Computer Organization & Architecture

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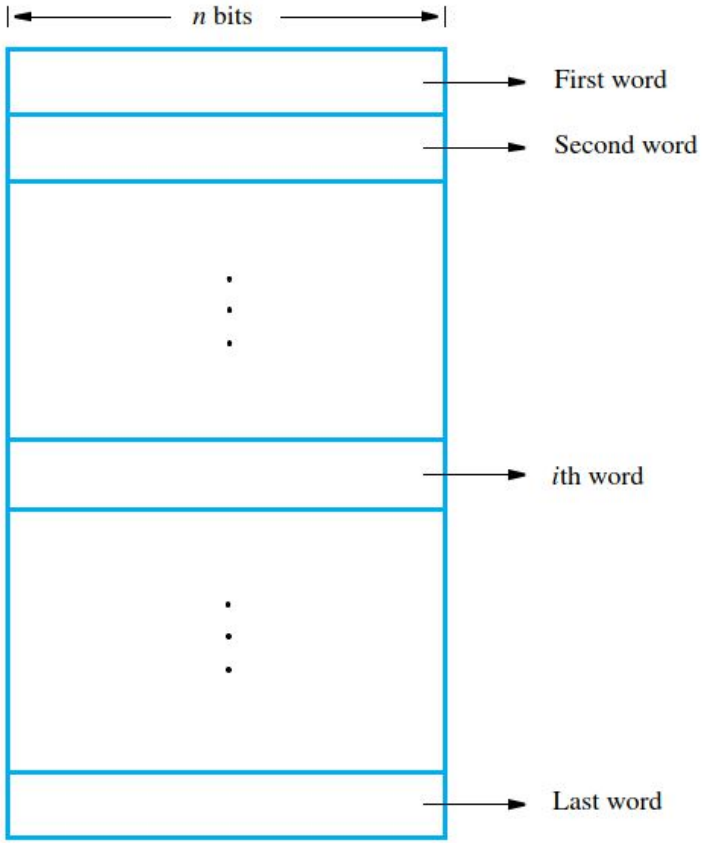
Instruction Set Architecture

Lecture Outline

- Memory Locations and Addresses
- Memory Operations
- Instructions and Instruction Sequencing

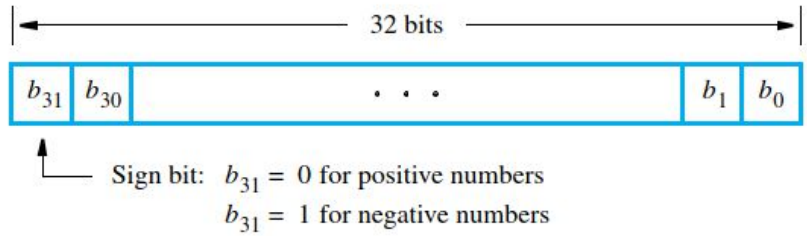
Memory Locations and Addresses

- How memory is organized?
  - Consist of millions of storage cells, each store one bit of information.
- Bits are normally handled in groups of fixed size.
  - Requires single basic operation.
- Each n-bit group is called word.
  - n-length describes the word length.
- Memory can be represented as a collection of words.

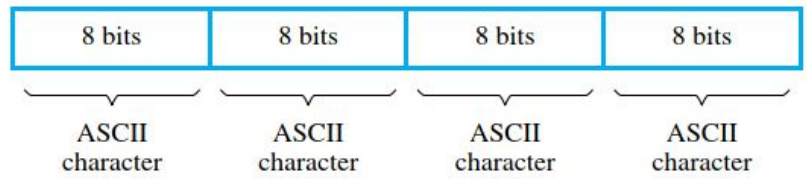


Memory Locations and Addresses

- Modern PCs have word length from 16 to 64 bits.
  - E.g: if 32-bit word length – a single word can store 32-bit signed number or four ASCIIencoded characters, each occupying 8 bits (byte).



(a) A signed integer



(b) Four characters

Memory Locations and Addresses

Accessing the memory:

- Machine instructions may require one or more words.
- Each word requires a distinct address in order to be accessed
  - 0 to 2(k-1) , for some suitable value of k.
- Address Space?
  - E.g: a 24-bit address generates an address space of 224 (16,777,216) locations.

Memory Locations and Addresses:

Byte Addressability

- Three basic information quantities: bit, byte, and word.
- The most practical assignment is to have successive addresses refer to successive byte locations in the memory..
- Byte-addressable memory is used for this assignment.
- Byte locations have address 0, 1, 2, ... thus, if the word length of the machine is 32-bits, locations are located 0, 4, 8, ... Consisting four bytes.

Memory Locations and Addresses

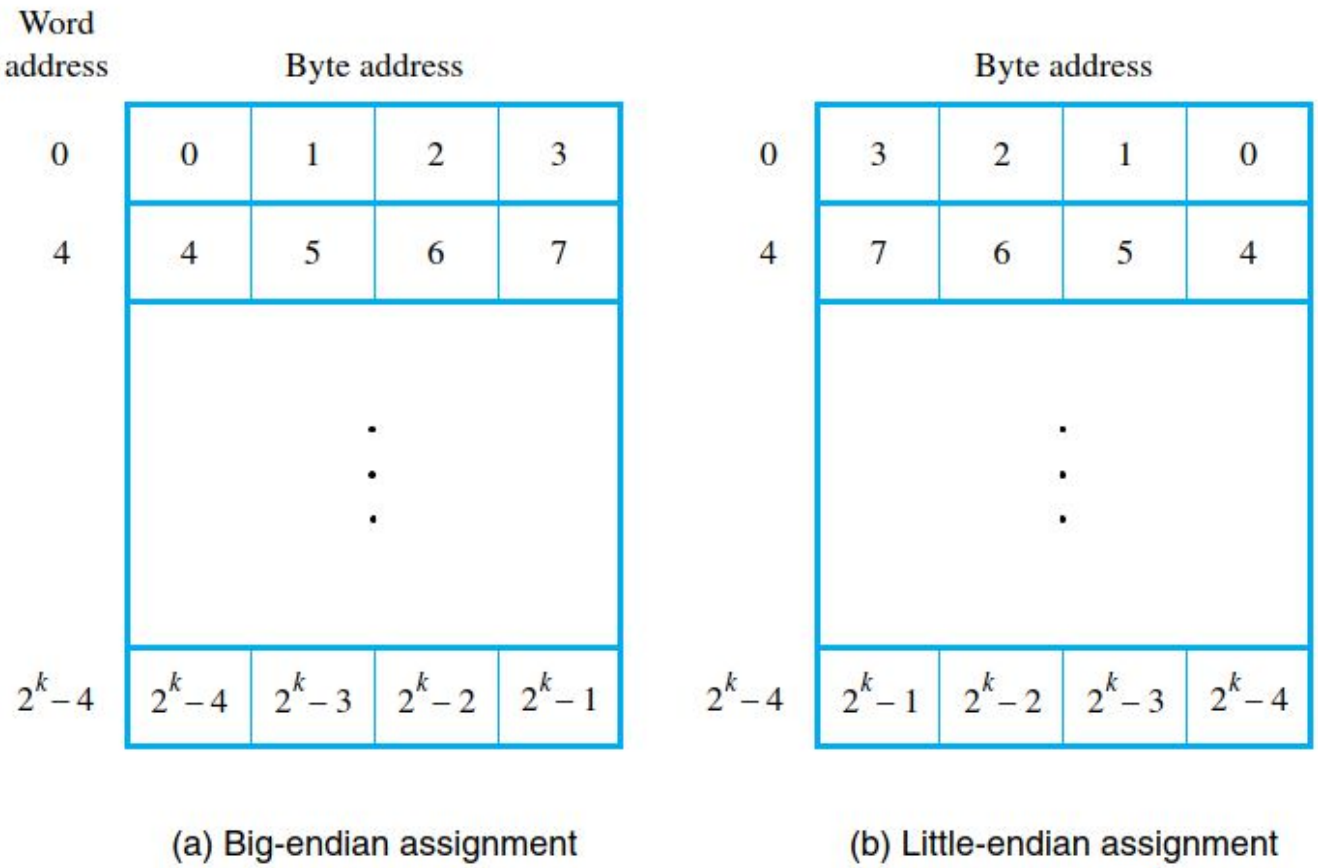
Big-Endian and Little-Endian Assignments

- Two ways that byte addresses can be assigned across words:

1. Big-Endian – When lower byte addresses are used for the more significant bytes (the leftmost bytes) of the word.

2. Little-Endian – Opposite ordering, where the lower byte addresses are used for the less significant bytes (the rightmost bytes) of the word.

Big-Endian and Little-Endian Assignments



(a) Big-endian assignment

(b) Little-endian assignment

Memory Locations and Addresses

Word Alignment

- aligned addresses make accessing of memory operands more efficient.

Accessing Numbers and Characters

- A number occupies one word, and can be accessed by specifying its word address.
- Individual characters can be accessed by their byte address.

Memory Operations

Two basic operations involving the memory are needed: Read and Write.

- Read Operation:
  - Transfers a copy of contents to memory and contents in memory are unchanged.
  - Processor sends address to the memory and makes request for access.
  - Memory reads the data stored and sends them to the processor.
- Write Operation:
  - Transfers an item of information from the processor to a specific memory location, overwriting the former contents of that location.
  - Processor sends the address of the desired location to the memory, together with the data to be written into that location.
  - The memory then uses the address and data to perform the write.

Instructions and Instruction Sequencing

A computer must have instructions capable of performing four types of operations:

- Data transfers between the memory and the processor registers
- Arithmetic and logic operations on data
- Program sequencing and control
- I/O transfers

Instructions and Instruction Sequencing

- What is register?
- Register transfer language?
- Types of Registers:
  - Accumulator
  - General Purpose Registers
  - Special Purpose Registers
    - MAR: Memory Address Register
    - MBR: Memory Buffer Register
    - PC: Program Counter
    - IR: Instruction Register