

# **x86 Assembly Programming**

Lesson 2 – Memory

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# Memory

- Computer memory is storage divided into one byte sections sometimes referred to as slots.
  - Slots are named by their physical address
    - 32 bit systems use 32bit addresses 0x00000000 to 0xFFFFFFFF
    - 64 bit systems use 64bit addresses 0x0000000000000000 to 0xFFFFFFFFFFFFFFFF
    - 64 bit systems running in 32 bit mode use 32 bit addresses
  - Each slot contains 1 byte of data
    - For example an ANSI C string “Hello!” would use 7 slots
      - 6 slots for Hello!
      - 1 slot for the null character Ø

Addresses for 32bit system 0x00000000 through 0xFFFFFFFF

Slot/Data	Physical Address
H	0x00000000
E	0x00000001
L	0x00000002
L	0x00000003
O	0x00000004
!	0x00000005
Ø	0x00000006
	0x00000007
	0xFFFFFFFF6
	0xFFFFFFFF7
	0xFFFFFFFF8
	0xFFFFFFFF9
	0xFFFFFFFFA
	0xFFFFFFFFB
	0xFFFFFFFFC
	0xFFFFFFFFD
	0xFFFFFFFFE
	0xFFFFFFFFF

# Memory & Memory Models

- Memory Types
  - RAM – Random Access Memory (PC Memory)
    - Volatile Integrated Circuits (IC)s which lose data during power failure. Data can be written and read from this type of memory.
  - ROM – Read Only Memory
    - Non-volatile Integrated Circuits (IC)s which permanently retain data even during power failure. Once programmed the data can only be read.
- Memory Models (Overview)
  - Flat – Intel 80386 and higher required single segment contains both code and data.
  - Segmented – 80x86 architecture also allows [segment + offset] to address memory locations

# Memory Models - Segmented

- Segmented Memory Model
  - Only model available on Intel 8086 and 8088 CPUs
    - Supports up to 1MB memory address space (20 bits) or 0xFFFF
    - Memory is addressable in a 64k window known as a segment
    - Segments start on 16 byte boundaries.
      - 0x00000, 0x00010, 0x00020 , 0x00030, 0x00040, ...
    - Segment is the first two bytes (4 hex digits) of the physical address
    - Offsets are 16 bits 0x0000 to 0xFFFF
    - Segment address notation is SEGMENT:OFFSET
    - For example, 16A2:4517 would result in physical address 1AF37

	1	6	A	2	0
+		4	5	1	7
	1	A	F	3	7

# Memory Models - Segmented

- Segmented Memory Model Continued
  - 80386 and higher systems support both 16 and 32 bit segmented models. This also applies to 64 bit processors running in 32 bit mode, but not when running in 64 bit mode. Simply put 64 bit mode doesn't support segmentation.
  - The 32 bit segmented model still uses 16 bit segments, however; the 16 bit segments are used as indexes to lookup the starting addresses of segments in the 32 bit address space.
  - Once the starting address is looked up the 32 bit offset is added to 32 bit starting address in order to reference the correct physical memory address.

# Memory Models - Flat

- Flat Memory Model
  - On 32 bit systems the memory model exclusively uses offsets and all segment registers are set to the same value.
  - On 32 bit systems it is possible to address up to 4Gb of memory or  $0xFFFFFFFF = 4294967295$  bytes.
  - In theory on 64 bit systems it should be possible to address 16 Exabytes.
  - The flat model simplifies writing of assembly code and makes the execution faster than the segmented model.
  - The segmented model is becoming deprecated and the flat model will be used exclusively throughout this training.

# Try it!

Try your best to do it manually

Solve	Answer
What is the physical address of 2222:2323 ?	
What is the 32 bit physical address range (in hex) for 4GB of RAM?	
What is the 64 bit physical address range (in hex) for 8GB of RAM?	