ACHIEVING PREDICTABLE TIMING AND FAIRNESS THROUGH COOPERATIVE POLLING

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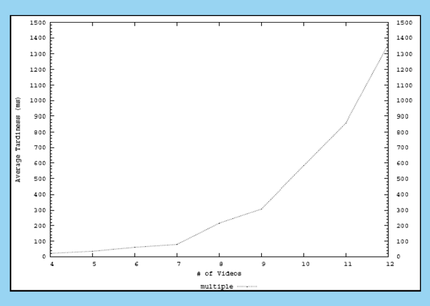
Can one CPU scheduler fit all?

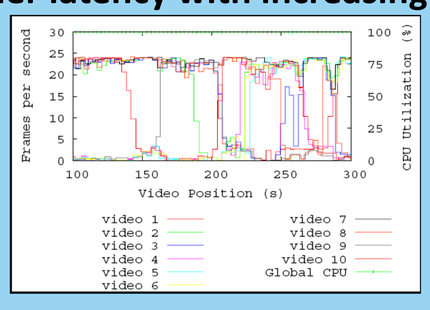
A. Traditional Scheduling Approach

- multi-level feedback queue algorithm – hasn't changed in 30 years.
  - Separate CPU and IO intensive jobs
  - Priority based.
  - Breaks down for mixed CPU and IO intensive jobs, like video applications, security enabled web servers, databases etc.
- Using real time priority leads to starvation and live locks.
- Behavior can be hard to predict
  - deadlocks, live locks or priority inversion may occur.
  - poor adaptation for adaptive time-sensitive workloads.

B. O(1) scheduler



Dispatcher latency with increasing videos



Frame rate of all 10 simultaneous videos

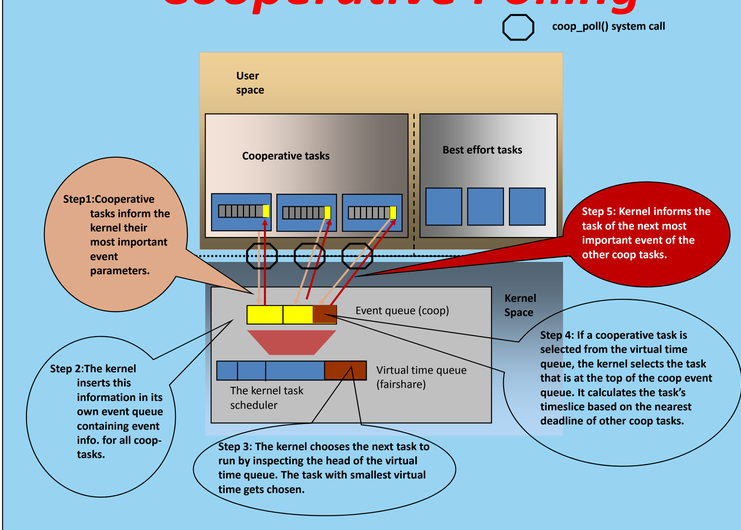
- Dispatcher latency:
  - actual – requested dispatch time.
- The latency increases quickly under heavy load with increasing videos.
- Some of the videos experience noticeable interruptions.

C. Pure Fairshare Scheduling

- Time based approach opposed to priority.
- No starvation. Overall fairness in the system.
- Better balance between desktop and server performance needs.
- Benefits from recent infrastructural components
  - Fine grained time accounting.
  - High resolution timers.
  - Effective data structures (heaps, red-black trees etc.)

Q: Can we do better?
A: Yes, by combining fair sharing with *cooperation.*

D. Overview of Our Approach: *Cooperative Polling*



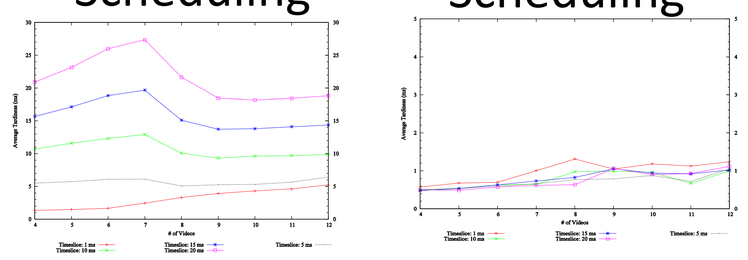
- Have overall fairness.
- Allow cooperation between time sensitive tasks via the kernel:
  - Give preferential treatment to TS tasks within the boundaries of fairness.
  - facilitates uniform fidelity across tasks.

E. Overview of our implementation

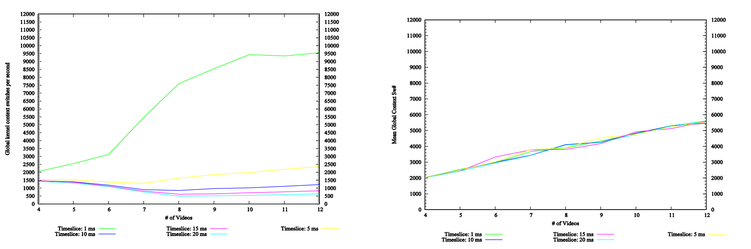
- Virtual time based.
- One new system call :coop_poll()
- Uses efficient heaps for priority queues.
- Benefits from high resolution one-shot timers & precise time accounting in the kernel.
- We use playback of multiple videos to represent a rich workload of multiple time-sensitive applications.

F. Pure Fairshare *vs* Cooperative Approach

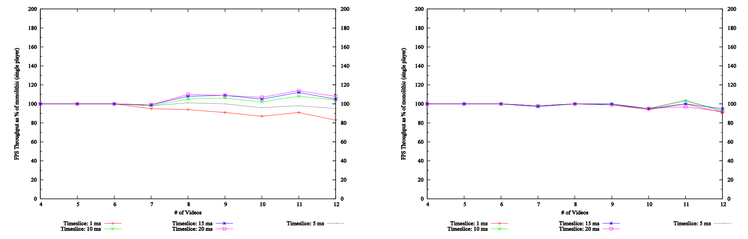
Fairshare Scheduling | Cooperative Scheduling



Dispatcher Latency.



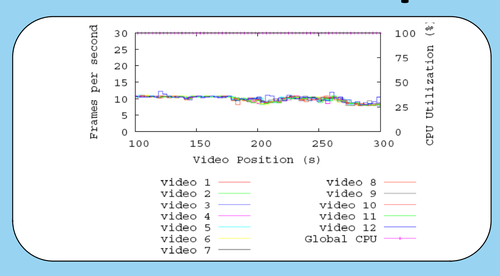
Context Switch Rate.



Throughput as a % of single player case.

- Fairshare at finest granularity has 5x latency of coop, yet context switch rate is 2x worse.
  - ***Cooperative approach leverages application information to context switch in a much more strategic fashion.***

G. Coordinated Adaptation



Frame rate of all 12 videos at overload.

The videos are able to maintain a uniform quality even at overload.

H. Conclusion

Coop + fairshare:

- Gives better timeliness (smaller latency) even under overload.
- Facilitates coordinated adaptation for multiple adaptive tasks.
- Informed context switching is cache efficient – leading to a better timeliness-throughput balance.