Department of Computer Science
UNIVERSITY OF COLORADO BOULDER

Design and Analysis of Operating Systems CSCI 3753

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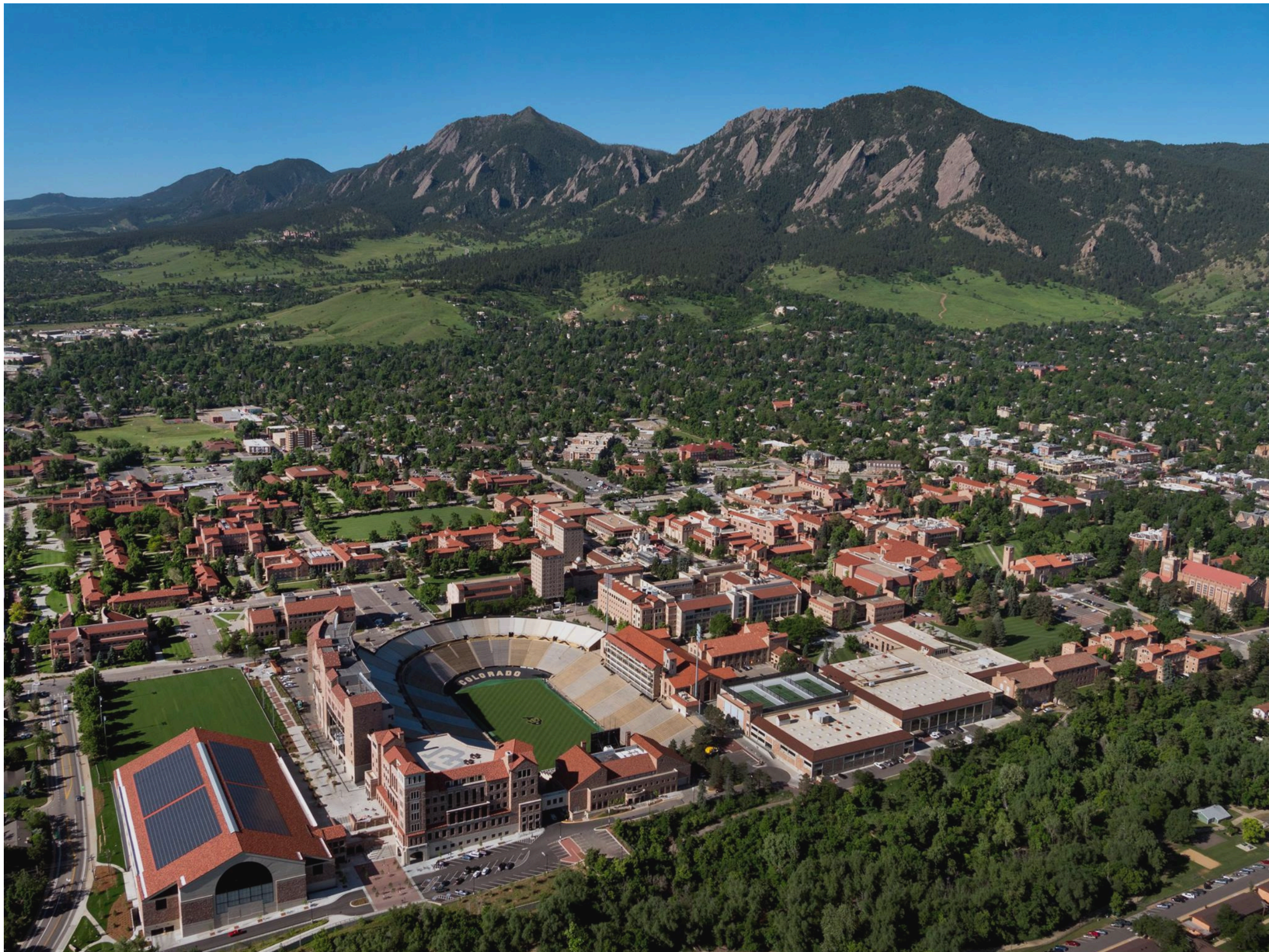
These slides adapted from materials provided by the textbook authors.



Realtime and Multi-Core Scheduling

Real Time Scheduling in Linux

- Linux also includes three **real-time** scheduling classes:
  - Real time FIFO – soft real time (SCHED_FIFO)
  - Real time Round Robin – soft real time (SCHED_RR)
  - Real time Earliest Deadline First – hard real time as of Linux 3.14 (SCHED_DEADLINE)

- Only processes with the priorities 0-99 have access to these RT schedulers

Real Time Scheduling in Linux

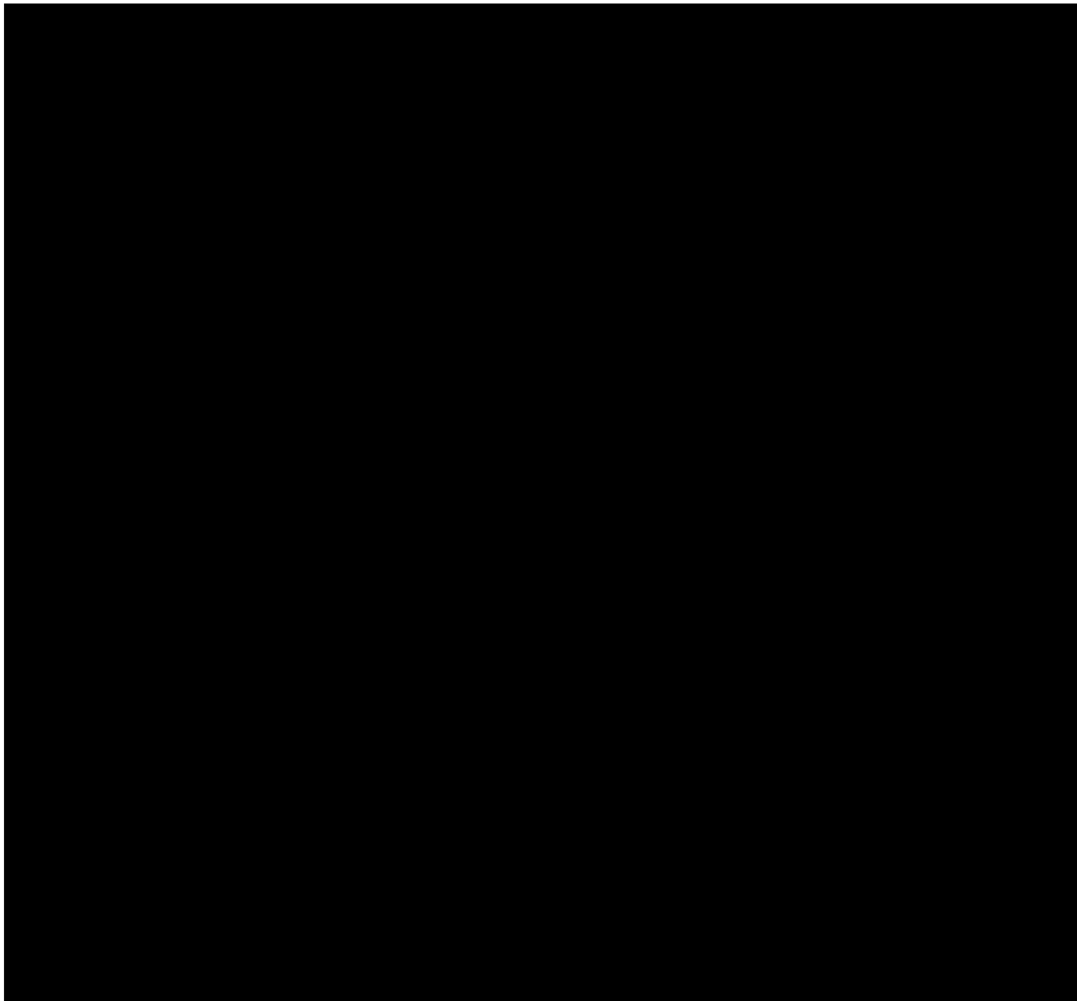
- A real time FIFO task continues to run until it voluntarily yields the processor, blocks or is preempted by a higher-priority real-time task
  - no timeslices
  - all other tasks of lower priority will not be scheduled until it relinquishes the CPU
  - two equal-priority Real time FIFO tasks do not preempt each other

Real Time Scheduling in Linux

- SCHED_RR is similar to SCHED_FIFO, except that such tasks are allotted timeslices based on their priority and run until they exhaust their timeslice
- Non-real time tasks continue to use CFS algorithm
- SCHED_DEADLINE uses an Earliest Deadline First algorithm to schedule each task.

Multi-Core Scheduling

- Scheduling over multiple processors or cores is a new challenge.
    - A single CPU/processor may support multiple cores
- Variety of multi-core schedulers being tried. We'll just mention some design themes.
- In *asymmetric multiprocessing* - one CPU handles all scheduling, decides which processes run on which cores



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Multi-Core Scheduling

- In symmetric multi-processing (SMP), each core is self-scheduling.
- Another self-scheduling SMP approach is when each core has its own ready queue
- Most modern OSs support this paradigm
- Caching is important to consider
- To maximally exploit caching, tasks tend to stick to a given core/processor processor affinity
    - In hard affinity, a process specifies via a system call that it insists on staying on a given CPU core
    - In soft affinity, there is still a bias to stick to a CPU core, but processes can on occasion migrate.
    - Linux supports both

Multi-Core Scheduling

Load balancing

- Goal: Keep workload evenly distributed across cores
- Otherwise, some cores will be under-utilized.
- When there is a single shared ready queue, there is automatic load balancing
- Cores pull in processes from the ready queue whenever they're idle.
- push migration – a dedicated task periodically checks the load on each core, and if imbalance, pushes processes from more-loaded to less-loaded cores
- Pull migration – whenever a core is idle, it tries to pull a process from a neighboring core
- Linux and FreeBSD use a combination of pull and push

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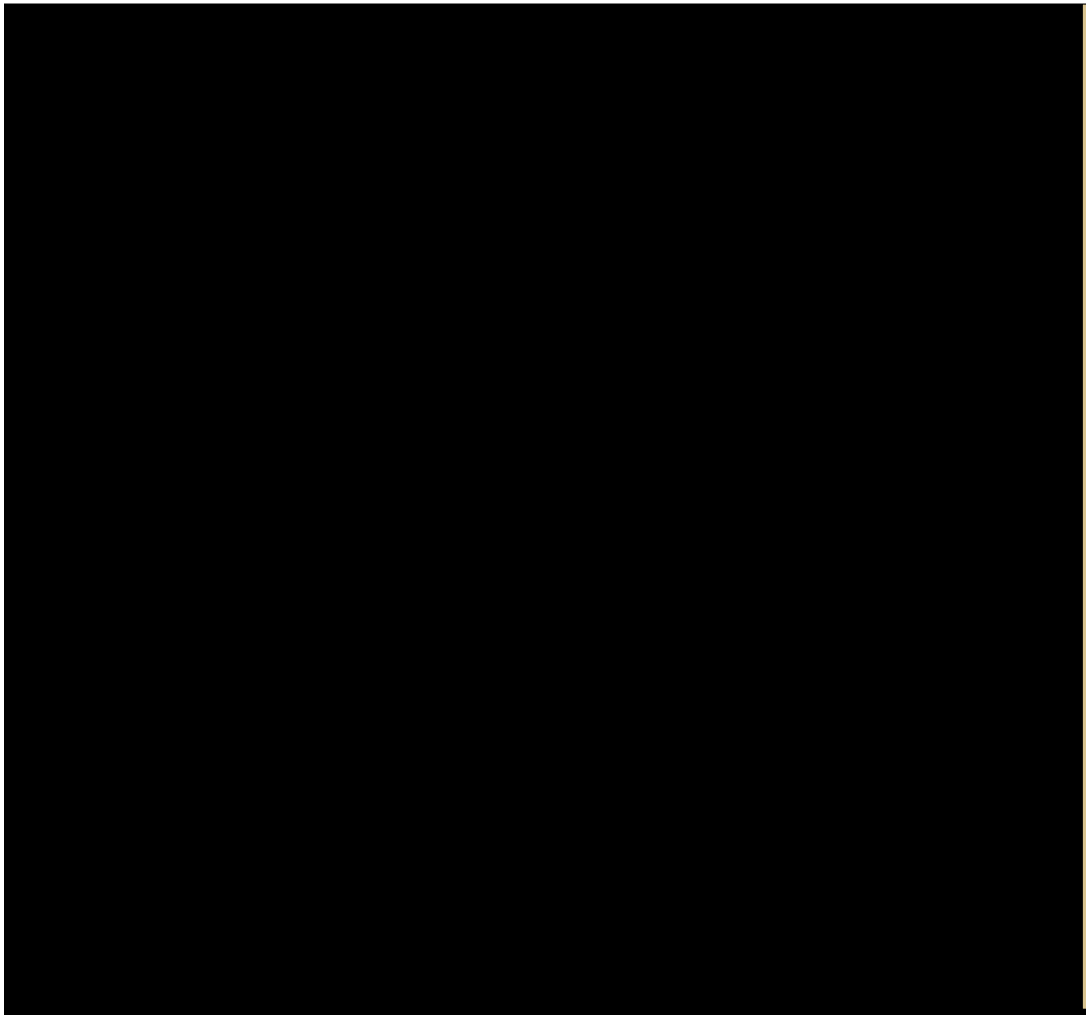

Multi-Core Scheduling

Load balancing

- Load balancing can conflict with caching
  - Push/pull migration causes caches to be rebuilt
- Load balancing can conflict with power management
  - Mobile devices typically want to save power
  - One approach is to power down unused cores
  - Load balancing would keep as many cores active as possible, thereby consuming power
- In systems, often conflicting design goals

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