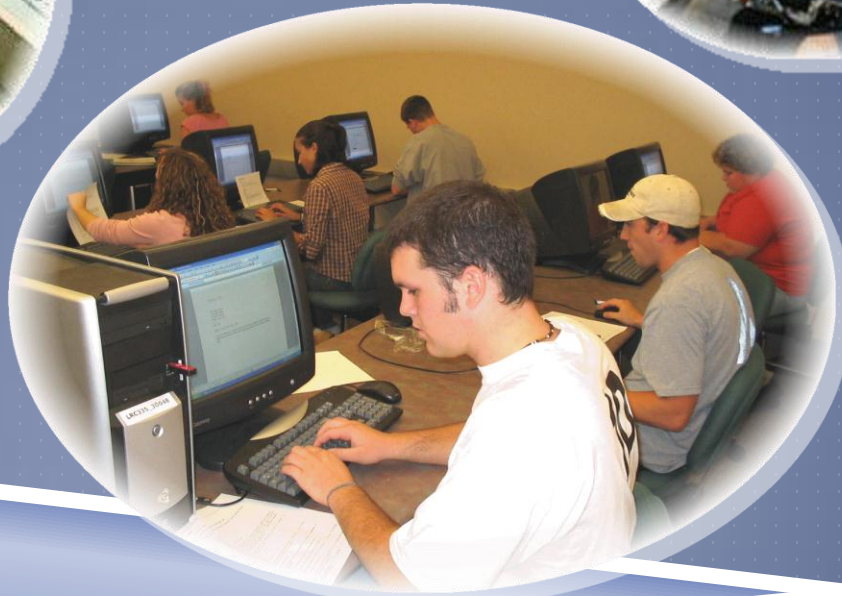


TECHNOLOGY IN ACTION



TECHNOLOGY IN ACTION

Hardware Review
Behind the Scenes:
A Closer Look at System Hardware

CHAPTER TOPICS

- ▶ Computer switches
- ▶ Binary number system
- ▶ Inside the CPU
- ▶ Cache memory
- ▶ Types of RAM
- ▶ Computer buses
- ▶ Creating faster CPUs

BINARY LANGUAGE

- ▶ Computers work in binary language
- ▶ Consists of two numbers: 0 and 1
- ▶ Everything a computer does is broken down into a series of 0s and 1s
- ▶ Switches: Devices inside the computer that can be flipped between these two states: 1 or 0, on or off

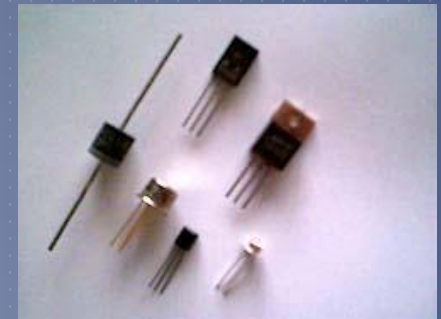


SWITCHES

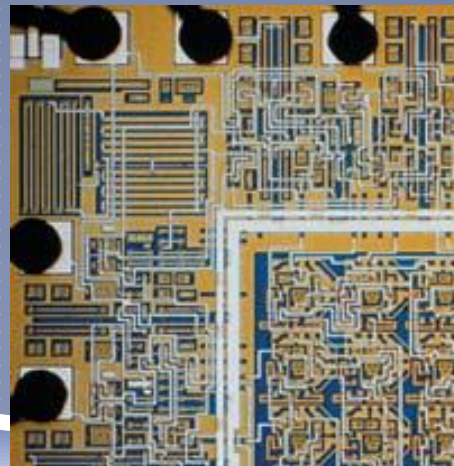
- ▶ Nonmechanical devices in computers that open and close circuits
- ▶ Types of electrical switches:
 - ▶ Vacuum tubes
 - ▶ Transistors:
 - ▶ Semiconductors
 - ▶ Integrated circuits



Vacuum Tube



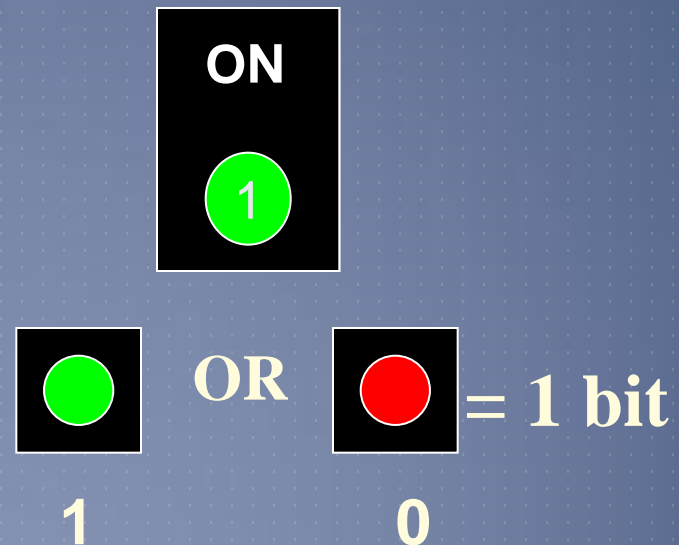
Transistors



Integrated Circuits

SWITCHES REPRESENTING DATA

- ▶ The on/off state of a switch represents one bit of data
- ▶ Bit (binary digit)
 - ▶ On = 1
 - ▶ Off = 0



THE BINARY NUMBER SYSTEM

- ▶ Describes a number as powers of 2
- ▶ Also referred to as base 2 numbering system
- ▶ Used to represent every piece of data stored in a computer: all of the numbers, letters, and instructions

THE BINARY NUMBER SYSTEM

- ▶ Number systems are organized ways to represent numbers
- ▶ Each number in one system has a corresponding number in another.

	128 2x64	64 2x32	32 2x16	16 2x8	8 2x4	4 2x2	2 2x1	1	
Binary	0	1	0	1	1	0	0	1	
Base 10	0 +	64 +	0 +	16 +	8 +	0 +	0 +	1 =	89

$$\begin{array}{ccc} 01011001 & = & 89 \\ \text{Binary} & & \text{Base 10} \end{array}$$

REPRESENTING LETTERS AND SYMBOLS

▶ American Standard Code for Information Interchange (ASCII)

- ▶ 8 bits = 1 byte = alphanumeric character or symbol
- ▶ 256 different combinations

ASCII

01100001 = a

01000001 = A

00100011 = #

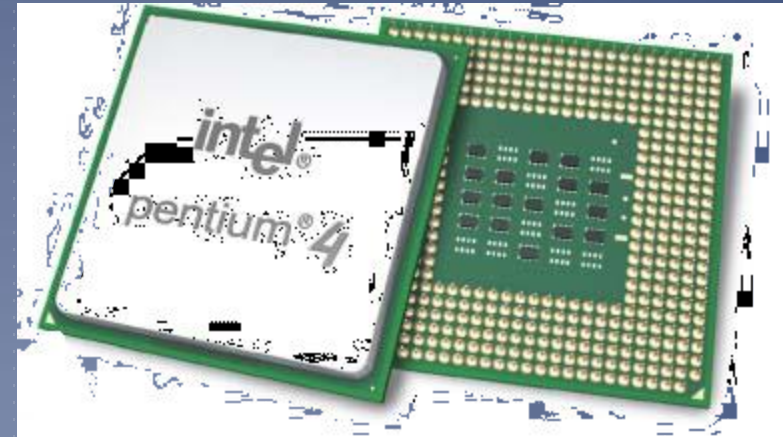
01101101 = m

• Unicode

- 16 bits equal 1 byte
- 65,000 different combinations, used for all languages

THE CPU: PROCESSING DIGITAL INFORMATION

- ▶ The CPU is the brains of the computer
- ▶ Different types of CPUs
 - ▶ Intel and AMD chips: Used in most Windows-based PCs
 - ▶ Apple systems use different CPU design
- ▶ Differentiating CPUs
 - ▶ Processing power
 - ▶ Clock speed and cache



Processors on the Market Today

Processor	Manufacturer	Number of Transistors	Typical Clock Speed	Levels of Cache Storage	Description
Athlon 64 FX – 60	AMD	233 million	2.6 GHz	2	64-bit processor for heavy computation and demanding video gaming needs.
Core Duo	Intel	151.6 million	1.6 - 2.16 GHz	2	Designed specifically for mobile computers; transfers power only to those areas of the processor that need it, improving battery life.
Itanium 2	Intel	410 million	1.3 – 1.66 GHz	3	Seen in high-end server computers.
Pentium 4 Extreme Edition 955	Intel	225 million	3.46 GHz	Each processor core has its own 2 MB L2Cache	This processor uses a dual-core design and hyperthreading to Process four tasks at once.
Pentium D Dual Core	Intel	230 million	2.8 - 3.4 GHz	2	New dual-core processor for more efficient multitasking. No hyperthreading capabilities.
PowerPC G4	Freescale Semiconductor (once part of Motorola)	57 million	1.5 – 1.67 GHz	3	Until 2006, powered the Apple line of computers.
Dual Core PowerPC G5	IBM	58 million	2.0 - 2.5 GHz	2	Powerful 64-bit processor for heavy computational needs.
Sempron	AMD	68.5 million	2.0 GHz	2	Affordable performance for today's value-conscious buyers of desktop PCs.
Turion	AMD	114 million	1.6 – 2.4 GHz	2	Optimized for better performance in thinner and lighter laptops for longer battery life and compatible with wireless technologies.

THE CPU MACHINE CYCLE

▶ Fetch

- ▶ The program's binary code is “fetched” from its temporary location in RAM and moved to the CPU

▶ Decode

- ▶ The program's binary code is decoded into commands that the CPU understands.

▶ Execute

- ▶ The ALU performs the calculations.

▶ Store

- ▶ The results are stored in the registers

“Inside the Chip” by
Intel

Video Clip

THE SYSTEM CLOCK

- ▶ Located on the motherboard
- ▶ Controls the CPU's processing cycles
- ▶ Clock cycle
 - ▶ Pulse or tick
- ▶ Clock speed
 - ▶ Number of pulses per second
 - ▶ Measured in hertz (Hz)

THE CONTROL UNIT

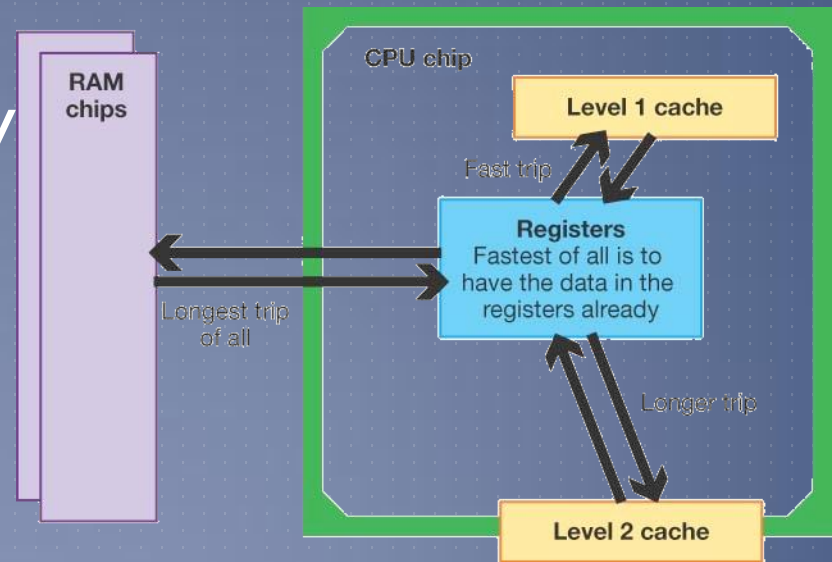
- ▶ Manages the switches inside the CPU
- ▶ Is programmed by CPU designers to remember the sequence of processing stages for that CPU
- ▶ Moves each switch to its correct setting (on or off)
- ▶ Then performs the work of that stage

THE ARITHMETIC LOGIC UNIT (ALU)

- ▶ Part of the CPU designed to perform mathematical operations (addition, subtraction, multiplication, division, etc.)
- ▶ Also performs logical OR, AND, and NOT operations
- ▶ Is fed data from the CPU registers
 - ▶ Word size: Number of bits a computer can work with at a time

CACHE MEMORY

- ▶ Small amount of memory located on the CPU chip or near it
- ▶ Stores recent or frequently used instructions and data
- ▶ Used for quick access by the CPU
- ▶ Different levels of cache

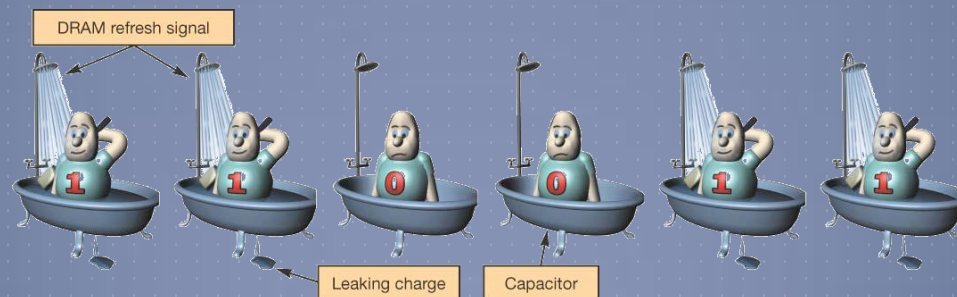


RAM: THE NEXT LEVEL OF TEMPORARY STORAGE

- ▶ Volatile: When you turn off your computer, the data is erased
- ▶ Several kinds of RAM exist
- ▶ Each type of RAM has a different design
 - ▶ Some types work at much faster speeds
 - ▶ Some transfer data more quickly

TYPES OF RAM: DRAM

- ▶ Dynamic RAM (DRAM)
 - ▶ Cheapest and most basic type of RAM
 - ▶ Loses its electrical charge
 - ▶ Needs to be refreshed
 - ▶ Many types of DRAM
 - ▶ SDRAM: Synchronous DRAM
 - ▶ DDR SDRAM: Double data rate SDRAM



TYPES OF RAM: SRAM

- ▶ Static RAM (SRAM)
 - ▶ Does not lose its electrical charge
 - ▶ Faster than DRAM
 - ▶ More expensive than DRAM
 - ▶ Used only in locations like cache memory

BUSES: THE CPU'S DATA HIGHWAY

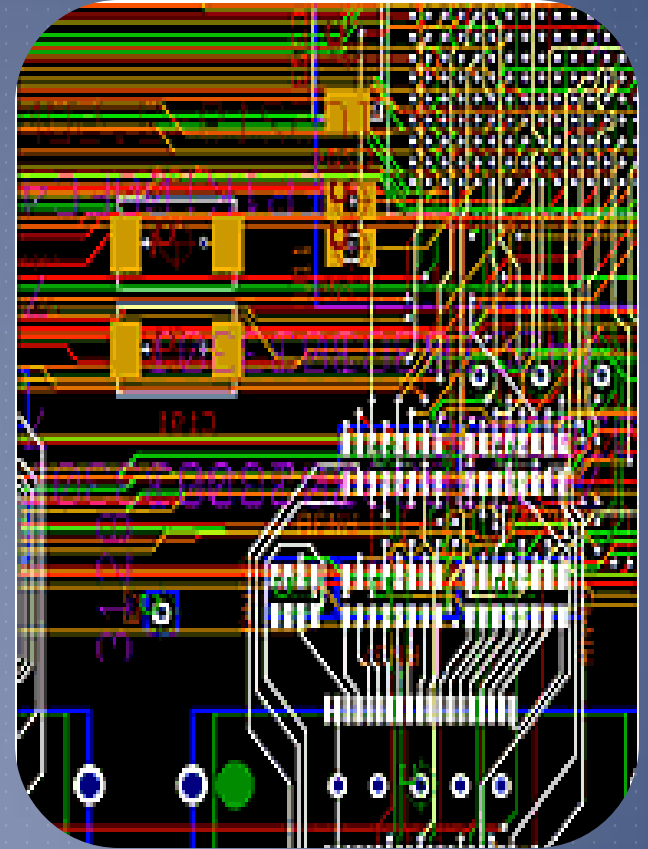
► Bus

- Electrical pathway used to move data between components
- Local bus: Connects the CPU with the memory
- Expansion bus: Connects the CPU with peripheral devices



BUS PERFORMANCE

- ▶ **Bus clock speed**
 - ▶ Rate of speed data moves from one location to another
 - ▶ Measured in MHz (millions of clock cycles per second)
- ▶ **Bus width**
 - ▶ The number of bits of data moved on a bus at any one time
 - ▶ Measured in bits
 - ▶ 16 bits
 - ▶ 32 bits



TYPES OF EXPANSION BUSES

▶ ISA and EISA

- ▶ Found on older computers
- ▶ Connects mouse, modem, and sound card

▶ PCI

- ▶ Faster than ISA and EISA
- ▶ Found on modern computers
- ▶ Connects network, modem, and sound cards

▶ AGP

- ▶ Used for three-dimensional graphics
- ▶ Connects the graphics card and memory

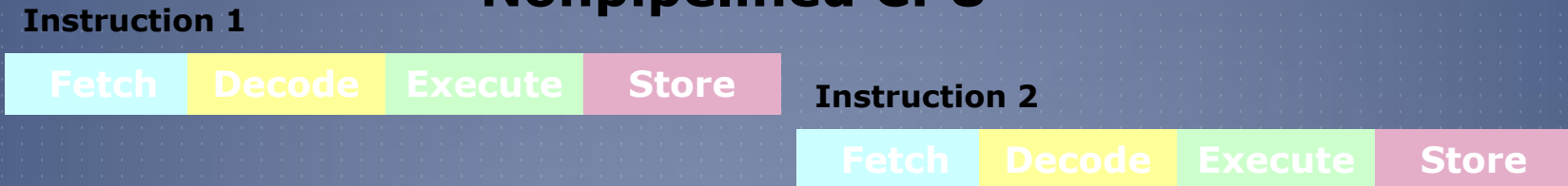
MOORE'S LAW

- ▶ Number of transistors on a CPU will double every 18 months
- ▶ First chip had 29,000 transistors
- ▶ Pentium chip 169,000,000 transistors
- ▶ Moore's Law has been accurate for more than 40 years
- ▶ Law has remained accurate into the 21st century

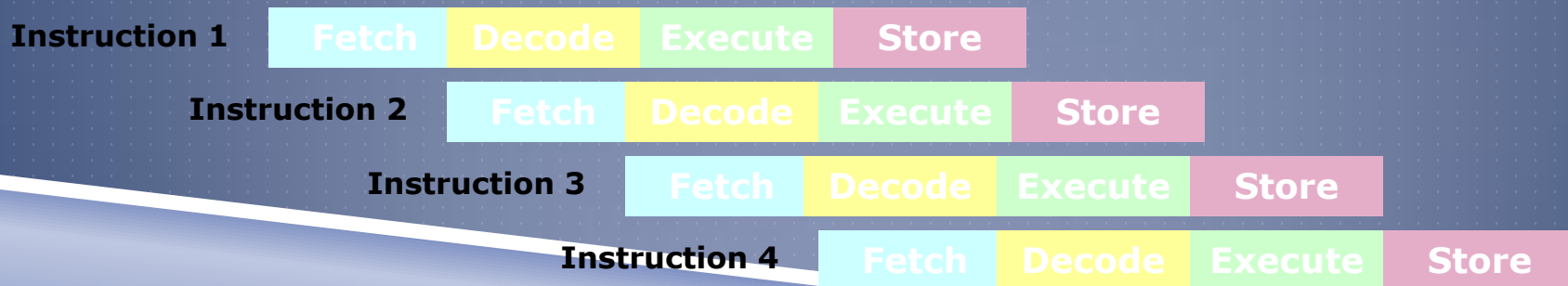
MAKING COMPUTERS FASTER

- ▶ **Pipelining:** The CPU processes more than one instruction at a time

Nonpipelined CPU



Pipelined CPU



MAKING COMPUTERS FASTER

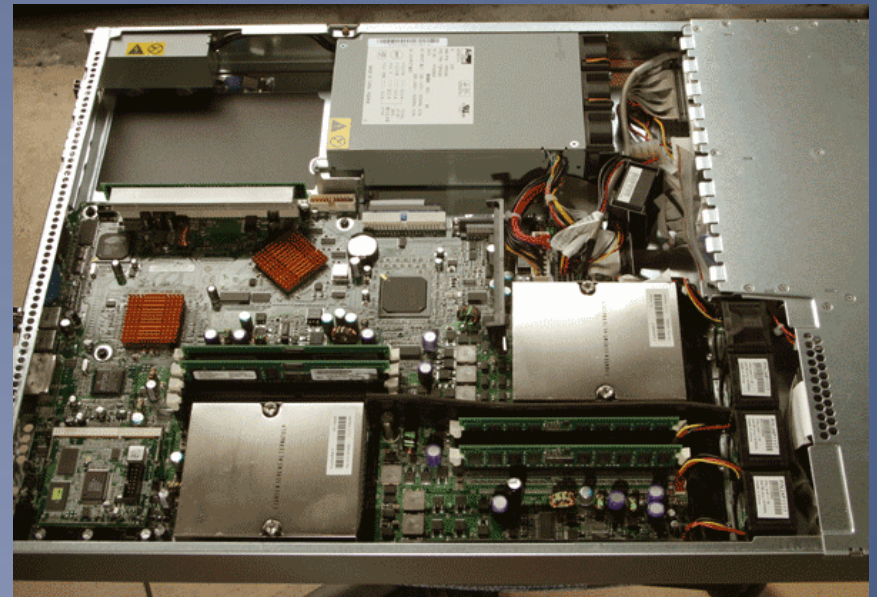
- ▶ Dual processing

- ▶ Two CPUs on the same system
- ▶ Each processor shares the workload

- ▶ Parallel processing

- ▶ Network of computers
- ▶ Each computer works on a portion of the problem simultaneously

Dual processors



DUAL-CORE PROCESSING AND HYPERTHREADING

- ▶ Two separate parallel processing paths
- ▶ Almost as fast as two separate processors
- ▶ Hyperthreading allows the processor to run four tasks at once
- ▶ Allows multiple applications to execute much more quickly

COMPUTING CLUSTERS

- ▶ Group of computers
- ▶ Connected by “clustering software”
- ▶ Load-balancing principle
- ▶ Not as fast as supercomputers
- ▶ Can be set up on Linux systems for free

CHAPTER 9 SUMMARY QUESTIONS

- ▶ What is a switch and how does it work in a computer?

CHAPTER 9 SUMMARY QUESTIONS

- ▶ What is the binary number system and what role does it play in computer system?

CHAPTER 9 SUMMARY QUESTIONS

- ▶ What is inside the CPU and how do these components operate?

CHAPTER 9 SUMMARY QUESTIONS

- ▶ How does a CPU process data and instructions?

CHAPTER 9 SUMMARY QUESTIONS

- ▶ What is cache memory?

CHAPTER 9 SUMMARY QUESTIONS

- ▶ What types of RAM are there?

CHAPTER 9 SUMMARY QUESTIONS

- ▶ What is a bus and how does it function in a computer system?

CHAPTER 9 SUMMARY QUESTIONS

- ▶ How do manufacturers make CPUs so that they run faster?