



CSARCH Lecture Series: Binary Data Organization

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Overview

Reflect on the following questions:

- What is bit, byte, nibble or word?
- What does least significant and most significant mean?
- What does endianness mean?

Overview

- This sub-module discusses the various binary data organization
- The objectives are as follows:
 - ✓ Explain the different levels of binary data organization
 - ✓ Explain the difference between little endian and big endian

Binary Data Organization

- Binary digits (also known as bits) can be group to form various organizations:

Organization	Number of bits	Usage
Bit (binary digit)	2 cells – 0 or 1	Basic unit
Crumb	2 bits	*largely defunct term. rarely used
Nibble	4 bits	Hex digit, BCD digit
Byte	8 bits	Smallest addressable data unit
Half word	16 bits	Definition of word is architecture-dependent
Word	32 bits	A 32-bit architecture considers 1 word as 32-bit
Double word	64 bits	
Quad word	128 bits	

Binary Data Organization

- Given a byte, bit 7 is the most significant bit (MSb) while bit 0 is the least significant bit (LSb)
- Bit is abbreviated as **lowercase b** while byte is abbreviated as **capital B**
- Computer architecture convention states that numbering starts at 0 (not 1)

7	6	5	4	3	2	1	0
MSb*							LSb*

Binary Data Organization

- Example: 10010110_2
- 0 is the least significant bit (LSb) (i.e., bit 0) while 1 is the most significant bit (MSb) (i.e., bit 7)

Binary Data Organization

- Least significant and most significant can be extended to nibble, byte, word or any binary data organization
- Example: 10010110_2 or 96_{16}
- 0110_2 or 6_{16} is the least significant nibble while 1001_2 or 9_{16} is the most significant nibble
- Example: $123ACAFE_{16}$
- FE_{16} is the least significant byte (LSB) while 12_{16} is the most significant byte (MSB)



- Given $12AB3456CAFE5678_{16}$
 - What is the least significant bit?
 - What is the most significant bit?
 - What is the least significant byte?
 - What is the most significant byte?
 - What is the least significant word?
 - What is the most significant word?



Try

→ Pause your video first before answering

- Given $12AB3456CAFE5678_{16}$
 - What is the least significant bit? 0
 - What is the most significant bit? 0
 - What is the least significant byte? 78
 - What is the most significant byte? 12
 - What is the least significant word? CAFE5678
 - What is the most significant word? 12AB3456

Byte Ordering System - Endianness

- Endianness refers to the convention used to interpret the byte ordering of multi-byte stored in the computer memory.
- Two types: Big endian and Little endian
- Coined by Danny Cohen based on his paper “On Holy Wars and a Plea for Peace” (published in IEEE Computer, October 1981 issue).
- Based on Jonathan Swift’s novel “Gulliver's Travel”.
- Tension between Lilliput and Blefuscu on which side to crack the soft boiled egg – small end or big end?

Little Endian Byte Ordering System

- Multi-byte stores the least-significant byte at the lowest memory byte address, followed by the other bytes in ascending order of their significance
- The address of the multi-byte is the address of the least-significant byte.

Address	Data (hex)
0003	55
0002	44
0001	33
0000	22

- Example: address 0000 contains 16-bit data 3322
- Example: address 0000 contains 32-bit data 55443322

Big Endian Byte Ordering System

- Multi-byte stores the most-significant byte at the lowest memory byte address, followed by the other bytes in ascending order of their significance
- The address of the multi-byte is the address of the most-significant byte.

Address	Data (hex)
0003	55
0002	44
0001	33
0000	22

- Example: address 0000 contains 16-bit data 2233
- Example: address 0000 contains 32-bit data 22334455

To recall...

- What we have learned:
 - ✓ Explain the different levels of binary data organization
 - ✓ Explain the difference between little endian and big endian