
Introduction

CSE 410, Spring 2007
Computer Systems

<http://www.cs.washington.edu/410/>

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Reading and References

- Reading
 - » *Computer Organization and Design, Patterson and Hennessy*
 - Chapter 1
 - Chapter 2, secs. 2.1-2.4

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Administrative

- Instructor:
 - » Hal Perkins
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- TA:
 - » Daria Craciunoiu
- All class info is on the web site
 - » <http://www.cs.washington.edu/410/>
 - » links for sending us email will be there too

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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

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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

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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

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Computers

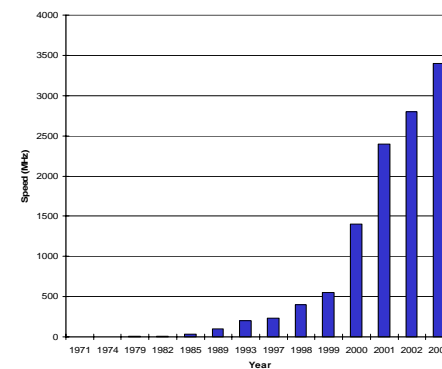
- Computers impact our lives in a huge number of ways:
 - » Computer-controlled brakes in your car
 - » You look up everything with Google
 - » You take a picture of a bad cut with your cell phone and email it to your doctor
 - » You download music for your MP3 player
- All this has been enabled by an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

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Evolution of Intel CPU Speeds

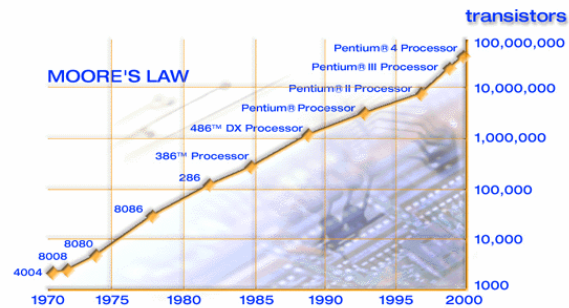


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Illustration of Moore's Law



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A modern CPU

- Recent 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
 - »

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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 (2-4 now, 16-64 soon) [called “multi-core”]
 - » (How will we take advantage of this? Open question...)

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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
- Layers can be hardware, software, or a combination

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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

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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
 - » Why not a “real” computer? (e.g., x86)

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Architecture Families

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

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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

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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

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Many possible implementations

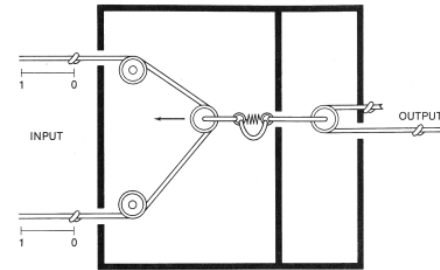


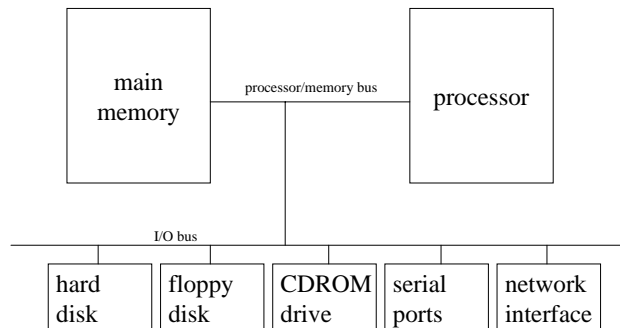
Figure 2.4 The Apraphulian AND gate.

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A typical organization



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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)

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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