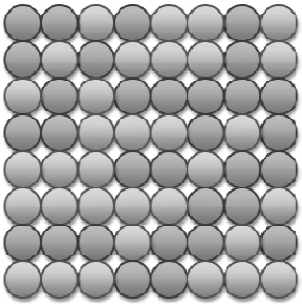


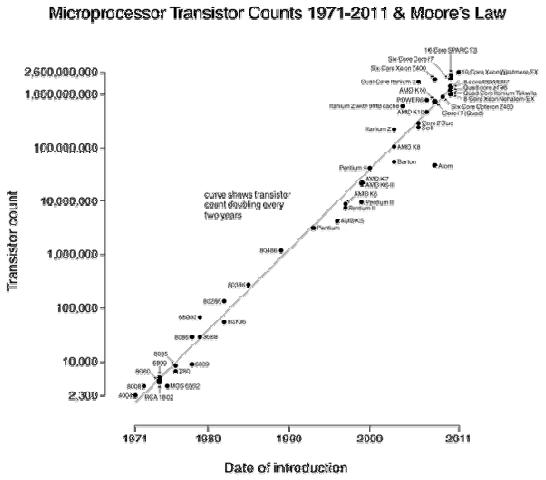
UNIT 10A

Concurrency: Multitasking & Deadlock

Concurrency

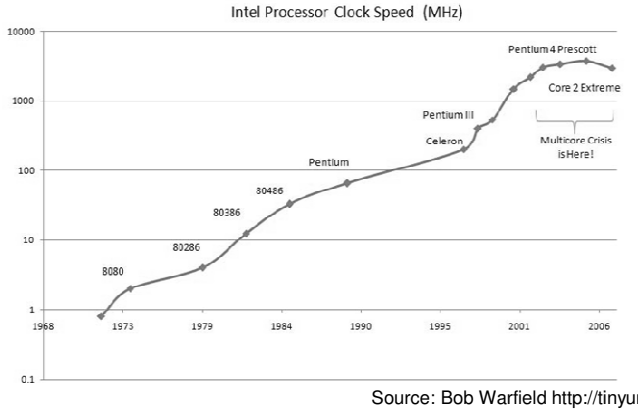
- Concurrency is the process of performing more than one process at a time.
- Computing has many ways to implement concurrency:
  - parallel processing
  - pipelining
  - multitasking
  - distributed computing

Recall Moore's Law



Source: Wikimedia Commons http://tinyurl.com/3d7qf3m

Clock Speed Is No Longer Increasing

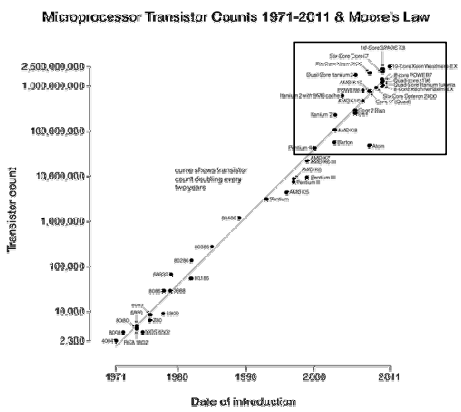


Source: Bob Warfield http://tinyurl.com/3pt6we9

- 1 MHz is 1,000,000 cycles/second
- Each cycle is like "step" operation in MARS

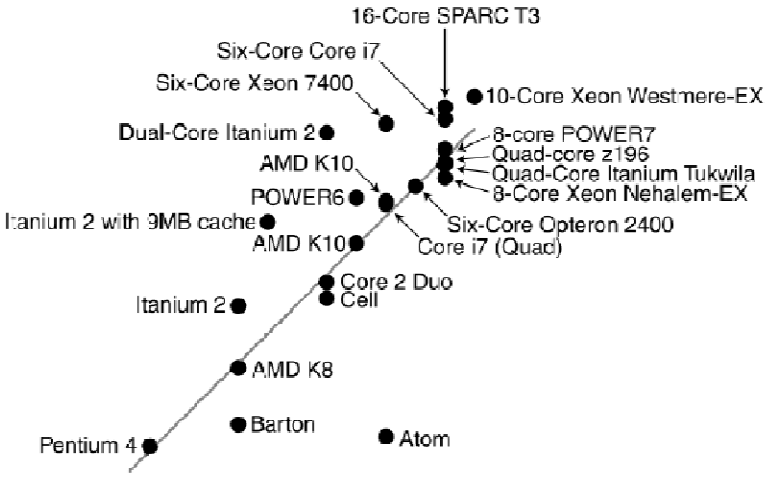
Moore's Law

- MARS single *pc* (program counter) indicates next instruction
- multi-core executing simultaneously at multiple *pc's*
- prediction: thousands of cores



Source: Wikimedia Commons http://tinyurl.com/3d7qf3m

New Processors are Multi-Cores



Multitasking & Operating Systems

- **Multitasking** - The coordination of several computational processes on one processor or several cores.
- An **operating system** (OS) is the system software responsible for the direct control and management of hardware and basic system operations.
- An OS provides a foundation upon which to run application software such as word processing programs, web browsers, etc.

from Wikipedia

Operating System "Flavors"

- UNIX
  - System V, BSD, Linux
  - Proprietary: Solaris, Mac OS X
- Windows
  - Windows XP
  - Windows Vista
  - Windows 7

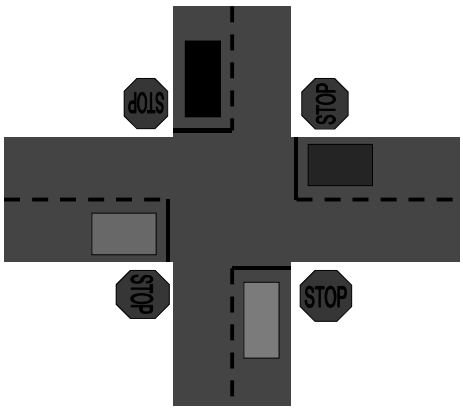
Single-core Multitasking

- Each (un-blocked) application runs for a very short time on the computer's processor and then another process runs, then another...
- This is done at such a fast rate that it appears to the computer user that all applications are running at the same time.
  - How do actors appear to move in a motion picture?

Critical Section

- A **critical section** is a section of computer code that must only be executed by one process or thread at a time.
- Examples:
  - A printer queue receiving a file to be printed
  - Code to set a seat as reserved
  - Web server that generates and returns a web page showing current registration in course

A Critical Section



Cars may not make turns through this intersection. They may only proceed straight ahead. When a car stops at this intersection, it can proceed straight ahead if there is no car to its left and no car to its right. Otherwise it must wait some random amount of seconds and then check again to see if it's safe to proceed. If not, it waits again, and so on.

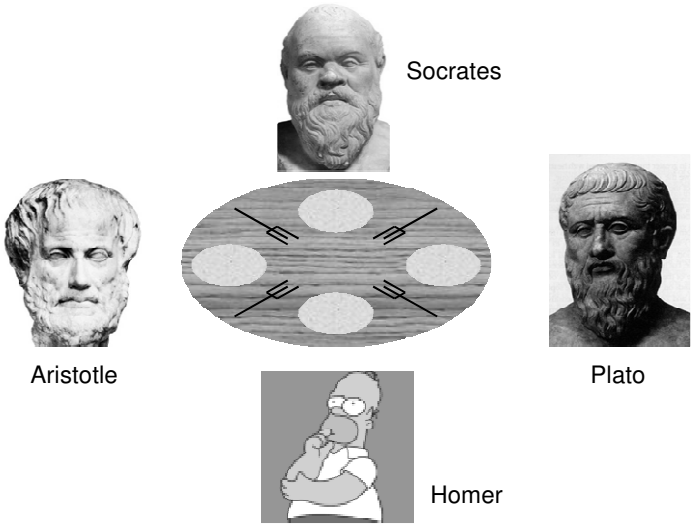
Shared Computing Resources

- memory
- tape drives
- disk drives
- printers
- communication ports
- input devices (keyboard, mouse)

Deadlock

- Deadlock is the condition when two or more processes are all waiting for some shared resource that other processes of the group hold, causing all processes to wait forever without proceeding.
- How can deadlock occur at the intersection with the 4-way stop?

Dining Philosopher's Problem



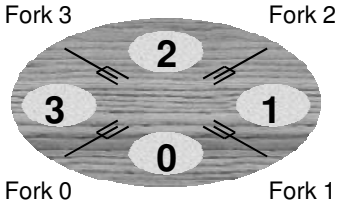
The Dining Philosopher's

- Each philosopher thinks for a while, then picks up his left fork, then picks up his right fork, then eats, then puts down his left fork, then puts down his right fork, thinks for a while...
  - We assume here that each philosopher thinks and eats for random times, and a philosopher cannot be interrupted while he picks up or puts down a single fork.
- Each fork models a "resource" on a computer controlled by an OS.
- Original problem proposed by Edsgar Dijkstra.

Dining Philosopher's Problem

- There are N philosophers.
- Philosopher i does the following:
  1. THINK
  2. Pick up fork i.
  3. Pick up fork (i+1) modulo N.
  4. EAT
  5. Put down fork i.
  6. Put down fork (i+1) modulo N.
  7. Go to step 1.

N=4



NOTE: (i+1) modulo N = i+1 , if 0 ≤ i < N-1
(i+1) modulo N = 0, if i = N-1

Dining Philosopher's Problem

- There are N philosophers.
- Philosopher i does the following:
  1. THINK
  2. Pick up fork i.
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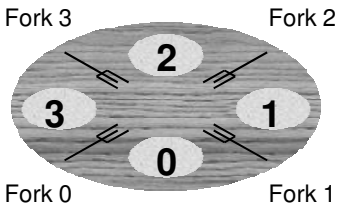
N=4

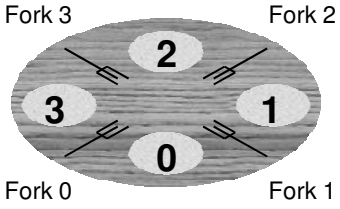


How can deadlock occur here?

Removing Deadlock

- Philosopher i performs the following:
  1. THINK
  2. If i is not equal to N-1:
     a. Pick up fork i
     b . Pick up fork i+1
  3. If i equals N-1:
     a. Pick up fork 0
     b . Pick up fork N-1
  4. EAT
  5. If i is not equal to N-1:
     a. Put down fork i
     b . Put down fork i+1
  6. If i equals N-1:
     a. Put down fork 0
     b . Put down fork N-1
  7. Goto step 1

N=4



Semaphores

- A (binary) semaphore S is a shared variable that holds an integer that is initialized to 1.
- We can use a semaphore to protect a critical section so that only one process accesses this section at a given time:

non-critical program code
Request S
CRITICAL SECTION
Release S
non-critical program code

Initially, semaphore S is 1. The first process to request S sets S to 0, blocking other processes from proceeding once they get to their request operations. Once the first process finishes running the critical section, it releases S, causing S to increase to 1, allowing another process to proceed into the critical section.

Other Types of Concurrency

- Parallel processing
- Concurrent networks
- Pipelining
- Distributed processing