

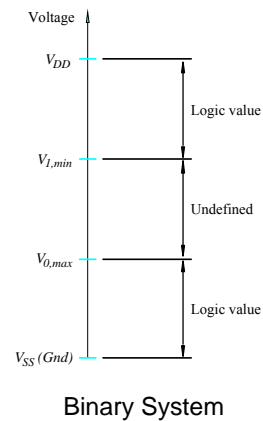
Course Overview

CIT 595
Spring 2008

INTRODUCTION

Digital Systems Organization & Design

- A **digital** system is one that uses discrete values for input, storage, processing, transmission etc. rather than a continuous spectrum of values (i.e. as in an analog system)
- In CIT 593 we studied that a **computer** is one such system
- In CIT 595 we will explore the organization and design of a computer system



Computer Architecture vs. Organization

Computer Architecture

- Logical aspects of system implementation as seen by the programmer
- Such as instruction sets and formats, opcode, data types, addressing modes
- E.g. LC3 ISA studied in CIT 593
- Answers the question: *How do I design a computer?*
 - E.g. Do I want 1, 8, or 32 register?
 - We'll see that number of registers affects program performance due to organization of memory

Computer Architecture vs. Organization

Computer Organization

- Encompasses all physical aspects of computer systems
 - Circuit design, control signals, memory types
- Answers the question: *How does a computer work?*
- We will study this in CIT 595 and much more...

It will be evident that both architecture and organization are interrelated and interdependent

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Why study computer organization ?

- To understand the physical limitations of the underlying hardware on which your software runs
- Design better programs, including system software such as compilers, operating systems, and device drivers
- Optimize program behavior
- Evaluate computer system performance (time, price and space tradeoff)

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REVIEW

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The Computer Level Hierarchy

Each layer is an abstraction of the level below it

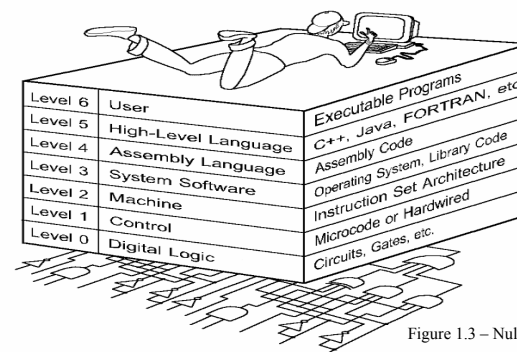


Figure 1.3 – Null and Lobur text

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The Computer Level Hierarchy

- Level 6: The User Level
 - Composed of application programs such as Word Processor, Paint etc.
 - The implementation of the application is hidden completely from the user
- Level 5: High-Level Language Level
 - The level allows users to write their own application with languages such as C, Java and many more
 - High-level languages are easier to read, write, and maintain
 - User at this level sees very little of the lower level

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The Computer Level Hierarchy

- Level 4: Assembly Language Level
 - Lowest human readable form before dealing with 1s and 0s (machine language)
 - Assembler converts assembly to machine language
- Level 3: System Software Level
 - Operating System software supervises other programs
 - Controls execution of multiple programs
 - Protects system resources. E.g. Memory and I/O devices
 - Other utilities
 - Compilers, Interpreters, Linkers, Libraries etc.
 - The software can be written in both assembly and high-level language
 - High-level is much more portable i.e. easier to modify to work on other machines

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The Computer Level Hierarchy

- Level 2: Machine Level
 - Also known as the Instruction Set Architecture (ISA) Level
 - Consists of instructions that are particular to the architecture of the machine
 - Programs written in machine language (0s and 1s) need no compilers, interpreters, or assemblers
- Level 1: Micro-architectural Level
 - In Null & Lobur text this level is called "Control level"
 - Detailed organization of a processor implementation
 - How the control unit interprets machine instructions (from fetch thru execute stages)
 - There can be different implementations of an ISA

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The Computer Level Hierarchy

- Level 0: Digital Logic Level
 - This level is where we view physical devices as just switches (On/Off)
 - Instead of viewing their physical behavior (i.e. in terms of voltages and currents) we use two value logic i.e. 0 (off) and 1 (on)
 - We will briefly look at the physical electronic components – mainly the transistor technology

CIT 593	CIT 595
level 6 - 4, and level 2	level 3, 1, 0

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First Generation Digital Computer

- On the ENIAC, all programming was done at the digital logic level
- Programming the computer involved moving plugs and wires



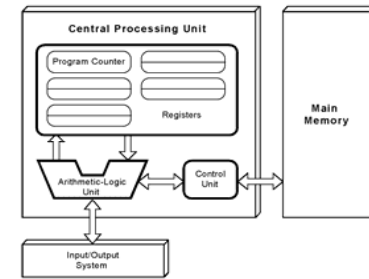
Source: <http://www.computermuseum.li/Testpage/05HISTORYCD-ENIAC-Photos-I.htm>

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The von Neumann Model

- The capacity to carry out sequential instruction processing
- The data transfer between the CPU & memory or CPU & I/O system done using a *bus*
 - A bus collection of electrical wires that can transfer x-bits



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PREVIEW

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Digital Logic Design

- Fundamental concepts of electricity
 - Current, voltage, resistance
- Electronic “switches”
 - Vacuum tube → transistor
 - Transistor - basis of Logic gates (NOT/OR/AND)
 - Computer components such as ALU, memory are built from logic gates



8K memory

Source: www.techtree.com

Other sources:

<http://www.computermuseum.li/Testpage/IntroToVacuumTubes.htm>

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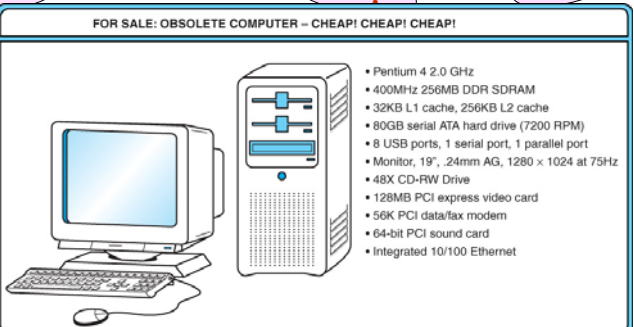
Computer System Example

PCI!??

DDR!??

MHz!??

FOR SALE: OBSOLETE COMPUTER – CHEAP! CHEAP! CHEAP!



- Pentium 4 2.0 GHz
- 400MHz 256MB DDR SDRAM
- 32KB L1 cache, 256KB L2 cache
- 80GB serial ATA hard drive (7200 RPM)
- 8 USB ports, 1 serial port, 1 parallel port
- Monitor, 19", .24mm AG, 1280 x 1024 at 75Hz
- 48X CD-RW Drive
- 128MB PCI express video card
- 56K PCI data/fax modem
- 64-bit PCI sound card
- Integrated 10/100 Ethernet

L1 Cache!??

What does it all mean?

USB!??

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Before we jump into the example....

Measurement Metric

- Kilo- (K) = 1 thousand = 10^3 and 2^{10}
- Mega- (M) = 1 million = 10^6 and 2^{20}
- Giga- (G) = 1 billion = 10^9 and 2^{30}
- Tera- (T) = 1 trillion = 10^{12} and 2^{40}

- Whether a metric refers to a power of 10 or 2 **typically** depends upon what is being measured
 - Power of 2 is associated with memory size
 - Power of 10 is associated with speed i.e. how fast is information transferred

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Pentium 4 2.0 GHz

- 2.0 GHz refers to clock speed/rate of the Pentium 4
- Clock
 - Is used to synchronize events in the computer system
 - Events are synchronized on the clock tick or pulse or cycle
 - Clock Speed/Rate = $1/\text{Clock Cycle}$
- Hz = Hertz = cycles per second (frequency)
 - E.g. 1GHz = 10^9Hz (Giga = 10^9)
- Clock Speed is crucial for computer performance
 - 2 billion instructions can be executed in one second OR 1 instruction takes 0.5×10^{-9} s or 0.5ns
 - However we will see that the number of instruction executed in a second is only proportional to the speed (not equal)

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400 MHz 256MB DDR SDRAM

- DDR SDRAM is type of memory
 - Synchronous Dynamic Random Access Memory
 - DDR – Dual Data Rate (has to do with how data accessed on the clock pulse)
- 400 MHz refers to rate at which data is transferred between CPU and Memory (i.e. bus transfer rate)
- The memory capacity is 256MB (i.e. how much information you can store)
- More DRAM mechanics in chapter 6 (Null & Lobur).

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32KB L1 and 256KB L2 Cache

- Memory speed has not caught with processor speed
- To avoid bottleneck, provide small fast memory in between CPU and main memory called **Cache**
 - Cache is faster than main memory in terms of data access
 - Caches can be hierarchical (2 levels is common)
- Constructed from memory called Static Random Access Memory (SRAM)
 - We will look into the cache mechanics in chapter 3 & 6 (Null & Lobur text)

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80 GB serial ATA hard drive

- Hard Drive is non-volatile information storage device
- Its storage capacity is greater than memory
 - E.g. 512 MB DRAM vs. 80 GB Hard Drive
 - But they are inherently slower in term of accessing data
 - This due to medium of storage used
 - Many techniques of placing data blocks on disk can increase drive performance
- ATA stands for *advanced technology attachment*
 - Describes how the hard disk interfaces with (or connects to) inside a computer system
 - Brief discussion on interfaces on I/O topic
 - Other Interfaces e.g. SCSI, SATA, Fibre Channel

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Peripheral Component Interface PCI

- A **peripheral** is a type of computer hardware device that is added to a computer in order to expand its abilities.
- PCI is dedicated I/O bus for peripherals such as video, audio, fax/modems & Ethernet etc.
- The PCI specification covers
 - The physical size of the bus (including wire spacing),
 - Electrical characteristics, bus timing, and protocols.
 - The specification was formed by PCI Special Interest Group

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More realistic view of computer system

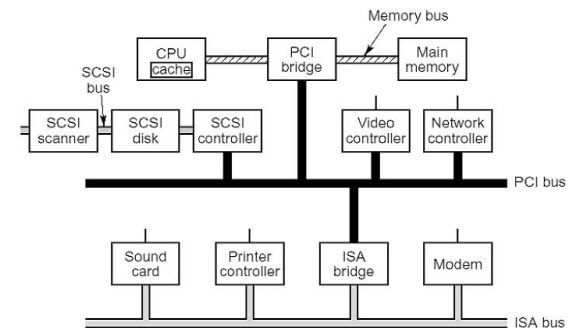


Figure 2-30 (Structured Computer Organization – Tanenbaum)

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Other components in Example

- USB – Universal Serial Bus
 - Designed to allow peripherals to be connected using a single standardized interface socket
 - Improve plug-and-play capabilities by allowing devices to be connected and disconnected without rebooting the computer
- CD-R/W or DVD R/W
 - Optical data storage
 - More recent e.g. Blue-Ray and HD format
- Ethernet, Display Monitors

Note:

Not be able to touch on the above topics
If interested take it up as project topic

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One more thing ...

- Anything missing from the example?
 - An Operating System (O.S)
- System is really incomplete without O.S., why?
 - Controls execution of multiple programs
 - Protects system resources. E.g. Memory and I/O devices
 - Manages the File System on Hard Disk
- Topics
 - Operating System (O.S) design
 - O.S. services
 - Concept of processes, and threads
 - Programming Tools

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Other Advanced Topics

1 or 2 from the list below (due time constraint):

- Virtual Machines
 - Look at Java Virtual Machine (JVM)
- Garbage Collection in Collection in modern programming languages
- Processor Architectures
 - Multiprocessors and Parallel

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Looking Forward

- Learn the components introduced in detail and also see their interaction with other components

Project

- You will also get a chance to do some exploring of you own on hardware or software technology
- It may be existing or emerging technology

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Next Time

- Historical Development & some background on transistors
- Boolean Algebra