Introduction

CSE 410, Spring 2006

Computer Systems

http://www.cs.washington.edu/education/courses/410/06sp/

Reading and References

- Reading
  - » Chapter 1, *Computer Organization and Design, Patterson and Hennessy*
- Other References
  - » The Rope and Pulley Wonder, in *The Tinkertoy Computer, A. K. Dewdney*

Administrative

- Instructor:
  - » Doug Johnson
- TAs:
  - » Jarret Falkner
  - » Jim Li
- All class info is on the web site
  - » http://www.cs.washington.edu/410/CurrentQtr
  - » links for sending us email are there too

Class Overview

- Provide an introduction to the inner workings of computer systems
- Levels of abstraction
  - » bits, bytes, assembly language
  - » operating system concepts
  - » higher level languages - C, C++, Java, …
  - » application programs

Goal

- You will understand
  - » what is actually happening when a computer system is running application programs
- So that you will be able to
  - » make good design choices as a developer, project manager, or system customer
  - » calibrate your hype-o-meter with facts

The structure of this class

- The hardware / software interface
  - » the elements of a computer system
  - » what parts are visible to the software
  - » instruction set architecture (ISA)
  - » what happens inside the CPU
- Operating systems
  - » services an OS performs for an application
  - » design of various OS components
  - » OS mechanisms and policies
  - » why my OS crashes ☺

Computers

- Computers impact our lives in a huge number of ways:
  - » Computer-controlled brakes in your car
  - » You look up everything with Google
  - » You take a picture of a bad cut with your cell phone and email it to your doctor
  - » You download music for your MP3 player
- All this has been enabled by an incredible advance in microprocessor technology

Evolution of Intel CPU Speeds

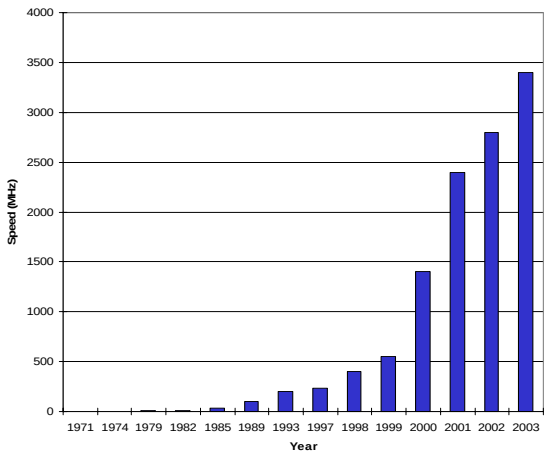
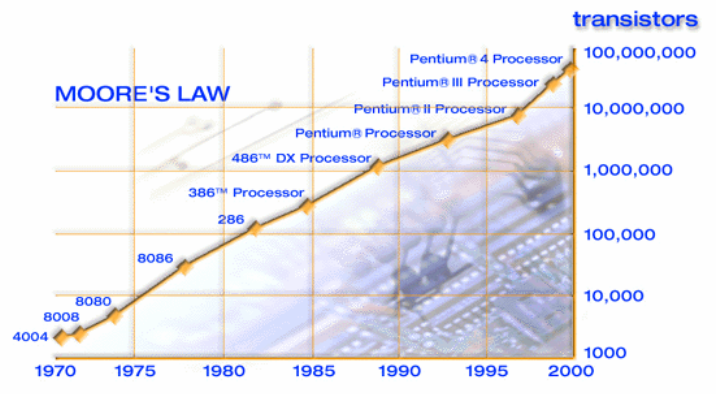


Illustration of Moore's Law



A modern CPU

- Latest Intel P4
  - » 3.6 gigahertz
  - » 2 MB L2 cache
  - » 20-stage pipeline
  - » out-of-order instruction execution
  - » branch prediction
  - » 100s of instructions executing at once
  - » "hyper-threading" technology
  - » …….

What's next

- We're in trouble
  - » hard to go much faster with uniprocessors
  - » chips have gotten so big, it's a long way from one side to the other (in cycles)
  - » as chips get bigger, chance of errors in the chip goes up
  - » we need new ways to build faster computers
  - » these new ways usually involve adding more parallelism
- In a few years, every chip will have multiple CPUs on it (maybe 4 to 16) [called "multi-core"]

Layers of abstraction

- Abstraction
  - » defines a layer in terms of functions / interfaces
  - » isolates a layer from changes in the layer below
  - » improves developer productivity by reducing detail needed to accomplish a task
  - » helps define a single architecture that can be implemented with more than one organization

Architecture and Organization

- Architecture
  - » defines elements and interfaces between layers
  - » ISA: instructions, registers, addressing
- Organization
  - » components and connections
  - » how instructions are implemented in hardware
  - » many different organizations can implement a single architecture

Computer Architecture

- Specification of how to program a specific computer family
  - » what instructions are available?
  - » how are the instructions formatted into bits?
  - » how many registers and what is their function?
  - » how is memory addressed?
  - » how does I/O work?
- The MIPS 1 architecture is the basis for the first half of this course

Architecture Families

- IBM 360, 370, … (the first computer family)
- PowerPC 601, 603, …
- DEC VAX, PDP-11
- Intel x86: 286, 386, 486, Pentium, P4,…
- Intel IA64 Itanium
- MIPS R2000, R3000, R4000, R5000, ...
- SUN Sparc

Computer Organization

- Processor
  - » datapath (functional units) manipulate the bits
  - » control hardware manages the manipulation
- Memory
  - » Registers – 100s of bytes, very fast, on the CPU
  - » cache memory – 1000s of bytes, fast, on the CPU
  - » main memory – millions of bytes, slower, off the CPU
- Input / Output
  - » interface to the rest of the world

Architecture and Organization

- Architecture is a layer of abstraction
- One architecture can be implemented with many organizations
- One organization can support multiple architectures
- Different manufacturing technologies

Many possible implementations

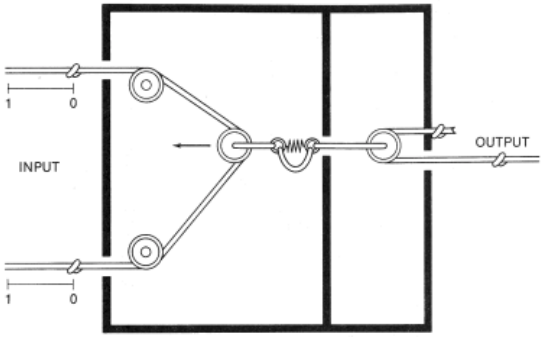
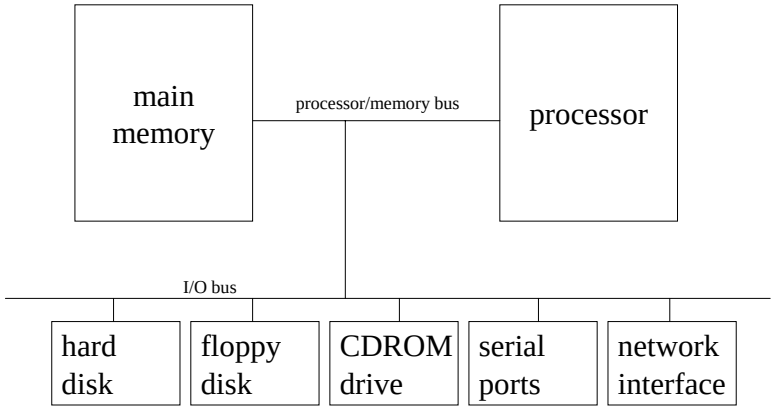


Figure 2.4 The Apraphulian AND gate.

A typical organization



Change Organization or Architecture?

- Theory
  - » Organization changes provide incremental changes in speed and cost for same software
  - » Architecture changes enable breakthrough changes in speed and cost for new software
- Real life
  - » incremental changes are very rapid (once a year)
  - » breakthrough changes are very costly (once a decade)

A quick hardware tour

- System board
  - » CPU, memory, I/O bus
- Hard disk
  - » 3600+ RPM, 8ms latency, 3-15 ms seek
- Monitor
  - » CRT, LCD
- Mouse, keyboard
  - » embedded processors