



# Computer Fundamentals

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Lecture 10



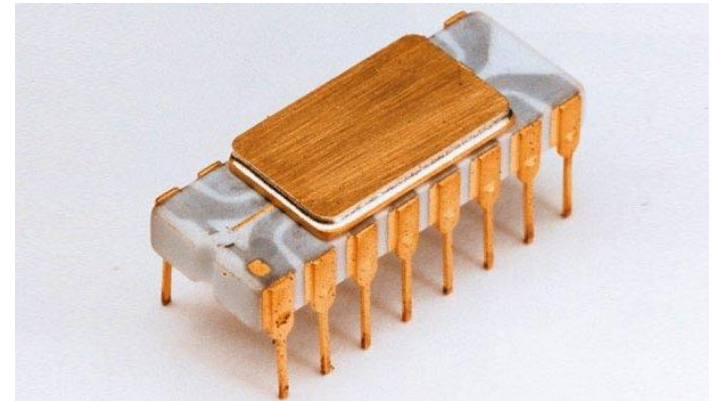
# Outline

## ➤ Modern CPUs



# Intel 4004

- The 1<sup>st</sup> commercially available microprocessor
- Introduced in 1971
- 4-bit CPU
- 2250 transistors
- 740 kHz max clock rate
- Packaged in 16-pin ceramic package
- As powerful as ENIAC
  - ❑ Which had 18000 vacuum tubes and occupied a large room
- Targeted use: Calculators
- Cost: less than \$100



Source: <https://www.linkedin.com/pulse/intel-4004-italian-job-edoardo-piccari>



# Intel 4004 (cont.)

- Busicom, Japanese calculator manufacturer
  - ❑ Demanded from Intel to develop 16 separate IC's
  - ❑ For a line of new calculators
- Chief designers
  - ❑ Federico Faggin
  - ❑ Ted Hoff
  - ❑ Masatoshi Shima
- Intel known only as memory manufacturer at that time
  - ❑ Was quite small
  - ❑ Lacked resources to do all 16 chips
- Ted Hoff came up with the idea
  - ❑ Do all 16 on a single chip
- Later realized that 4004 could have other uses



# Intel Pentium IV

- Introduced in December 2001
- Single core CPU
- 55 million transistors
- 32-bit processor
- 2 ALU's
- 3.8 GHz max clock rate
- For PC's and low-end workstations
- Introductory cost: around \$600



Source: <https://www.amazon.com/Intel-Pentium-2-6Ghz-SL6PP-Socket/dp/B004NKB7GE>

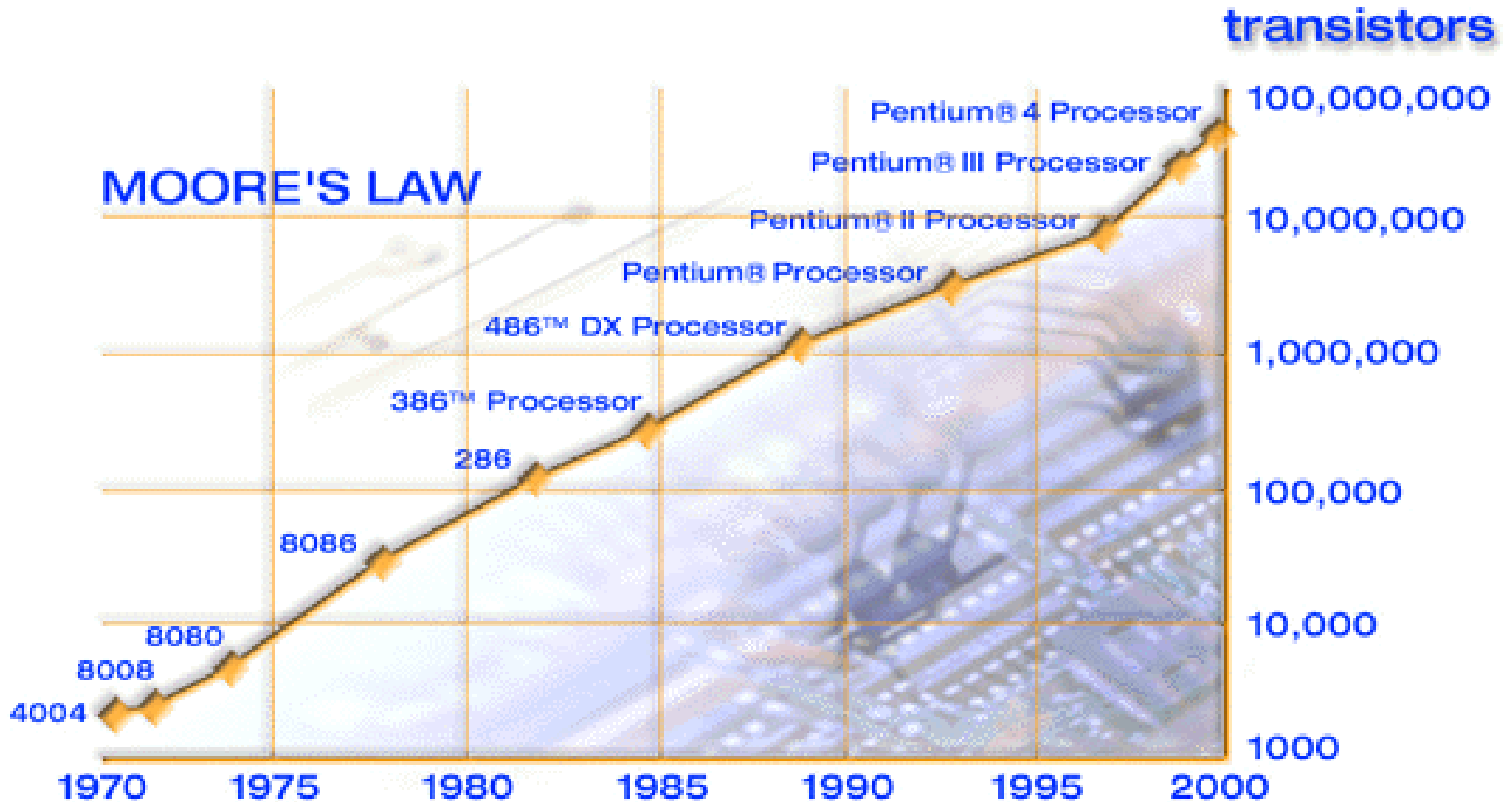


# Moore's Law

- Gordon Moore, one of the founders of Intel
  - ❑ Predicted that
    - The number of transistors on an IC OR the capability of microprocessors
    - Will double every year
  - ❑ Later modified it to 18 months
- Still holds true
- In fact, time required for doubling is contracting
  - ❑ Closer to a year now



# Moore's Law (cont.)





# Word Length

- 4004 dealt with data in chunks (words) of 4-bits at a time
- Pentium IV deals with data in chunks of 32-bit length
- New processors deal with 64-bit chunks at a time





# Clock Frequency

- 4004 worked at a clock frequency of 740 kHz
- Pentium IV worked at 3.8 GHz
- Latest processors have clock frequencies in GHz
- Higher clock frequency results in more power
  - ❑ If both processors have same design
  - ❑ Example: PowerPC & Pentium 4 microprocessors at same frequency
    - Former performs better due to superior design



# Enhancing Performance

- Computing capability of microprocessor
- Can be enhanced in different ways
  - ❑ By increasing clock frequency
  - ❑ By having a more effective caching algorithm and the right cache size
  - ❑ By adding more functional units (e.g. ALU's, FPU's etc.)
  - ❑ Improving architecture (registers, bus etc.)



# Looking Inside the Processor

## ➤ Architecture

### ❑ Determines

- Location of CPU parts
- Word size
- Number of registers
- Pipelines

### ❑ Main difference between CPUs



# Microcomputer Processors

## ➤ Intel

- ❑ Leading manufacturer of processors
- ❑ Intel 4004 was worlds first commercial microprocessor
- ❑ IBM PC in 80s powered by Intel 8088
- ❑ Well known Intel processors
  - Centrino
  - Itanium
  - Pentium IV
  - Xeon
  - Core i7





# Microcomputer Processors (cont.)

- Advanced Micro Devices (AMD)
  - ❑ Main competitor to Intel
  - ❑ Originally produced budget products
  - ❑ Current products outperform Intel
  - ❑ Designed processors
    - Sempron
    - Athlon FX 64
    - Athlon XP





# Microcomputer Processors (cont.)

## ➤ Freescale

- ❑ A subsidiary of Motorola
  - Apple computers primarily have Freescale
- ❑ Currently focuses on Linux market

## ➤ IBM

- ❑ Historically manufactured mainframes
- ❑ Series of high performance microprocessor called POWER
  - Performance Optimization With Enhanced RISC (POWER)
  - Named as POWER1, POWER2, up to recent POWER9



# Comparing Processors

- Speed of processor
- Size of cache
- Number of registers
- Word size
- Speed of Front side bus



# Advanced Processor Topics

## ➤ RISC processors

- ❑ Reduced Instruction Set Computing
- ❑ Smaller instruction sets
  - May process data faster
  - Processor capable of executing those instructions using fewer cycles
- ❑ IBM Power, iPhone, iPad and several Android based-systems

## ➤ Parallel processing

- ❑ Multiple processors in a system
  - Computational task is broken down in several subtasks
  - Processed independently
- ❑ Symmetric Multiple Processing
  - Number of processors is a power of 2
  - Divide and crush
- ❑ Massively Parallel Processing
  - Thousands of processors
  - Mainframes and super computers





# Extending Processors Power

- Standard computer ports
  - ❑ Keyboard and mouse ports
  - ❑ USB ports
  - ❑ Parallel
  - ❑ Network
  - ❑ Modem
  - ❑ Audio
  - ❑ Serial
  - ❑ Video



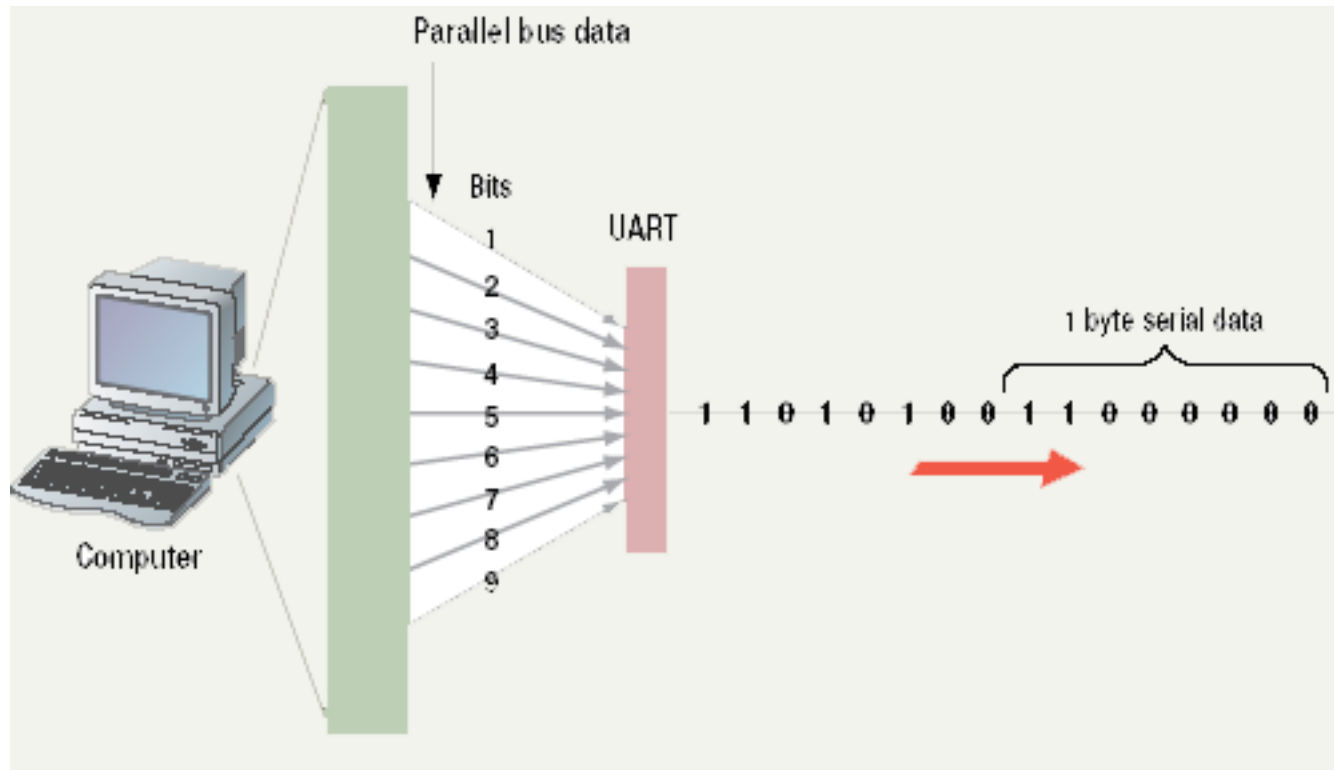


# Extending Processors Power (cont.)

- Serial and parallel ports
  - ❑ Connect to printers or modems
  - ❑ Parallel ports move bits simultaneously
    - Made of 8 - 32 wires
    - Internal busses are parallel
  - ❑ Serial ports move one bit
    - Lower data flow than parallel
    - Requires wires for control and ground purposes
  - ❑ Universal Asynchronous Receiver/Transmitter (UART)
    - Converts from parallel to serial and vice versa
  - ❑ Why USB based on serial architecture?
    - Serial architecture provides higher clock rate than parallel
    - Parallel interface support low frequencies
    - Otherwise bits arrive with lag, causing errors

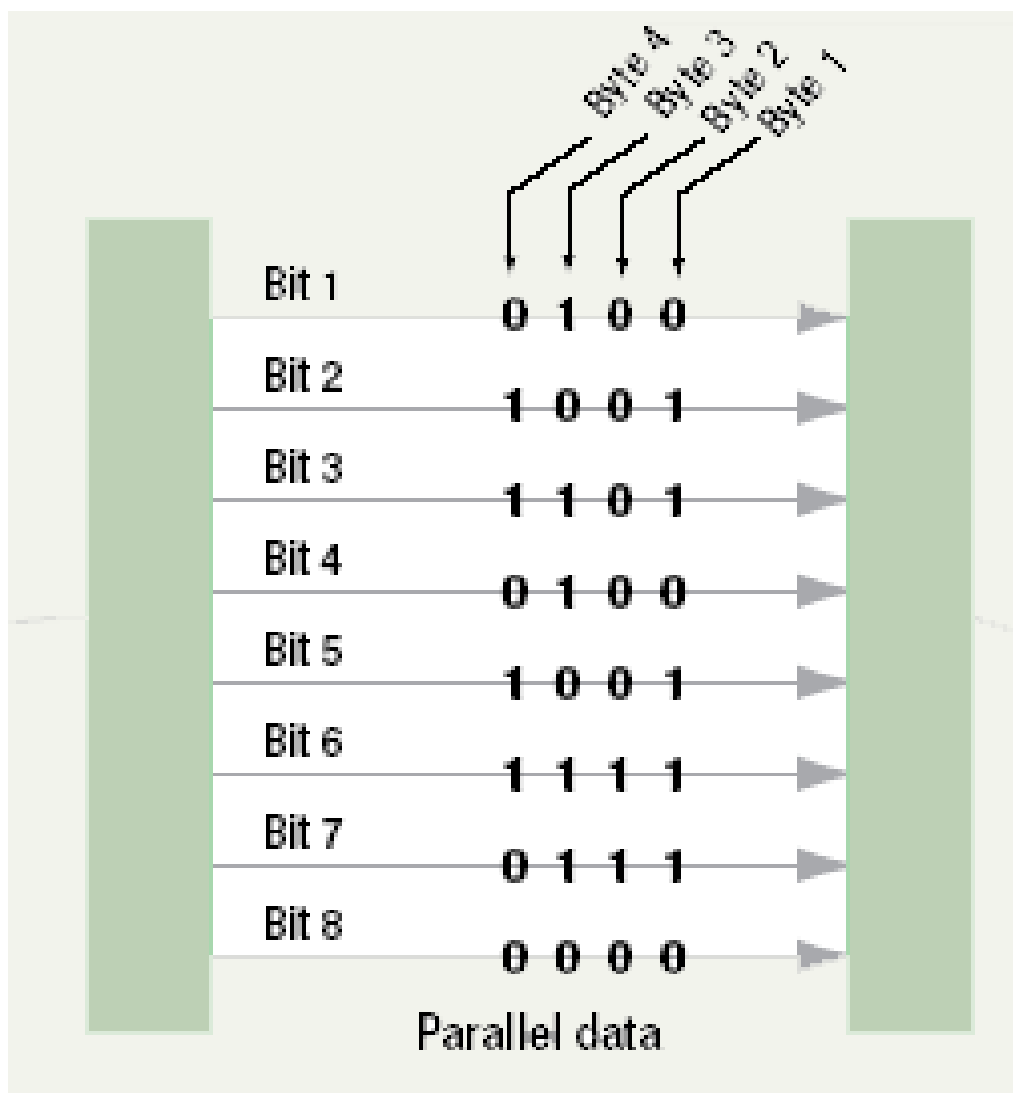


# Serial Communications





# Parallel Communications





# Extending Processors Power

## ➤ SCSI

- ☐ Small Computer System Interface
  - Set of standards
  - Physical connection between computers and peripheral devices
  - For transferring data
- ☐ Supports dozens of devices
- ☐ External devices daisy chain
- ☐ Fast hard drives and CD-ROMs

## ➤ USB

- ☐ Universal Serial Bus
- ☐ Most popular external bus
- ☐ Supports up to 127 devices
- ☐ Hot swappable

## ➤ FireWire

- ☐ IEEE 1394
- ☐ Cameras and video equipment
- ☐ Hot swappable
- ☐ Port is very expensive



# Specialized Expansion Ports

## ➤ Expansion slots and boards

- ❑ Allows users to configure machine
- ❑ Slots allow addition of new devices
- ❑ Devices are stored on cards
- ❑ Computer must be off before inserting

## ➤ PC Cards

- ❑ Expansion bus for laptops
- ❑ Standardized by PCMCIA
  - Personal Computer Memory Card International Association
- ❑ Hot swappable
- ❑ Small card size
- ❑ Three types
  - I for memory
  - II for network adapters
  - III for hard drives

## ➤ Plug and play

- ❑ New hardware detected automatically
- ❑ Prompts to install drivers
- ❑ Non-technical users can install devices





# Microcontrollers

- A type of microprocessor systems
- Not very powerful, not expensive
- Found embedded in
  - ☐ Video games
  - ☐ VCRs
  - ☐ Microwave ovens
  - ☐ Printers
  - ☐ Autos, etc.
- Complete CPU on a chip
- Direct input/output capability and memory
- Specialized application-specific components
- More than 90% of the microprocessors are microcontrollers
  - ☐ Manufactured for embedded computing applications
- In 2000, 365 million microprocessors and 6.4 billion microcontrollers manufactured