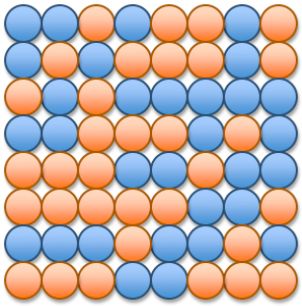
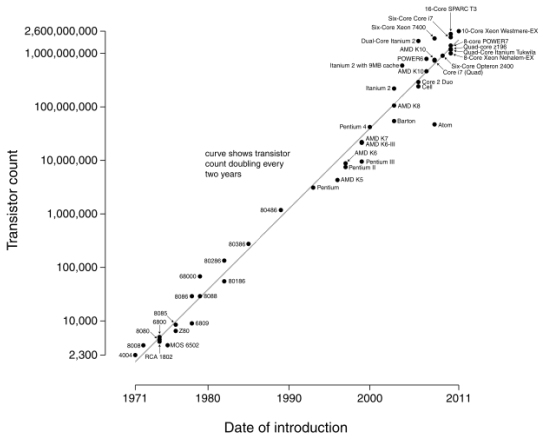


UNIT 10B
Concurrency: Multitasking & Distributed Processing

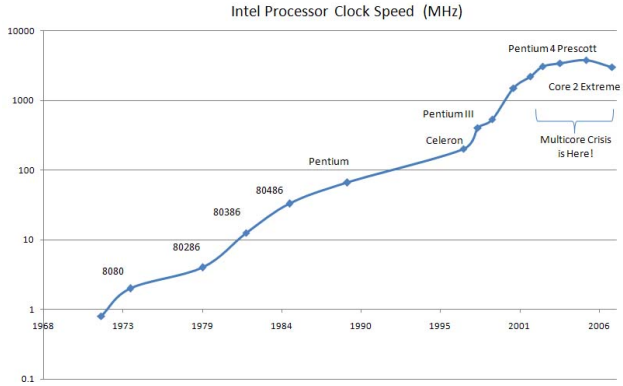
Recall Moore's Law

Microprocessor Transistor Counts 1971-2011 & Moore's Law



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

Clock Speed Is No Longer Increasing

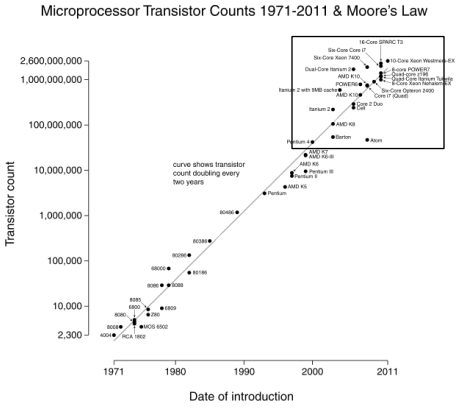


Source: Bob Warfield http://tinyurl.com/3pt6we9

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

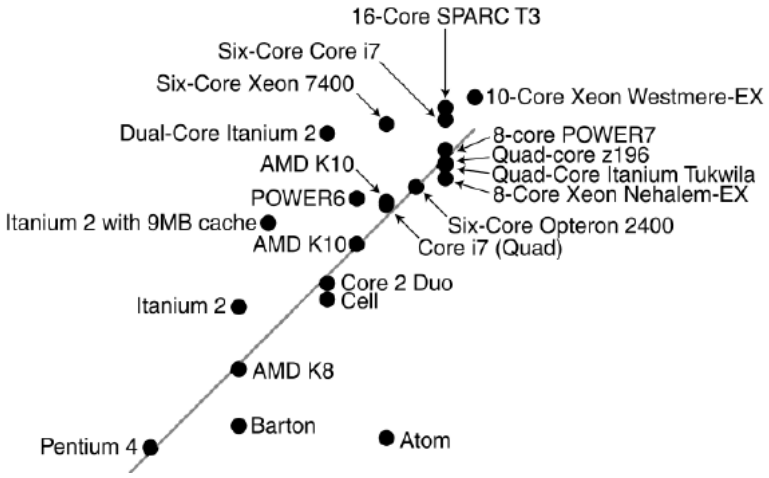
Moore's Law

- 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

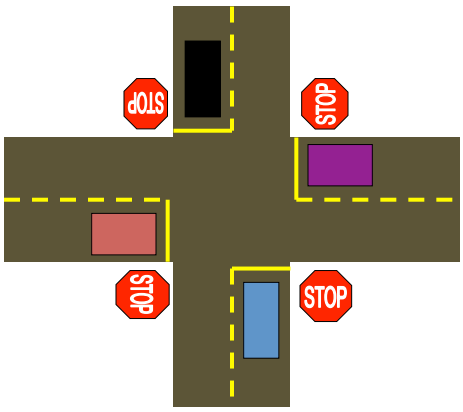


- Each (un-blocked) application runs for a very short time on the computer's processor and then another process runs, then another...
- This is done at such a fast rate that it appears to the computer user that all applications are running at the same time.
  - How do actors appear to move in a motion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

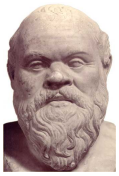
Shared Computing Resources

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

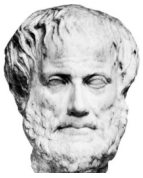
Deadlock

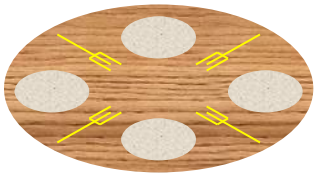
- Deadlock is the condition when two or more processes are all waiting for some shared resource that other processes of the group hold, causing all processes to wait forever without proceeding.
- How can deadlock occur at the intersection with the 4-way stop?

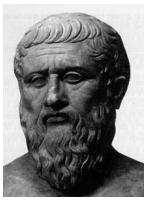
Dining Philosopher's Problem



Socrates







Aristotle

Plato

Homer

The Dining Philosopher's

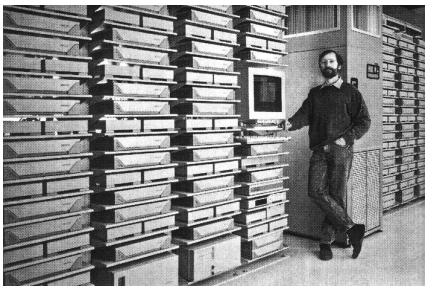
- Each philosopher thinks for a while, then picks up his left fork, then picks up his right fork, then eats, then puts down his left fork, then puts down his right fork, thinks for a while...
  - We assume here that each philosopher thinks and eats for random times, and a philosopher cannot be interrupted 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.

Distributed Systems

- A distributed system is an application that consists of processes that
  - execute on multiple computers connected through a network, and
  - cooperate to accomplish a task.
- Advantages
  - open
    - add new parts and interact with remote users
  - scalable
    - system can be altered to accommodate changes in numbers of users, resources, computer systems

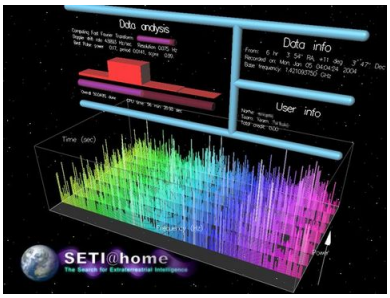
Render Farms

- Rendering
  - flatten a 3-d space to a 2-d
  - lighting (raytracing)
  - potential concurrency
    - frames
    - pixels within a frame
- Toy Story (1995)
  - about 4 hours for each frame
  - 80 SPARCstation 20 systems
  - 1 SPARCserver 1000 system



SETI@home

- Search for Extraterrestrial Intelligence
  - telescopes pointed at the sky
  - scan for "artificial signals"
- SETI@Home
  - splits data into work units
    - frequency: 10 kHZ
    - time: 107s
  - SETI@home screensaver
    1. receives work unit
    2. processes work unit
    3. returns work unit



Challenge of Distributed Computing: Reliability in Context of Failure

Failure is the defining difference between distributed and local programming, so you have to design distributed systems with the expectation of failure. Imagine asking people, "If the probability of something happening is one in 1013, how often would it happen?" Common sense would be to answer, "Never." That is an infinitely large number in human terms. But if you ask a physicist, she would say, "All the time. In a cubic foot of air, those things happen all the time." When you design distributed systems, you have to say, "Failure happens all the time." So when you design, you design for failure. It is your number one concern.

— Ken Arnold

Examples of Failures

- permanent network failures
- dropped messages between sender and receiver
- an individual computer breaks
- a process crashes or goes into an infinite loop