Multiprocessor OS

CS 256/456

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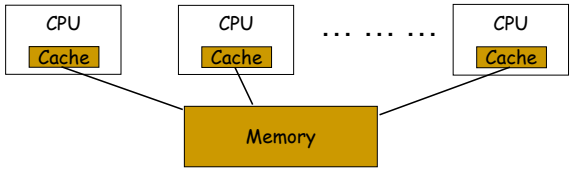
Multiprocessor Hardware

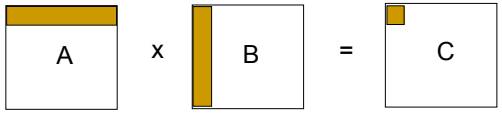
- A computer system in which two or more CPUs share full access to the main memory
- Each CPU might have its own cache and the coherence among multiple cache is maintained
  - write operation by a CPU is visible to all other CPUs
  - writes to the same location is seen in the same order by all CPUs (also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

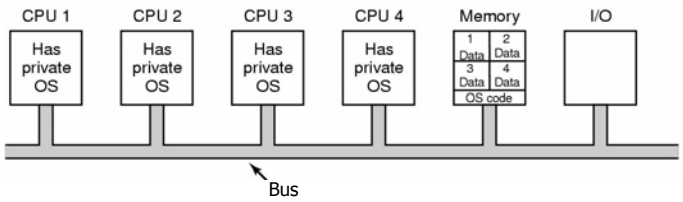


  - Strong synchronization

Single-processor OS vs. Multi-processor OS

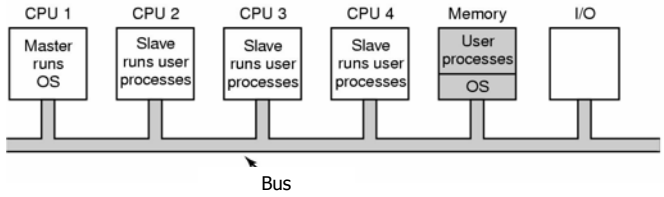
- Single-processor OS
  - easier to support kernel synchronization – why?
    - disabling interrupts to prevent concurrent executions
    - fine-grained locking vs. coarse-grained locking
  - easier to perform scheduling
    - which to run, not where to run
- Multi-processor OS
  - OS structure
  - synchronization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

Multiprocessor OS



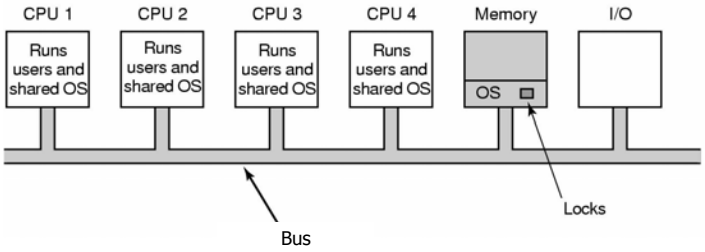
- Each CPU has its own operating system
  - quick to port from a single-processor OS
- Disadvantages
  - difficult to share things (processing cycles, memory, buffer cache)

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

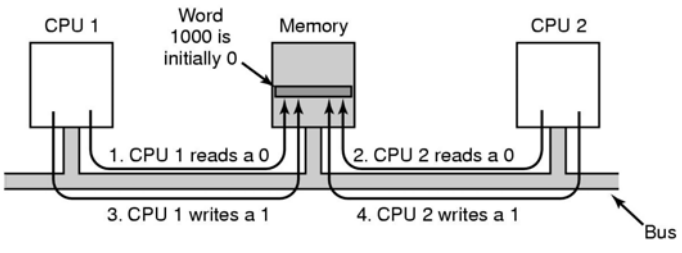
Protecting short critical region – busy waiting is OK

- 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
```

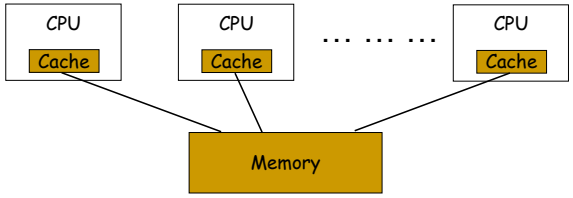
TSL on Multiprocessor



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

More on TSL Locks

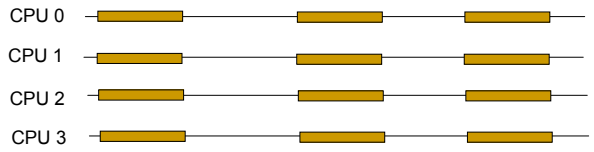
- Every TSL is a read/write, imagine multiple CPUs are busy waiting on one block, there will be a lot of traffic on the bus



- 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

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