Multiprocessor OS

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

Comparisons on OS Extension/Customization

- Approaches
  - Exokernel
  - Downloading code into the kernel
  - The graybox approach
  - OS configuration
  - Virtual machine

- Comparison on
  - flexibility
  - how much changes in the original OS?
  - overall simplicity
  - overhead of each customization/extension

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)

Multiprocessor Applications

- Multiprogramming
  - Multiple regular applications running concurrently

- Concurrent servers
  - Web servers, ...

- Parallel programs
  - Utilizing multiple processors to complete one task
  - Strong synchronization
Single-processor OS vs. Multi-processor OS

- **Single-processor OS**
  - easier to support kernel synchronization - why?
  - easier to perform scheduling - less complex.

- **Multi-processor OS**
  - OS structure
  - synchronization
  - scheduling

Multiprocessor OS

- **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

- **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
  - Bus

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
- CMP R1, #0
- JNE entry_section
- RET

exit_section:
- MOV LOCK, #0
- RET

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

Spin or Yield?

- Multi-processor synchronization.
  - A process is waiting for an event, triggered by another process.
  - Spinning wastes CPU cycles
  - Switching also uses up CPU cycles
  - Should it spin wait or yield the processor?
Multiprocessor Scheduling

- Timesharing
  - using a single wait queue (protected by synchronization) for scheduling

- cache affinity
  - affinity-based scheduling

- synchronization of parallel programs
  - gang scheduling

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