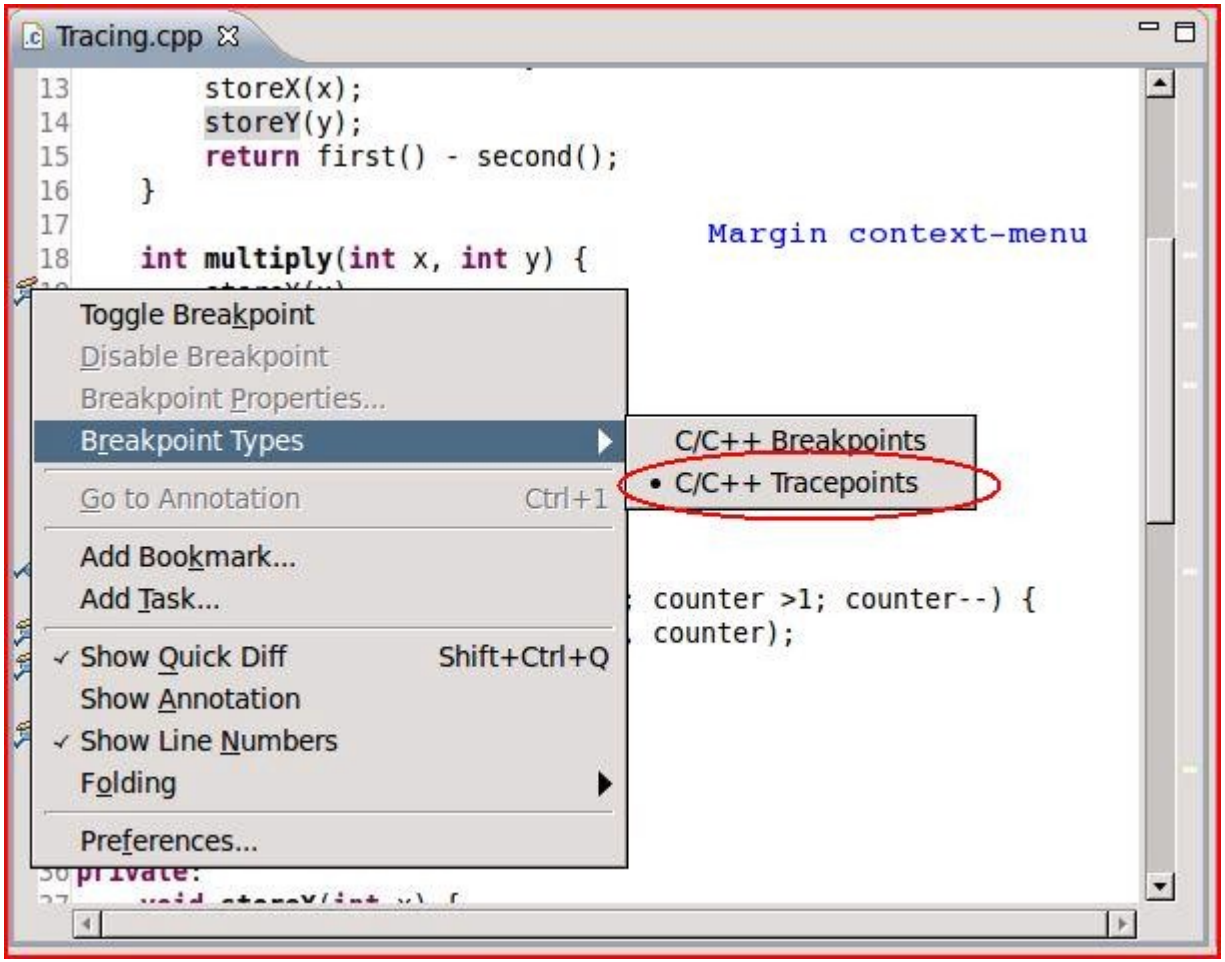
➢ Eclipse's integration of GDB’s Dynamic Tracepoints

Eclipse Tracepoints

- Creation of tracepoints is done as for breakpoints
- Enable/Disable
- Dynamic condition
- Specification of data to be gathered using symbolic expressions and memory addresses (actions)
- Pass count
- Trace-state variables can be used in conditions and actions
- Tracepoints are only in effect if tracing is enabled

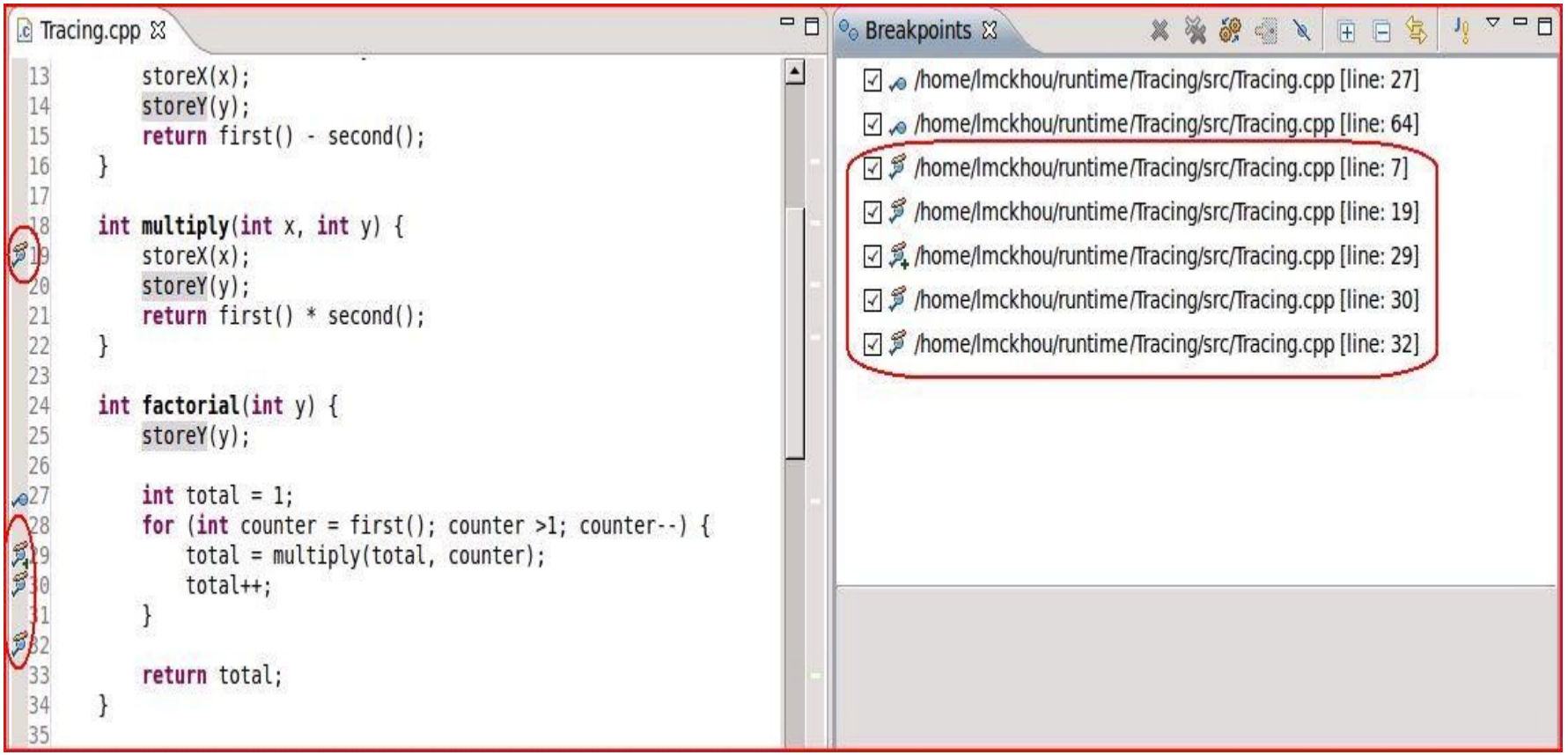
Eclipse Tracepoints Selection

- Tracepoints treated as breakpoints



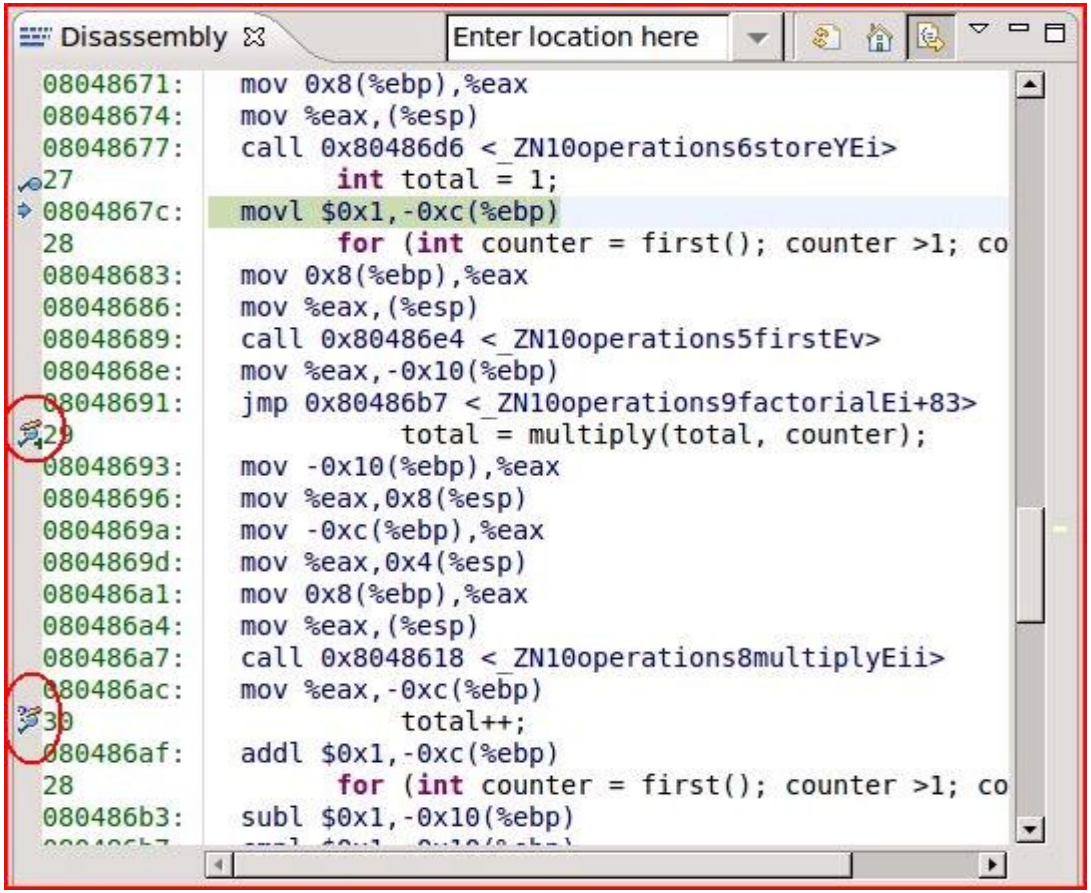
Eclipse Tracepoints Display

- Tracepoints
- Tracepoints with actions



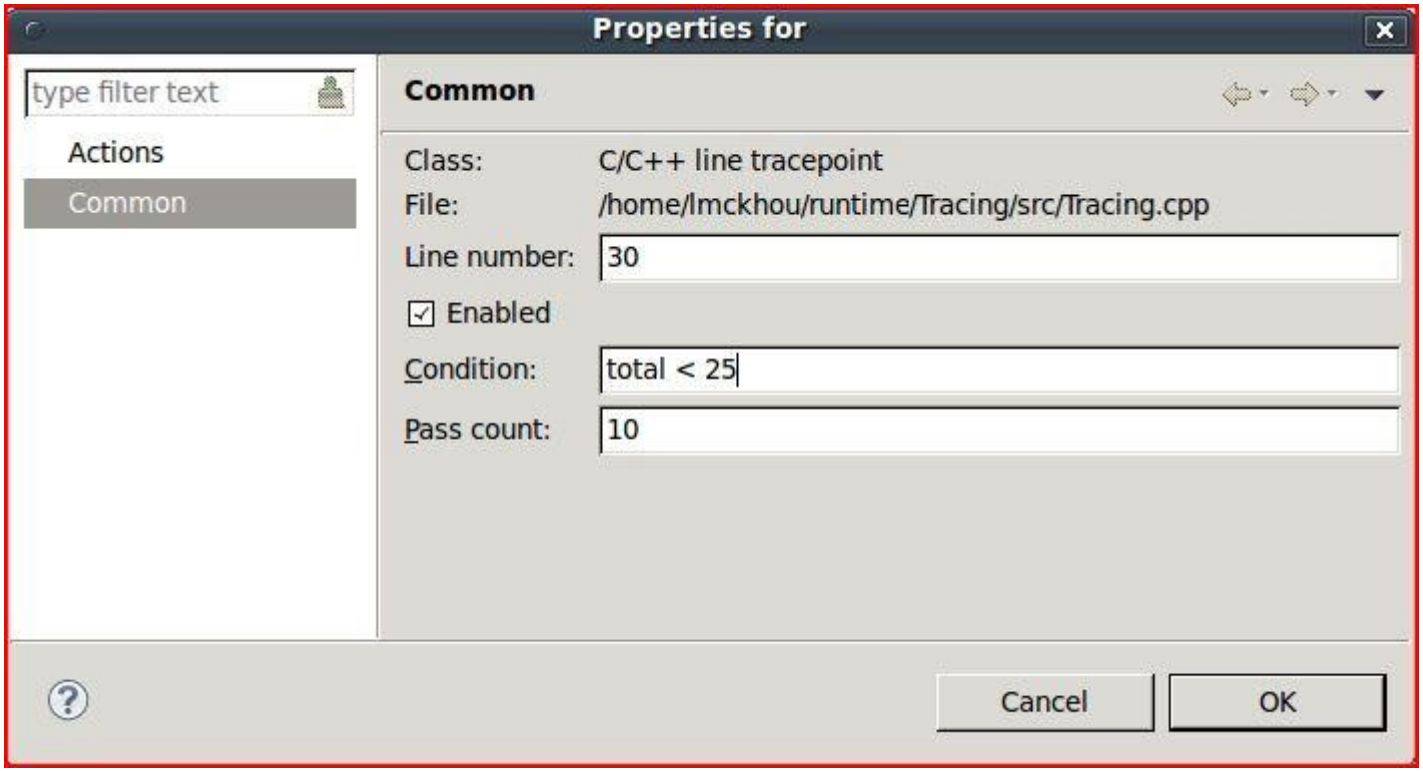
Eclipse Tracepoints Disassembly

- Disassembly view support for Tracepoints
- Tracepoint with condition

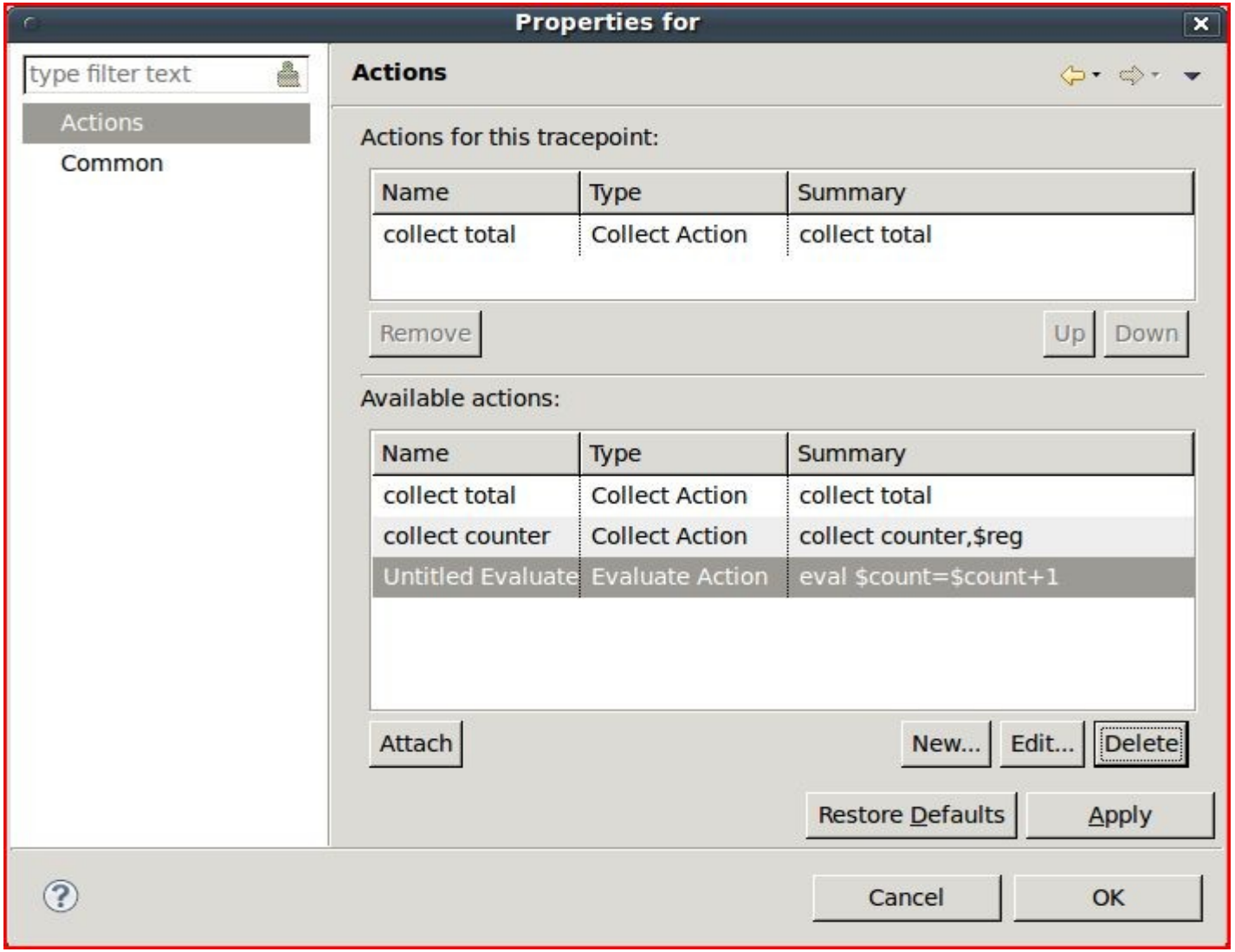


Eclispe Tracepoints Properties

- Tracepoints properties
  - Location
  - Enablement
  - Condition
  - Pass count

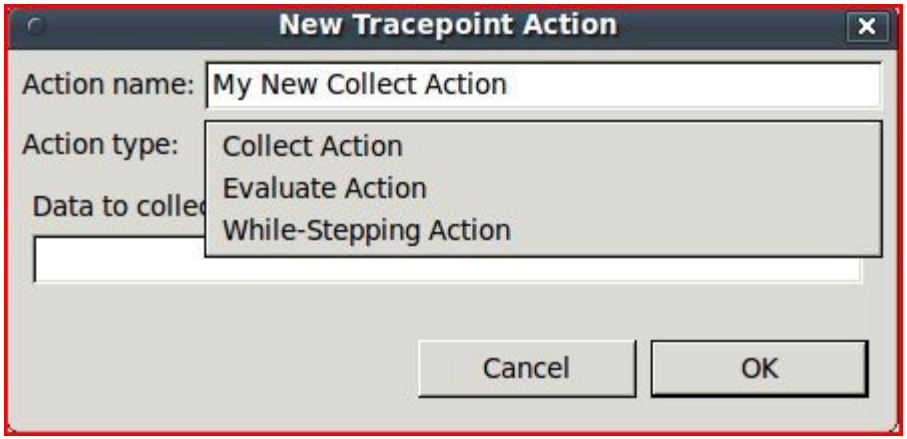


Eclipse Tracepoints Actions

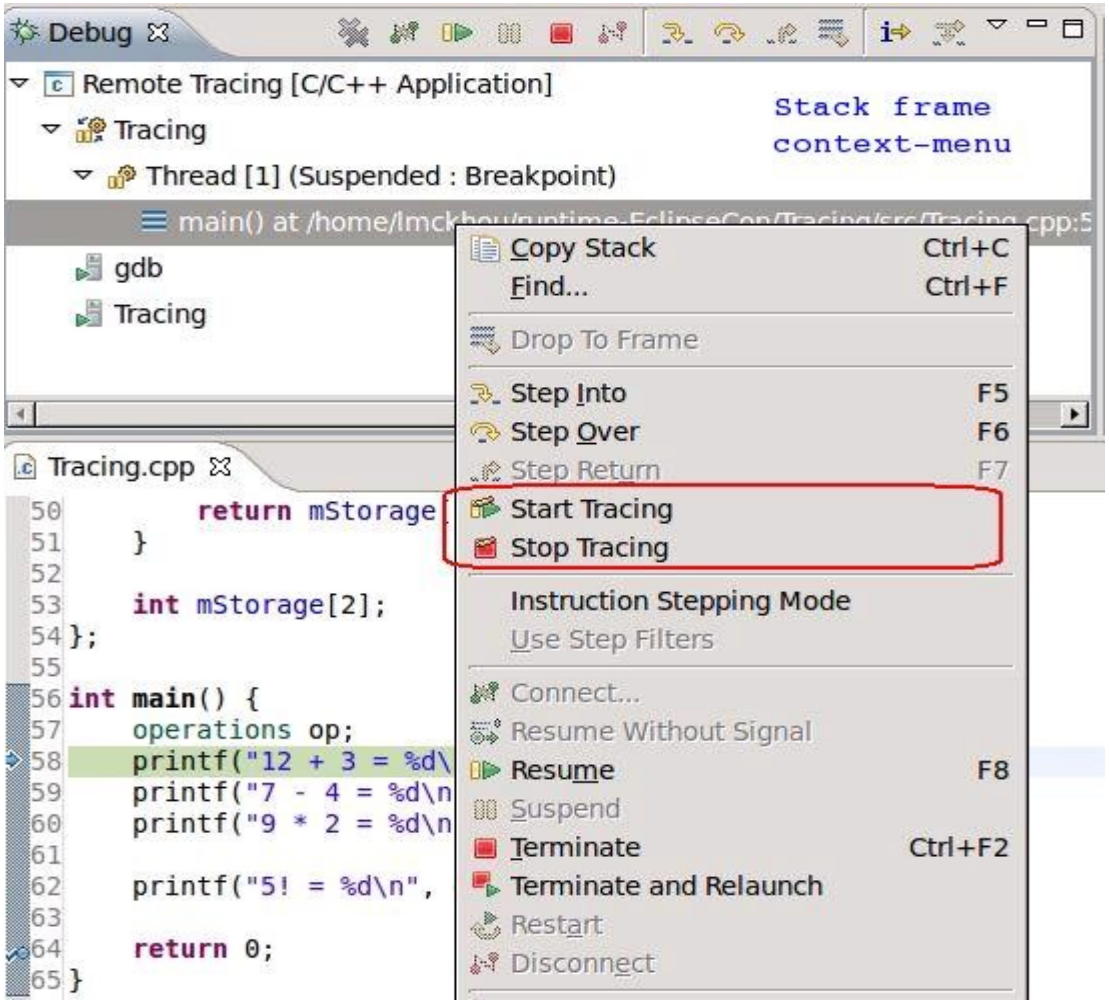


Eclipse Tracepoints Actions

- Tracepoints action types
  - Collect
  - Evaluate
  - While-Stepping
    - Collect
    - Evaluate

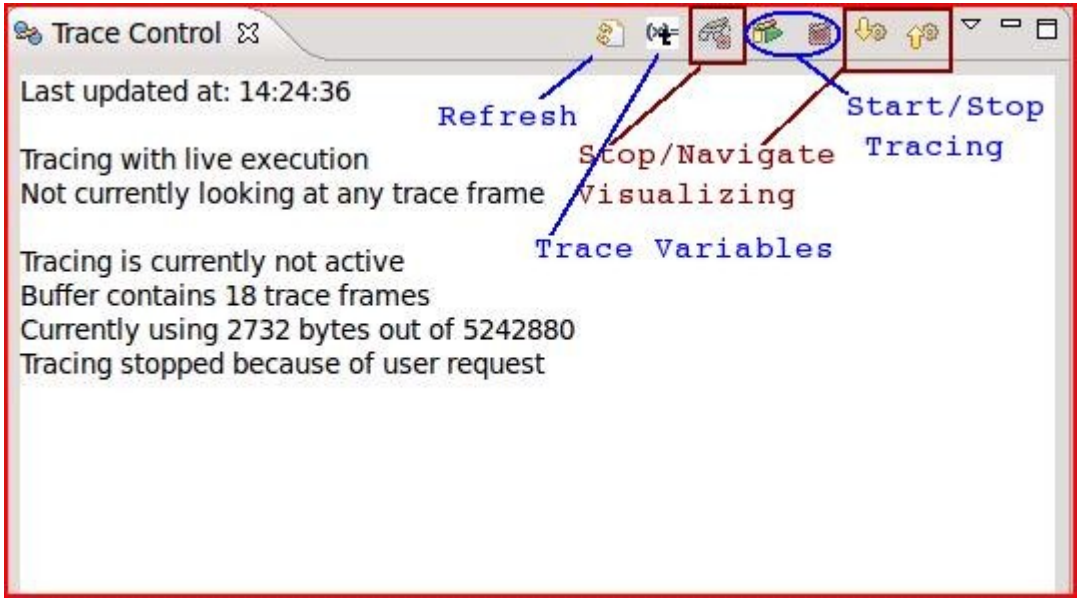


Eclipse Tracepoints Control

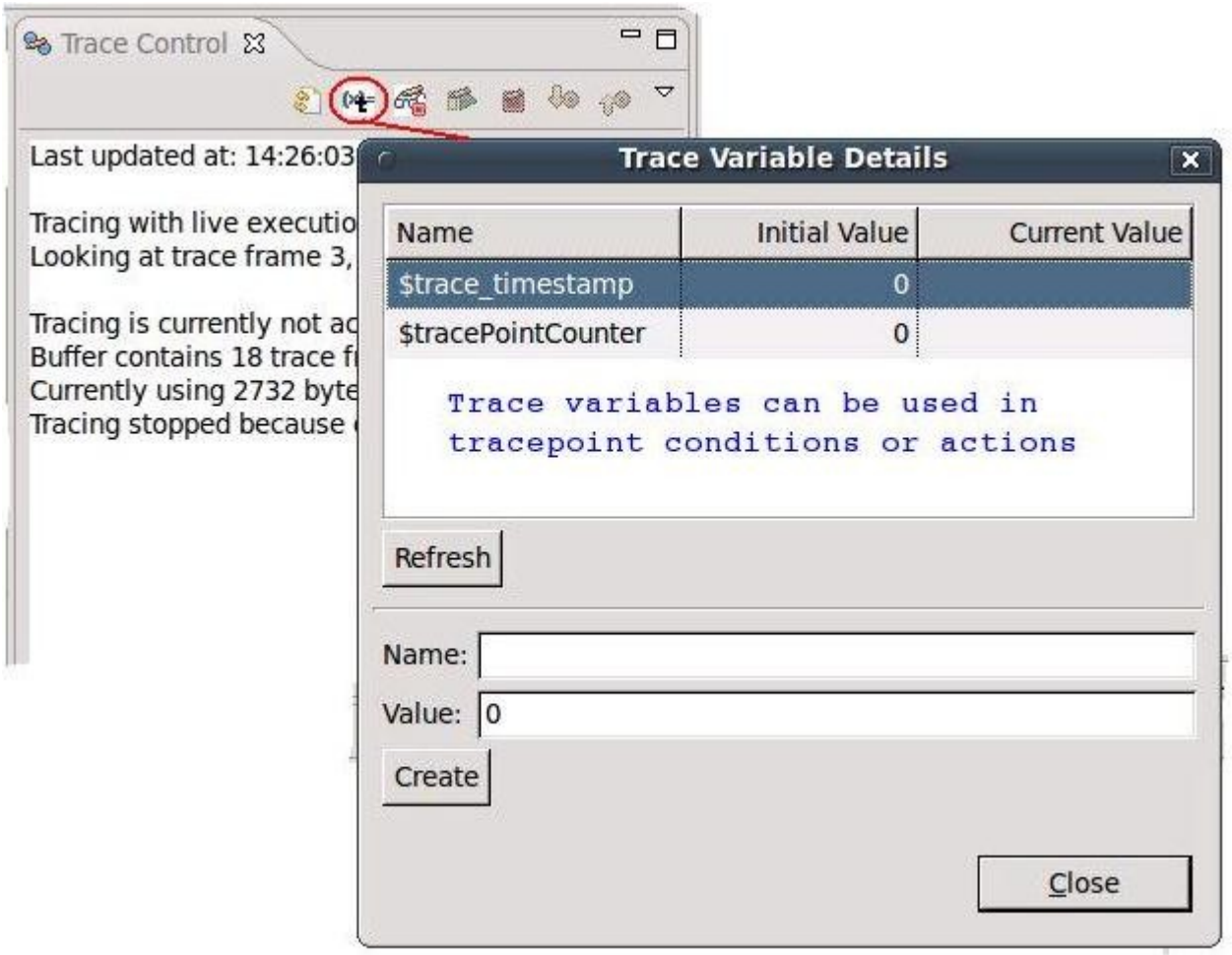


Eclipse Tracepoints Control

- Trace Control View
  - Refreshing info
  - Trace Variables
  - Start/Stop Tracing
  - Navigate during Visualization
  - Stop Visualization

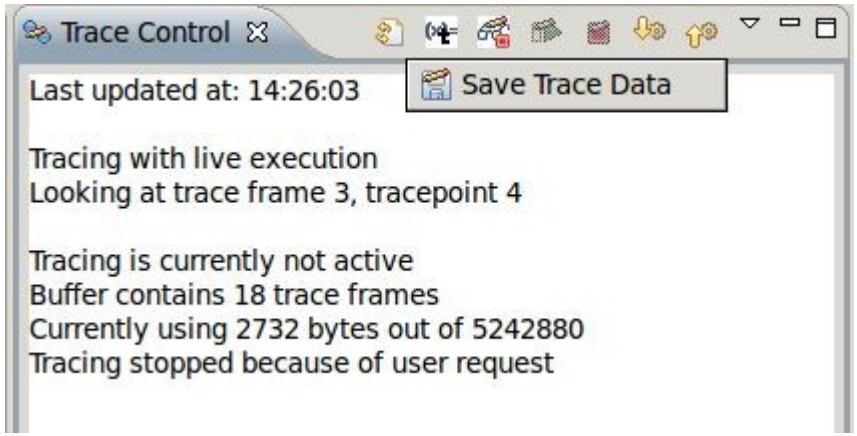


Eclipse Tracepoints Variables



Eclipse Trace Data

- Resulting trace data
  - can be stored to file
  - can be visualized in Eclipse immediately or in the future

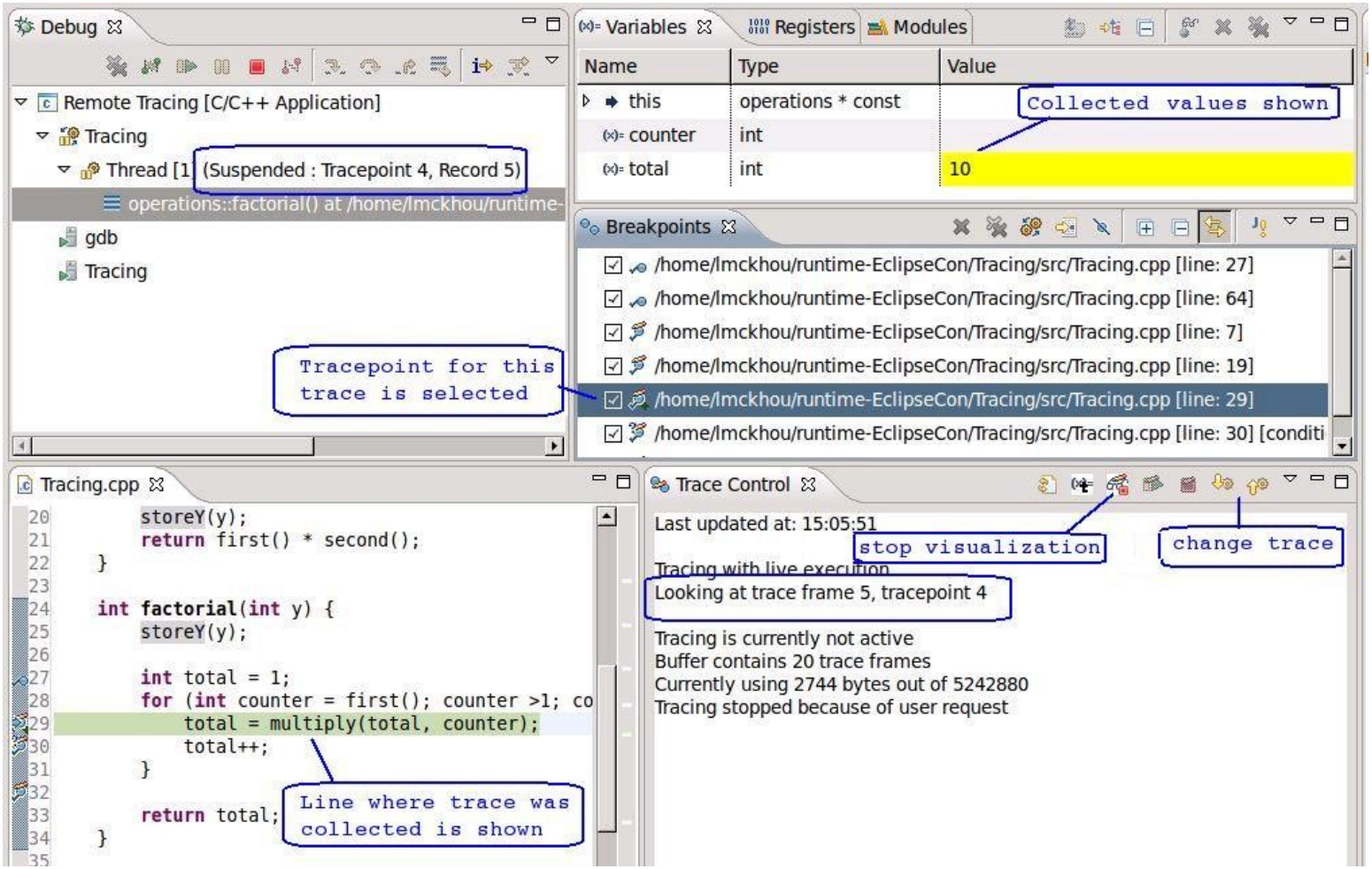


Eclipse Trace Data Visualization

- Navigation through data records using GDB
- Each data record is a snapshot of debug information
- Records can be examined using standard debugger views
  - As if debugger was attached at a specific point in time
  - Only collected information can be shown
  - Highlighting of the tracepoint of interest
- All collected data of a record can also be dumped as plain text

- Trace data can be saved to file
- Saved trace data can be examined offline

Eclispe Trace Data Visualization



Eclipse Static Tracepoints

- Next phase of development
- Using GDB and UST
- Handled like Dynamic Tracepoint, except for creation

Eclipse Static Tracepoints

- Creation of tracepoint done by designer before compilation

- As for Dynamic tracepoints:
  - Enable/Disable tracepoints dynamically
  - Dynamic condition
  - Can additionally have dynamic tracing specified (actions)
  - Pass count
  - Trace-state variables
  - ...

Planned Tracepoint Features

- Support for Fast Tracepoints
  - Explicit or implicit support?
- Support for Static Tracepoints
- Support for Observer mode
- Support for Global Actions (affecting all tracepoints)

Planned Tracepoint Features

- Disabling tracepoints during Tracing
- Tracepoints Enhanced Visualization:
  - Currently the user must have an idea of what has been collected
  - Goal is to directly and only show what has been collected
- Fast Tracepoints on 3-byte instruction
  - Currently fast tracepoints are 5-byte jumps insert in the code
  - New 3-byte jump to a nearby location to the 5-byte jump

Getting it to work for you in five easy steps

1. Downloading Eclipse Linux Package:
   - http://eclipse.org/downloads
   - Choose: “Eclipse IDE for C/C++ Linux Developers”
2. Extract it: tar xf <packageFile>
3. Run it: cd <packageDir> ; ./eclipse
4. Create a (dummy) C/C++ project: “Hello World” is fine
5. Start debugging... GDB... GCC... etc...

Questions?

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