## Computer Architecture1 Lecture 2 303 ح

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## INTRODUCTION TO MICROPROCESSORS

- The microprocessor is one of the most important components of a digital computer.
$\square$ It acts as the brain of the computer system.
$\square$ As technology has progressed, microprocessors have become faster, smaller and capable of doing more work per clock cycle.
$\square$ Sometimes, microprocessor is written as $\mu P$.
( $\mu$ is pronounced as $M u$ )


## INTRODUCTION TO MICROPROCESSORS

## Definition:

Microprocessor is the controlling unit or CPU of a micro-computer, fabricated on a very small chip capable of performing ALU operations and communicating with the external devices connected to it.

## HISTORY OF MICROPROCESSORS

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>4-Bit Microprocessors
>8-Bit Microprocessors
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>32-Bit Microprocessors
>64-Bit Microprocessors

## INTRODUCTION

$>$ Fairchild Semiconductors (founded in 1957) invented the first IC in 1959.
>In 1968, Robert Noyce, Gordan Moore, Andrew Grove resigned from Fairchild Semiconductors.
$>$ They founded their own company Intel (Integrated Electronics).
>Intel grown from 3 man start-up in 1968 to industrial giant by 1981.
>lt had $\mathbf{2 0 , 0 0 0}$ employees and $\$ 188$ million revenue.

## 4~BIT MICROPROCESSORS

## INTEL 4004

$>$ Introduced in 1971.
>lt was the first microprocessor by Intel.
$>$ It was a 4-bit $\mu \mathrm{P}$.
>lts clock speed was 740 KHz .
>lt had 2,300 transistors.
$>$ It could execute around 60,000 instructions per
second.

## INTEL 4040

>Introduced in 1974.
$>$ It was also 4-bit $\mu$ P.

## 8~BIT MICROPROCESSORS

## INTEL 8008

>Introduced in 1972.

>lt was first 8-bit $\mu$ P.
>lts clock speed was 500 KHz .
>Could execute 50,000 instructions per second.

## INTEL 8080

>Introduced in 1974.
$>$ It was also 8-bit $\mu$ P.
$>$ Its clock speed was 2 MHz .
>It had 6,000 transistors.
$>$ Was 10 times faster than 8008.
$>$ Could execute 5,00,000 instructions per second.
$>$ Introduced in 1976.

## INTEL 8085

$>$ It was also 8-bit $\mu \mathrm{P}$.
> Its clock speed was 3 MHz .
$>$ Its data bus is 8 -bit and address bus is 16 -bit.
$>$ It had 6,500 transistors.
$>$ Could execute 7,69,230 instructions per second.
$>$ It could access 64 KB of memory.
$>$ It had 246 instructions.
> Over 100 million copies were sold.

## 16~BIT MICROPROCESSORS

> Introduced in 1978.

## INTEL 8086

$>$ It was first 16-bit $\mu \mathrm{P}$.
> Its clock speed is $4.77 \mathrm{MHz}, 8$ MHz and 10 MHz , depending on the version.
$>$ Its data bus is 16-bit and address bus is 20-bit.
> It had 29,000 transistors.
> Could execute 2.5 million instructions per second.
> It could access 1 MB of memory.
$>$ It had 22,000 instructions.
$>$ It had Multiply and Divide instructions.

## INTEL 8088

$>$ Introduced in 1979.
$>$ It was also 16 -bit $\mu$ P.
$>$ It was created as a cheaper version of Intel's 8086.
> It was a 16-bit processor with an 8-bit external bus.
> Could execute 2.5 million instructions per second.
$>$ This chip became the most popular in the computer industry when IBM used it for its first PC.

## INTEL 80186 \& 80188

 $>$ Introduced in 1982.
$>$ They were 16 -bit $\mu$ Ps.
$>$ Clock speed was 6 MHz .
$>80188$ was a cheaper version of 80186 with an 8 -bit external data bus.
$>$ They had additional components like:
$>$ Interrupt Controller
>Clock Generator
>Local Bus Controller
>Counters

## INTEL 80286

> Introduced in 1982.
$>$ It was 16 -bit $\mu$ P.
>lts clock speed was 8 MHz .
$>$ Its data bus is 16 -bit and address bus is 24-bit.
> It could address 16 MB of memory.
>It had 1,34,000 transistors.
$>$ It could execute 4 million instructions per second.

## 32~BIT MICROPROCESSORS

>Introduced in 1986.
$>$ It was first 32-bit $\mu$ P.
$>$ Its data bus is 32-bit and address bus is 32-bit.
$>$ It could address 4 GB of memory.
$>$ It had 2,75,000 transistors.
$>$ Its clock speed varied from 16 MHz
to 33 MHz depending upon the various versions.
>Different versions:
>80386 DX
$>80386$ SX
$>80386$ SL
$>$ Intel 80386 became the best selling microprocessor in history.

# INTEL 80486 

>Introduced in 1989.
>lt was also 32 -bit $\mu \mathrm{P}$.
$>$ It had 1.2 million transistors.
$>$ Its clock speed varied from 16 MHz to 100 MHz depending upon the various versions.
>lt had five different versions:
$>80486 \mathrm{DX}$
$>80486 \mathrm{SX}$
$>80486 \mathrm{DX} 2$
$>80486 \mathrm{SL}$
$>80486 \mathrm{DX} 4$
>8 KB of cache memory was introduced.
$>$ Introduced in 1993.

## MNTEL PENTVUM $>$ It was also 32-bit $\mu$ P.

> It was originally named 80586.
> Its clock speed was 66 MHz .
$>$ Its data bus is 32-bit and address bus is 32-bit.
$>$ It could address 4 GB of memory.
> Could execute 110 million instructions per second.
> Cache memory:
$>8 \mathrm{~KB}$ for instructions.
$>8 \mathrm{~KB}$ for data.

## INTEL PENTIUM PRO

> Introduced in 1995.
$>$ It was also 32-bit $\mu$ P.
> It had L2 cache of 256 KB.
> It had 21 million transistors.
$>$ It was primarily used in server systems.
$>$ Cache memory:
$>8 \mathrm{~KB}$ for instructions.
$>8 \mathrm{~KB}$ for data.
$>$ It had L2 cache of 256 KB.

## INTEL PENTIUM II

>Introduced in 1997.
>lt was also 32-bit $\mu$ P.
>lts clock speed was 233 MHz to 500 MHz .
$>$ Could execute 333 million instructions per second.
>MMX technology was supported.
>L2 cache \& processor were on one circuit.

## INTEL PENTIUM II

 XEON> Introduced in 1998.
$>$ It was also 32-bit $\mu$ P.
$>$ It was designed for servers.
> Its clock speed was 400 MHz to $\mathbf{4 5 0} \mathbf{~ M H z}$.
> L1 cache of 32 KB \& L2 cache of $512 \mathrm{~KB}, 1 \mathrm{MB}$ or 2 MB.
$>$ It could work with 4 Xeons in same system.

## INTEL PENTIUM III

>Introduced in 1999.
>lt was also 32-bit $\mu$ P.
>lts clock speed varied from 500 MHz to 1.4 GHz .
$>$ It had 9.5 million transistors.

## INTEL PENTIUM IV

$>$ Introduced in 2000.
$>$ It was also 32-bit $\mu$ P.
$>$ Its clock speed was from 1.3 GHz to 3.8 GHz .
$>$ L1 cache was of 32 KB \& L2 cache of 256 KB.
$>$ It had 42 million transistors.
$>$ All internal connections were made from aluminium to copper.
$>$ Introduced in 2006.

## INTEL DUAL CORE

$>$ It is 32-bit or 64-bit $\mu \mathrm{P}$.
$>$ It has two cores.
$>$ Both the cores have there own internal bus and L1 cache, but share the external bus and L2 cache (Next Slide).
> It supported SMT technology.
> SMT: Simultaneously MultiThreading
$>$ E.g.: Adobe Photoshop supported SMT.

## Dual CPU Core Chip



# 64~BIT MICROPROCESSORS 

## INTEL CORE 2

$>$ Introduced in 2006.
$>$ It is a 64-bit $\mu \mathrm{P}$.
$>$ Its clock speed is from 1.2 GHz to 3 GHz .
>lt has 291 million transistors.
>It has 64 KB of L1 cache per core and 4 MB of L2 cache.
>lt is launched in three different versions:

$>$ Intel Core 2 Duo<br>$>$ Intel Core 2 Quad<br>$>$ Intel Core 2 Extreme

## INTEL CORE 17

>Introduced in 2008.

$>$ It is a 64-bit $\mu \mathrm{P}$.
>It has 4 physical cores.
$>$ Its clock speed is from 2.66 GHz to 3.33 GHz .
>lt has $\mathbf{7 8 1}$ million transistors.
$>$ It has 64 KB of L 1 cache per core, 256 KB of L2 cache and 8 MB of L3 cache.

## INTEL CORE I5

>Introduced in 2009.

$\Rightarrow$ It is a 64-bit $\mu \mathrm{P}$.
>lt has 4 physical cores.
$>$ Its clock speed is from 2.40 GHz to 3.60 GHz .
>lt has $\mathbf{7 8 1}$ million transistors.
$>$ It has 64 KB of L 1 cache per core, 256 KB of L2 cache and 8 MB of L3 cache.

## INTEL CORE 13

$>$ Introduced in 2010.

$>$ It is a 64-bit $\mu \mathrm{P}$.
>lt has 2 physical cores.
$>$ Its clock speed is from 2.93 GHz to 3.33 GHz .
>lt has $\mathbf{7 8 1}$ million transistors.
$>$ It has 64 KB of L 1 cache per core, 512 KB of L2 cache and 4 MB of L3 cache.

## SYSTEM BUS

- The CPU sends various data values, instructions and information to all the devices and components inside the computer.
- If you look at the bottom of a motherboard you'll see a whole network of lines or electronic pathways that join the different components together.
- This network of wires or electronic pathways is called the 'Bus'.


## BOTTOM OF MOTHERBOARD



## TYPES OF SYSTEM BUSES

- Data Bus
- Address Bus
- Control Bus


## System Bus Model



Data Bus
Address Bus
Control Bus

## DATA BUS

- A collection of wires through which data is transmitted from one part of a computer to another is called Data Bus.
- Data Bus can be thought of as a highway on which data travels within a computer.
- This bus connects all the computer components to the CPU and main memory.
- The size (width) of bus determines how much data can be transmitted at one time.
- E.g.:
- A 16-bit bus can transmit 16 bits of data at a time.
- 32-bit bus can transmit 32 bits at a time.


## ADDRESS BUS

- A collection of wires used to identify particular location in main memory is called Address Bus.
- Or in other words, the information used to describe the memory locations travels along the address bus.
- The size of address bus determines how many unique memory locations can be addressed.
- E.g.:
- A system with 4-bit address bus can address $2^{4}=16$ Bytes of memory.
- A system with 16 -bit address bus can address $2^{16}=64 \mathrm{~KB}$ of memory.
- A system with 20-bit address bus can address $2^{20}=1 \mathrm{MB}$ of memory.


## CONTROL BUS

- The connections that carry control information between the CPU and other devices within the computer is called Control Bus.
- The control bus carries signals that report the status of various devices.
- E.g.:
- This bus is used to indicate whether the CPU is reading from memory or writing to memory.

