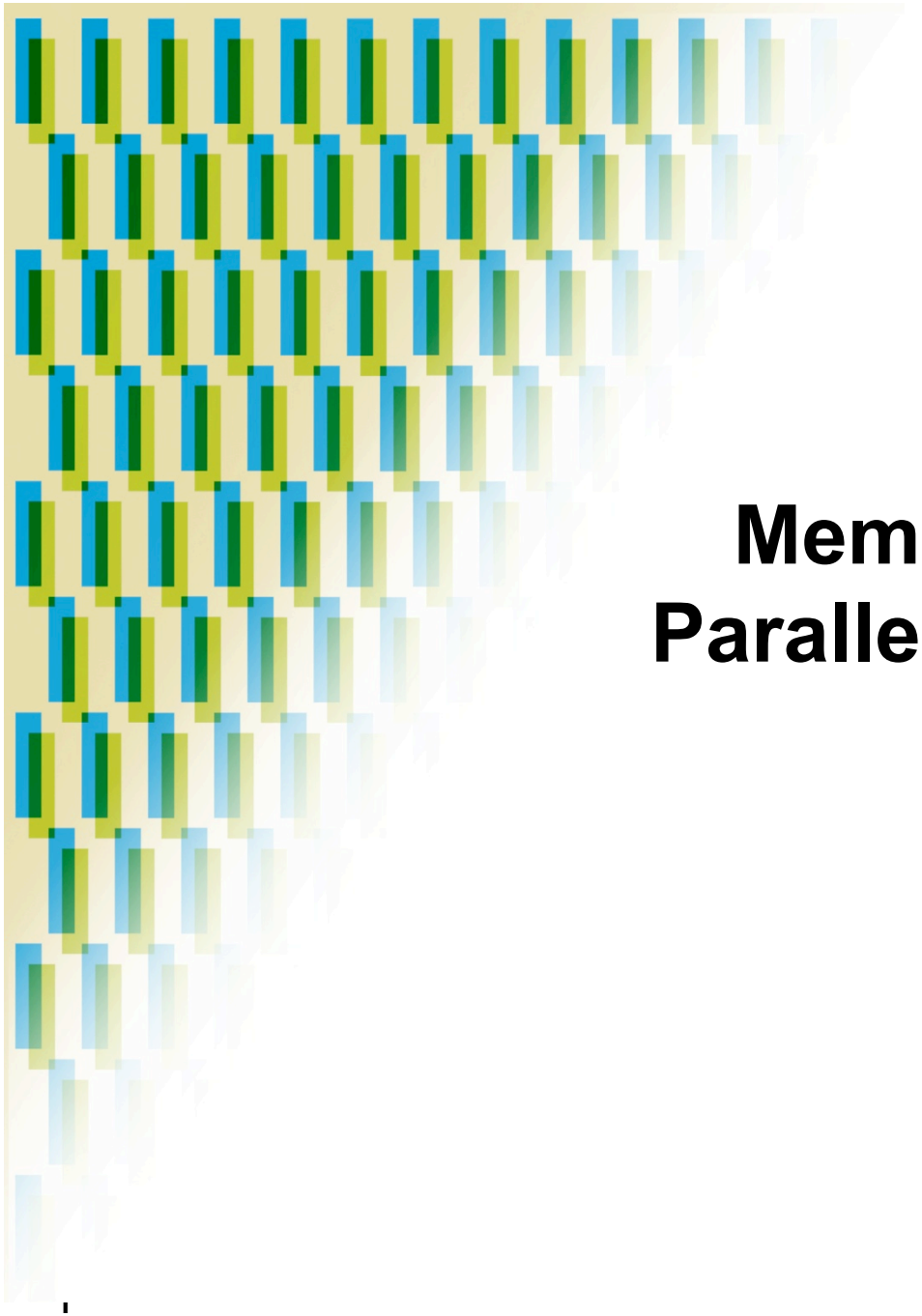
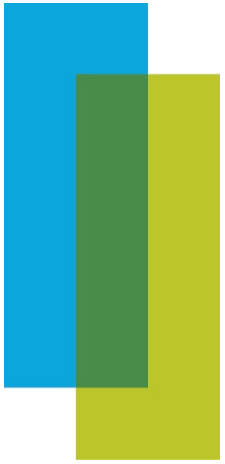


TOTALVIEW TECHNOLOGIES

Memory Debugging Parallel Applications on BlueGene

SciComp
May 21, 2009
Ed Hinkel



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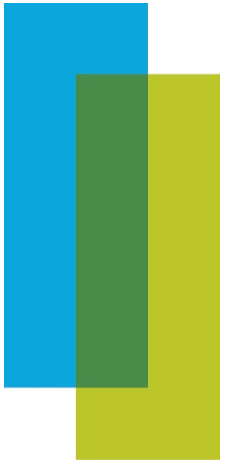
Agenda

- Introduction
- Memory (mis) Management
- Memory Debug Options & Issues
- Memory Debugging Techniques
- What's New



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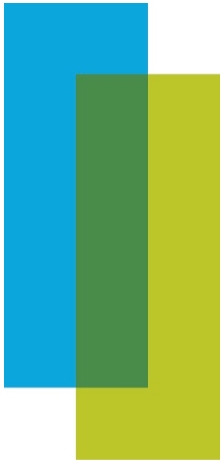
Memory Bugs

Can be very elusive!

- **Memory bugs are often not immediately fatal**
- **Memory bugs can lurk in a code base for long periods of time**
- **Memory bugs can suddenly emerge when**
  - A program is ported to a new architecture
  - Programs are scaled up to a larger size
  - When code is adapted and reused from one program to another.
- **Most memory bugs are not detected by compilers**



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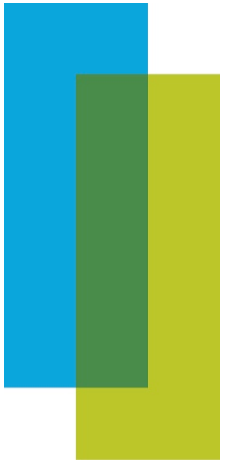
Memory bugs are often manifested in unusual ways

- Memory bugs often go undetected until the worst possible time
- Symptoms often surface long after the actual damage is done
- Some only surface after hours or even days of operation
- In many cases, the programs affected are “innocent bystanders”



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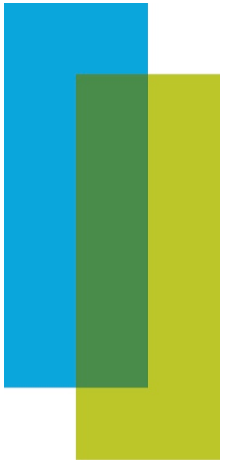
Memory Issues are on the Rise

- Core counts are growing at an amazing rate
- But the Memory "per CPU" is trending downward
- Proper memory management is becoming more critical
- More than ever, you need to really know how memory is being used



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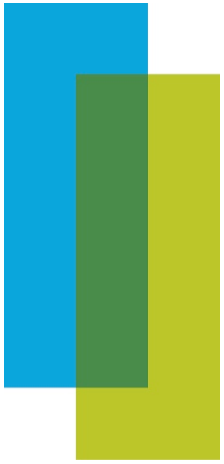
What is a Typical Memory Bug?

- **A Memory Bug is a mistake in the management of heap memory**
  - **Failure to check for error conditions**
  - **Leaking: Failure to free memory**
  - **Dangling references: Failure to clear pointers**
  - **Memory Corruption**
    - **Writing to memory not allocated**
    - **Over running array bounds**



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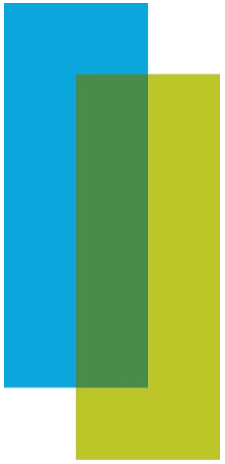
Memory Debugging Options

- **Developers have a range of options (many free) for memory debugging… But:**
  - **Many programs are often singular in function, requiring an array of "solutions".**
  - **Most often, there is significant "overhead" issues to consider:**
    - **Performance hits can often be huge, with unacceptable slowdowns**
    - **Additional memory usage can make bad things worse**
    - **Special instrumentation requirements can often produce an unwelcome exercise of the Heisenberg uncertainty principle**
    - **Scalability can be a big problem**



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Memory Debugging Options

So,

How Does One

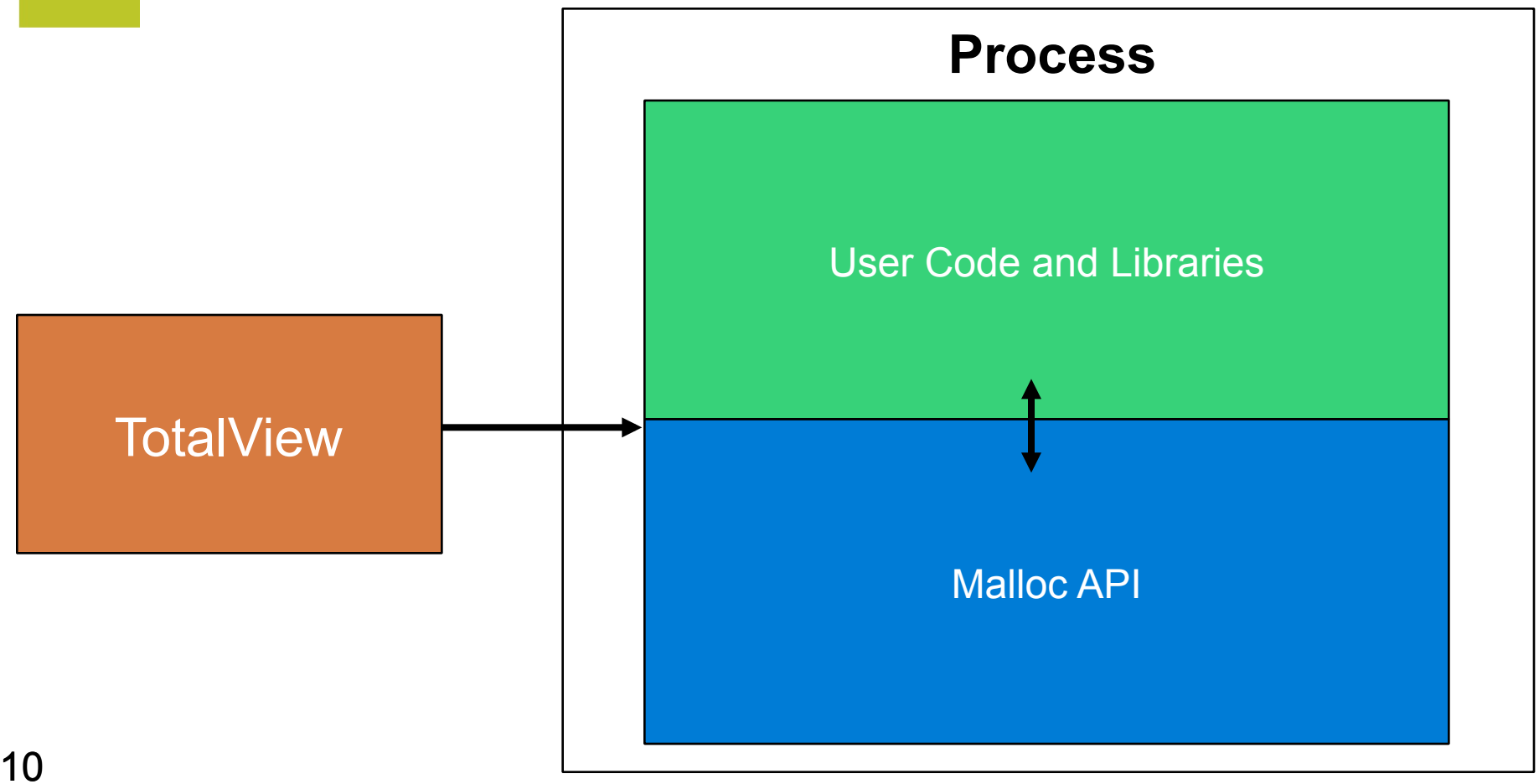
Memory Debug Effectively?

TotalView Memory Debugging Products

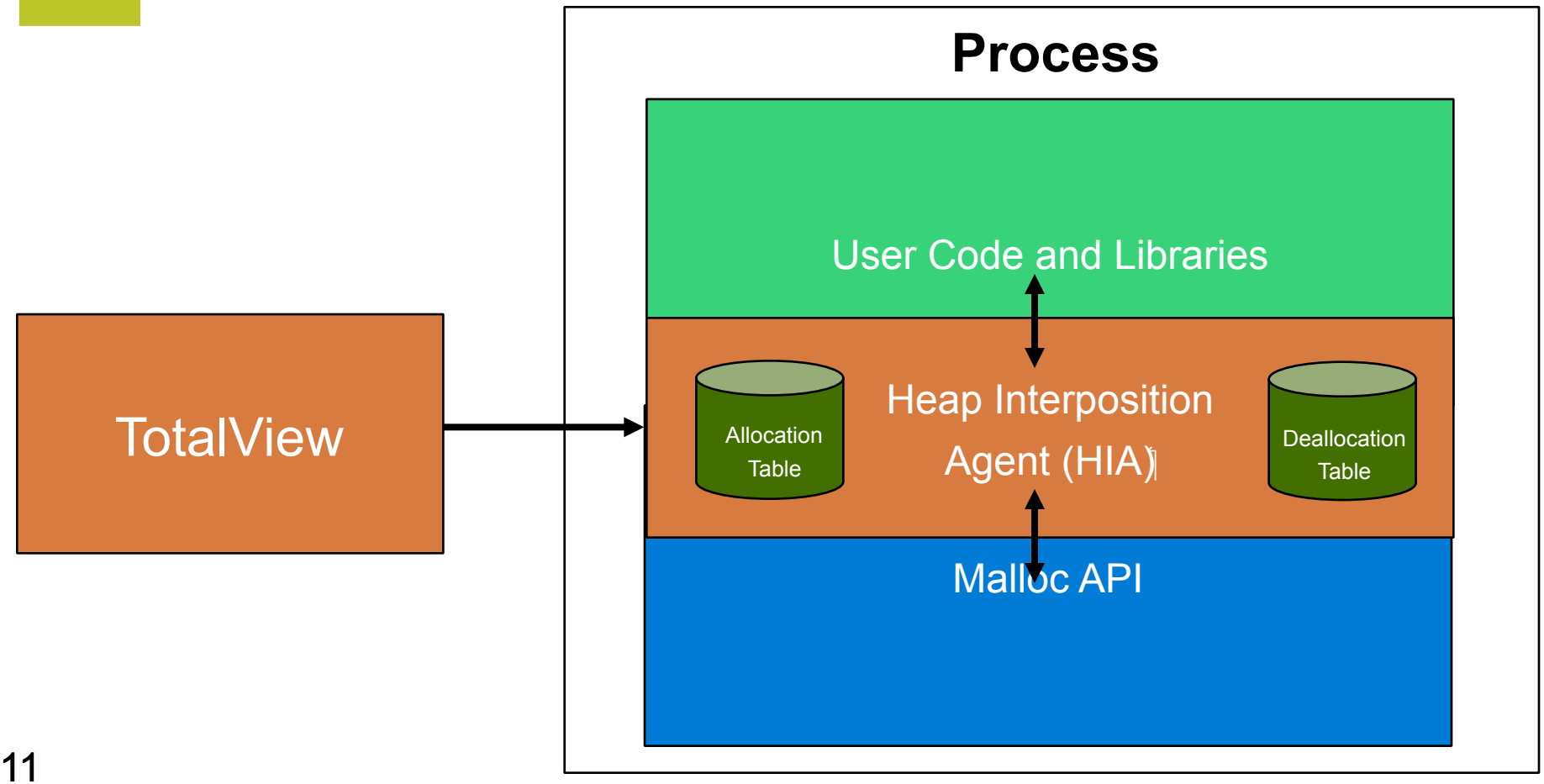
- **TotalView Source Code Debugger**
  - Fully integrated Memory Debugging Capabilities

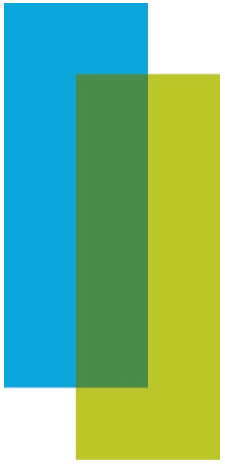
- **MemoryScape Memory Debugger**
  - Standalone Memory Debugging
    - Non-developer environments
    - Quality Assurance
    - Test groups
    - Customers

TotalView's Interposition Agent



TotalView's Interposition Agent





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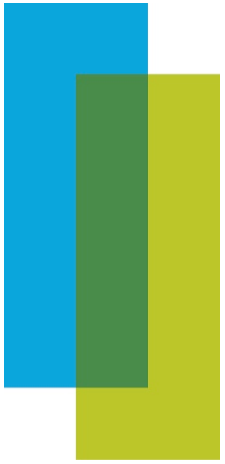
TotalView HIA Technology

- **Advantages of TotalView HIA Technology**

  - **Use it with your existing builds**
    No Source Code or Binary Instrumentation
  - **Programs run nearly full speed**
    - **Low performance overhead**
  - **Low memory overhead**
    - **Efficient memory usage**
  - **Support for a wide range of platforms – including Cell**



Memory Debugger Features

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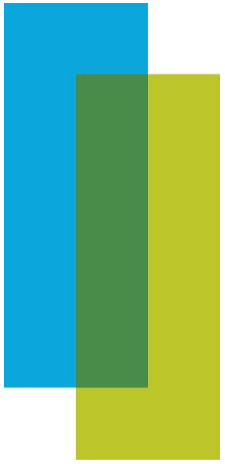
- Automatic allocation problem detection
- Heap Graphical View
- Leak detection
- Block painting
- Dangling pointer detection
- Deallocation/reallocation notification
- Memory Corruption Detection - Guard Blocks
- Memory Hoarding
- Memory Comparisons between processes
- Collaboration features



Enabling Memory Debugging

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Setting up a memory debug session…

Fexibility is Key

Enabling Memory Debugging
Memory Event Notification

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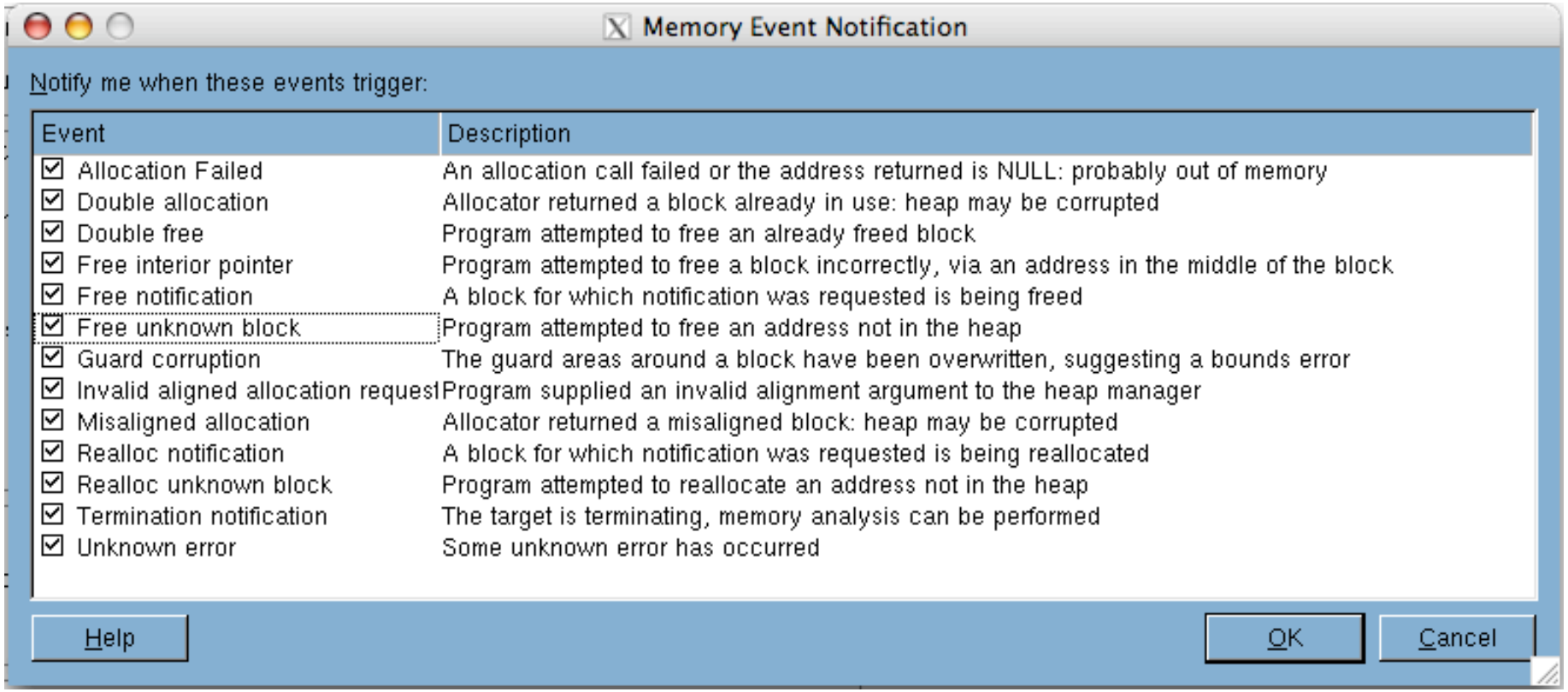
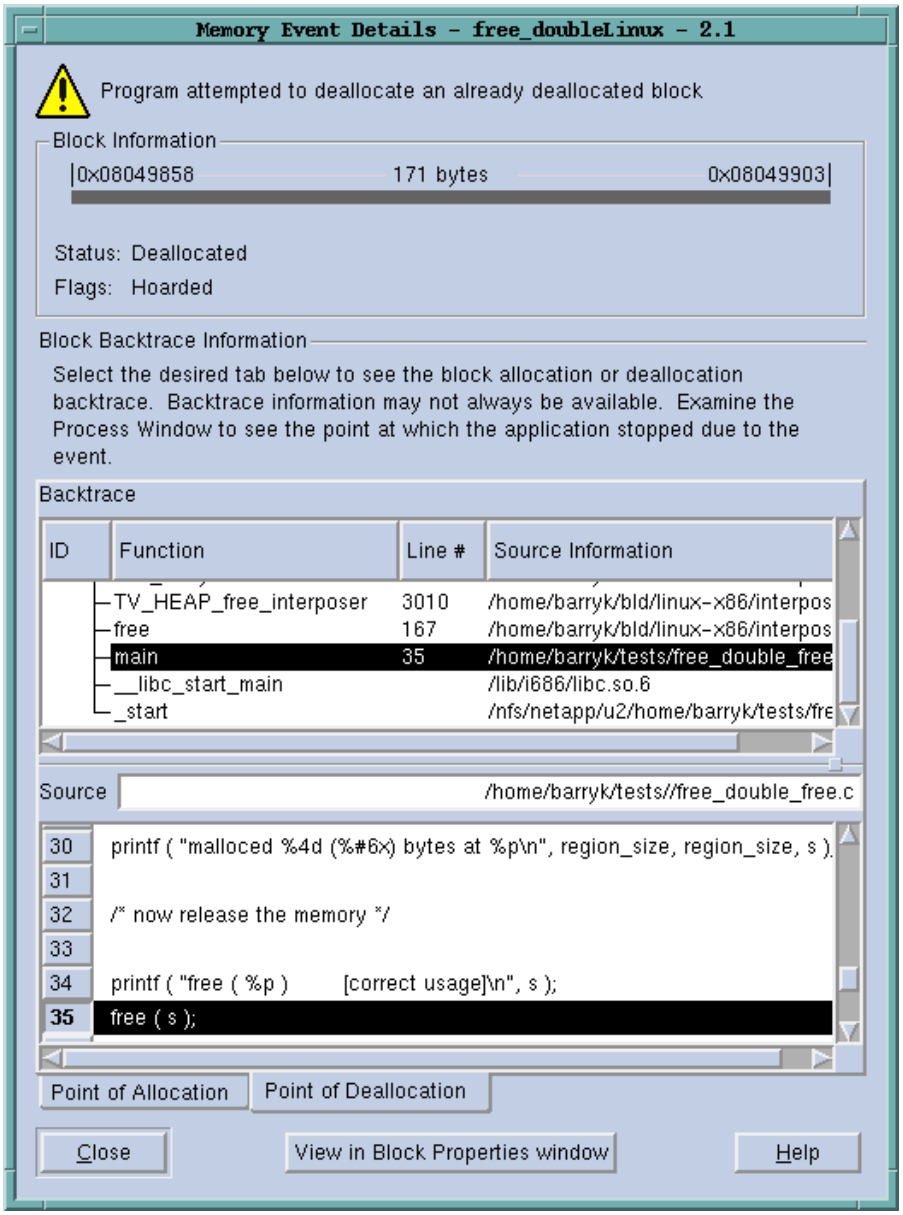
Halt execution on memory event or error

Use the **Advanced** button to control actions for individual events.

Advanced...



Memory Event Details Window



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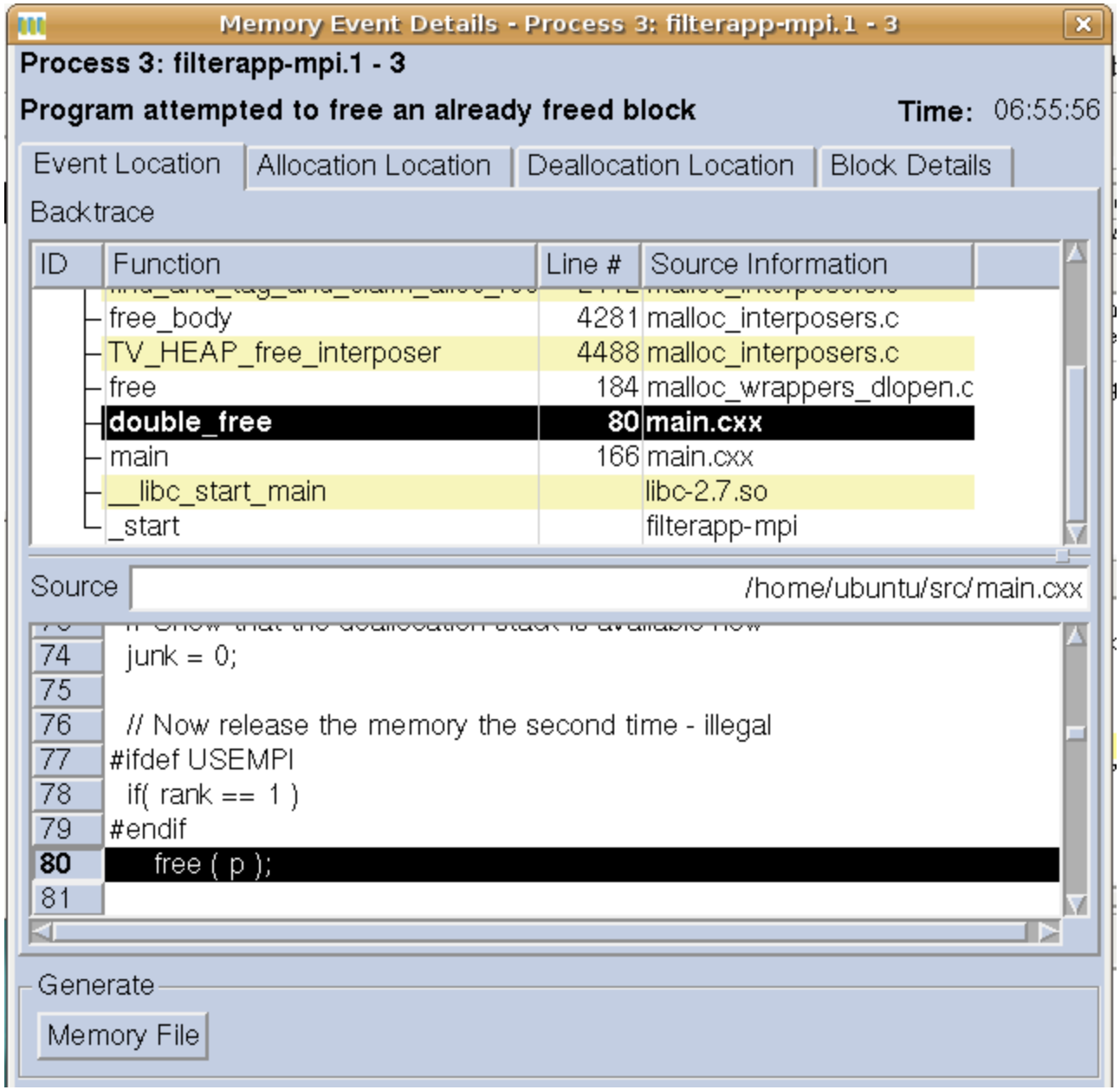
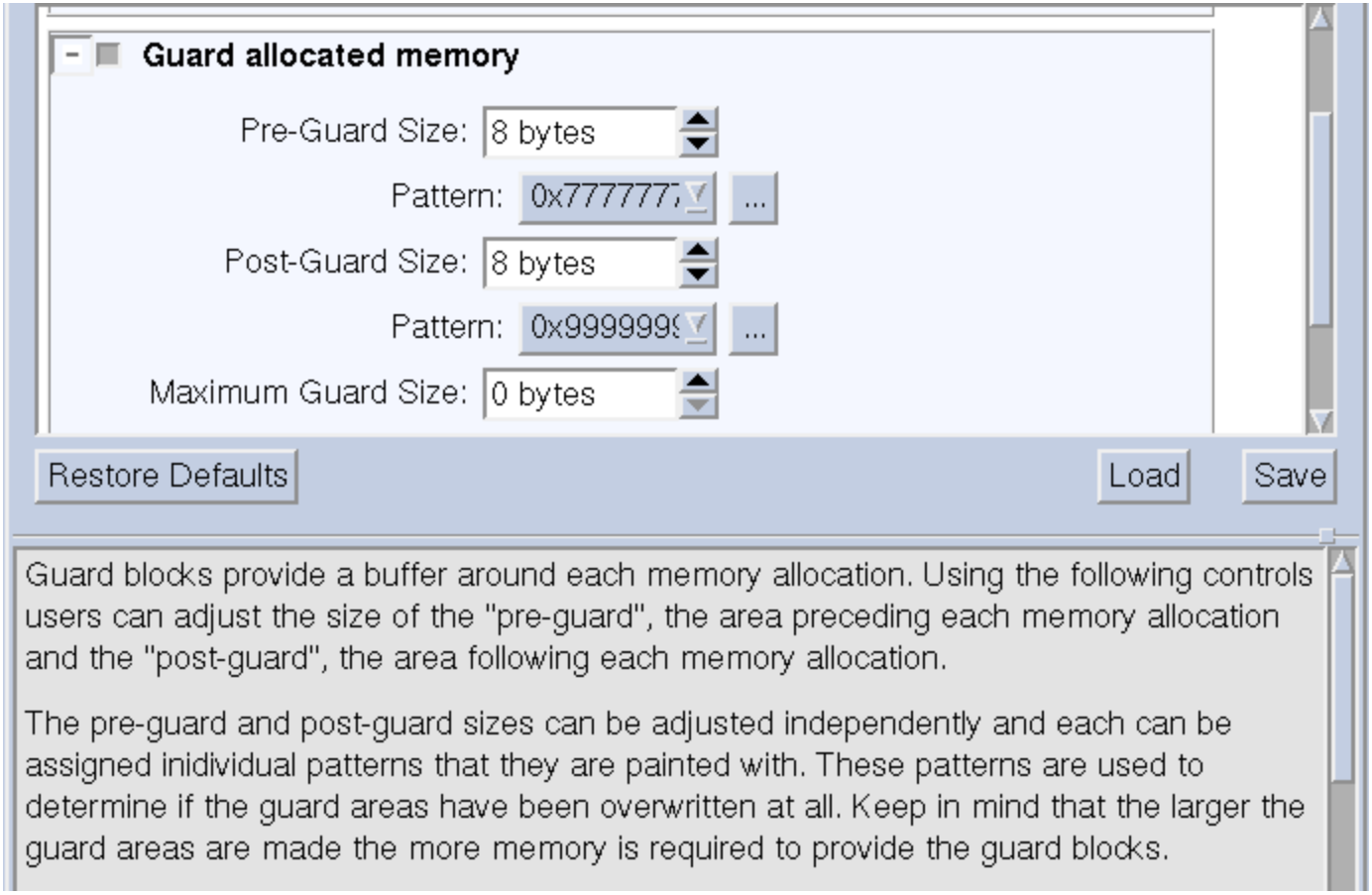
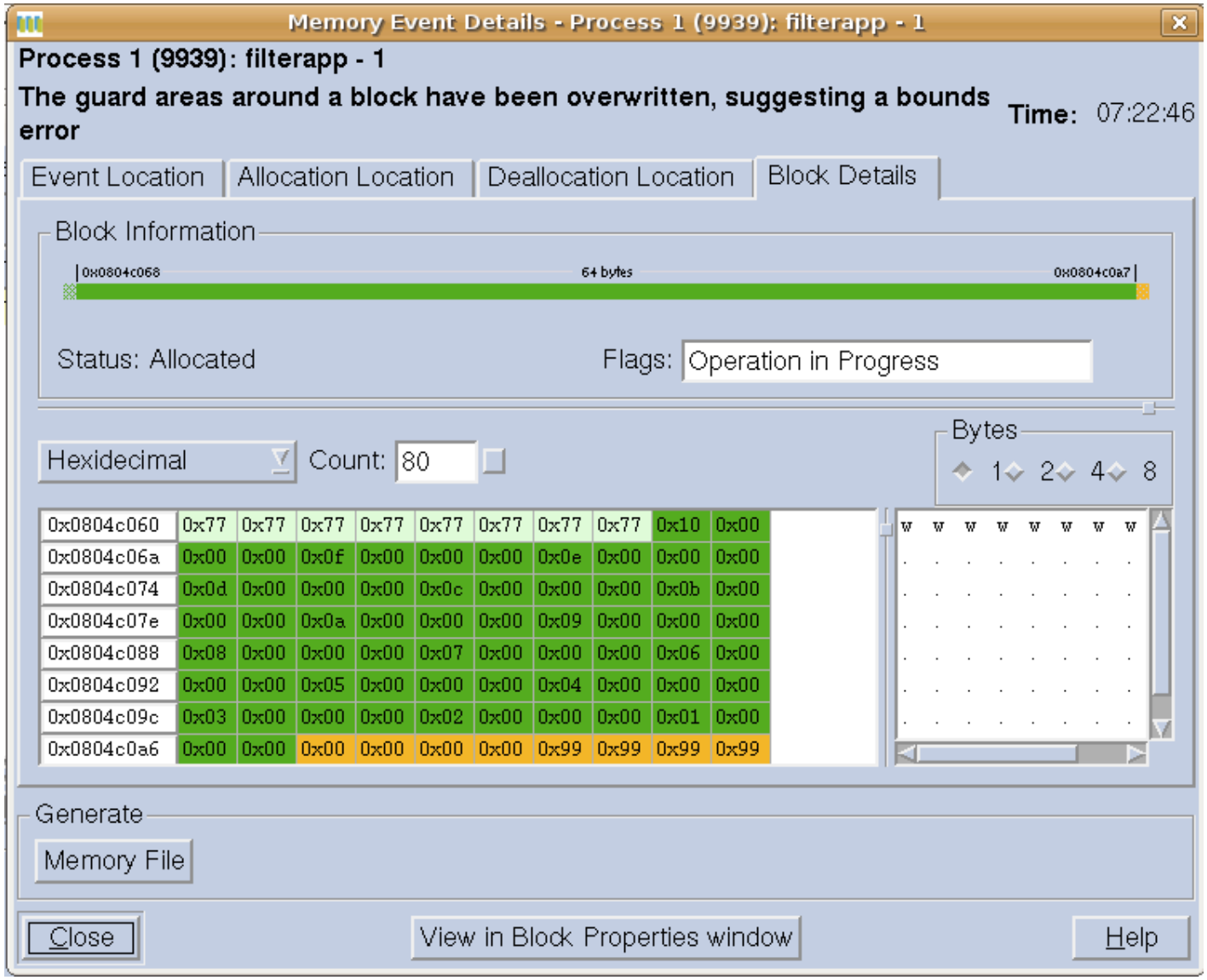


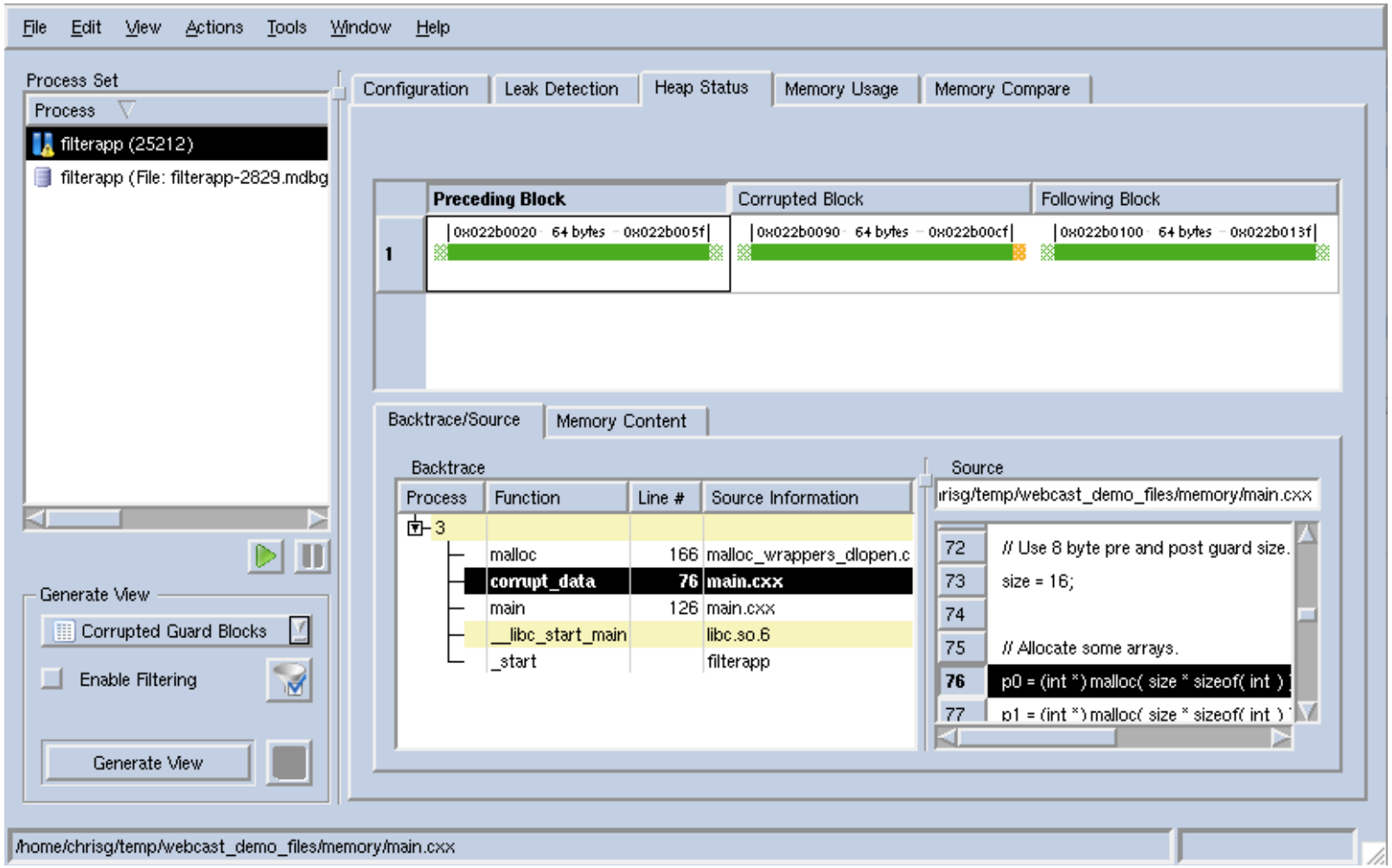
Memory Corruption Detection (Guard Blocks)



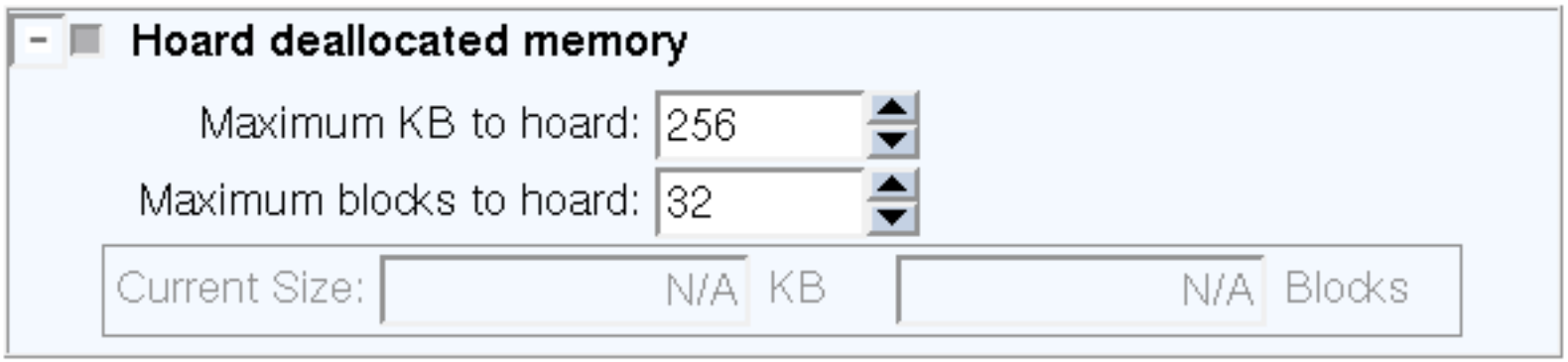
Memory Corruption Detection (Guard Blocks)



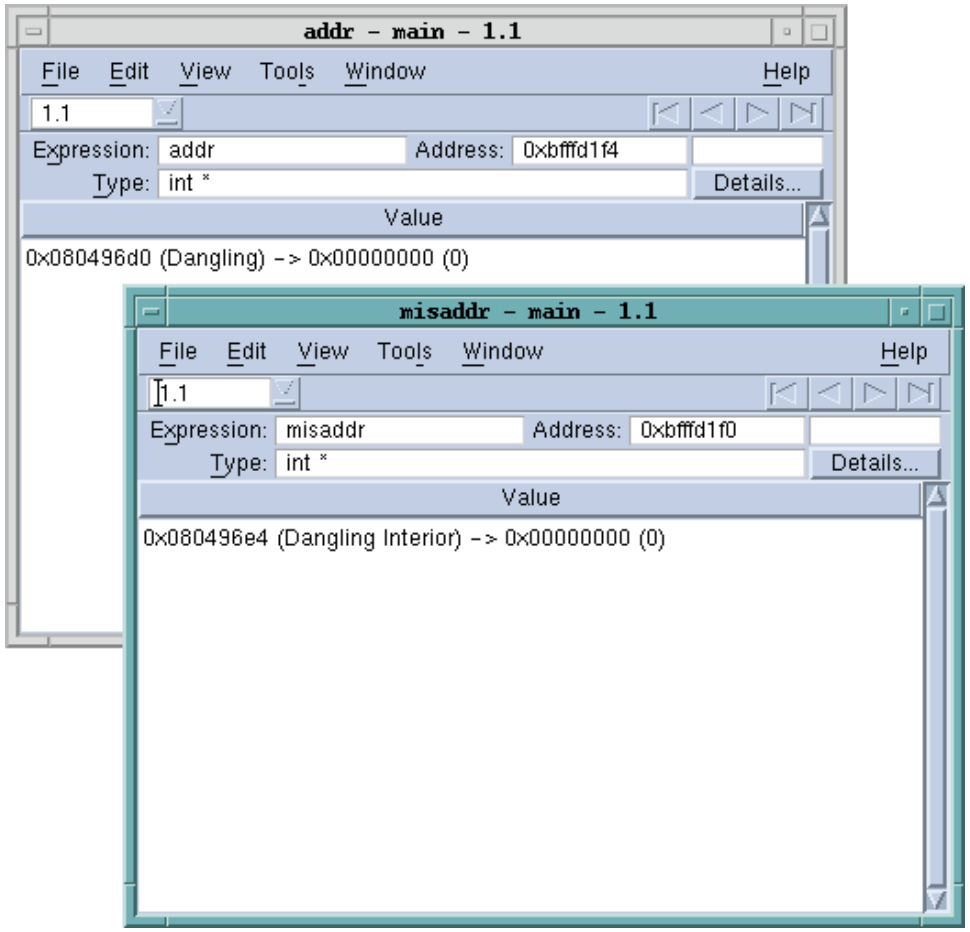
Memory Corruption Report



Enabling Memory Debugging
Painting & Hoarding



Dangling Pointer Detection



Heap Graphical View

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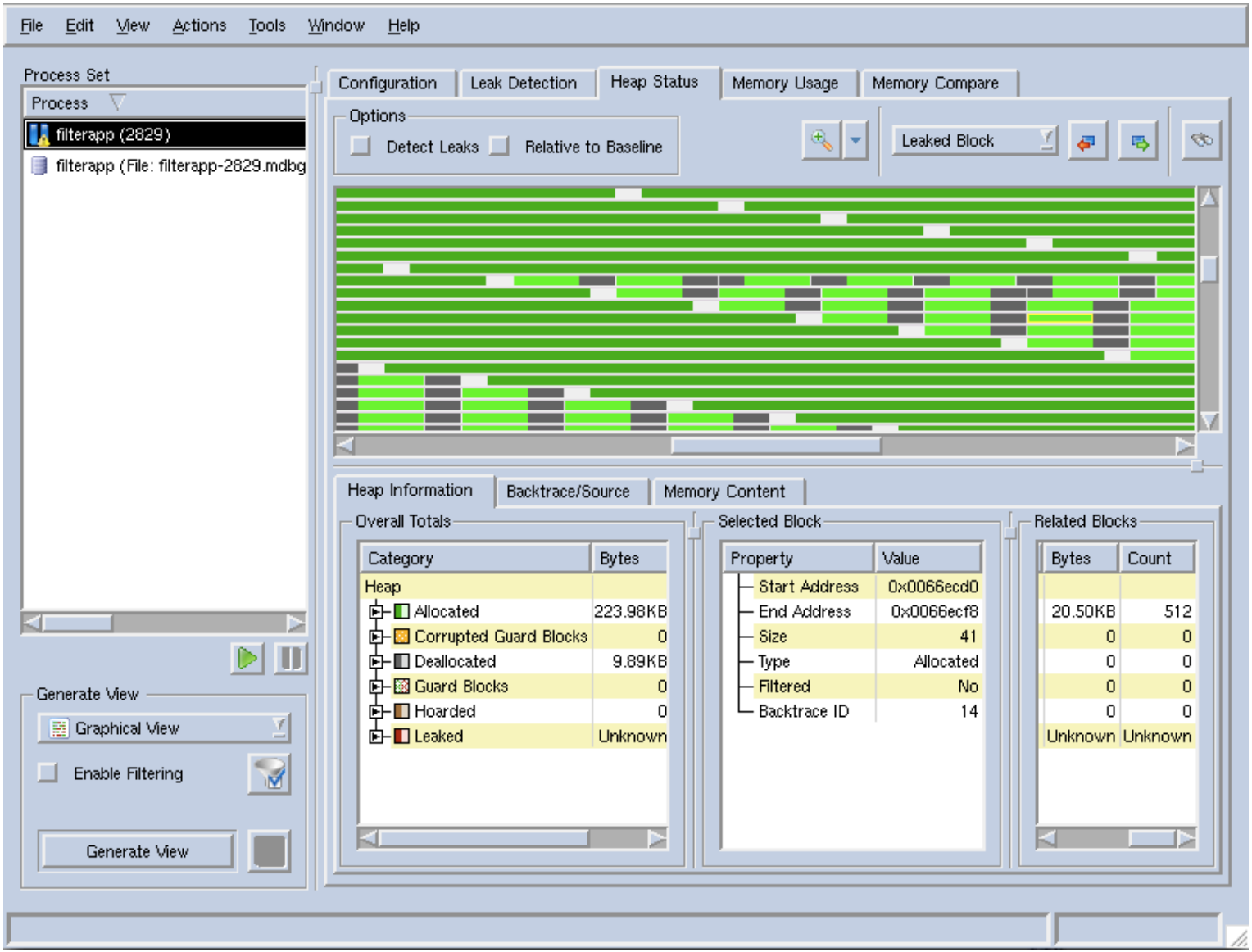
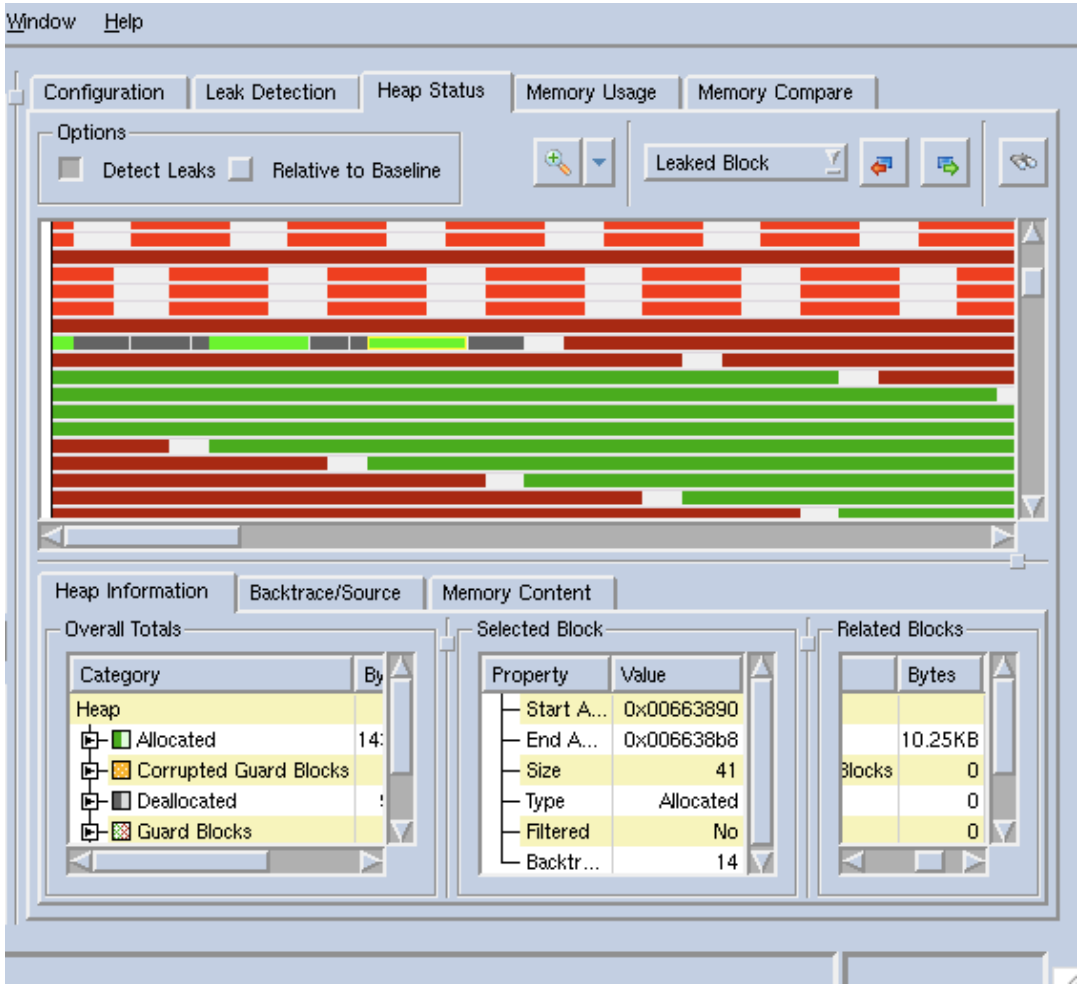


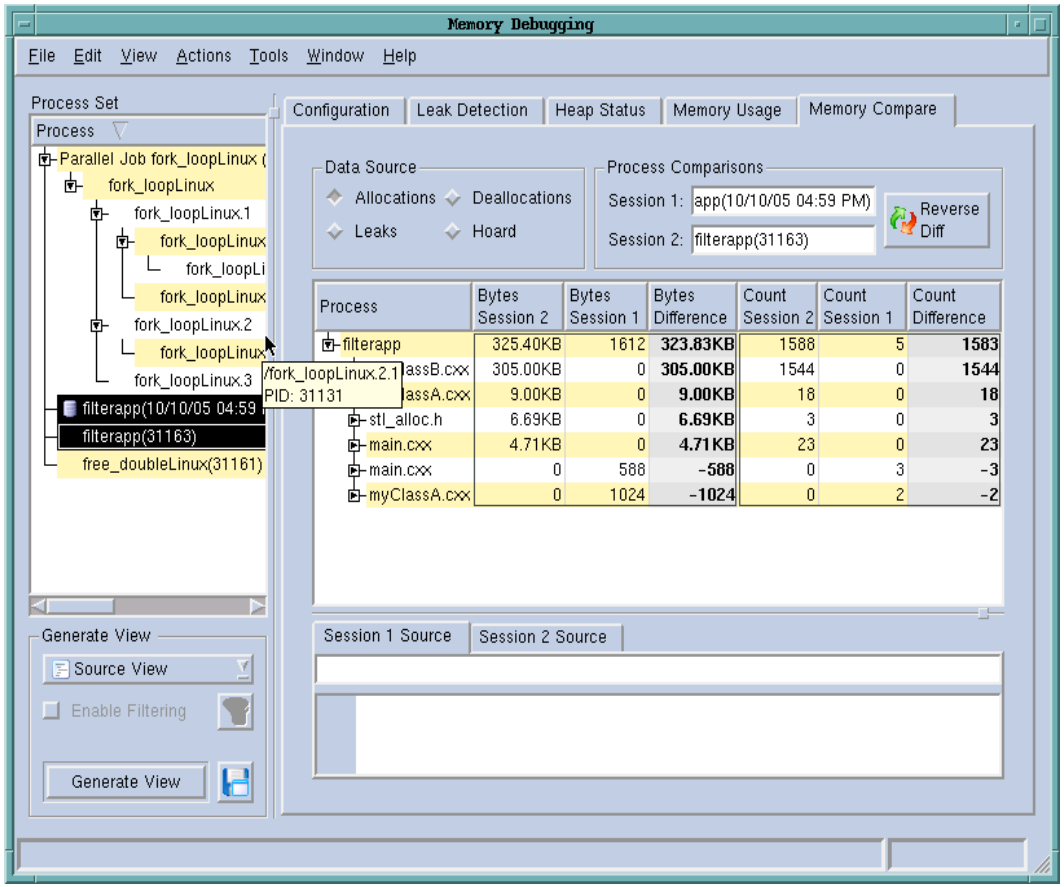
Leak Detection



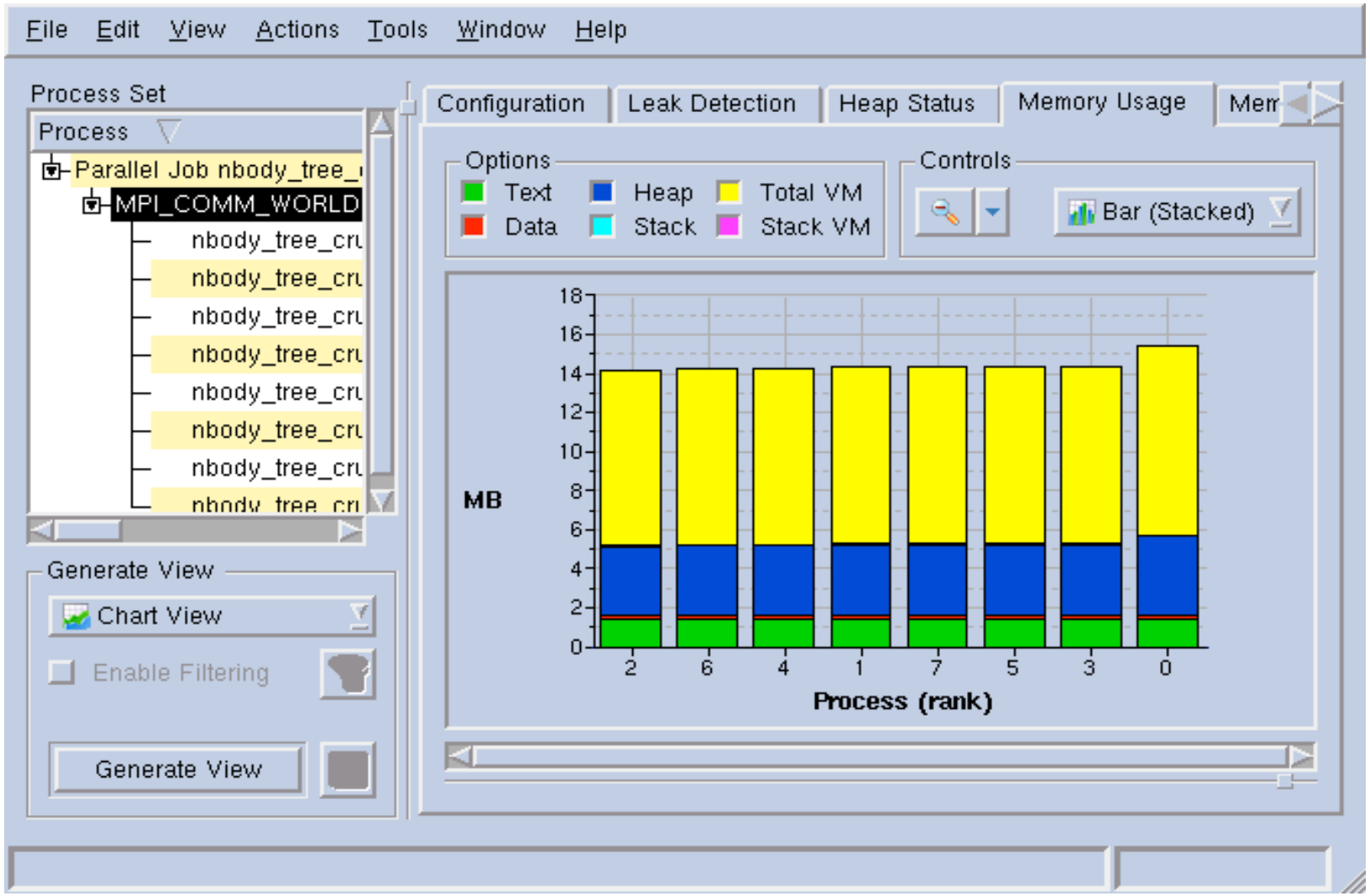
- Based on Conservative Garbage Collection
- Can be performed at any point in runtime
- Helps localize leaks in time

Memory Comparisons

- **"Diff" live processes**
  - Compare processes across cluster
- **Compare with baseline**
  - See changes between point A and point B
- **Compare with saved session**
  - Provides memory usage change from last run

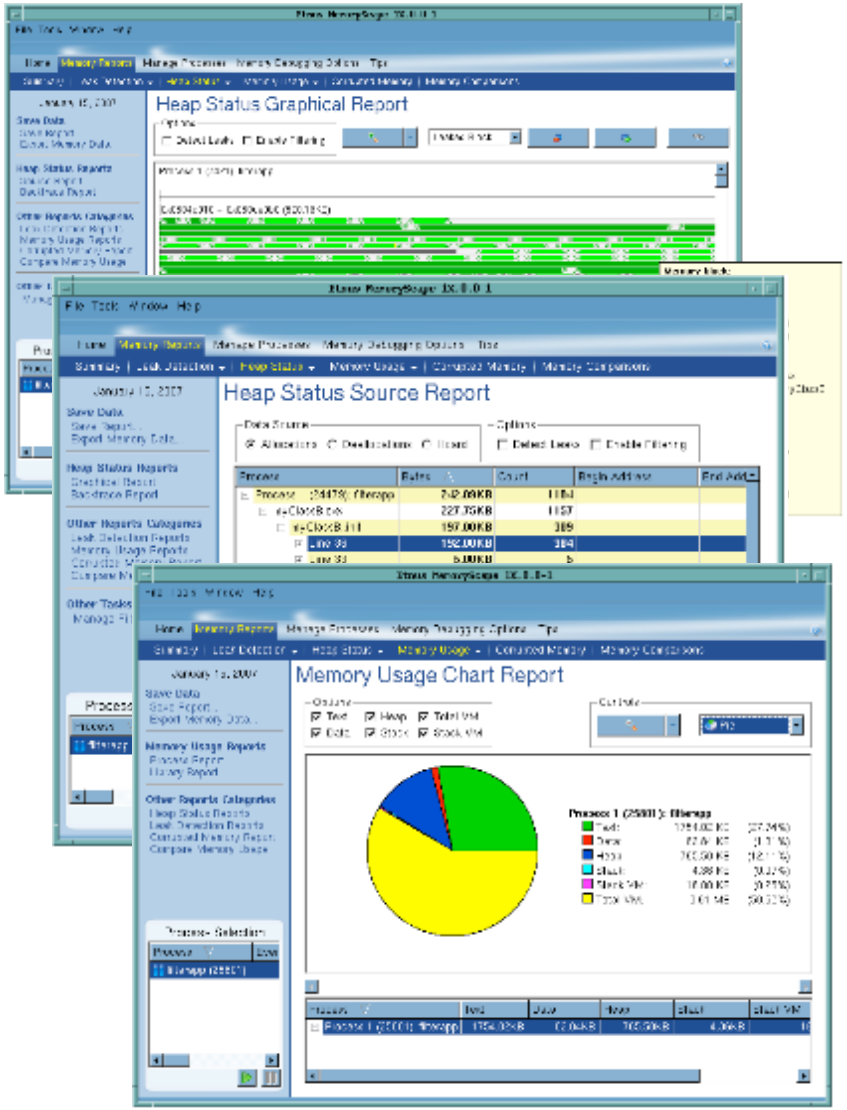


Memory Usage Statistics



Memory Reports

- **Multiple Reports**
  - Memory Statistics
  - Interactive Graphical Display
  - Source Code Display
  - Backtrace Display
  - HTML - interactive format
- **Allow the user to**
  - Monitor Program Memory Usage
  - Discover Allocation Layout
  - Look for Inefficient Allocation
  - Find Memory Leaks



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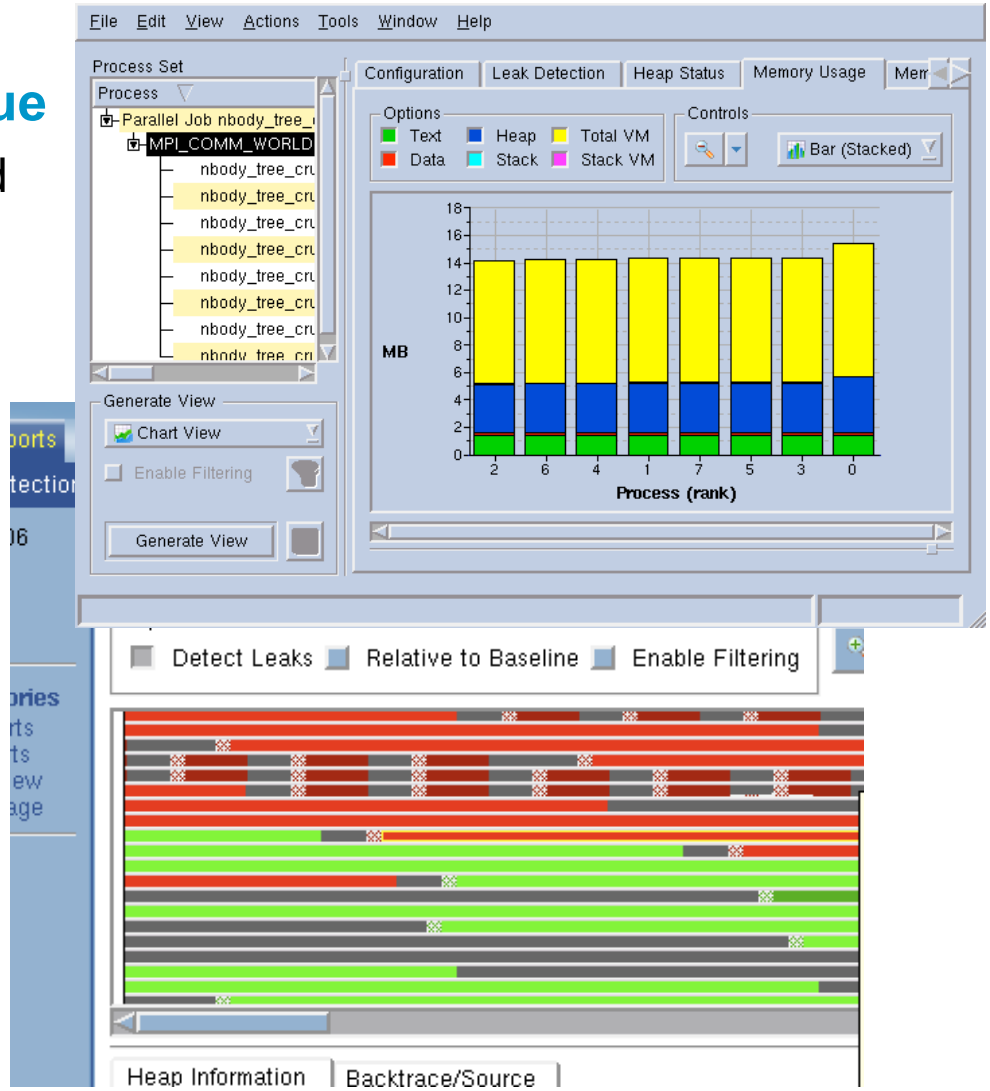
Script Mode – MemScript - Tvscript

- **Automation Support**
  - Scripting lets users run tests and check programs for memory leaks without having to be in front of the program
  - Simple command line program
    - Doesn't start up the GUI
    - Can be run from within a script or test harness
  - The user defines
    - What configuration options are active
    - What thing to look for
    - Actions to be taken for each type of event that may occur

Parallel Memory Debugging

- **Memory is a growing issue**
  - Node resources are limited
  - Predicting and managing memory usage across parallel applications is complex
- **Analysis may include**
  - Comparing usage across
    - Processes of job
    - Time
    - Datasets
  - Exploring layout of allocations
  - Leak detection
  - Buffer overflow detection



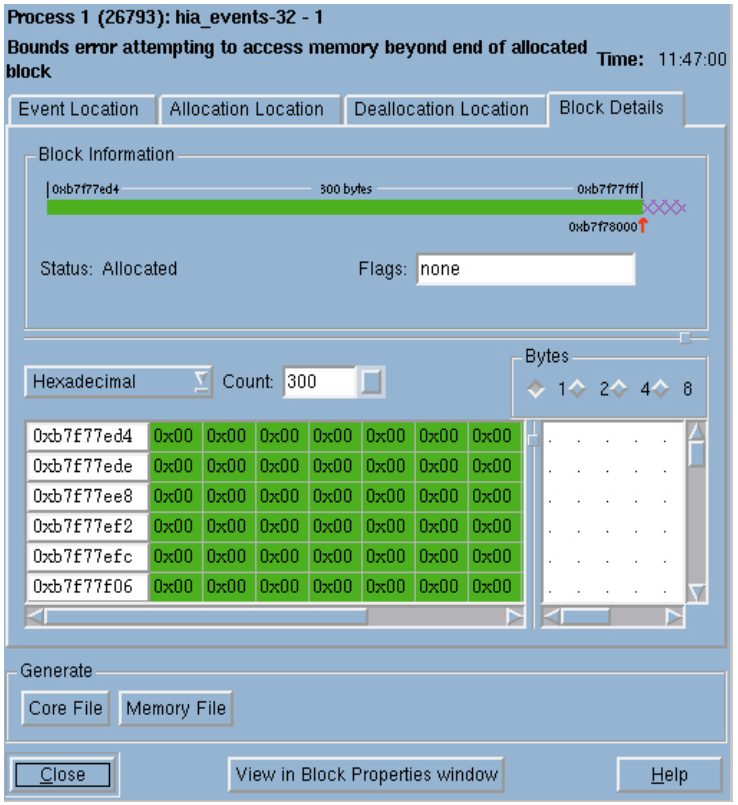
TotalView provides complimentary set of memory 'tools'

- **Guard Blocks**
  - Low runtime overhead, small size, over- and under-runs
  - Identify heap allocation bounds errors after the fact
- **HIA Events**
  - Low overhead, only catch certain types of errors
- **Memory Statistics**
  - No overhead, very high level, pick out outliers and patterns
- **Heap Graphical Display**
  - Detailed view, understand re-allocation and fragmentation behavior
- **Leak Detection**
  - Analysis of state
- **(de)allocation Hoard**
  - Helps identify dangling pointers
- **RedZones (TV 8.7, MS 2.5)**
  - Low runtime overhead, large size, over- or under-runs
  - Flags heap allocation bounds errors as they happen

Coming in TotalView 8.7 and MemoryScape 3.0

- Redzones -

- **Allocates a "protected page"**
  - adjacent to selected heap allocations
  - Before or after
- **A write into this space triggers immediate events**
  - Event occurs as the write is happening
- **Pages have a fixed size**
  - If there are many heap allocations this can potential have a large memory usage overhead
- **Ways to manage Redzones memory overhead**
  - Turn redzones on and off manually
  - Specify (by size) what allocations you want to have redzones on



Thanks!

QUESTIONS?

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