Computer Fundamentals

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Lecture 10

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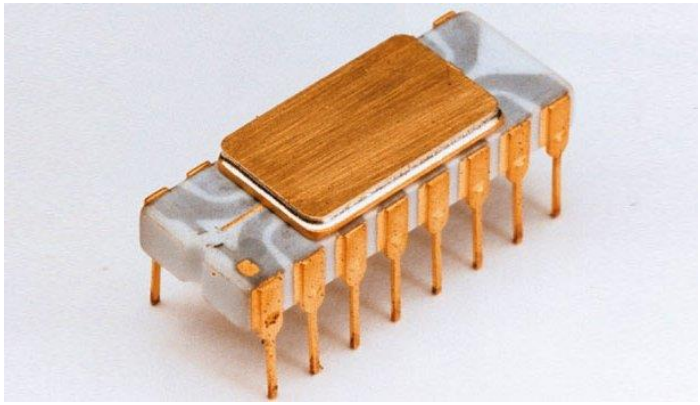
Outline

- Modern CPUs

Intel 4004

- The 1st 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

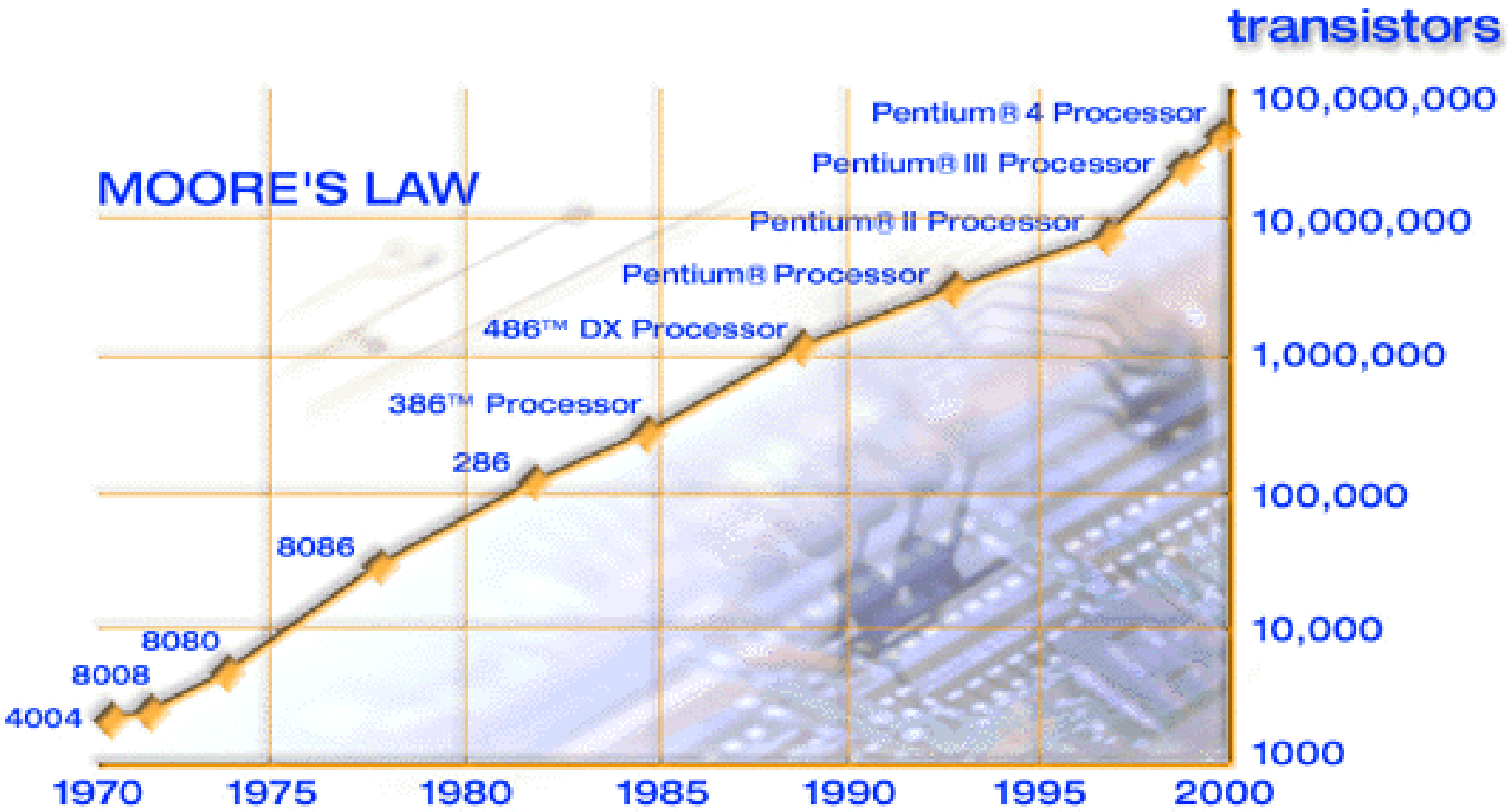
- Introduced in December 2001
- Single core CPU
- 55 million transistors
- 32-bit processor
- 2 ALU's
- 3.8 GHz max clock rate
- For PC's and low-end workstations
- Introductory cost: around $600

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

- Frequency of processor
- Size of cache
- Word size
- Speed of system 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 (SMP)
    - Processors share common memory
    - Number of processors preferably a power of 2 (divide and crush)
  - Massively Parallel Processing
    - Thousands of processors
    - Mainframes and super computers

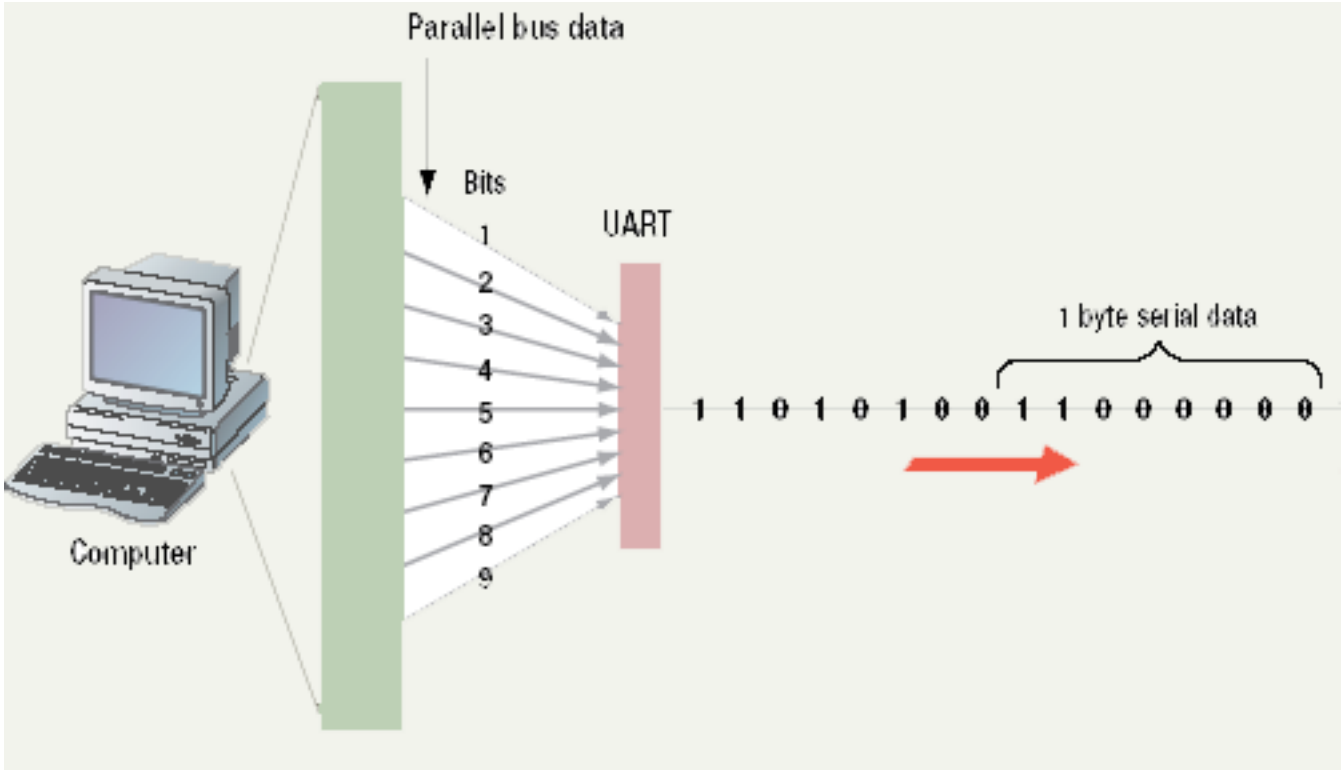
Extending Processors Power

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

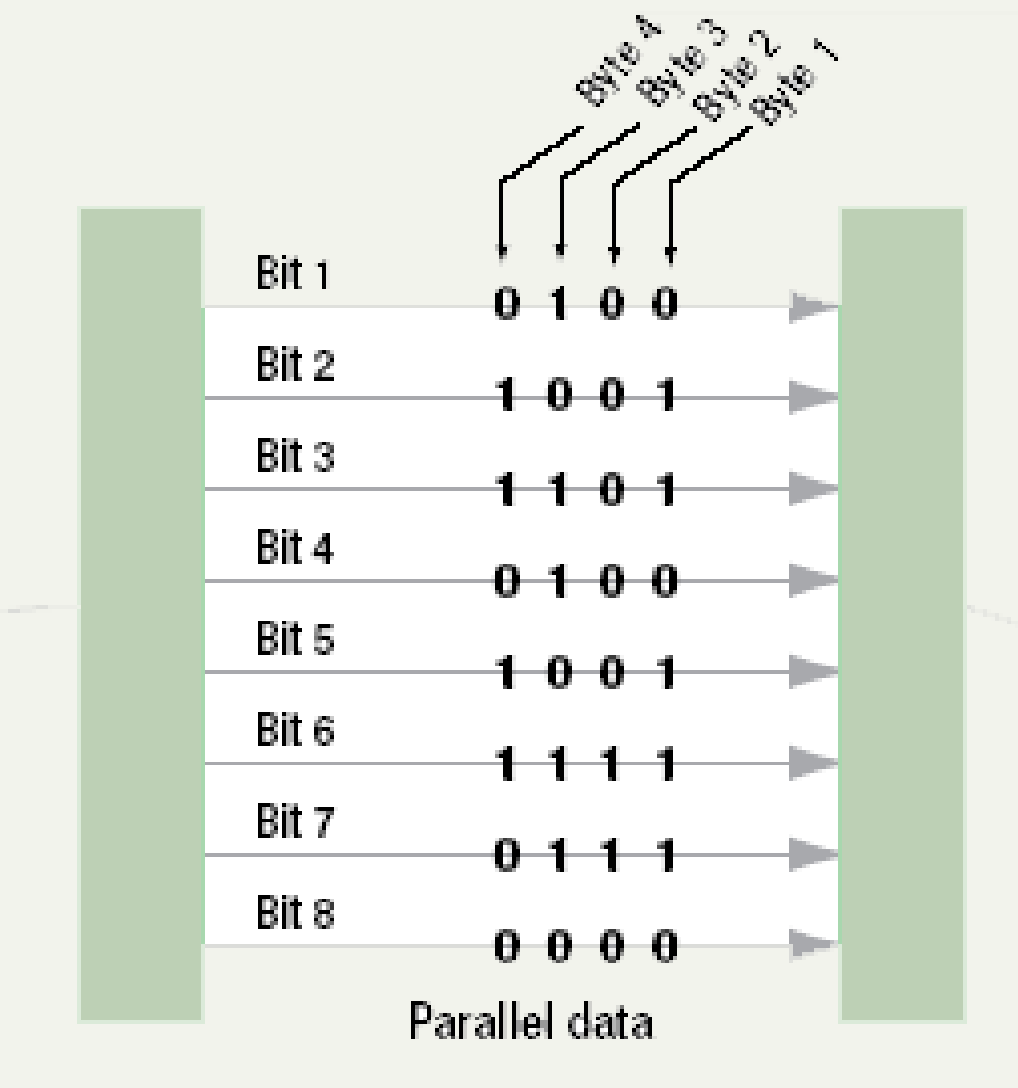
Extending Processors Power (cont.)

- 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 (cont.)

- 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 micro-controllers manufactured