Memory, Data, & Addressing I

CSE 351 Autumn 2023

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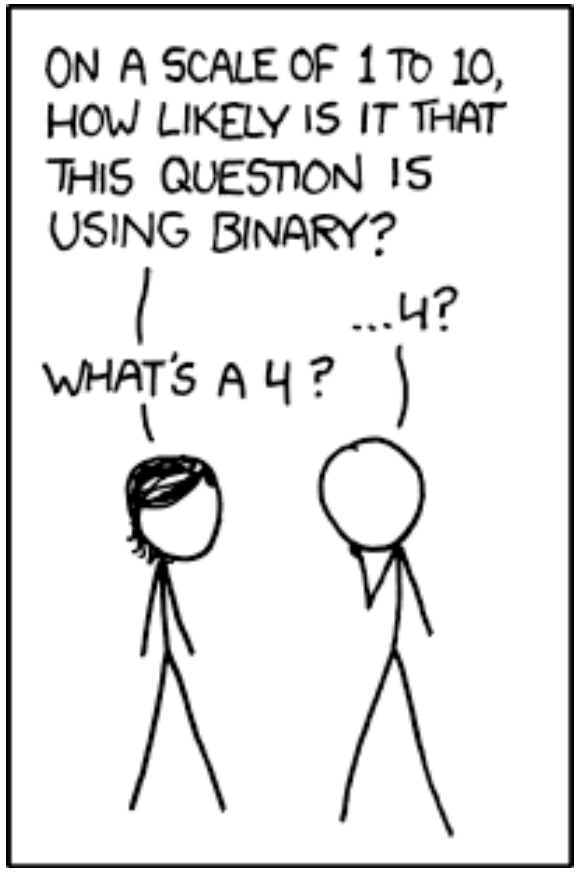


http://xkcd.com/953/

Relevant Course Information

- Upcoming deadlines
  - Pre-Course Survey and HW0 due tonight
  - HW1 due Monday (10/2)
  - Lab 0 due Monday (10/2)
    - This lab is *exploratory* and looks like a HW; the other labs will look a lot different
- Ed Discussion etiquette
  - For anything that doesn't involve sensitive information or a solution, post publicly (you can post anonymously!)
  - If you feel like you question has been sufficiently answered, make sure that a response has a checkmark

EPA

- Encourage class-wide learning!
- Effort
  - Attending support hours, completing all assignments
  - Keeping up with Ed Discussion activity
- Participation
  - Making the class more interactive by asking questions in lecture, section, support hours, and on Ed Discussion
- Altruism
  - Helping others in section, support hours, and on Ed Discussion

Memory & Data I

Lesson Summary (1/2)

- Memory is a long, *byte-addressed* array
  - Word size bounds the size of the *address space* and memory
  - Address of chunk of memory given by address of lowest byte in chunk
- Endianness determines memory storage order for multi-byte data
  - Least significant byte in lowest (little-endian) or highest (big-endian) address of memory chunk
- Programming Data
  - Variable declaration allocates space for data type size
  - Assignment results in value being put in memory location

Lesson Summary (2/2)

- Terminology:
  - byte-oriented memory, word size, address, address space
  - most-significant bit (MSB), least-significant bit (LSB), big-endian, little-endian

- Learning Objectives:
  - (Define the concept of pointers and) their significance in computer memory organization.
  - (Design code that can correctly) interpret and manipulate multi-byte data in both little-endian and big-endian byte orderings.

- What lingering questions do you have from the lesson?

Memory & Data I – Context

Modern System Details

- Current x86-64 systems use **64-bit (8-byte) words** ("64-bit machines")
  - Potential address space: $\mathbf{2^{64}}$ addresses
    2^{64} bytes ≈ **1.8 x 10^{19} bytes**
    = 18 billion billion bytes = 18 EB (exabytes)
  - Actual physical address space: **48 bits**
    - This is sufficient space for now and allows for some operating system tricks
    - Example address: `0x 7f fc 3d d5 06 94`

- There's a lot more to this story… stay tuned for virtual memory!

Discussion Question

- Discuss the following question(s) in groups of 3-4 students
  - I will call on a few groups afterwards so please be prepared to share out
  - Be respectful of others' opinions and experiences

- Over time, computers have grown in word size:

Word size	Instruction Set Architecture	First? Intel CPU	Year Introduced
8-bit	??? (Poor & Pyle)	Intel 8008	1972
16-bit	x86	Intel 8086	1978
32-bit	IA-32	Intel 386	1985
64-bit	IA-64	Itanium (Merced)	2001
64-bit	x86-64	Xeon (Nocona)	2004

  - What do you think were some of the *causes*, *advantages*, and *disadvantages* of this trend?

Memory & Data I – Practice

Group Work Time

- During this time, you are encouraged to work on the following:
  1) If desired, continue your discussion
  2) Work on the lesson problems (solutions at the end of class)
  3) Work on the homework problems

- Resources:
  - You can revisit the lesson material
  - Work together in groups and help each other out
  - Course staff will circle around to provide support

Practice Questions (1/2)

- By looking at the bits stored in memory, I can tell what a particular 4 bytes is being used to represent.

  A. True B. False

  many possible encoding schemes

- We can fetch a piece of data from memory as long as we have its address.

  A. True B. False

  need: ① address ✓
  ② data size ✗

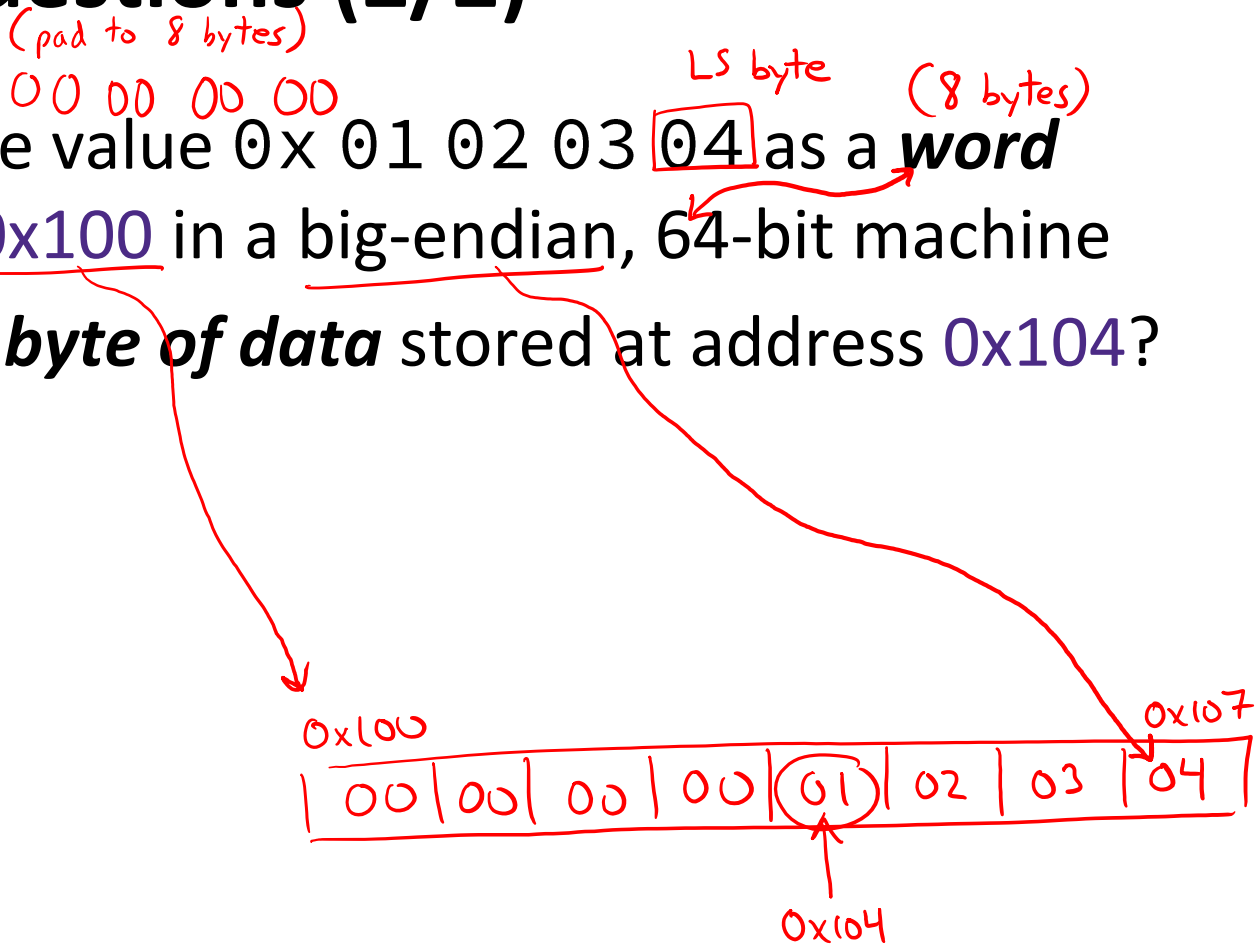
- Which of the following bytes have a most-significant bit (MSB) of 1?

  → 8 bits = 2 hex digits

  0b 0110 0011 — A. 0x63
  0b 1001 0000 — B. 0x90
  0b 1100 1010 — C. 0xCA
  0b 0000 1111 — D. ~~0xF~~ 0x0F

Practice Questions (2/2)

- We store the value 0x 01 02 03 04 as a ***word*** at address 0x100 in a big-endian, 64-bit machine
- What is the ***byte of data*** stored at address 0x104?



A. 0x04
B. 0x40
C. 0x01
D. 0x10
E. We're lost…