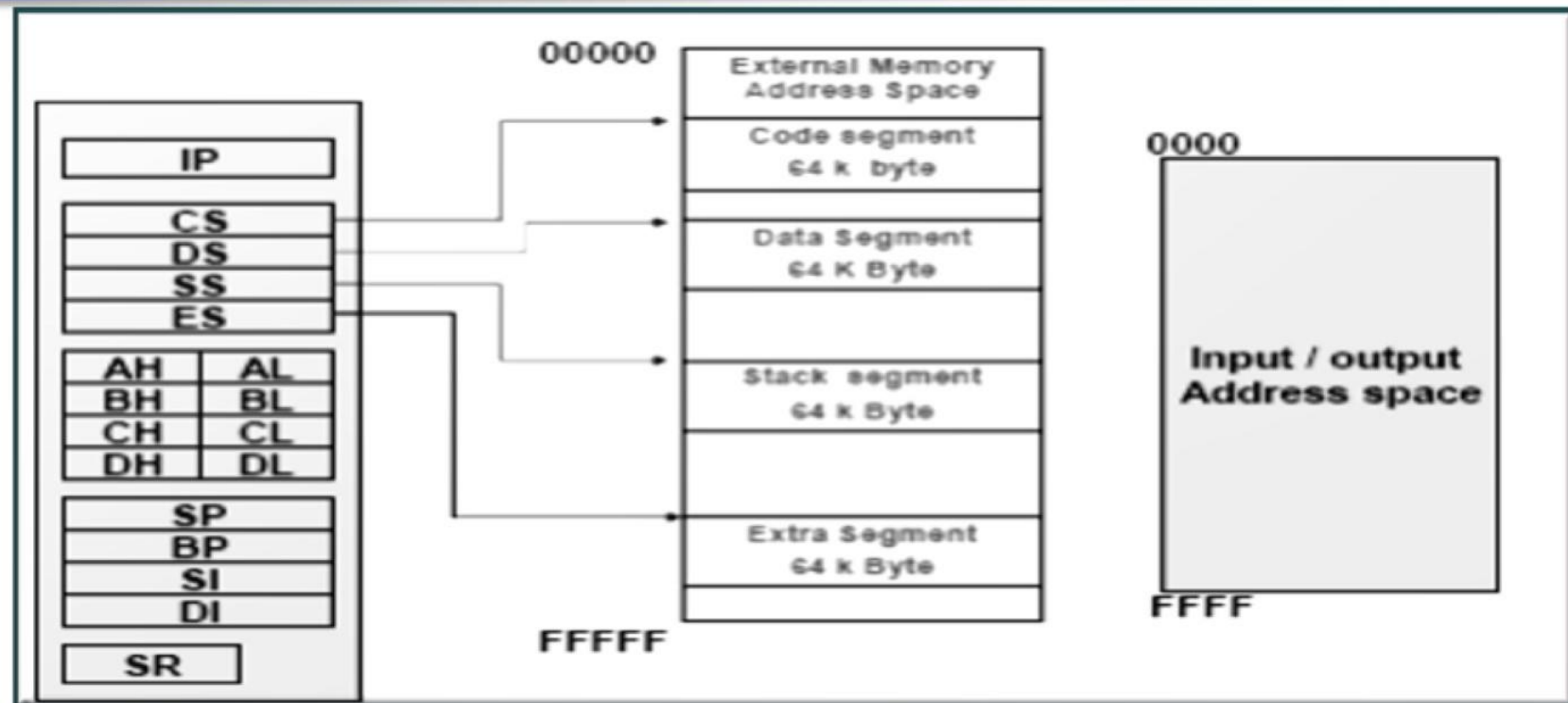# Evolution of 80X86 Family

- **8086, in 1978**
  - ☐ First 16-bit microprocessor
  - ☐ 20-bit address bus, i.e. 2^{20} = 1MB memory
  - ☐ First pipelined microprocessor
- **8088**
  - ☐ Data bus: 16-bit internal, 8-bit external

- **80286, 80386, 80486**
 - ☐ Real/protected modes
  - ☐ Virtual memory

Software Model of the 8086 Microprocessor

- 8088/8086 microprocessor includes 13 16-bit internal registers:
  - Instruction pointer (IP)
  - Data registers (AX, BX, CX, and DX)
  - Pointer registers (BP and SP)
  - Index registers (SI and DI)
  - *Segment registers* (CS, DS, SS, and ES).
  - Status register (SR) or (Flag register)

Software Model of the 8086 Microprocessor
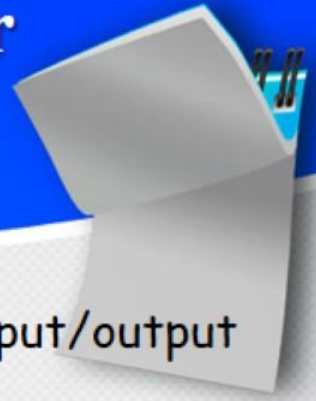
- 8086 architecture implements independent memory and input/output address spaces.
- The memory address space is 1,048,576 bytes (1 M byte) in length and the I/O address space is 65,536 bytes (64 Kbytes) in length.

Memory Address Space and Data Organization

❑ The 8086 microprocessor supports 1Mbytes of memory.

❑ This memory space is organized from a software point of view as individual bytes of data stored at consecutive addresses over the address range 00000_{16} to $FFFFF_{16}$.

❑ The memory in an 8086-based microcomputer is actually organized as 8-bit bytes, not as 16 bit words.

❑ The 8086 can access any two consecutive bytes as a word of data.

❑ The lower address byte is the least significant byte of the word and the higher address byte is its most significant byte.

Memory Address Space and Data Organization

Example: From figure (a)

These two bytes represent the word
$0101010100000010_2 = 5502_{16}$.

The high byte   low byte

The lower address byte (00724)
The higher address byte (00725)

LOW   in LOW
HIGH in HIGH

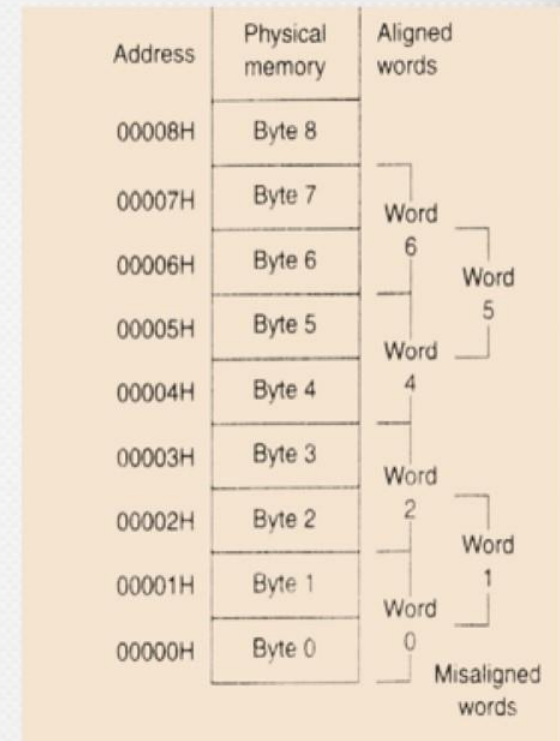| Address	Memory (hexadecimal)
	:
00724	02
00725	55
	:

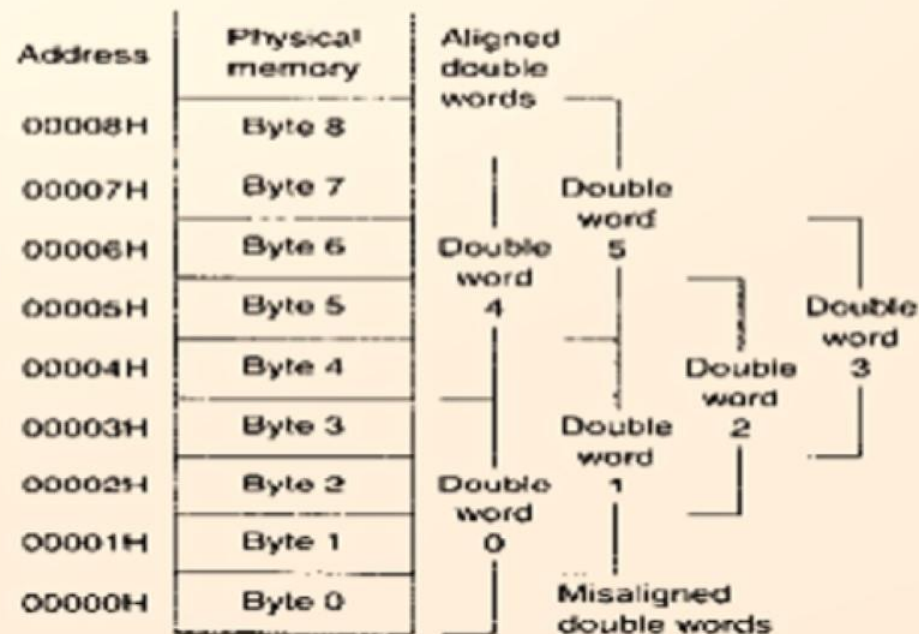Figure (a)

Memory Address Space and Data Organization

▪ To permit efficient use of memory, words of data can be stored at what are called even- or odd-addressed word boundaries.

▪ The least significant bit of the address determines the type of *word boundary*. If this bit is 0, the word is said to be held at an *even-address boundary*.

▪ A word of data stored at an even-address boundary, such as 00000_{16}, 00002_{16}, 00004_{16}, and so on, is said to be an <u>aligned word</u>. (all aligned words are located at an address that is a multiple of 2).

▪ A word of data stored at an odd-address boundary, such as 00001_{16}, 00003_{16}, or 00005_{16} and so on, is called <u>misaligned word</u>.

Address	Physical memory	Aligned words
00008H	Byte 8	
00007H	Byte 7	Word 6
00006H	Byte 6	
00005H	Byte 5	Word 4
00004H	Byte 4	
00003H	Byte 3	Word 2
00002H	Byte 2	
00001H	Byte 1	Word 0
00000H	Byte 0	

Word 5
Word 1
Misaligned words

Memory Address Space and Data Organization

■ A **double word** corresponds to four consecutive bytes of data stored in memory.

Address	Physical memory	Aligned double words
00008H	Byte 8	
00007H	Byte 7	Double word 5
00006H	Byte 6	Double word 4
00005H	Byte 5	
00004H	Byte 4	Double word 3
00003H	Byte 3	Double word 2
00002H	Byte 2	Double word 1
00001H	Byte 1	Double word 0
00000H	Byte 0	Misaligned double words

Memory Address Space and Data Organization

Example1:

Show how the word of data (02ED) store in memory location starting at address (EF05D)? Is the word aligned or misaligned?

02ED WORD   , START ADDRESS = FE05D

MISALIGNED WORD.

	:
FE05D	ED
FE05E	02
	:

Example2:

Show how the double word of data (FF24EB55) store in memory location starting at address (A000E)? Is the double word aligned or misaligned?

WORD 2= FF24   WORD1=EB55

START ADDRESS A000E

	:
A000E	55
A000F	EB
A0010	24
A0011	FF
	:

Example3:

You have the following figure; What is the value of the word stored in memory starting at address (0210C)? Is the word aligned or misaligned?

WORD OF DATA = 0F22

0F	22
0210D	0210C

ALIGNED WORD

0210B	:
0210C	22
0210D	0F
0210E	5A
0210F	00
02110	33
	:

Example4:

You have the above figure; What is the value of the double word stored in memory starting at address (0210C)? Is the double word aligned or misaligned?

FIRST BUS CYCLE
  WORD 1   (0F22)
  SECOND BUS CYCLE
    WORD2 (005A)

DOUBLEWORD= 005A0F22

8086 microprocessor internal registers

8086 consists of 13 register , All registers of size 16-bits

- ☐ Data registers (AX, BX, CX, and DX).
- ☐ *Segment registers* (CS, DS, SS, and ES).
- ☐ Instruction pointer (IP).
- ☐ Index registers (SI and DI).
- ☐ Pointer registers (BP and SP).
- ☐ Status register (SR) or (Flag register).