Delphi Tools Update: Instrumenting Threaded Programs

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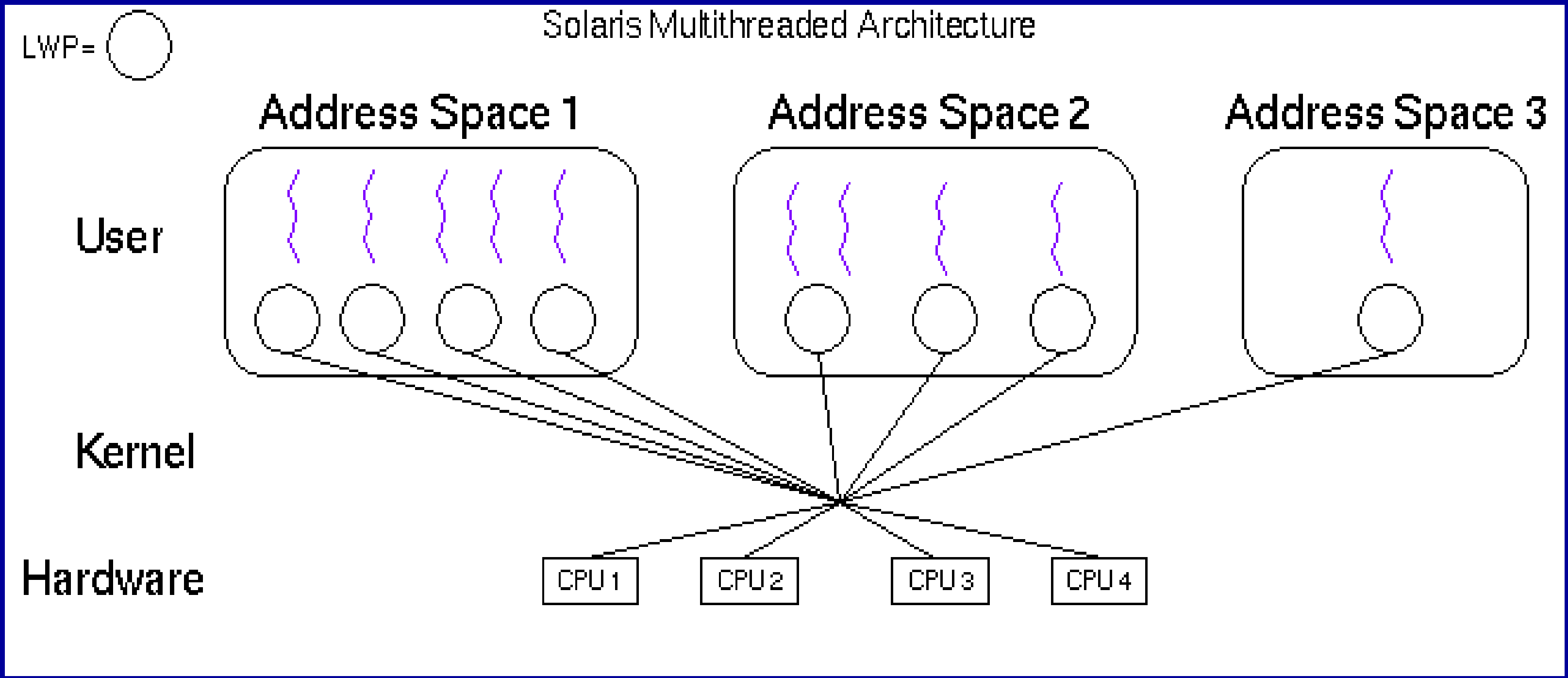
Outline

- Motivation
- Design Issues
- Implementation Highlights
- Current Status
- Future Work

Motivation

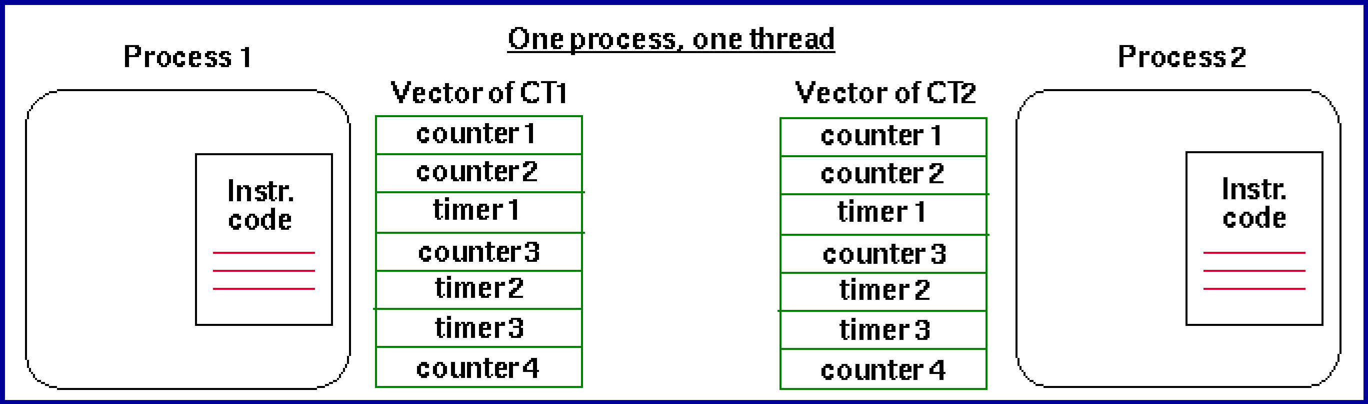
- Why support multithreaded applications?
  - Exploit multiprocessor hardware, application concurrency
  - Used heavily in transaction processing, UI's, servers



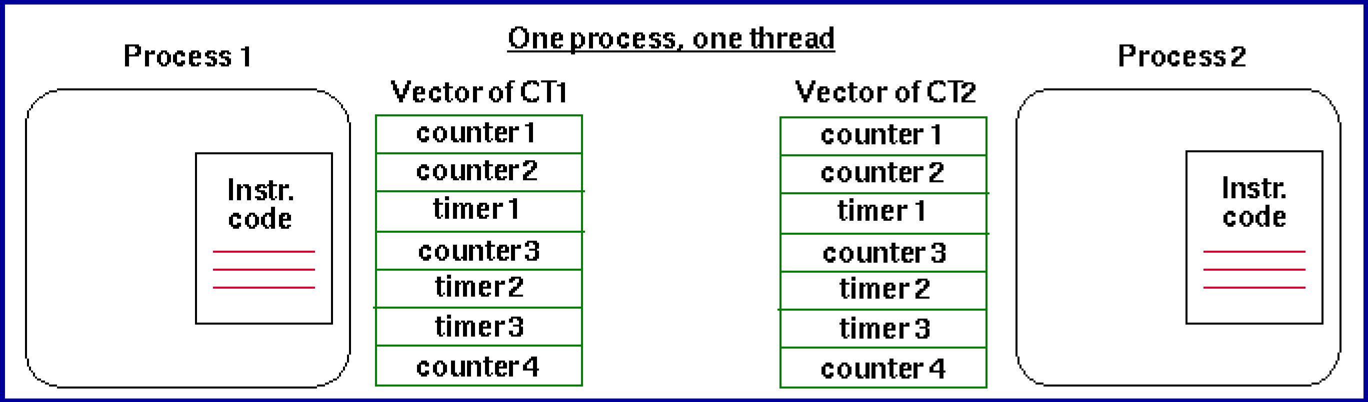
Motivation

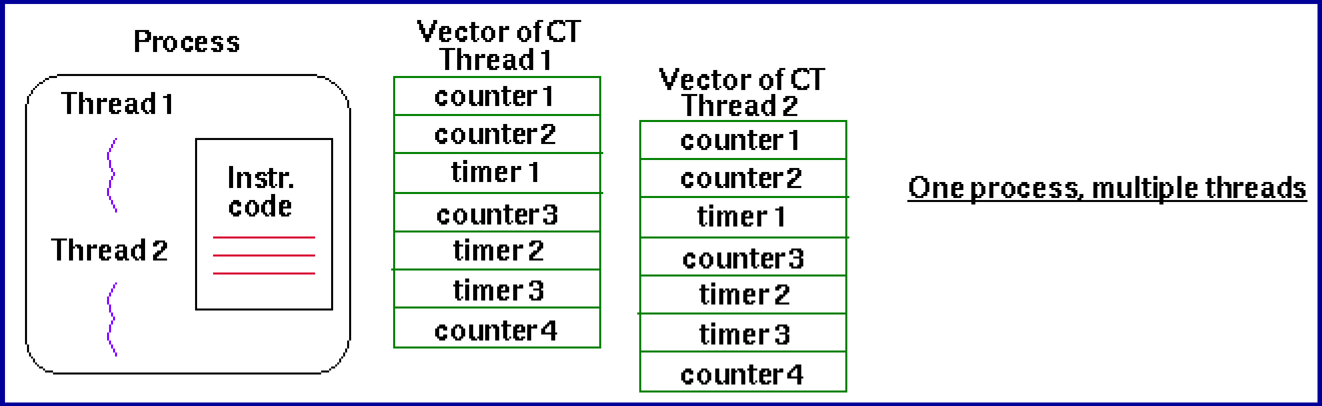
- Metric computation. What is new?
  - For single or few threads:
    "cpu time for thread 1 / process 2"
    "cpu time for thread 2 / process 2"
  - For all threads, individually
  - For all threads, cumulative

Previous Paradyn Program Instrumentation



Program Instrumentation w/Threads

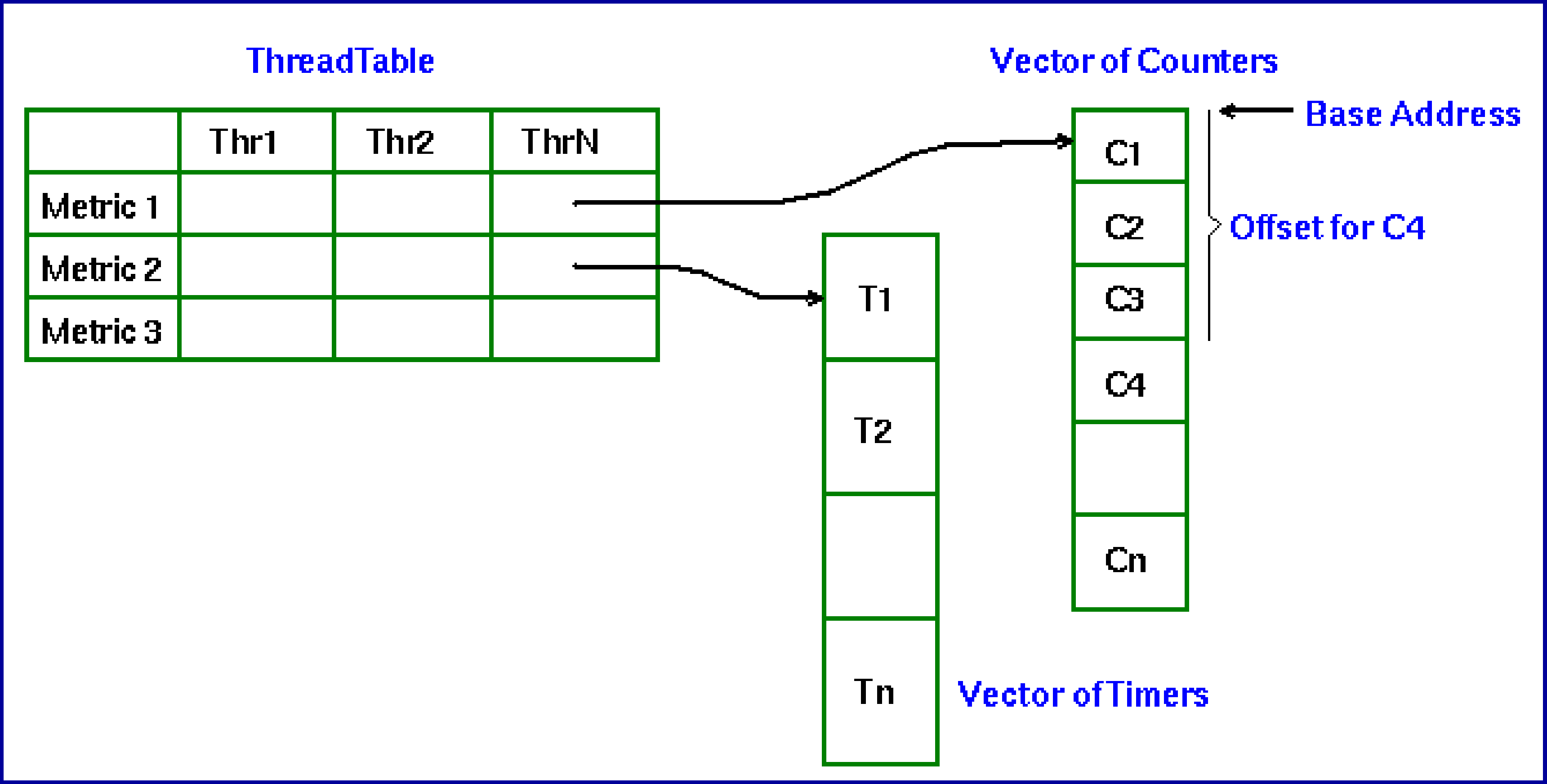




Design issues

- Every thread shares the same program instrumentation
- Vector of counters or timers per thread
  - More memory usage, but better speed
  - More straight forward implementation
- Two base applications scenarios
  - Few threads, few LWPs: exploiting parallelism
  - Many threads, dynamic (e.g. servers)

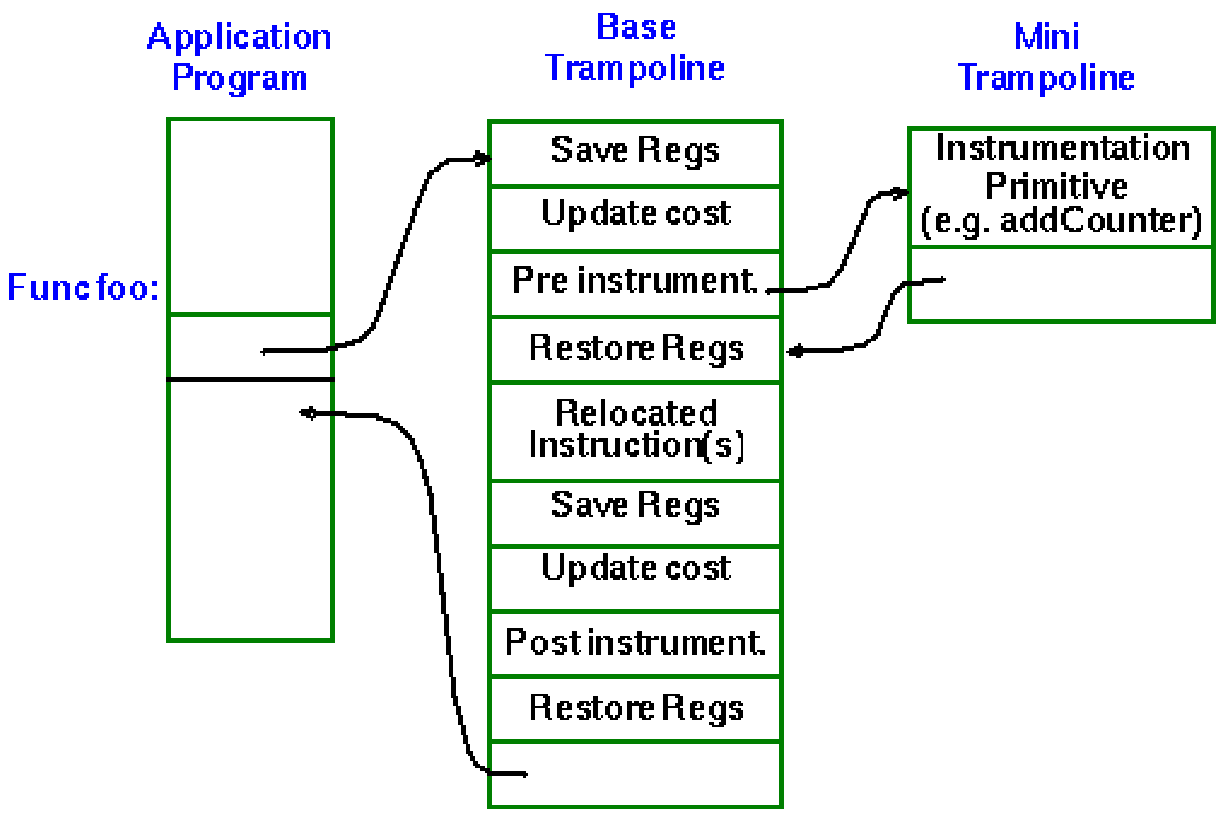
Design for Instrumenting Threads



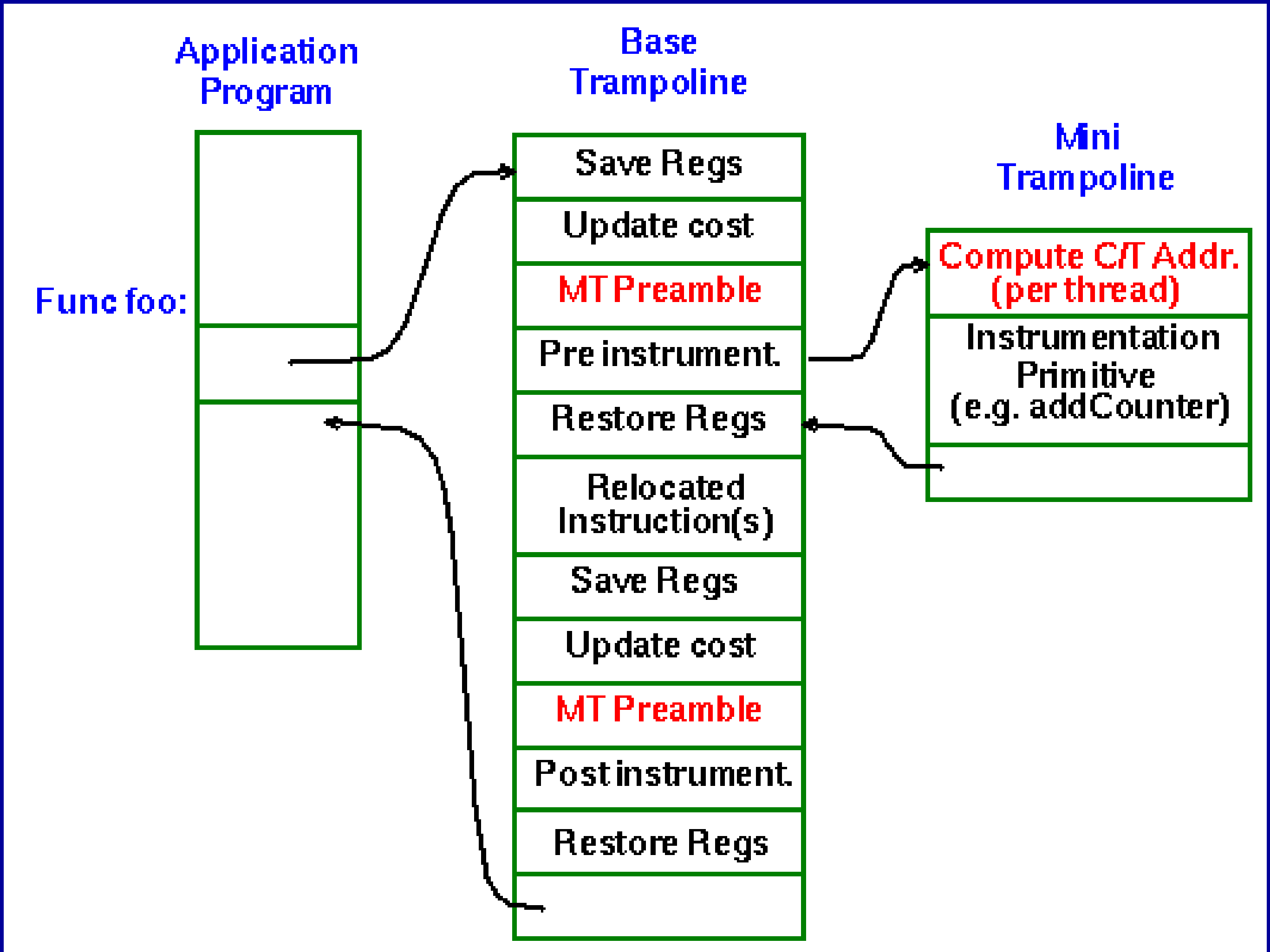
Design for Instrumenting Threads

- Whole process vs. Threads
  - Important performance issue!
  - Whole process metrics are computed per process ⇒ no need to aggregate threads
  - "thr_1" is equivalent to whole process
  - Aggregation is done for processes, not for threads

Original Base Trampoline



Modified Base Trampoline



Current Design - Issues

- Thread Table indexed by thread id's, points to vector of counters or timers
- Separate sets of counters/timers per thread
- Creation of vectors of counters/timers on demand, never removed, but re-used!
- Counters/timers allocated by blocks
- Virtual CPU timer for each thread

Current Design - Key Operations

- Add thread
  - Update thread table entry
  - Create same counter/timers as for other threads
  - Enable only counter/timers that apply to new thread
- Delete thread
  - De-allocate all counter/timers + all vectors for this thread
  - Update thread table entry

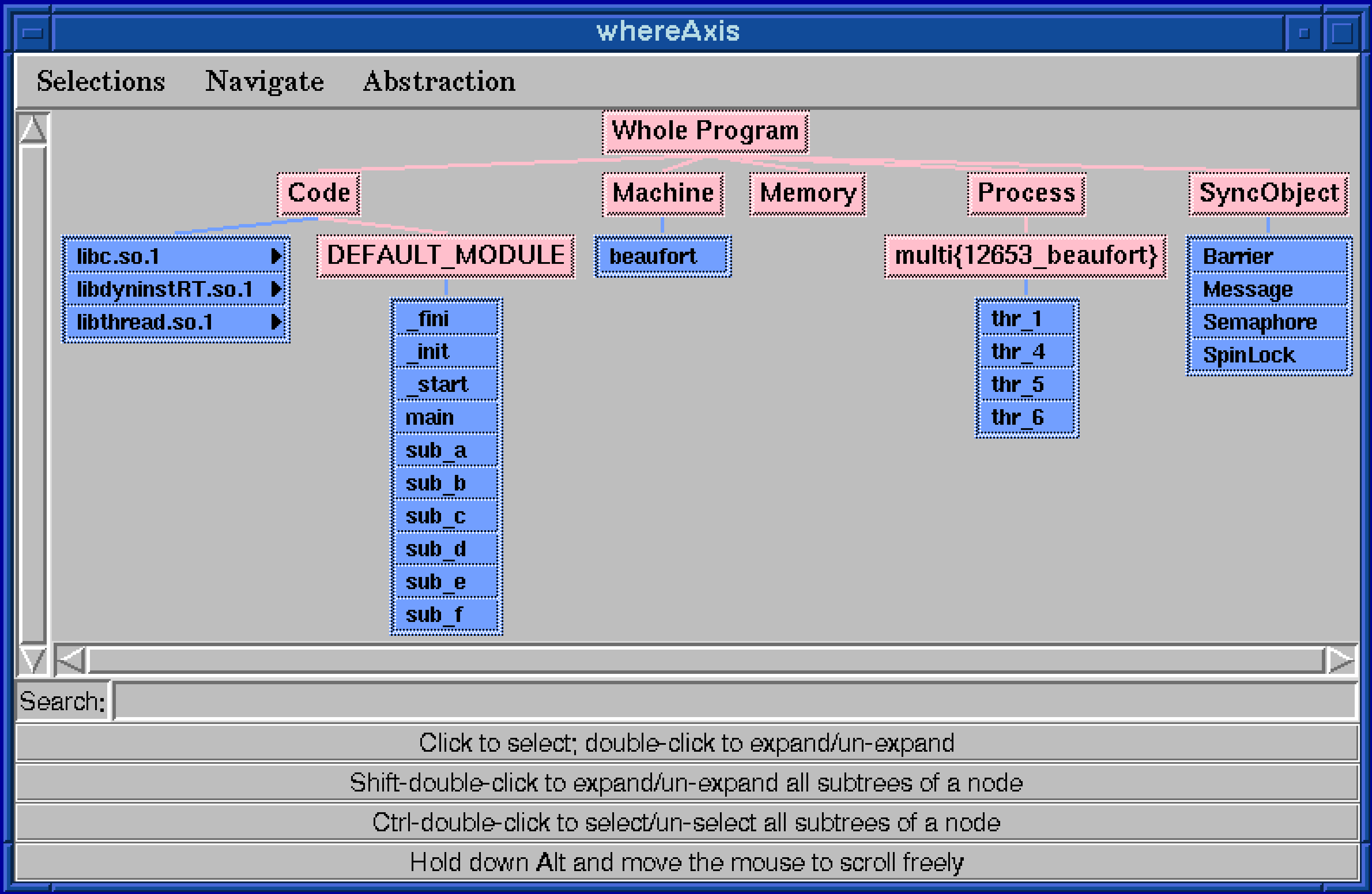
Current Design - Key Operations

- Add counter/timer
  - Common case: there is space in vector of counter/timers and we just add new entry
  - Special case: there is no space available and we create a new vector for all threads and add new entry
- Delete counter/timer
  - Tag counter/timer as invalid. It does not de-allocate memory

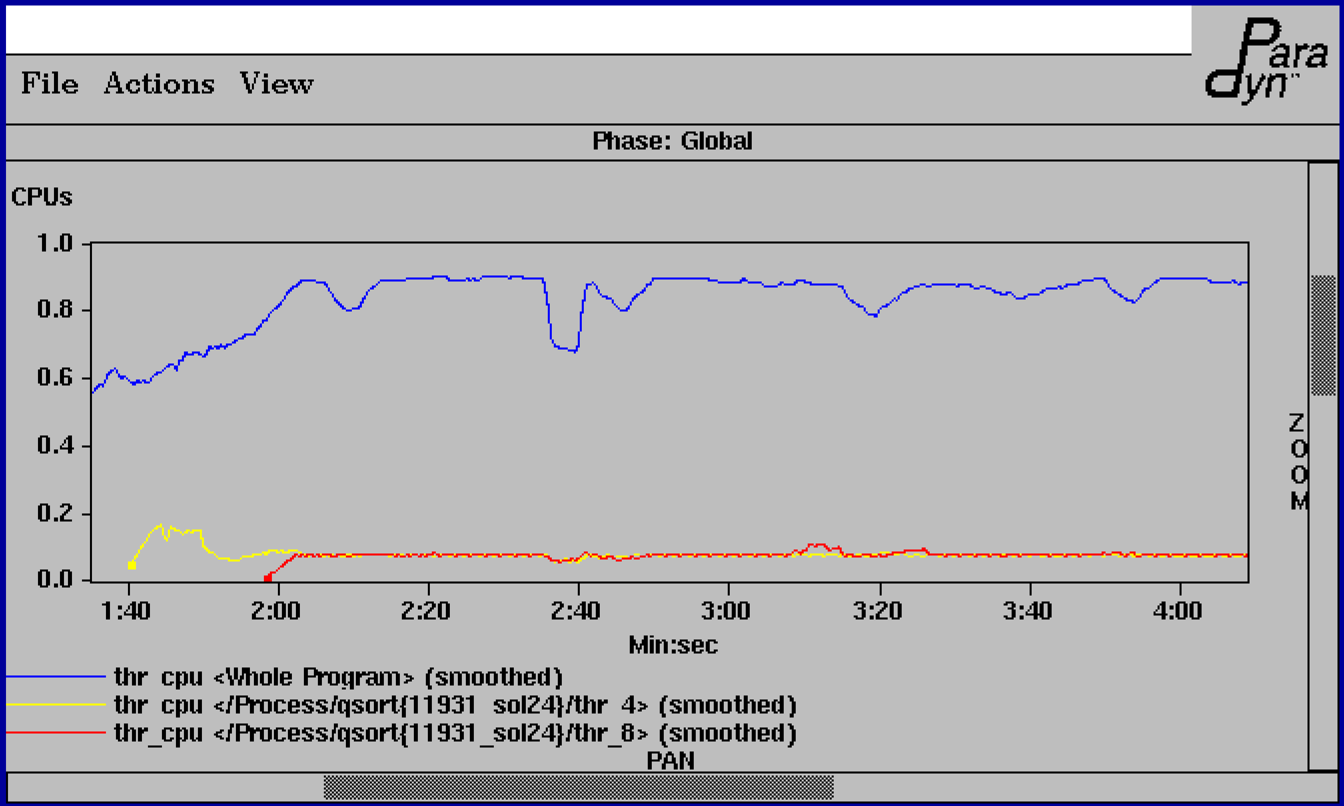
Current Design - Comments

- Advantages
  - Reasonable memory usage
  - Fast execution of mini-trampoline code
- Disadvantage
  - Only de-allocates memory for counter/timers and vectors when a thread is deleted

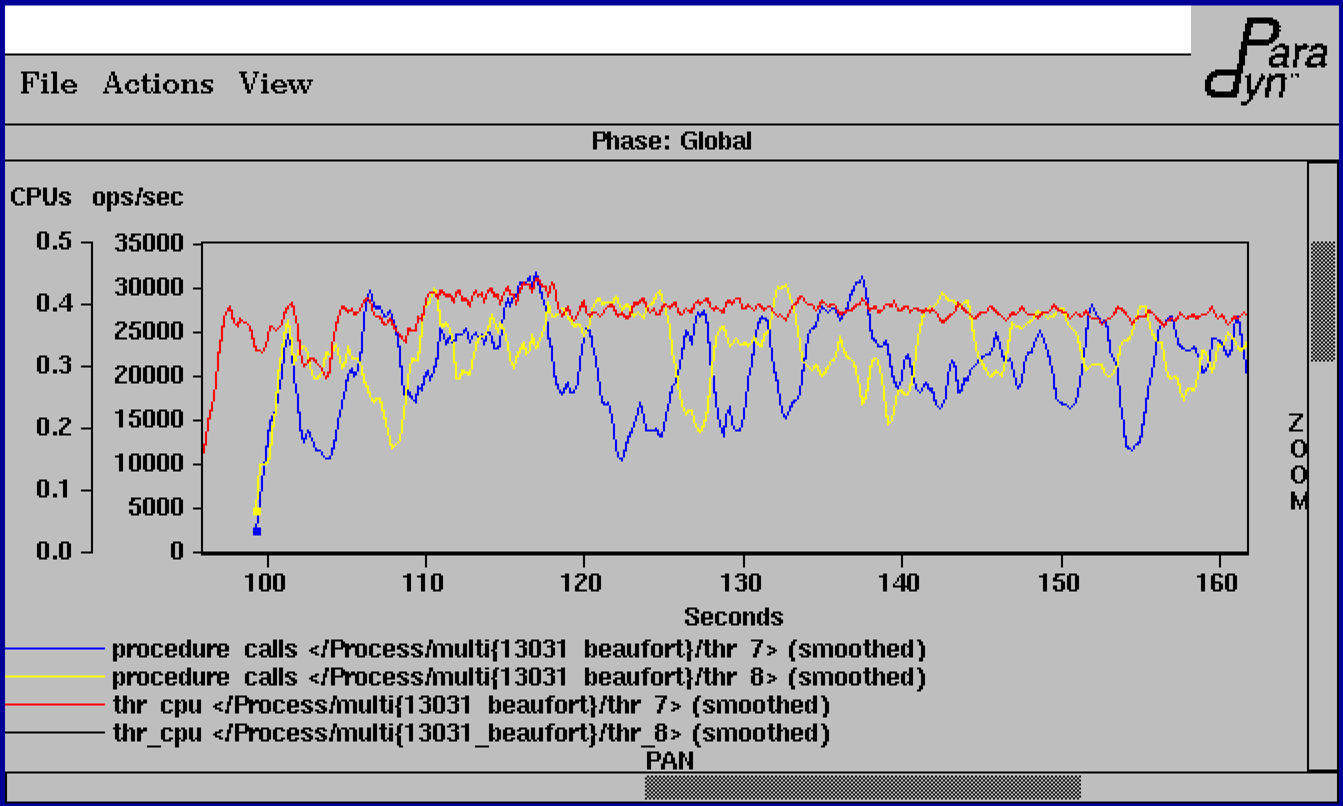
Current Design - Resources



Example Measurements



Example Measurements



Current Design - Comments

- Must instrument thread context switch
  - Identify appropriate functions in thread package
- For Solaris threads
  - *"_onproc_deq":* stop timer, thr context switch
  - *"_resume_ret"*: start timer, thread is about to resume execution
- A little messy: requires internal knowledge
  - Only done once per thread package

Current Design - CPU metric

```
resourceList stopThread is procedure {
   items {"_onproc_deq"};
   flavor { unix };
   library true;
}

resourceList resumeThread is procedure {
   items {"_resume_ret"};
   flavor { unix };
   library true;
}
```

Current Design - CPU metric

```
metric cpuTime {
…
base is processTimer {
    foreach func in stopThread {
      append preInsn func.entry (* stopProcessTimer(cpuTime); *)
    }
    foreach func in resumeThread {
      append preInsn func.entry (* startProcessTimer(cpuTime); *)
    }
    append preInsn $start.entry constrained
      (* startProcessTimer(cpuTime); *)
    prepend preInsn $start.return constrained
      (* stopProcessTimer(cpuTime); *)
    append preInsn $exit.entry constrained
      (* stopProcessTimer(cpuTime); *)
  }
}
```

Current Design - Cost

Base-Trampoline Section. MT Version (SPARC Architecture)

```
// Instrumentation code - Part of the Base Trampoline
//  MT Preamble
basetramp:    sethi  %hi(0x12400), %o5
basetramp+4:  call  %o5 + 0x3dc ! 0x127dc<DYNINSTthreadPos>
basetramp+8:  nop
basetramp+12: sll  %o0, 2, %l0
basetramp+16: sethi  %hi(0x42b400), %l1
basetramp+20: or  %l1, 0x130, %l1
basetramp+24: add  %l0, %l1, %l0
basetramp+28: mov  %l0, %l7
basetramp+32: nop
```

Current Design - Cost

Mini-trampoline (SPARC architecture)

```
// Instrumentation code ("add counter" primitive)
// Load counter
minitramp:    sethi  %hi(0x61800),%l0
minitramp+4:  ld  [%l0+0x3e0],%l0 ! 0x61be0
<DYNINSTdata+1760>
// Increment counter
minitramp+8:  inc  %l0
// Store counter
minitramp+12: sethi  %hi(0x61800),%l1
minitramp+16: st  %l0, [%l1+0x3e0] ! 0x61be0
<DYNINSTdata+1760>
// Branch to base trampoline or next mini-trampoline
minitramp+20: b,a   basetramp
minitramp+24: nop
```

Current Design - Cost

Mini-trampoline. MT Version (SPARC Architecture)

```
// Instrumentation code ("add counter" primitive)
// Load CT Vector Address
minitramp:    ld   [ %l7 ], %l2
// Compute offset for this counter
minitramp+4:  mov  0x12b, %l3
minitramp+8:  sll  %l3, 0x42, %l3
minitramp+12: add  %l2, %l3, %l2
// Load counter address and value
minitramp+16: ld   [ %l2 ], %l1
minitramp+20: ld   [ %l1 ], %l0
// Increment and store counter
minitramp+24: inc  %l0
minitramp+28: st   %l0, [ %l1 ]
// Branch to base trampoline or next mini-trampoline
minitramp+32: b,a   basetramp
minitramp+36: nop
```

Current Status

- Solaris threads support
- Thread low-level instrumentation in place and working
- Measurements can be gathered for a multiple threads using new structure

What is next?

- Testing small multithreaded applications running on multiprocessors
  – Exploit relationship threads/LWPs/CPUs
- Evaluate and tune performance
- Test large-scale application: Oracle on Solaris is initial target.