Lecture (01)

Introduction to the Microprocessor and Computer

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A HISTORICAL BACKGROUND

The Microprocessor

- Called the CPU (**central processing unit**).
- The controlling element in a computer system.
- Controls memory and I/O through connections called buses.
- Memory and I/O controlled via instructions stored in memory, executed by the microprocessor.

The Microprocessor Age

- World's first microprocessor the Intel 4004.
- A 4-bit microprocessor-programmable
- controller on a chip.
- 4-bit-wide memory locations.
  - a **bit** is a binary digit with a value of one or zero
  - 4-bit-wide memory location often called a **nibble**
- The 4004 instruction set contained 45 instructions.
- Fabricated with then P-channel MOSFET technology.

- Executed instructions at slow rate 50 KIPs (**kilo-instructions per second**).
- 4-bit microprocessor debuted in early game systems and small control systems.
- Main problems with early microprocessor were speed, word width, and memory size.
- Evolution of 4-bit microprocessor ended when Intel released the 4040, an updated 4004.
- operated at a higher speed; lacked improvements in word width and memory size.
- still survives in low-end applications such as microwave ovens and small control systems

- Intel released 8008,it extended 8-bit version of 4004 microprocessor
- Addressed expanded memory of 16K bytes.
- Contained additional instructions, 48 total.
- Somewhat small memory size, slow speed, and instruction set limited 8008 usefulness.
- Intel introduced 8080 microprocessor, first of the modern 8-bit microprocessors .

What Was Special about the 8080?

- 8080 addressed four times more memory.
  - 64K bytes vs 16K bytes for 8008
- Executed additional instructions; 10x faster than 8008.
  - addition taking 20 µs on an 8008-based system, it required only 2.0 µs on an 8080-based system
- TTL (transistor-transistor logic) compatible, this made Interfacing much easier and less expensive.

The 8085 Microprocessor

- Intel Corporation introduced an updated version of the 8080—the 8085.
- Last 8-bit, general-purpose microprocessor developed by Intel.
- Slightly more advanced than 8080; executed software at an even higher speed.
  - 769,230 instructions per second vs 500,000 per second on the 8080.

- Main advantages of 8085 were its internal clock generator, system controller, and higher clock frequency.
- Intel has sold over 100 million of the 8085.
  - its most successful 8-bit, general-purpose microprocessor.
  - also manufactured by many other companies, meaning over 200 million in existence
- Applications that contain the 8085 will likely continue to be popular.

The Modern Microprocessor

- Intel released the 8086; a year or so later, it released the 8088.
- Both devices are 16-bit microprocessors.
  - executed instructions in as little as 400 ns (2.5 millions of instructions per second)
  - major improvement over execution speed of 8085
- 8086 & 8088 addressed 1M byte of memory.
  - 16 times more memory than the 8085.
- Higher speed and larger memory size allowed 8086 & 8088 to replace smaller minicomputers in many applications.
- Another feature was a 4 or 6-byte instruction cache or queue that prefetched instructions before they were executed.

- Improvements to the instruction set included multiply and divide instructions.
  - missing on earlier microprocessors
- Number of instructions increased.
  - from 45 on the 4004, to 246 on the 8085
  - over 20,000 variations on the 8086 & 8088
- These microprocessors are called CISC (complex instruction set computers) because of the number and complexity of instructions.
  - additional instructions eased task of developing efficient and sophisticated applications

- 16-bit microprocessor also provided more internal register storage space.
  - additional registers allowed software to be written more efficiently.

The 80286 Microprocessor

- Intel introduced the 80286 in 1983.
  - an updated 8086
- Almost identical to the 8086/8088.
  - addressed 16M-byte memory system instead of a 1M-byte system.
- Instruction set almost identical except for a few additional instructions.
  - managed the extra 15M bytes of memory

- 80286 clock speed increased in 8.0 Mhz version.
  - executed some instructions in as little as 250 ns (4.0 MIPs)
- Some changes to internal execution of instructions led to 8X increase in speed for many instructions.

The 32-Bit Microprocessor

- Applications demanded faster microprocessor speeds, more memory, and wider data paths.
- Led to the 80386 in 1986 by Intel.
  - major overhaul of 16-bit 8086–80286 architecture
- Intel's first practical microprocessor to contain a 32-bit data bus and 32-bit memory address.

- Through 32-bit buses, 80386 addressed up to 4G bytes of memory.
- 80386SX addressed 16M bytes of memory through a 16-bit data and 24-bit address bus.
- 80386SL/80386SLC addressed 32M bytes memory via 16-bit data, 25-bit address bus.
- 80386SLC contained an internal cache to process data at even higher rates.

- Intel released 80386EX in 1995.
- Called an embedded PC.
  - contains all components of the AT class computer on a single integrated circuit.
- 24 lines for input/output data.
- 26-bit address bus; 16-bit data bus.
- DRAM refresh controller.
- Programmable chip selection logic

The 80486 Microprocessor

- In 1989 Intel released the 80486.
- 80386-like microprocessor.
- 8K-byte cache memory system.
- Internal structure of 80486 modified so about half of its instructions executed in one clock instead of two clocks.
- Available in a 50 MHz version, about half of instructions executed in 25 ns (50 MIPs)

The Pentium Microprocessor

- Introduced 1993, Pentium was similar to 80386 and 80486 microprocessors.
- Originally labeled the P5 or 80586.
- Introductory versions operated with a clocking frequency of 60 MHz & 66 MHz, and a speed of 110 MIPs.
- Cache size was increased to 16K bytes from the 8K cache found in 80486.
- 8K-byte instruction cache and data cache.
- Memory system up to 4G bytes.
- Data bus width increased to a full 64 bits.
- Wider data bus width accommodated double precision floating-point numbers used in high speed, vector-generated graphical displays.

TABLE 1–2 Many modern Intel and Motorola microprocessors.

Manufacturer	*Part Number*	*Data Bus Width*	*Memory Size*
Intel	8048	8	2K internal
	8051	8	8K internal
	8085A	8	64K
	8086	16	1M
	8088	8	1M
	8096	16	8K internal
	80186	16	1M
	80188	8	1M
	80251	8	16K internal
	80286	16	16M
	80386EX	16	64M
	80386DX	32	4G
	80386SL	16	32M
	80386SLC	16	32M + 8K cache
	80386SX	16	16M
	80486DX/DX2	32	4G + 8K cache
	80486SX	32	4G + 8K cache
	80486DX4	32	4G + 16 cache
	Pentium	64	4G + 16K cache
	Pentium OverDrive	32	4G + 16K cache
	Pentium Pro	64	64G + 16K L1 cache + 256K L2 cache
	Pentium II	64	64G + 32K L1 cache + 256K L2 cache
	Pentium III	64	64G + 32K L1 cache + 256K L2 cache
	Pentium 4	64	64G+32K L1 cache+ 512K L2 cache (or larger) (1T for 64-bit extensions)
	Pentium4 D (Dual Core)	64	1T + 32K L1 cache + 2 or 4 M L2 cache
	Core2	64	1T + 32K L1 cache + a shared 2 or 4 M L2 cache

Pentium Pro Processor

- A recent entry, formerly named the P6.
- 21 million transistors, integer units, floating point unit to increase the performance of software.
- Clock frequency 150 and 166 MHz
- Internal 16K level-one (L1) cache.
  - 8K data, 8K for instructions
  - Pentium Pro contains 256K level-two (L2) cache
- Pentium Pro uses three execution engines, to execute up to three instructions at a time.

Pentium II and Pentium Xeon Microprocessors

- Pentium II, released 1997, represents new direction for Intel.
- Intel has placed Pentium II on a small circuit board, instead of being an integrated circuit.
- Newer Pentium II uses a 100 MHz bus speed.
- Higher speed memory bus requires 8 ns SDRAM.
- Intel announced new version of Pentium II called Xeon .
  - Designed for high-end workstation and server applications
- Xeon available with 32K L1 cache and L2 cache size of 512K, 1M, or 2M bytes.
- Newer product represents strategy change.
  - Intel produces a professional and home/business version of the Pentium II

Pentium III Microprocessor

- Faster than Pentium II.
- Pentium III available with clock frequencies up to 1 GHz.
- Slot 1 version contains a 512K cache;
- flip-chip version contains 256K cache.
- Flip-chip cache runs at CPU clock speed;
- Slot 1 cache version runs at one-half CPU clock speed.
- Both versions use 100 MHz memory bus.

Pentium 4 and Core2 Microprocessors

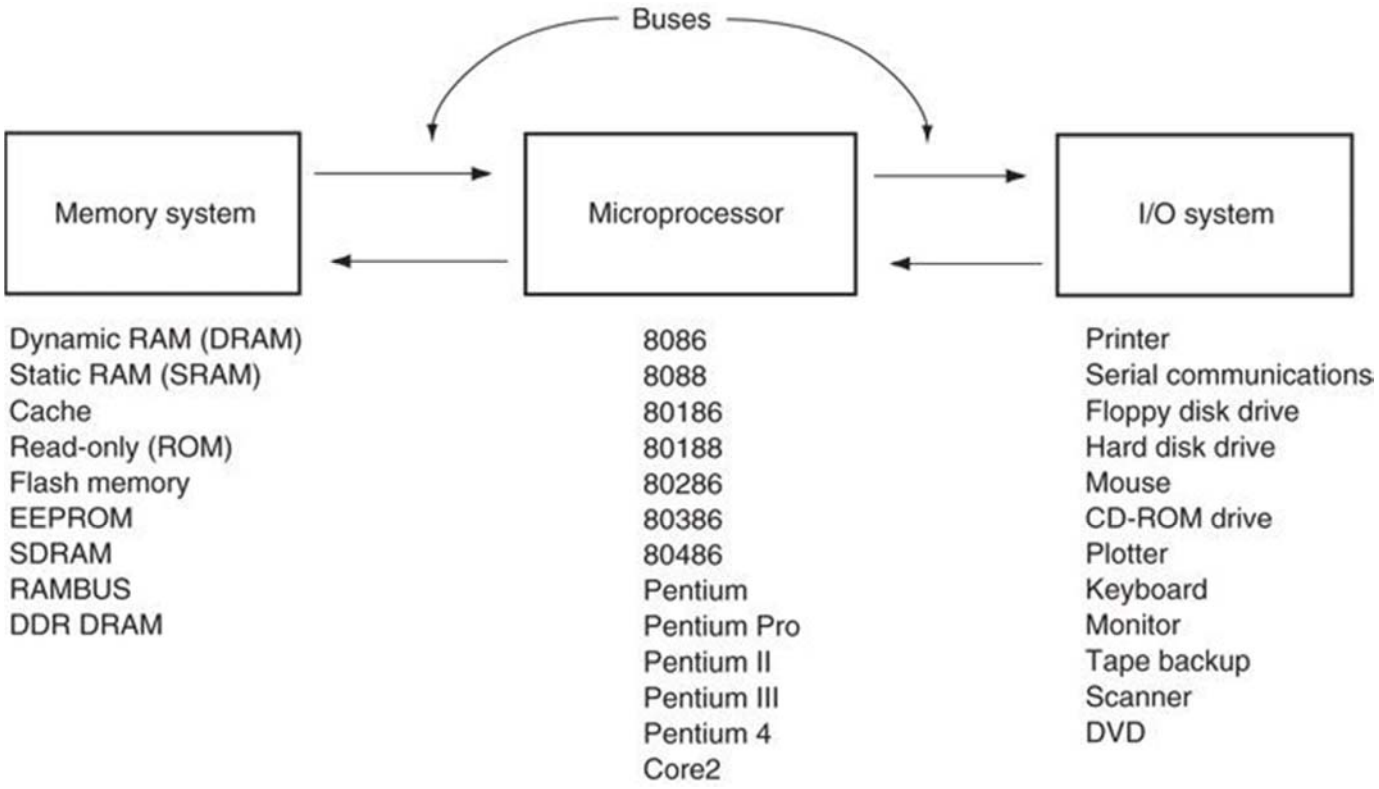
- Pentium 4 first made available in late 2000.
  - most recent version of Pentium called Core2
  - uses Intel P6 architecture.
- Pentium 4 available to 3.2 GHz and faster.
  - supporting chip sets use DDR SDRAM in place of SDRAM technology.
- Core2 is available at speeds of up to 3 GHz.
- A likely change is a shift from aluminum to copper interconnections inside the microprocessor.
- Copper is a better conductor.
  - should allow increased clock frequencies.

- Biggest advancement is inclusion of multiple cores.
  - each core executes a separate task in a program
- Increases speed of execution if program is written to take advantage of multiple cores.
  - called multithreaded applications (A multithreaded process with two threads executing in time clearly showing that the threads execute separately and execute mutually exclusively in time.)
- Intel manufactures dual and quad core versions; number of cores will likely increase to eight or even sixteen.

- In 2002, Intel released a new architecture 64 bits in width with a 128-bit data bus.
- Named Itanium.
- The Itanium architecture allows greater parallelism than traditional architectures.
- 128 general-purpose integer and 128 floating point registers; 64 predicate registers.
- Many execution units to ensure enough hardware resources for software.

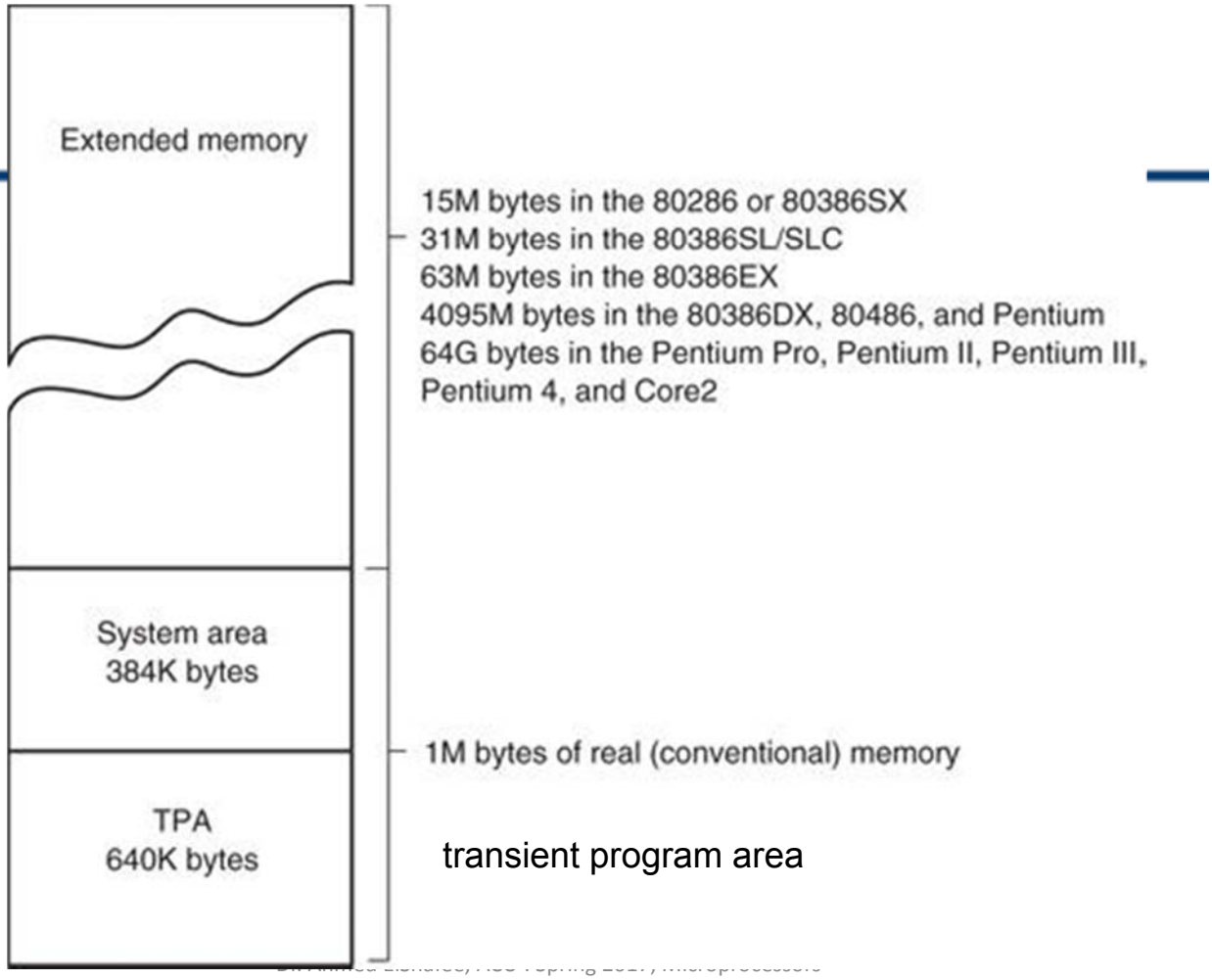
THE MICROPROCESSORBASED PERSONAL COMPUTER SYSTEM

- Computers have undergone many changes recently.
- Machines that once filled large areas reduced to small desktop computer systems because of the microprocessor.
- Figure shows block diagram of the personal computer.
- Diagram composed of three blocks interconnected by buses.
- bus is the set of common connections that carry the same type of information.



The Memory and I/O System

- Memory structure of all Intel-based personal computers similar.
- Figure illustrates memory map of a personal computer system.
- This map applies to any IBM personal computer.



- The memory system is divided into three main
- parts:
  1. TPA (transient program area).
  2. System area.
  3. XMS (extended memory system), the type of microprocessor in your computer determines whether an extended memory system exists.

The TPA (conventional memory)

- The transient program area (TPA) holds the DOS (disk operating system) operating system; other programs that control the computer system.
  - Stores any currently active or inactive DOS application programs.
  - Length of the TPA is 640K bytes.

The System Area (upper memory area)

- Smaller than the TPA; just as important.
- The system area contains programs on read only (ROM), and areas of read/write (RAM) memory for data storage.

- upper memory area (UMA) refers to memory between the addresses of 640 KB and 1024 KB (0xA0000–0xFFFFF) in an IBM PC or compatible.
- IBM reserved the uppermost 384 KB of the 8088 CPU's 1024 KB address space for ROM, RAM on peripherals, and memory-mapped input/output.
- For example, the monochrome video memory area runs from 704 to 736 KB (0xB0000–B7FFF).

I/O Space

- I/O devices allow the microprocessor to communicate with the outside world.
- I/O port address is similar to a memory address, except that instead of addressing memory, it addresses an I/O device.

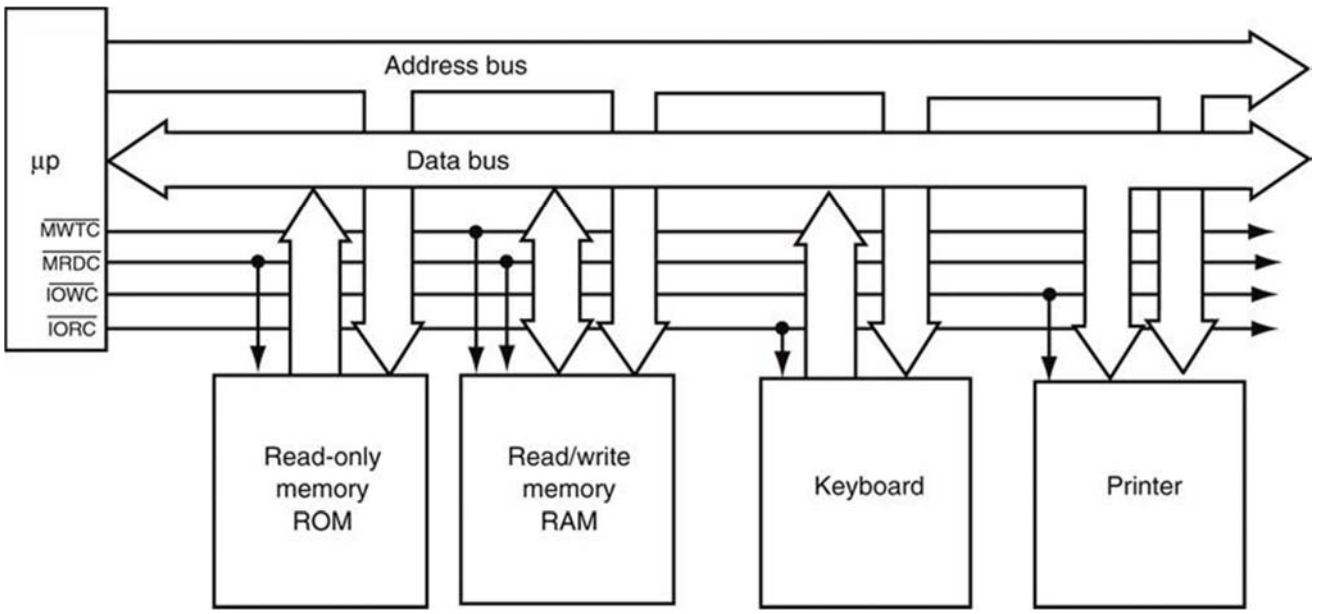
The Microprocessor

- Called the CPU (central processing unit).
- The controlling element in a computer system.
- Controls memory and I/O through connections called buses.
- Memory and I/O controlled via instructions stored in memory, executed by the microprocessor.
- Microprocessor performs three main tasks:
  - data transfer between itself and the memory or I/O systems.
  - simple arithmetic and logic operations.
  - program flow via simple decisions.

- Power of the microprocessor is capability to execute billions of millions of instructions per second from a program or software (group of instructions) stored in the memory system.
- Another powerful feature is the ability to make simple decisions based upon numerical facts.
  - a microprocessor can decide if a number is zero, positive, and so forth
- These decisions allow the microprocessor to modify the program flow, so programs appear to think through these simple decisions.

Buses

- A common group of wires that interconnect components in a computer system.
- Transfer address, data, & control information between microprocessor, memory and I/O.
- Three buses exist for this transfer of information: address, data, and control.
- Figure shows how these buses interconnect various system components.



- The address bus requests a memory location from the memory or an I/O location from the I/O devices.
- The data bus transfers information between the microprocessor and its memory and I/O address space.
- Data transfers vary in size, from 8 bits wide to 64 bits wide in various members of the Intel microprocessor family.

- Control bus lines select and cause memory or I/O to perform a read or write operation.
- In most computer systems, there are four control bus connections:
- $\overline{MRDC}$ (**memory read control**)
- $\overline{MWTC}$ (**memory write control**)
- $\overline{IORC}$ (**I/O read control**)
- $\overline{IOWC}$ (**I/O write control**).
- overbar indicates the control signal is activelow.

- These control signal names are slightly different in various versions of the microprocessor.
- The microprocessor reads a memory location by sending the memory an address through the address bus.
- Next, it sends a memory read control signal to cause the memory to read data.
- Finally data read from memory are passed to the microprocessor through the data bus.


Thanks,..
See you next week (ISA),…