ATPESC 2016

TotalView: Debugging from Desktop to Supercomputer

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RogueWave SOFTWARE
Accelerating Great Code

Our products and services

Tools

Klocwork On-the-fly static code analysis for app security

CodeDynamics Commercial dynamic analysis

OpenLogic Support Enterprise-grade SLA support

OpenLogic Audits Detailed open source license and security risk guidance

TotalView for HPC Scalable debugging

Zend Server Enterprise PHP app server

Zend Studio PHP IDE

Zend Guard PHP encoding and obfuscation

Libraries

SourcePro OS, database, network, and analysis abstraction for C++

Visualization Real-time data visualization at scale

PV-WAVE Visual data analysis

IMSL Numerical Libraries Scalable math and statistics algorithms

HydraExpress SOA/C++ modernization framework

HostAccess Terminal emulation for Windows

Stingray MFC GUI components

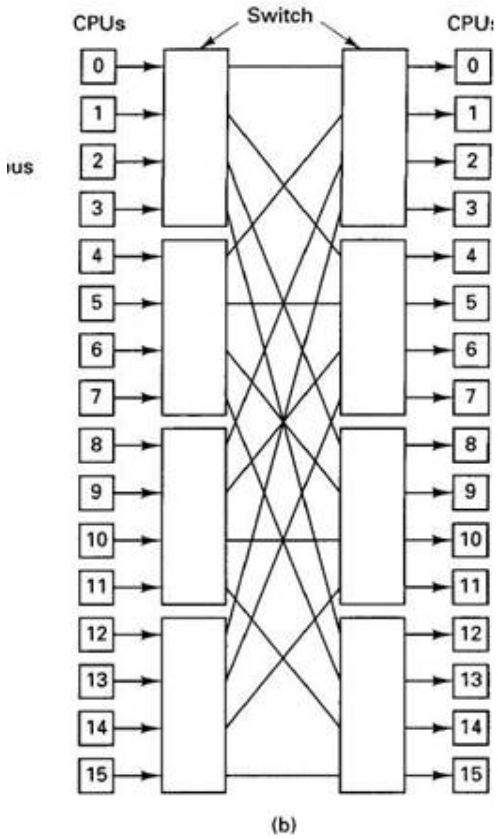
How does Rogue Wave help in HPC?

TotalView for HPC

- Source code debugger for C/C++/Fortran
  - Visibility into applications
  - Control over applications
- Scalability
- Usability
- Support for HPC platforms and languages

TotalView Overview

TotalView Origins



Mid-1980's Bolt, Berenak, and Newman (BBN) Butterfly Machine
An early 'Massively Parallel' computer

How do you debug a Butterfly?

- TotalView project was developed as a solution for this environment
  - Able to debug multiple processes and threads
  - Point and click interface
  - Multiple and Mixed Language Support
- Core development group has been there from the beginning and have been/are involved in defining MPI interfaces, DWARF, and lately OMPD (Open MP debugging interface)

Other capabilities added

- Support for most types of MPI
- Linux
- Lightweight Memory Debugging
- Type transformations – STL and user containers
- Memscript and tvscript
- Reverse Debugging - only on Linux x86-64
- Remote Display Client
- GPU debugging
- Intel Xeon Phi – Including KNL
- Currently looking at ARM64 port

Key features of TotalView

- Interactive Debugging
- Interactive Memory Debugging
- Reverse Debugging
- Unattended Debugging

Serial, Parallel and Accelerated applications

Memory Analysis

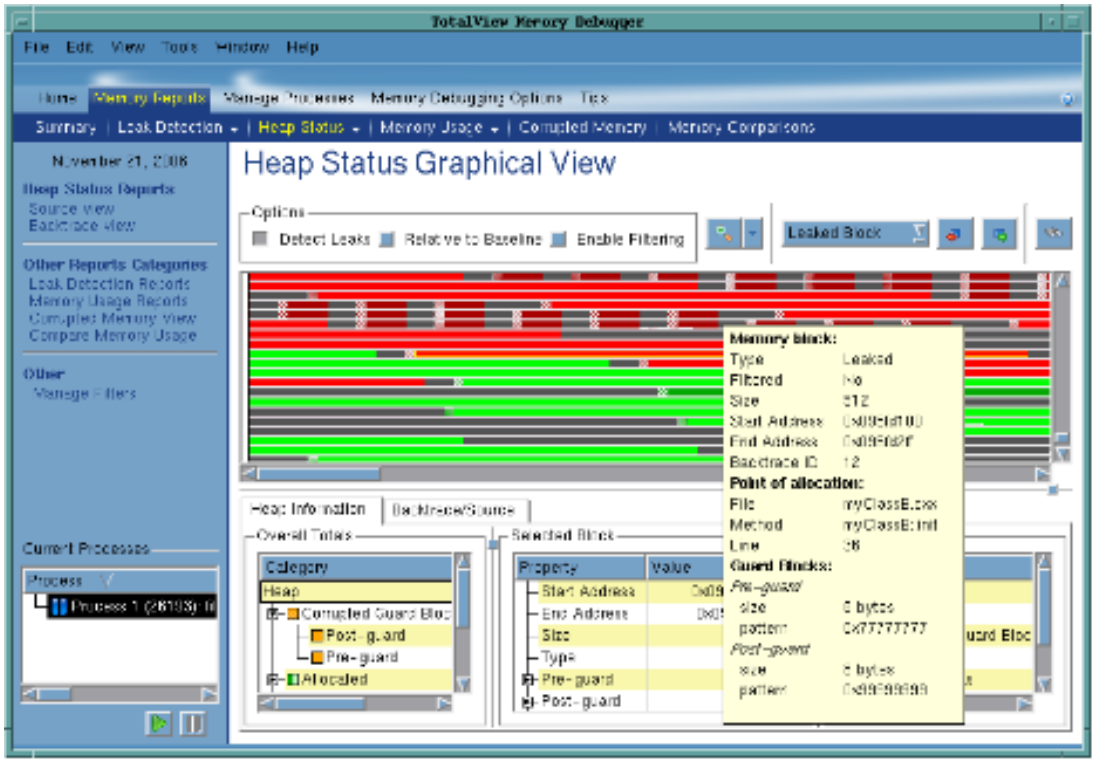
How do you identify buffer overflows?

Runtime Memory Analysis : Eliminate Memory Errors

- Detects memory leaks *before* they are a problem
- Explore heap memory usage

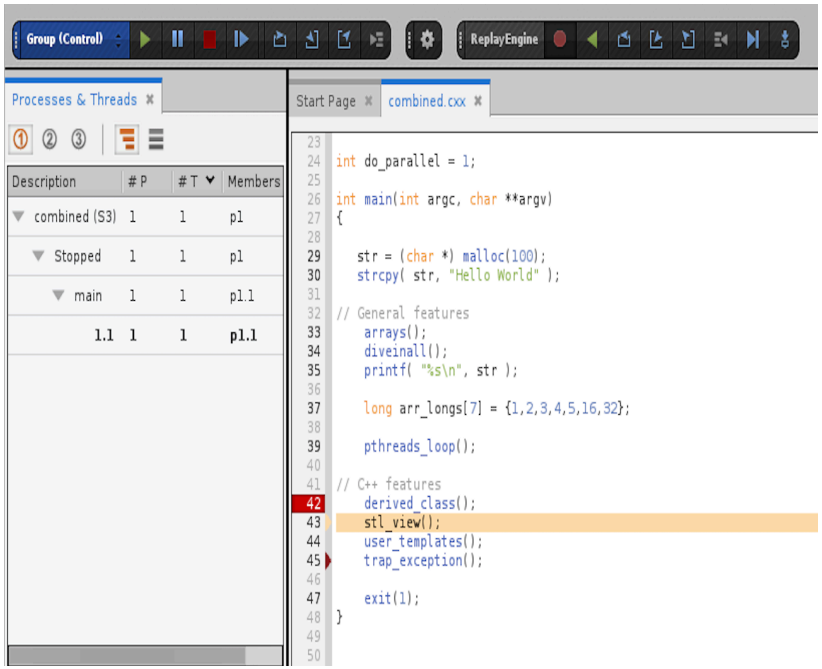
Features

- Detects
  - Malloc API misuse
  - Memory leaks
  - Buffer overflows
- Low runtime overhead
- Easy to use
  - Works with vendor libraries
  - No recompilation
  - No instrumentation



Reverse debugging

- How do you isolate an intermittent failure?
  - Without TotalView,
    - Set a breakpoint in code
    - Realize you ran past the problem
    - Re-load
    - Set breakpoint earlier
    - Hope it fails
    - Keep repeating
  - With TotalView
    - Start recording
    - Set a breakpoint
    - See failure
    - Run backwards/forwards in context of failing execution
  - Reverse Debugging
    - Re-creates the context when going backwards
    - Focus down to a specific problem area easily
    - Saves days in recreating a failure



memscript and tvscript

- Command line invocation to run TotalView and Memoryscape unattended
- tvscript can be used to set breakpoints, take actions at those breakpoints and have the results logged to a file. It can also do memory debugging
  - tvscript –create_actionpoint "method1=>display_backtrace show_arguments" \ -create_actionpoint "method.c#342=>print x" myprog –a dataset 1
- memscript can be used to run memory debugging on processes and display data when a memory event takes place. Exit is ALWAYS an event

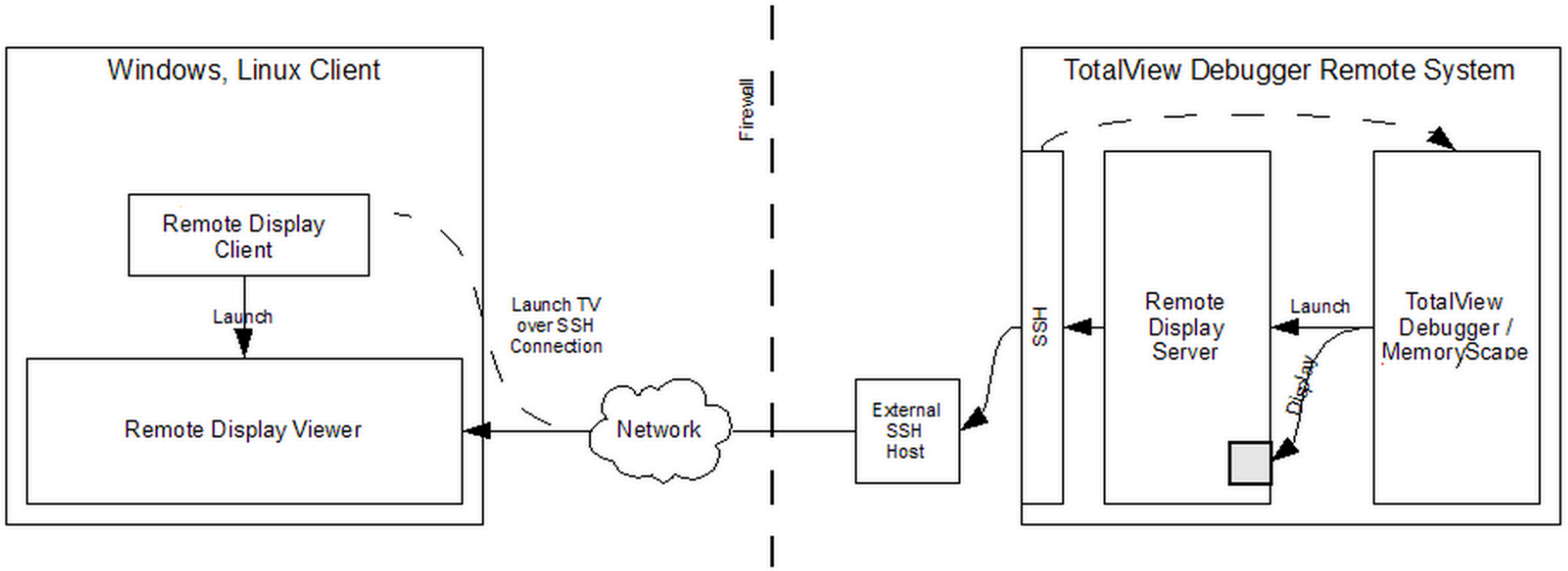
```
Memscrip -event_action \
"alloc_null=list_allocations,any_event=check_guard_blocks" \
-guard_blocks -maxruntime "00:30:00" -display_specifiers \
"noshow_pc,noshow_block_address,show_image"\
 myProgram -a myProgramArg1
```

- Memscript data can be saved in html, memory debug file, text heap status file

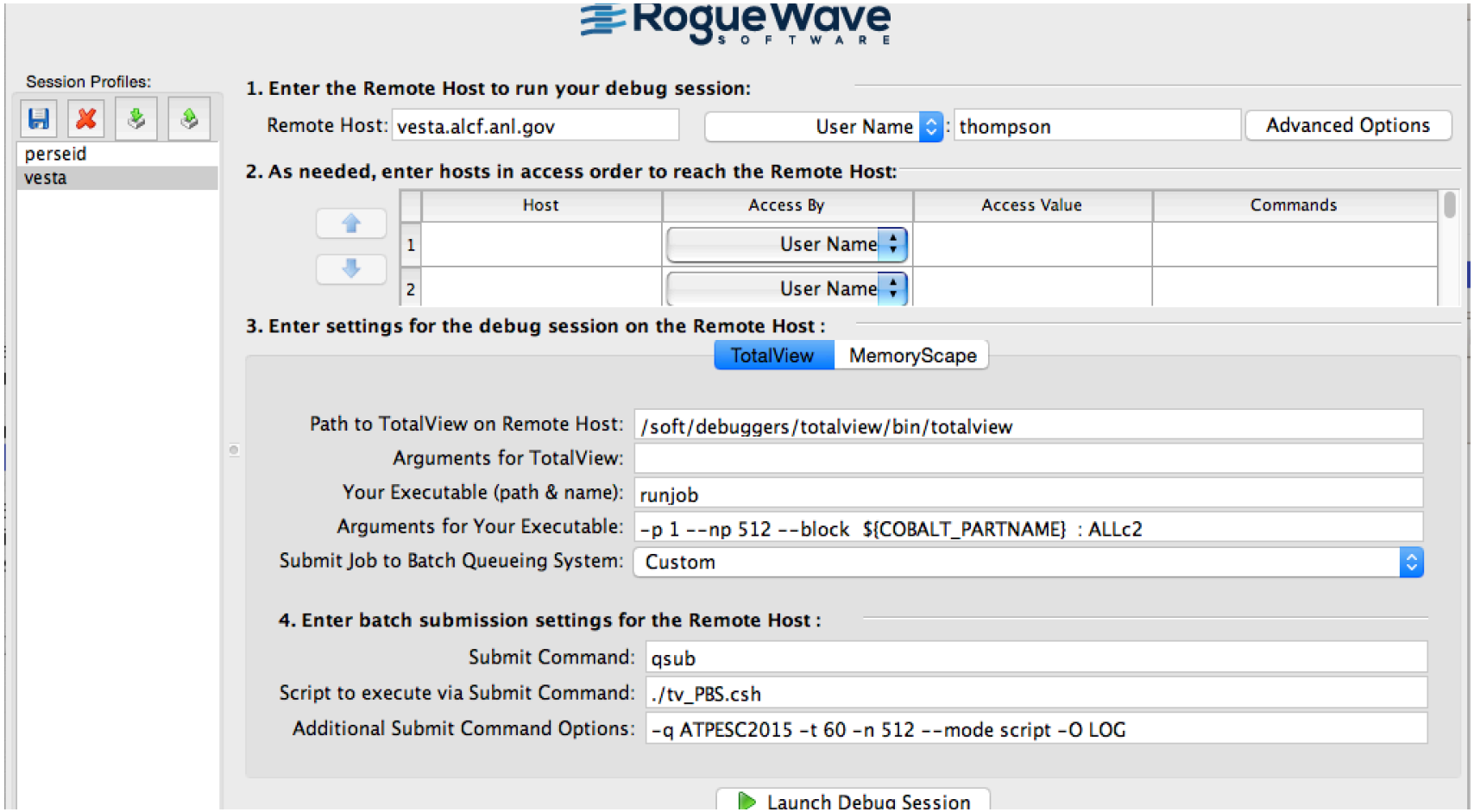
Remote Display Client (RDC)

- Push X11 bits and events across wide networks can be painful. The RDC can help

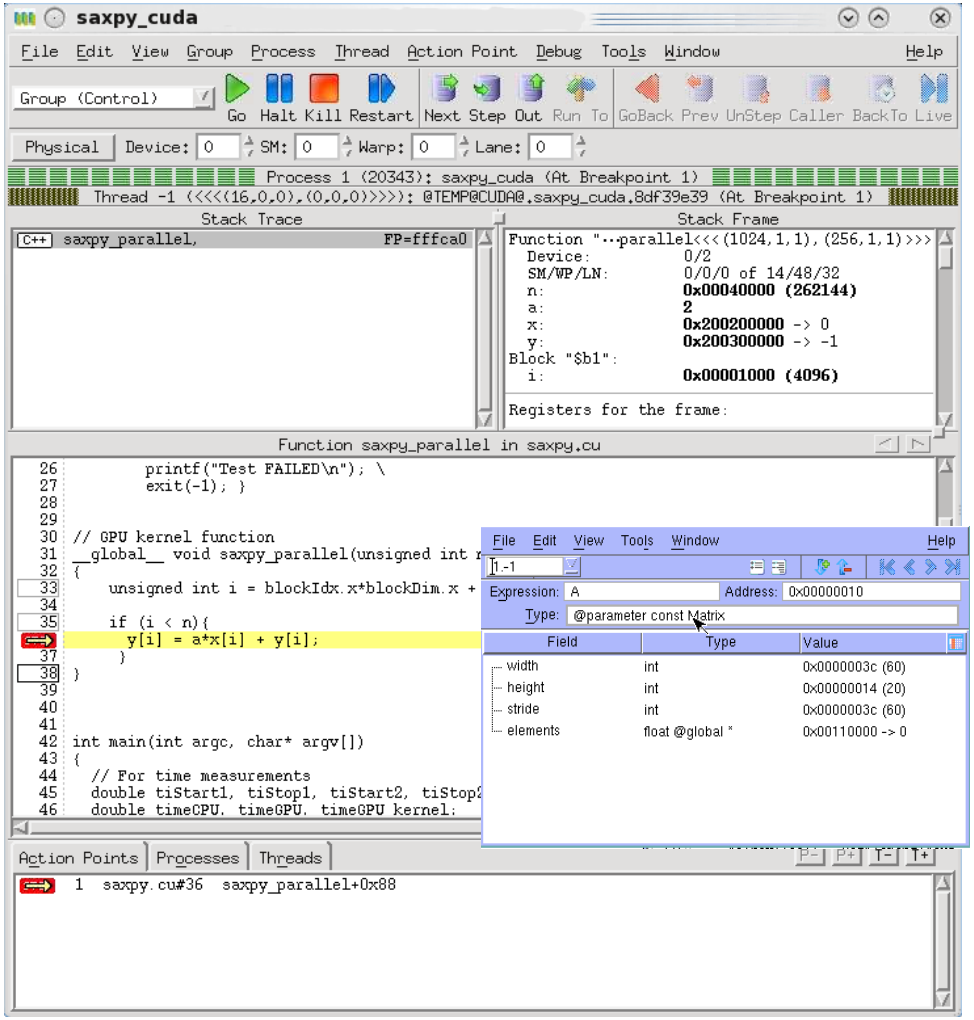
Figure 17 – Remote Display Components



The RDC setup



TotalView for the NVIDIA ® GPU Accelerator

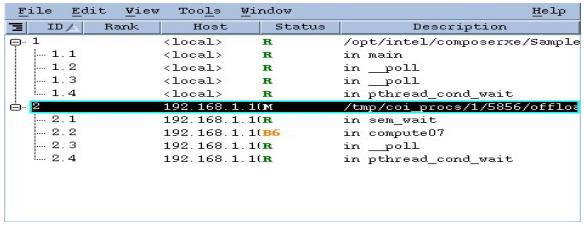


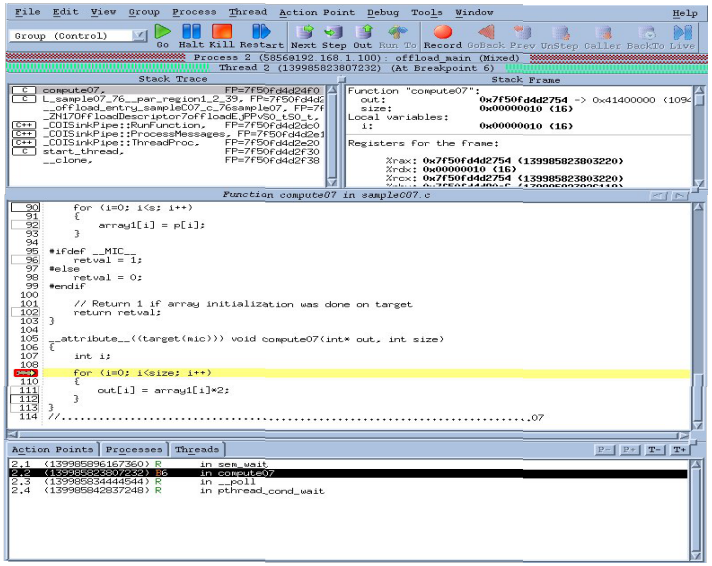
- NVIDIA CUDA 6.5, 7.0, 7.5, (8.0)
- Features and capabilities include
  - Support for dynamic parallelism
  - Support for MPI based clusters and multi-card configurations
  - Flexible Display and Navigation on the CUDA device
    - Physical (device, SM, Warp, Lane)
    - Logical (Grid, Block) tuples
  - CUDA device window reveals what is running where
  - Support for CUDA Core debugging
  - Leverages CUDA memcheck
  - Support for OpenACC

TotalView for the Intel® Xeon Phi™ coprocessor

Supports All Major Intel Xeon Phi Coprocessor Configurations

- Native Mode
  - With or without MPI
- Offload Directives
  - Incremental adoption, similar to GPU
- Symmetric Mode
  - Host and Coprocessor
- **Multi-device, Multi-node**
- Clusters
- KNL Support – Just works like a normal node
  - AVX2 support being added





User Interface

- MPI Debugging Features
  - Process Control, View Across, Shared Breakpoints
- Heterogeneous Debugging
  - Debug Both Xeon and Intel Xeon Phi Processes

Memory Debugging

- Both native and symmetric mode

Knights Landing Memory

- KNL will have on-board High Bandwidth Memory (HBM) which can be accessed much faster than going out to main memory.
  - Cache
  - Explicitly managed for placement of frequently accessed data
- MemoryScape will be able to track allocations made both the standard heap and the on-chip HBM
- Optimization may include making sure that the right data structures are available to the processor in HBM
  - MemoryScape can show you data structure usage and placement
- KNL machines starting to come online

Linux OpenPower (LE) support

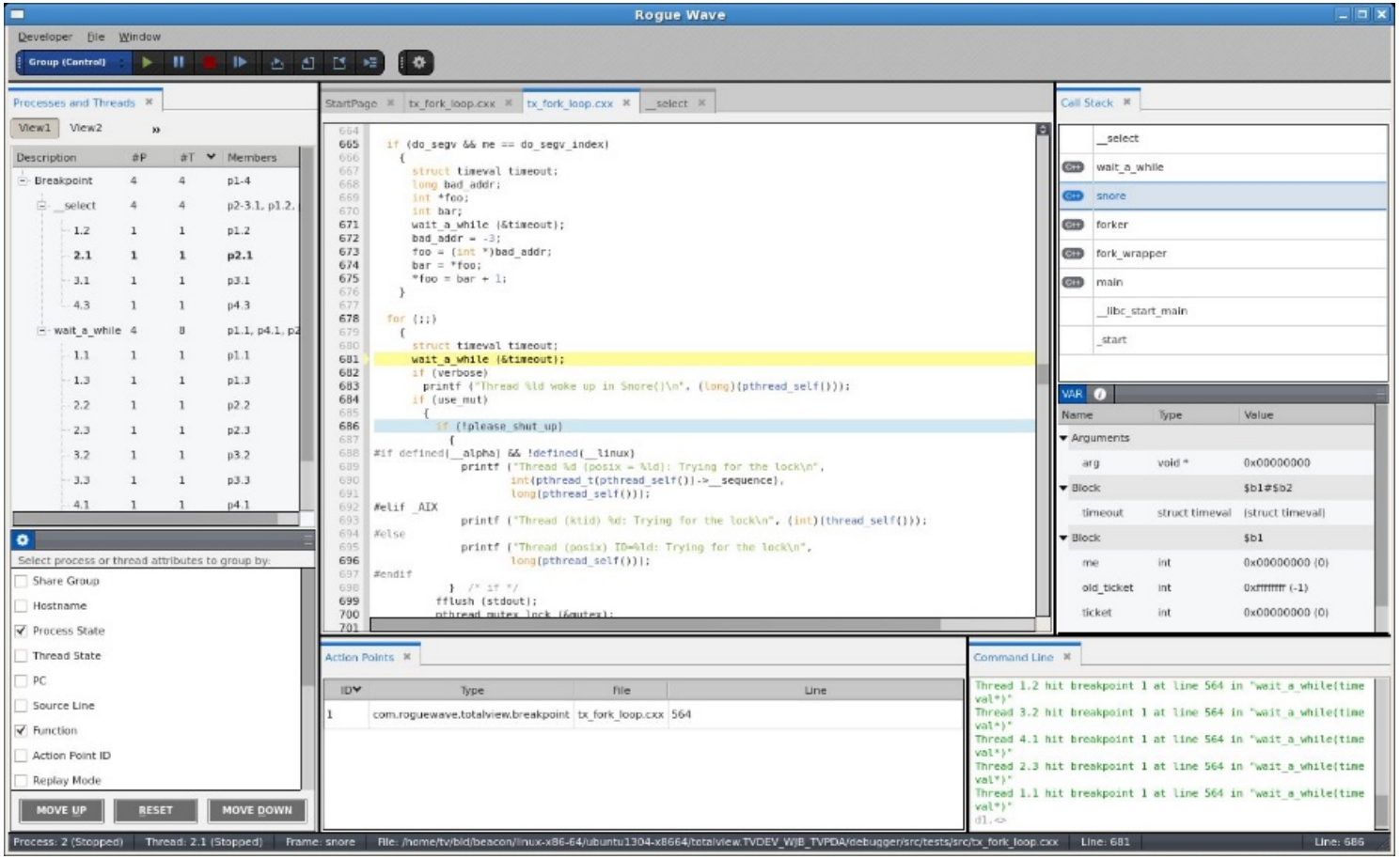
- Support for OpenPower (Linux power LE)
  - All major functionality
  - Support for CUDA Debugging on GPU Accelerators

TotalView's Memory Efficiency

- TotalView is lightweight in the back-end (server)
- Servers don't "steal" memory from the application
- Each server is a multi-process debugger agent
  - One server can debug thousands of processes
  - Not a conglomeration of single process debuggers
  - TotalView's architecture provides flexibility (e.g., P/SVR)
  - No artificial limits to accommodate the debugger (e.g., BG/Q ~~1 P/CN~~)
- Symbols are read, stored, and shared in the front-end (client)
- Example: LLNL APP ADB, 920 shlibs, Linux, 64 P, 4 CN, 16 P/CN, 1 SVR/CN

Process	VSZ (largest, MB)	RSS (largest, MB)
TV Client	4,469	3,998
MRNet CP	497	4
TV Server	304	53

New UI Framework – aka CodeDynamics



Using TotalView

For HPC we have two methods to start the debugger

The ‘classic’ method

- totalview –args mpiexec –np 512 ./myMPIprog myarg1 myarg2
- This will start up TotalView on the parallel starter (mpiexec, srun, runjob, etc) and when you hit ‘Go’ the job will start up and the processes will be automatically attached. At that point you will see your source and can set breakpoints.

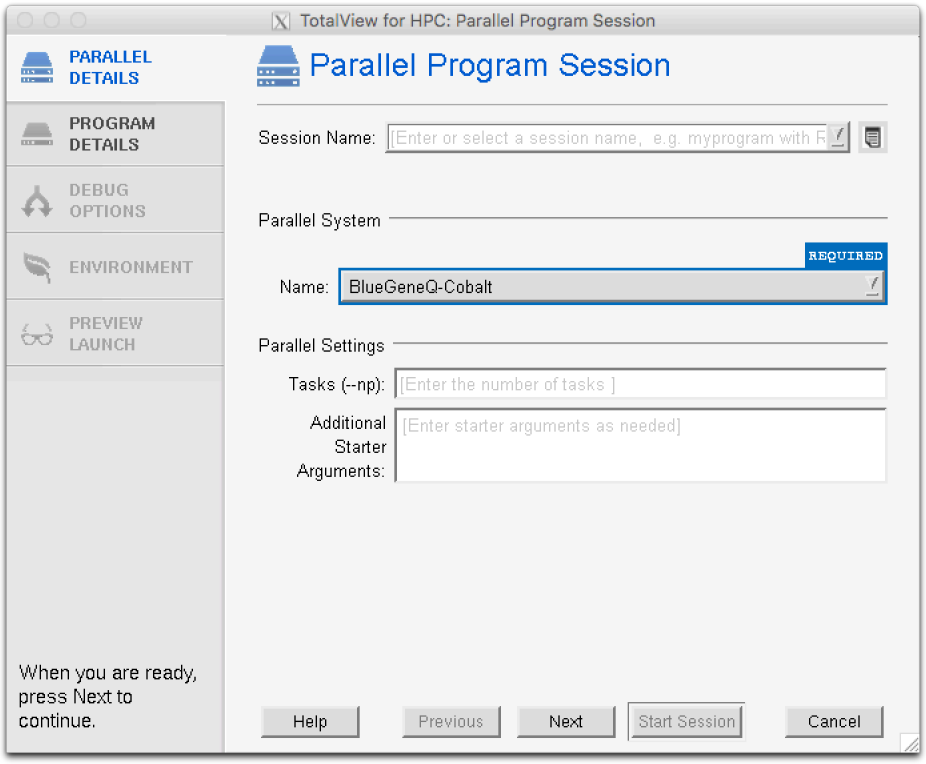
- Some points to consider…
  - You don’t see your source at first, since we’re ‘debugging’ the mpi starter
  - Some MPI’s don’t support the process acquistion method (most do, but might be stripped of symbols we need when packaging)
  - In general more scalable than the next method...

Starting TotalView

The ‘indirect’ method

- Simply ‘totalview’ or ‘totalview myMPIprog’ and then you can choose a parallel system, number of tasks, nodes, and arguments to the program.

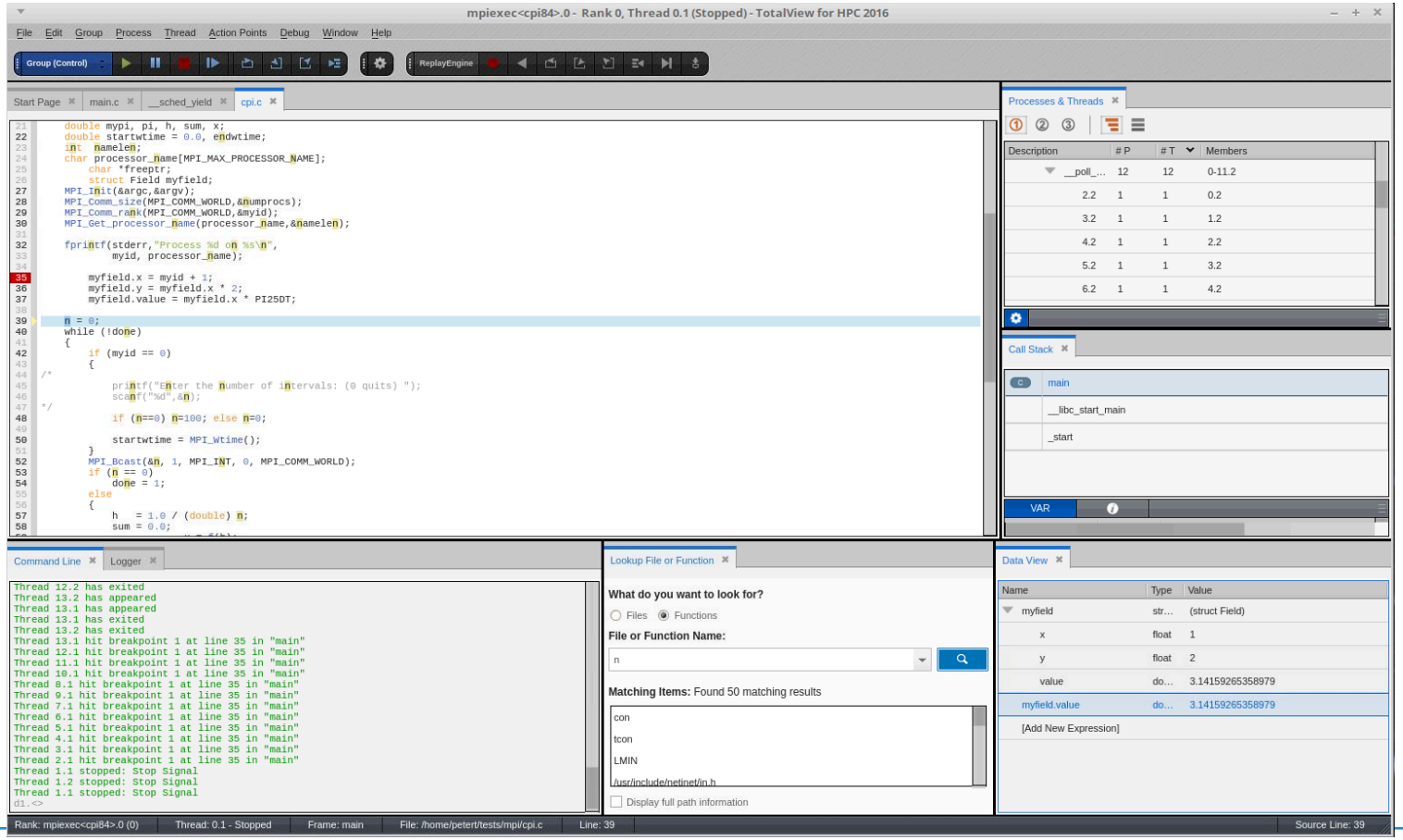
- With this method the program source is available immediately
- Less dependent on MPI starter symbols
- May not be as scalable as some ‘indirect’ methods launch a debug server per process



The New UI for HPC

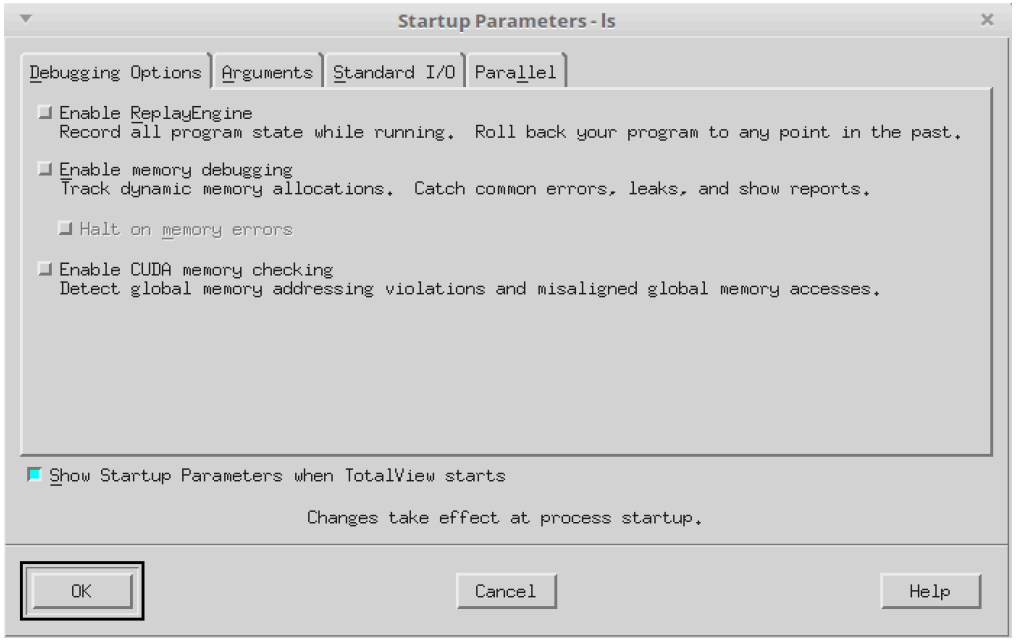
MPI debugging with the new UI requires starting in ‘classic’ mode with the –newUI argument

totalview –newUI –args mpiexec –np 4 ./cpi

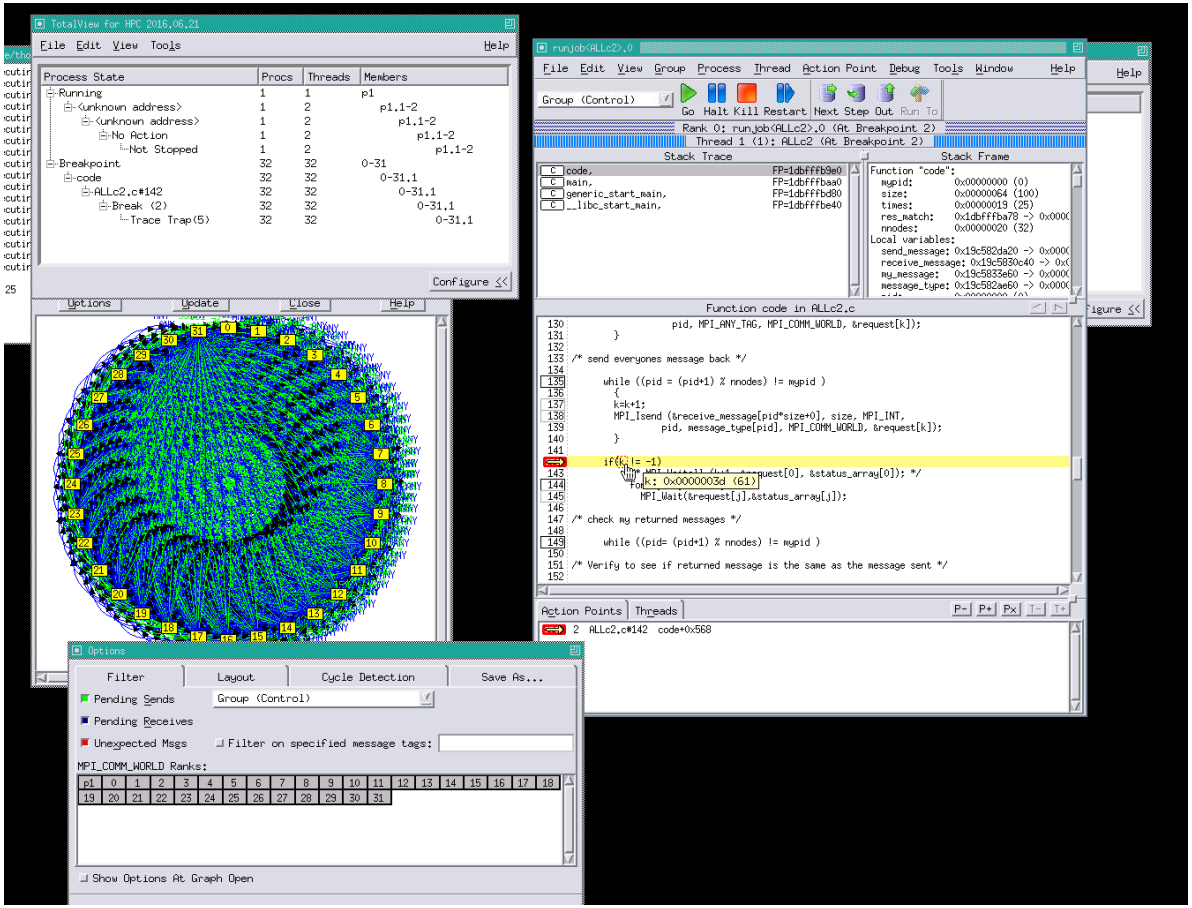


Starting MemoryScape and ReplayEngine

- MemoryScape must be enabled at the start of the program or your program can be linked against the Heap Interposition Agent (HIA) to have memory debugging always enabled. It can't be turned on when the program has been started.
- ReplayEngine can be enabled at the start, or at any point during debugging. Once started, it can't be disabled.

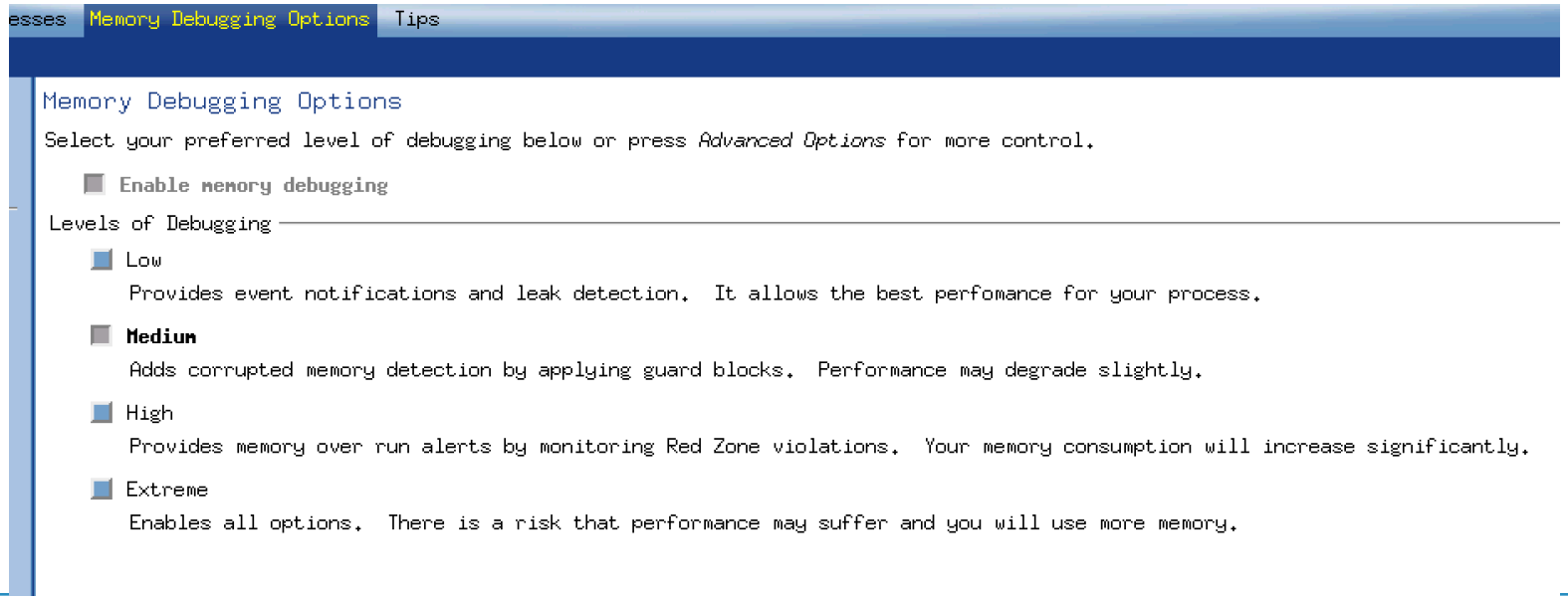


Running TotalView on Vesta

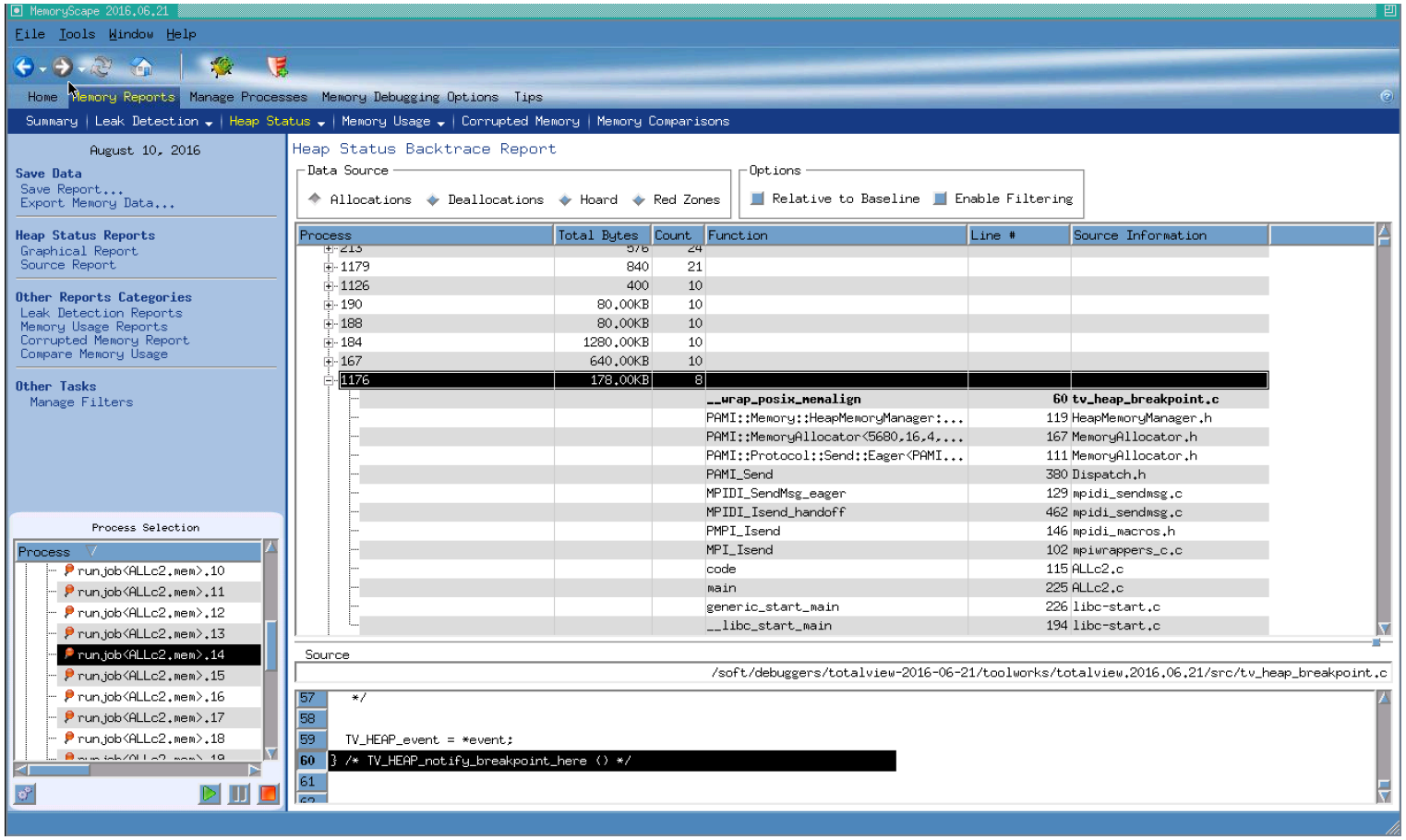


Memory Debugging on BG/Q

- In order to use memory debugging on the BG/Q, you must link against the agent. For instance, I first set up a environment variable
  - export TVLIB=/soft/debugger/totalview/linux-power/lib
  - mpixlc_r –g –o ALLc2.mem ALLc2.c –L$TVLIB \
  - –Wl,@$TVLIB/tvheap_bgqs.ld



One of many reports available



More Information

- Product documentation on website:

  http://www.roguewave.com/help-support/documentation/totalview

- Contact sales@roguewave.com with any inquires about our future plans with regard to TotalView product.

Questions

Thanks!

- Visit the website
  - http://www.roguewave.com/products/totalview.aspx
  - Documentation
  - Sign up for an evaluation
  - Contact customer support & post on the user forum