CSE 410 - Computer Systems
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http://www.cs.washington.edu/410

Administrative

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- <u>All</u> class info is on the web site
  - http://www.cs.washington.edu/410
  - also known as
    - http://www.cs.washington.edu/education/courses/cse410/01au/

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

- ## In other words ...
  - 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)
- Operating systems
  - services an OS performs for an application
  - design of various OS components

Elements of a computer system

- Start with a point of view
  - purchase a CD on the Web
  - get class schedule from MyUW
  - write a resume using Word
  - write a Java program to do image processing
  - write a C program to read real time data
  - write assembly language for matrix operations
  - write microcode for instruction emulation

"Top Level" elements

- At any level of abstraction, there are
  - elements at that level
  - the building blocks for those elements
- Rope analogy in the book
  - a cable: three hawsers twisted together
  - a hawser: three strands of many yarns
  - down to the molecular level and beyond

Purchase a CD on the Web

- the "top level" system includes
  - your browser, your desktop computer
  - connection to the internet (ISP)
  - server - http://www.amazon.com/
  - server application code
    - method="POST"
    - action="/exec/obidos/handle-buy-box=B00005NFZB/…"
    - ...

Write a resume using Word

- the "top level" system includes
  - winword.exe - the application program
  - Contemporary Resume.dot - document template
  - resume.doc - the file containing the text
  - Windows Explorer - file manager
  - network file and printer sharing

Write assembly language for matrix operations

- the "top level" system includes
  - programmer's editor (eg, Context)
  - assembler - convert source to machine language
  - linker, loader - build and run executable
  - Instruction Set Architecture (ISA) that you are writing the code for
    - defines the programmer-visible face of the CPU
    - in this class, we will be writing for MIPS 1 ISA

Layers of abstraction

- Abstraction

  - isolates a layer from changes in the layer below

  - improves developer productivity by reducing detail needed to accomplish a task

  - helps define a single <u>architecture</u> that can be implemented with more than one <u>organization</u>

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?

- The MIPS 1 architecture is the basis for the first half of this course

Architecture Families

- IBM 360, 370, …
- PowerPC 601, 603, …
- DEC PDP-11
- Intel x86 286, 386, 486, Pentium, …
- Motorola 680x0
- MIPS R2000, R3000, R4000, R5000, ...

Computer Organization

- Processor
  - datapath (functional units) manipulate the bits
  - control controls the manipulation

- Memory
  - cache memory - smaller, higher speed
  - main memory - larger, slower speed

- Input / Output
  - interface to the rest of the world

Organizations and Architectures

- Architecture is another abstraction layer
- One architecture can be implemented with many organizations
- One organization can support multiple architectures
- Different manufacturing technologies
  - TTL, ECL, PMOS, NMOS, CMOS
  - ropes and pulleys - see Dewdney reference
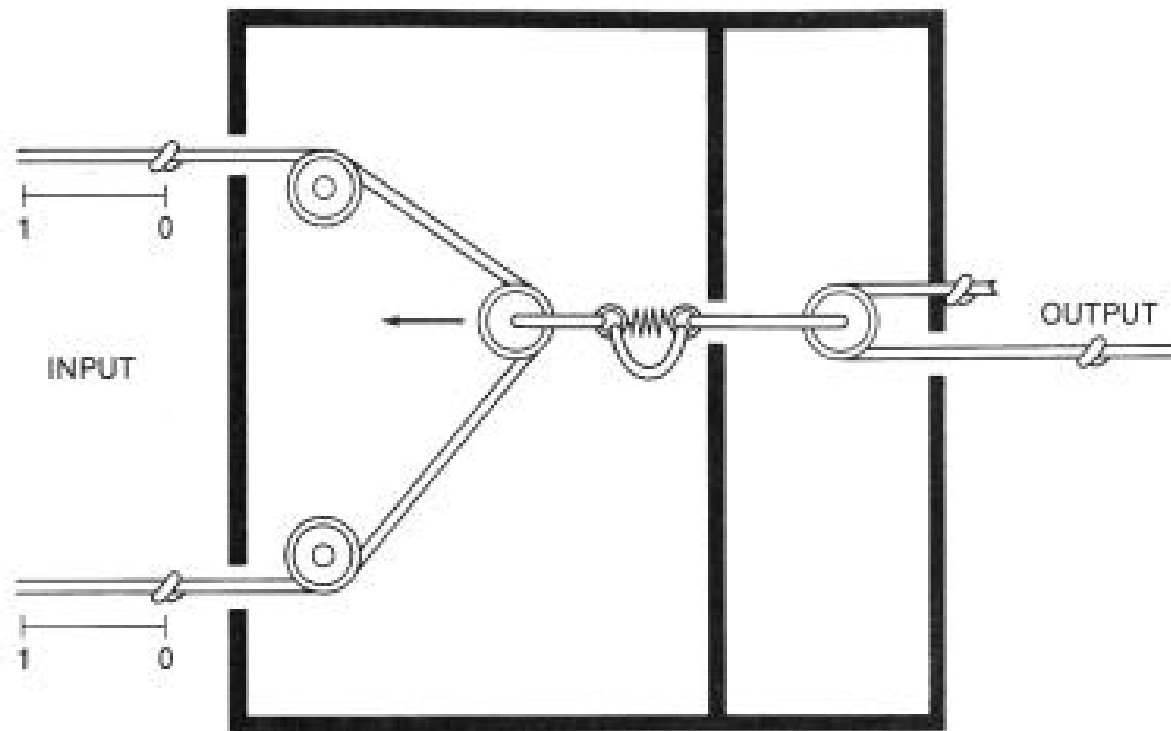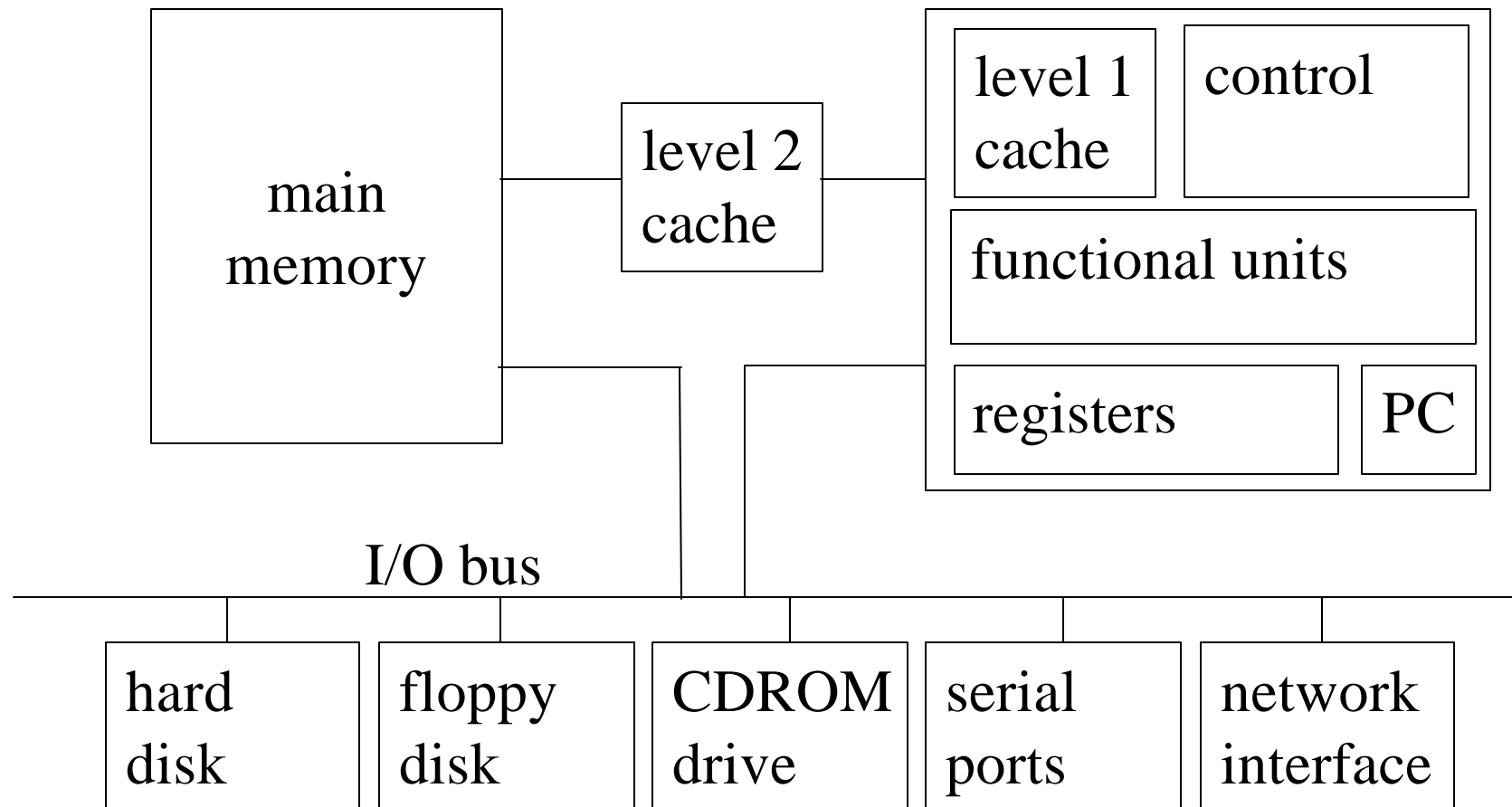
Many possible implementations

Figure 2.4 The Apraphulian AND gate.

A typical organization

```
+------------------+        +-------------+        +---------------------------------------+
|                  |        |             |        | +-------------+  +-----------------+   |
|                  |        |             |        | | level 1     |  | control         |   |
|                  |        | level 2     |        | | cache       |  |                 |   |
|   main           |--------| cache       |--------| +-------------+  +-----------------+   |
|   memory         |        |             |        | +-----------------------------------+ |
|                  |        |             |        | | functional units                  | |
|                  |        +-------------+        | +-----------------------------------+ |
|                  |                               | +------------------+  +-----------+   |
|                  |                               | | registers        |  |   PC      |   |
+------------------+                               | +------------------+  +-----------+   |
         |                   |          |          +---------------------------------------+
```

I/O bus

```
+----------+   +----------+   +----------+   +----------+   +-----------+
| hard     |   | floppy   |   | CDROM    |   | serial   |   | network   |
| disk     |   | disk     |   | drive    |   | ports    |   | interface |
+----------+   +----------+   +----------+   +----------+   +-----------+
```

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

  - breakthrough changes are very costly

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

Reading and References

- Reading

  – Chapter 1, Patterson and Hennessy, Computer Organization & Design

- Other References

  – A. K. Dewdney, The Rope and Pulley Wonder, in *The Tinkertoy Computer*, W. H. Freeman, New York, 1993