A QoS Aware Non-work-conserving Disk Scheduler

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Why QoS Aware?

- To be able to share a disk among users whilst providing tight QoS guarantees.
- Enforce *performance isolation*:
  
  *the performance experienced by an application (VM) should not suffer due to variations in the workload from other applications.*

- Important in virtualized systems
We consider QoS aware different from proportional share:

- QoS aware can specify tight and independent QoS guarantees in terms of:
  - Bandwidth
  - Delay
  - Bursts

- Proportional share
  - I/O Priorities
  - Disk share (in %) → disk performance is very difficult to predict
Why Non-work-conserving?

- Work-conserving schedulers suffer with *deceptive idleness*
- Non-work-conserving schedulers prevent deceptive idleness by *predicting future requests*:
  
  *A request that is soon to arrive might be closer to the current disk head position than other pending requests*.

- **The solution**: after serving a *synchronous and sequential* request, keep the disk idle
Previous Work

- CFQ – Complete Fairness Queuing
  - Non-work-conserving ✓
  - Proportional share (I/O priorities) ✗
- BFQ – Budget Fair Queuing
  - Non-work-conserving ✓
  - Proportional share (a disk share per application) ✗
- pClock
  - Work-conserving ✗
  - QoS aware (tags per request) ✓
**HTBS**

- **High-throughput Token Bucket Scheduler**
- Assigns tags per request in a fair-queueing like fashion (similar to pClock):
  - Request queue per application
  - Start and finish tags per request
- Non-work-conserving dispatch order.

- More details in the paper...
Experimental Setup

- AMD Athlon 2800 MHz dual-core, 4 GB RAM
- Low-end HDD → Samsung HD080HJ SATA, 80GB, 7200 rpm
- We implemented HTBS and pClock for Linux
- Microbenchmark → fio and dd
- Two experiments:
  - Measure how future request prediction increases throughput
  - Show that a QoS-aware work-conserving scheduler misses QoS guarantees in synchronous workloads
Experimental Results

Aggregated bandwidth achieved by pClock and HTBS using fio benchmark
Experimental Results

Aggregated bandwidth achieved by pClock and HTBS using *dd* processes
Experimental Results

pClock: four synchronous jobs with different bandwidth attributes (8800, 4000, 2000 and 800 KB/s)
Experimental Results

- Since there is a short amount of time between synchronous requests, a work-conserving scheduler cannot dispatch several requests from the same application, even if its guarantees are higher.
- QoS guarantees are missed.
Experimental Results

HTBS: four synchronous jobs with different bandwidth attributes (8800, 4000, 2000 and 800 KB/s)
HTBS could meet QoS guarantees, since it can dispatch several requests from the same application (depending on its QoS guarantees, and up to $B_{\text{max}}$).

- QoS guarantees are met
Future Directions

- Do some more experimentation using macrobenchmarks
  - Filebench
  - TCP
  - DVDStore
- Integrate with VMMs to provide QoS guarantees to VMs without decrease system overall throughput
Conclusions

- We presented HTBS, a new non-work-conserving QoS aware disk scheduler
- Through experiments with a Linux implementation, we showed that:
  - HTBS increases throughput when compared to other QoS-aware schedulers
  - HTBS can provide QoS guarantees even with synchronous workloads, unlike previous work
Thanks!

Questions?