Tracing in Parallel Systems

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Why Tracing?

- Parallel programs are complex
  - many processing tasks running concurrently
  - complex synchronization patterns
  - computation vs. waiting for synchronization event

  ⇨ hard to understand a performance result
- Tracing
  - record events and timing during execution
  - provide log data or even visualization for later analysis
- Where is the tracing done?
  - application software
  - system software

MPICH Tracing

- Compile mpicc with –mpilog flag
- Execute to produce log file (clog or slog)
- jumpshot to interactively visualize the traces

Tracing for Shared-Memory Parallel Programming

- What kinds of events you want to trace?
- Where is the tracing done?

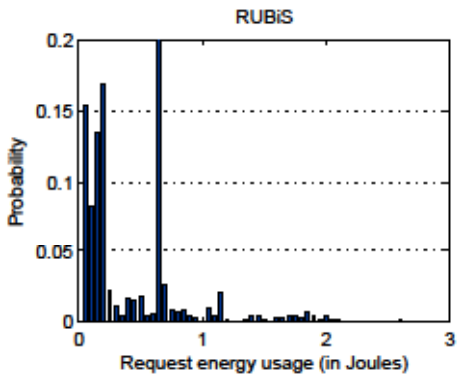
Tracing in Concurrent Server

- Goals:
  - Debug performance problems
  - Measure performance and resource accounting at each request
  - Request classification and anomaly detection
- Challenges
  - Highly multiprogrammed, many context switches
  - Request processing is multi-stage – web server, J2EE components, database
- Where is the tracing done?
  - Applications
  - Programming systems
  - Operating systems
  - … …

Requests in Server

- What is a "request"?
  - From application point of view, the task the server fulfills on behalf of a user demand;
  - From system point of view, the set of all activities (in the server system) in fulfilling a singe application request
- Tracking individual request
  - Microscopic view of the system
  - Allows performance management and resource accounting at request granularity

An Example of Request Energy Usage Distribution



Track Request CPU Usage

- Oftentimes a request maps to a process/thread
- How to track a process CPU usage in OS?
  - Sampling vs. tracking context switches
  - Accounting for interrupt handlers
- Exceptions that a request does not exactly map to a process
  - Process pooling
  - Multi-stage server
  - Background tasks

Resource Containers [Banga et al. OSDI1999]

- Tracking requests
  - Applications pass request handles when requests go from one stage to the next
- Request-granularity resource management
  - What is the default scheduling unit in operating systems?
  - Decouple scheduling context, protection domain, and resource allocation context
  - Flexible/better resource control – e.g., give certain users higher priority or guaranteed CPU allocation

Magpie [Barham et al. OSDI2004]

- Tracking requests transparently at the OS
  - Dump bunch of system events
  - Analyze the events afterward to find out request context propagations
    - process A sends something into a socket and process B reads out of the same socket a bit later
    - an interrupt handler is linked to a page cache entry which is later read by process C
- Flexibility
  - A framework with user-defined rules
  - Extending this into application level
- Not in real time

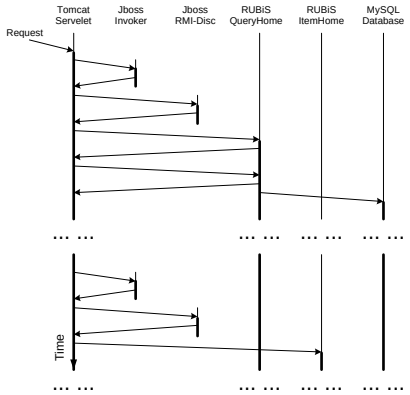
Utilization of Magpie Request Tracking

- Request classification
  - Each request is identified by its events
    - e.g., a chain of system call IDs
  - Put similar ones into groups/clusters
    - what is the good metric to quantify the difference between requests?
- Request modeling
  - Given an online workload, you can say
    - 80% are like this …
    - 19% are like this …
    - a couple of really weird ones

Real-Time Request Tracking [Our work, ASPLOS2008]

- Real-time tracking allows immediate system reaction
  - Adaptive OS management policy
  - Anomaly detection and quarantine
- Most request propagations are through inter-processing communications
  - ⇨ Tag request contexts to messages
- User-level request context propagation is hard to detect

An Example of Request Context Propagation



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