Multiprocessor OS

CS 256/456
Dept. of Computer Science, University of Rochester

Multiprocessor Hardware
- A computer system in which two or more CPUs share full access to the main memory
- Each CPU might have its own cache and the coherence among multiple cache is maintained
  - write operation by a CPU is visible to all other CPUs
  - writes to the same location is seen in the same order by all CPUs (also called write serialization)
  - bus snooping and cache invalidation

Multiprocessor Applications
- Multiprogramming
  - Multiple regular applications running concurrently
- Concurrent servers
  - Web servers, ... ...
- Parallel programs
  - Utilizing multiple processors to complete one task (parallel matrix multiplication)
  - Strong synchronization

Single-processor OS vs. Multi-processor OS
- Single-processor OS
  - easier to support kernel synchronization - why?
    - disabling interrupts to prevent concurrent executions
    - fine-grained locking vs. coarse-grained locking
  - easier to perform scheduling
    - which to run, not where to run
- Multi-processor OS
  - OS structure
  - synchronization
  - scheduling
Multiprocessor OS

- Each CPU has its own operating system
  - quick to port from a single-processor OS
- Disadvantages
  - difficult to share things (processing cycles, memory, buffer cache)

Multiprocessor OS – Master/Slave

- All operating system functionality goes to one CPU
  - no multiprocessor concurrency in the kernel
- Disadvantage
  - OS CPU consumption may be large so the OS CPU becomes the bottleneck (especially in a machine with many CPUs)

Multiprocessor OS – Shared OS

- All CPUs run a single OS instance
- The OS itself must handle multiprocessor synchronization
  - have a big kernel lock – only one processor can execute in the kernel at a time
  - support fine-grain synchronization

Multiprocessor Kernel Synchronization

- Protecting short critical region - busy waiting is OK
- Disabling interrupts does not work
- Software spin locks
- Hardware spin locks
  - using TSL

entry_section:
```
TSL R1, LOCK    | copy lock to R1 and set lock to 1
CMP R1, #0     | was lock zero?
JNE entry_section | if it wasn’t zero, lock was set, so loop
RET          | return; critical section entered
```

exit_section:
```
MOV LOCK, #0   | store 0 into lock
RET            | return; out of critical section
```
TSL on Multiprocessor

On multiprocessor, the TSL implementation is more complex, usually it has to lock the memory bus.

More on TSL Locks

- Every TSL is a read/write, imagine multiple CPUs are busy waiting on one block, there will be a lot of traffic on the bus.
- Precede each TSL lock will a trylock (basically a simple read).
  - only when trylock shows the lock is not locked, a TSL lock will be applied.

Multiprocessor Scheduling

- Timesharing
  - using a single wait queue (protected by synchronization) for scheduling.
- Cache affinity
  - affinity-based scheduling.
- Synchronization of parallel programs
  - gang scheduling.

Multiprocessor Scheduling in Linux 2.6

- One queue per processor
  - contain multiple priority arrays as in single-processor scheduling.
- One task tends to stay in one queue
  - for cache affinity.
- Tasks move around when load is unbalanced
  - e.g., when the length of one queue is less than one quarter of the other
  - which one to pick?
- No native support for gang scheduling.
Disclaimer

- Parts of the lecture slides contain original work by Andrew S. Tanenbaum. The slides are intended for the sole purpose of instruction of operating systems at the University of Rochester. All copyrighted materials belong to their original owner(s).