Tutorial #2
Memory Models

Anirban Lahiri & Prashant Agrawal
Department of Computer Science & Engineering
IIT Kharagpur

Outline

- Memory Models
  - ✓ Flat
  - ✓ Real Mode
  - ✓ Protected

Segmented Memory Model

- Segmentation divides the processor's addressable memory space into smaller protected address spaces called segments.
- Segments can be used to hold code, data and stack for a program or system data structures
- If more than one program is running on a processor, each program can be assigned its own set of segments
- Multiple programs can run on the same processor without interfering with one another
  - The processor then enforces the boundaries between these segments

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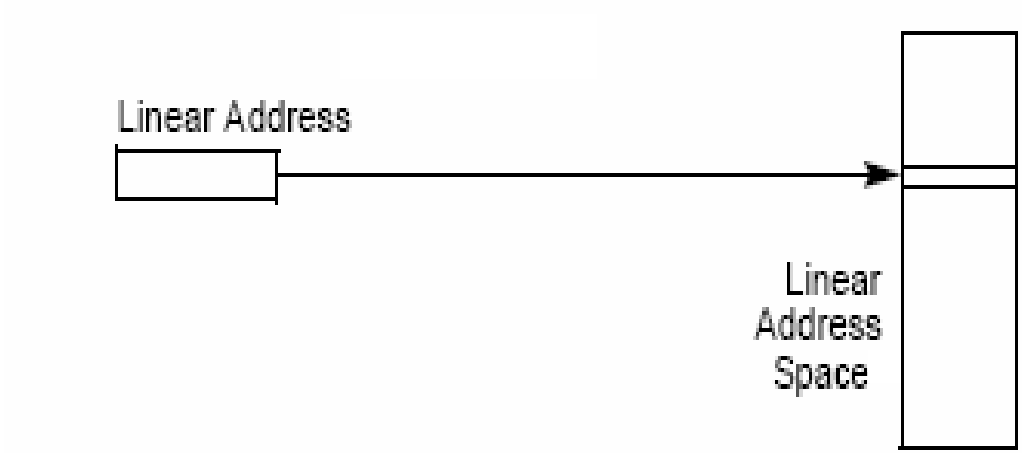
Flat Memory Model



Flat memory model

- Linear addresses are used for all memory locations
- Address space (32 bit) : 0 to 2^{32}-1

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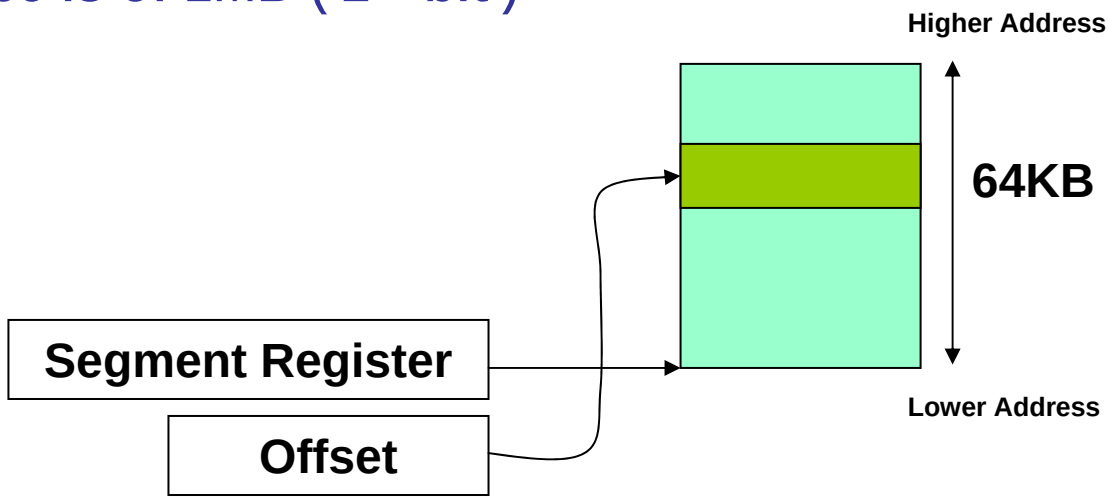
Real-Mode Memory Model

- 8086 & 8088 processors operated exclusively in real-mode
- 80286 and above can operate in both real and protected mode
- In real mode, the processor can address only the first 1MB of memory space
- Processor begins in real mode by default whenever power is applied or processor is reset

Real-Mode Memory Model

- Segment register contains the segment base address
- Offset is of 16-bit
  - Each segment is of 64KB(2^{16})
- Linear Address is of 20-bit
  - Address space is of 1MB (2^{20} bit)

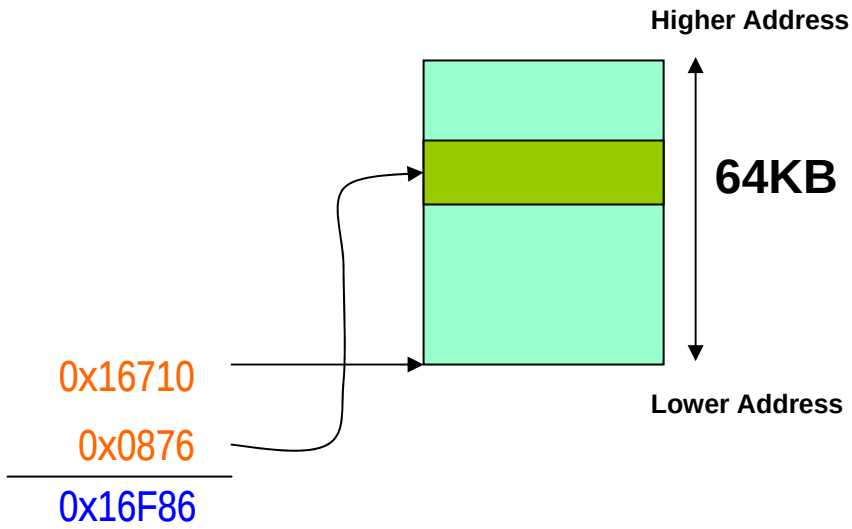


Real-Mode addressing

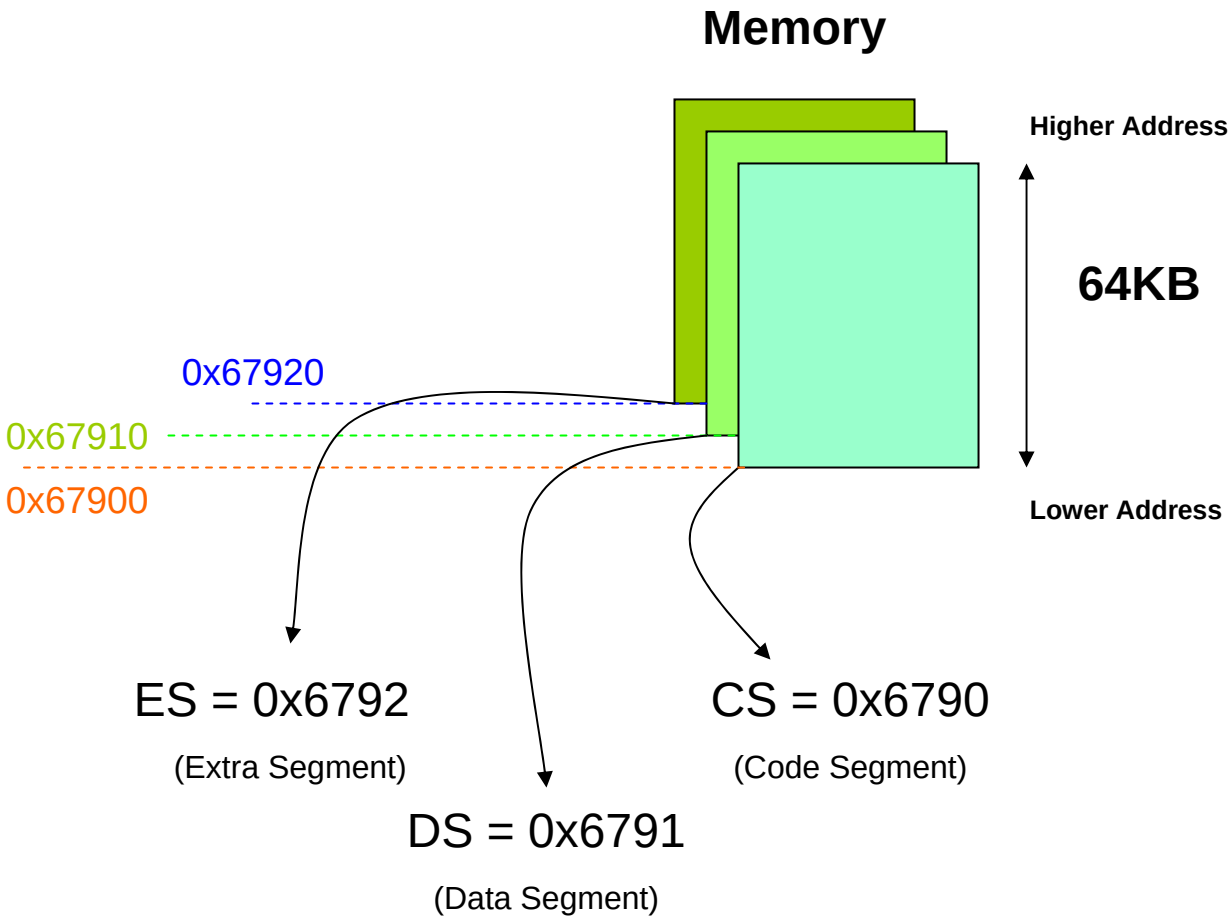
- Address Computation
  - Memory Address = Segment Register*16 + Offset
  - Segment Register : 16bit
  - Offset : 16 bit
  - Memory Address : 20bit

Eg.

For address in the data segment
DS = 0x1671
Offset = 0x0876
Memory Address = 0x1671*16 + 0x0876
= 0x16F86



Real-mode addressing (contd...)



Real-mode addressing (contd...)

- Eg.

For address in the data segment — 0x16710
DS = 0x1671 — 0x0876
Offset = 0x0876 — 0x16F86
Memory Address = 0x1671*16 + 0x0876
= 0x16F86

For address in the code segment — 0x16700
CS = 0x1670 — 0x0886
Offset = 0x0886 — 0x16F86
Memory Address = 0x1670*16 + 0x0886
= 0x16F86

The two addresses refer to the same location in memory!!!

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Protected Mode Addressing

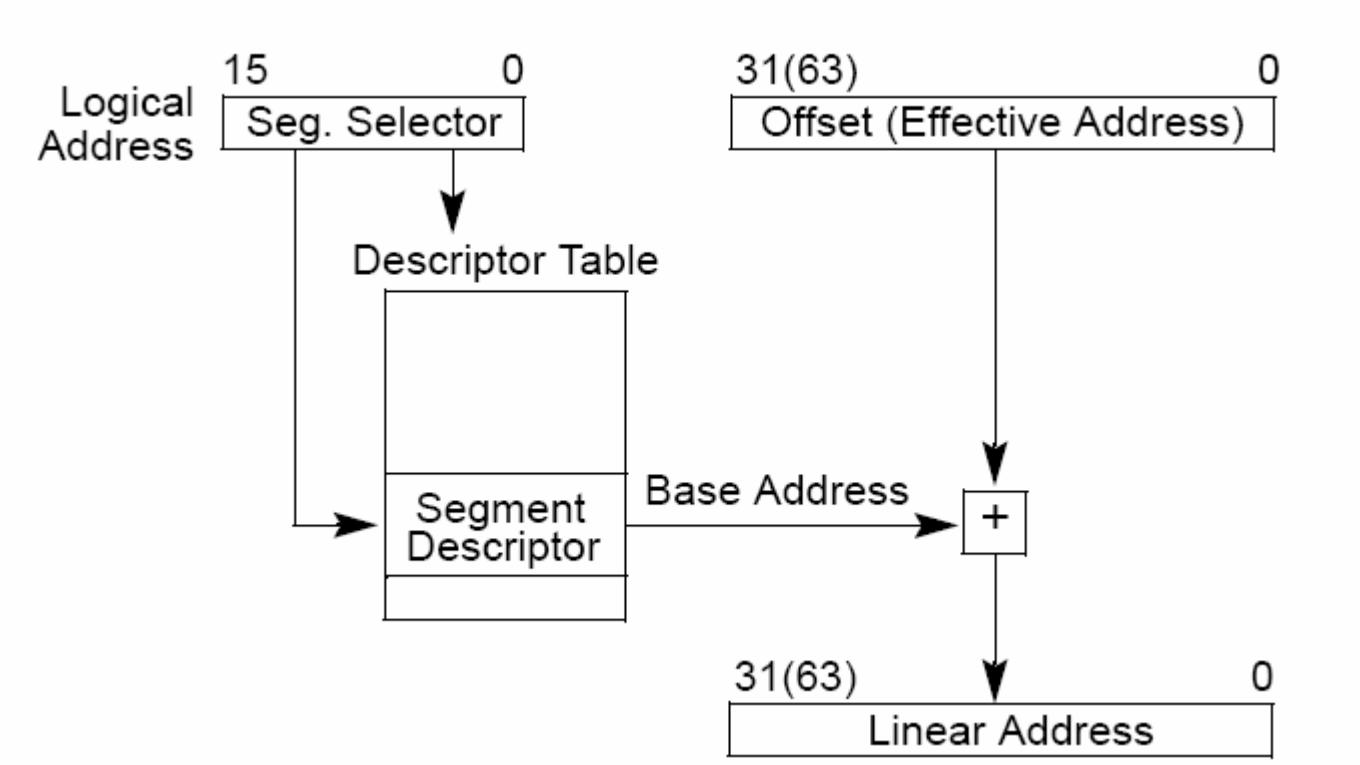
- Protected mode addressing allows accessing more than 1MB of memory.
- Addressing this extended section of the memory system requires a change to the segment plus an offset addressing scheme used with real mode addressing.
- The segment registers doesn't contain segment base address. Instead it contains a segment selector that selects a descriptor from a descriptor table.

Protected Mode Addressing

- Because the segment register and offset address still access memory, protected mode instructions are identical to real mode instructions
- Most programs written to function in real mode will function without change in the protected mode
- The difference between modes is in the way that the segment register is interpreted by the processor to access the memory segment

Protected Mode Addressing

Logical address to linear address mapping



Ref: IA-32 Intel® Architecture Software Developer's Manual Volume 3: System Programming Guide

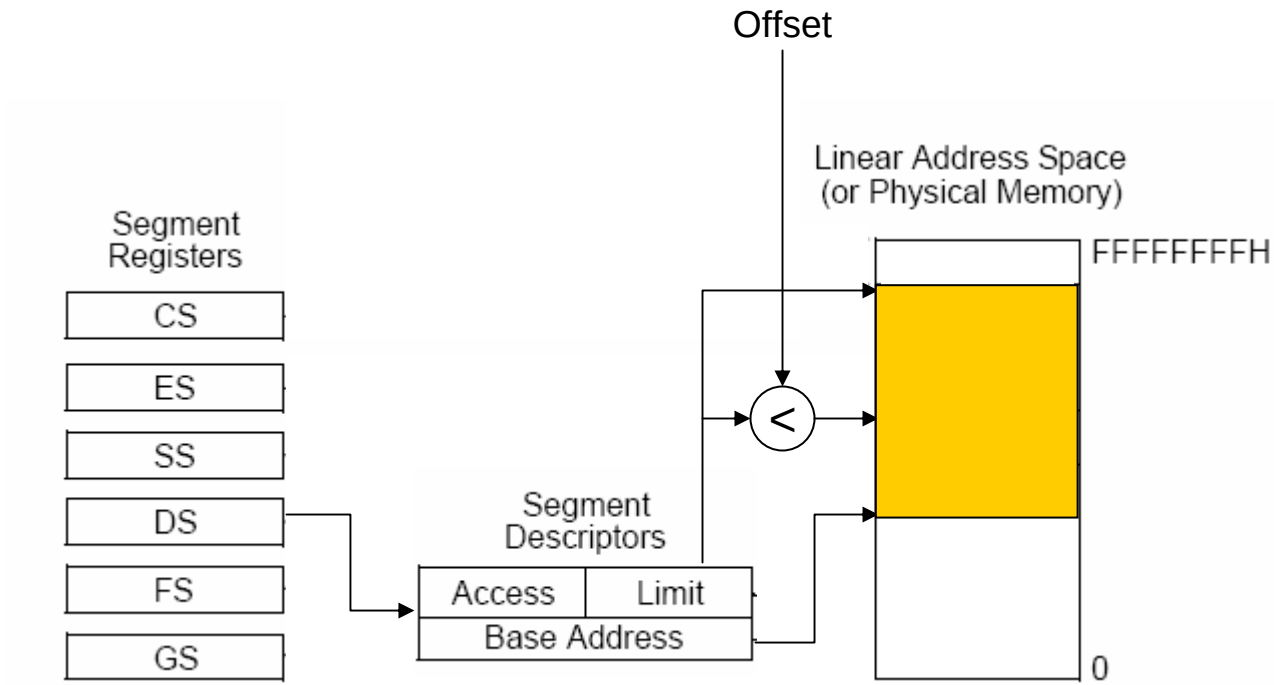
Protected Mode Addressing

- Segment Register : 16bits
- Address Offset : 32bits
  - Each segment can be up to 2^{32} bytes(4GB) long
- A segment register contains a segment selector
  - Segment selector is a pointer to a Segment Descriptor Table (SDT)
  - Segment Descriptor Table contains an entry (segment descriptor) for each segment in the system
- Types of Segment Descriptor Table
  - Global Descriptor Table (GDT)
  - Local Descriptor Table (LDT)

Segment Descriptor

- Each segment descriptor consists of
  - Segment base address
  - Segment limit
  - Access rights

Protected Mode Addressing



“640 K ought to be enough for anybody”

- Bill Gates, 1981