Fundamentals of Engineering Exam Review Computers

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Outline

- Computer Hardware
- Computer Software

NOTE: These slides were created by following Sections 47 and 48 from the FE Review Manual – Rapid Preparation for the General Fundamentals of Engineering Exam, 2nd Edition by Michael R. Lindeburg, PE. ISBN: 978-1-59126-072-1

Computer Hardware

Computer Architecture

- Central Processing Unit
- Main Memory
- External (Peripheral) Devices

Microprocessors (CPU)

- Microprocessors
  - Arithmetic and logic unit (ALU)
    - Executes commands and manipulates data
  - Accumulators
    - Hold data and instructions for further manipulation in the CPU
  - Registers
    - Used for temporary storage of instructions or data
    - Program Counter is a special register that always contains the address of the next instruction to be executed
    - Instruction Register holds the current instruction during its execution
  - Stacks
    - Provide temporary data storage in sequential order (LIFO)
  - Control unit
    - Fetches and decodes incoming instructions

Buses

- Microprocessors communicate with support chips and peripherals through a bus or channel
  - Bus refers to the physical path
  - Channel refers to the logical path
- Buses
  - Address Bus
    - Directs memory and input/output via device transfers
    - Number of lines in the address bus determines the amount of RAM that can be directly addressed (n address lines = 2^n words of memory)
  - Data Bus
    - Carries the actual data and is the busiest bus (generally)
  - Control Bus
    - Communicates control and status information

Microprocessor Specifics

- Crystal-controlled clocks control instruction and data movements
- Clock rate is specified in microprocessor cycles per second
  - This is generally the number of instructions the microprocessor can handle per second
  - The speed can also be specified in flops, which is the number of floating point operations it can perform per second
  - MIPS is another speed term, which is millions of instructions per second
- CISC (complex) and RISC (reduced instruction-set computing) are types of microprocessors

Computer Operation Control

- Operating System
  - Controls the computer at its most basic level and provides the environment for application programs
  - Manages memory, schedules processing operations, accesses peripheral devices, communicates with the user, and resolves conflicting requirements for resources
- BIOS
  - Basic Input/Output System
- ROM
  - Read-Only Memory
  - Some or all of the OS can be stored in ROM
  - Also known as a bootstrap loader
- Interrupt
  - Signal that stops the execution of the current instruction and transfers control to another memory location

Computer Memory

- Computer memory consists of many equally sized storage locations, each with an associated address
- Bit – 1 or 0
- Nibble – 4 bits
- Byte – 8 bits
- Half-Word – 16 bits on a 32-bit microprocessor
- Word – 32 bits on a 32-bit microprocessor
- Double-Word – 64 bits on a 32-bit microprocessor

Memory Locations

- Kilo – $2^{10} = 1024$
- Mega – $2^{20} = 1{,}048{,}576$
- Giga – $2^{30} = 1{,}073{,}741{,}824$
- Video Memory
  - Contains what is displayed on the screen
- Cache Memory
  - Holds the most recently read and frequently read data, making subsequent retrieval much faster than reading from a drive or even from main memory

Types of Memory

- RAM – Random Access Memory, volatile
- ROM – Read-Only Memory, non-volatile
- PROM – Programmable Read-Only Memory, non-volatile
- EPROM – Erasable Programmable Read-Only Memory, non-volatile
  - Firmware is used to describe programs stored in ROMs and EPROMs
- EEPROM – Electrically Erasable Programmable Read-Only Memory (flash memory), non-volatile
- Virtual Memory – programs and data larger than main memory can be accessed by the computer
  - Paging – pages are switched in and out of RAM from disk storage

Parity

- Parity ensures the bits within a byte of memory are correct
  - A 9^{th} bit (the parity bit) is the check bit
  - The 9 bits make up a frame
  - In odd-parity recording, the parity bit will be set so there is an odd number of one-bits in the frame
  - In even-parity recording, the parity bit will be set so there is an even number of one-bits in the frame

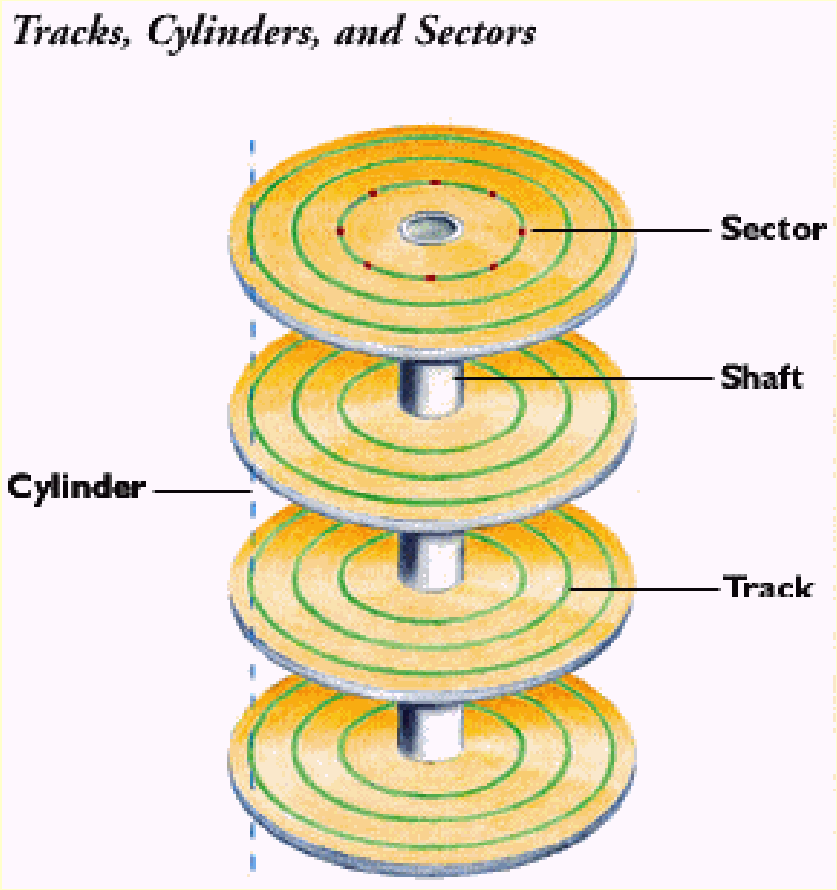
Transmission Speed

- The transmission speed (or baud rate) in bits per second (bps) is the number of bits that pass through the data line each second
- If there is a one-to-one correspondence between modulations and bits, one baud unit is the same as one bit per second
- Multiplexed transmission allows more than one device to send along the same link
  - Frequency Division Multiplexing (FDM)
  - Time Division Multiplexing (TDM)

Random Secondary Storage Devices

- Random Access Storage Devices, also known as mass storage devices, include magnetic and optical disk drives
  - Individual records can be accessed without having to read through the entire file
- Magnetic disk drives are composed of several platters, each with one or more read/write heads
  - Tracks are concentric storage areas
  - Sectors are pie-shaped subdivisions of each track
  - Cylinders consist of the same numbered track on all drive platters
- The average seek time is the average time it takes to move a head from one location a new location

Hard Drives



Sample Hardware Questions

- Which of the following best defines a buffer?
  - A region where extra information goes once the main memory is full
  - A temporary storage region used to compensate for signal time differences
  - The same thing as main memory
  - A permanent memory region where start-up information is store

- Which of the following best defines a word?
  - The equivalent of four bytes; the basic unit of data transfer
  - The largest number of bytes that can be used in arithmetic operations
  - Eight contiguous bits in computer memory
  - The smallest number of bytes that can be used in arithmetic operations

- A 256K-word memory uses 16-bit words. How many parallel data lines are required to pass data to the CPU for processing? Do not count clock, sync, or other protocol lines.
  - 2
  - 8
  - 9
  - 16

- A simple controller board has two thousand 8-bit memory locations and two 8-bit registers. How many different states can this board be in?
  - 2002
  - 2^8
  - 2^{2002}
  - $2^{16,016}$

Computer Software

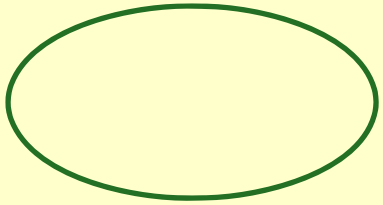
Character Coding

- Coding refers to the manner in which alphanumeric data and control characters are represented by sequences of bits
- ASCII – American Standard Code for Information Interchange is a 7-bit code permitting $2^7 = 128$ different combinations
- EBCDIC – Extended Binary Coded Decimal Interchange Code uses 8 bits, allowing $2^8 = 256$ different characters
  - Hexadecimal (base 16) is often used to represent EBCDIC values

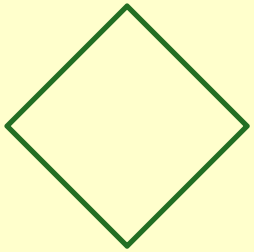
Programs

- A program is a sequence of computer instructions that performs some function
- An algorithm is a procedure consisting of a finite set of well-defined steps
- A flowchart is a step-by-step drawing representing a specific procedure or algorithm

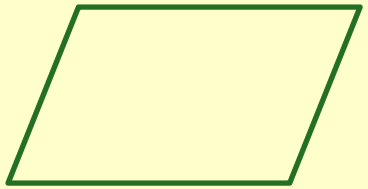
Flowchart Symbols



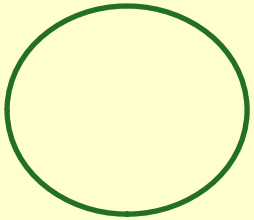
Terminal



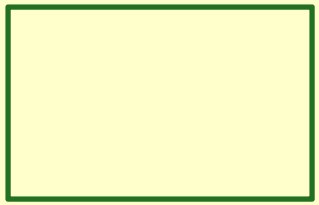
Decision



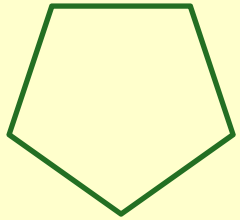
Input/Output



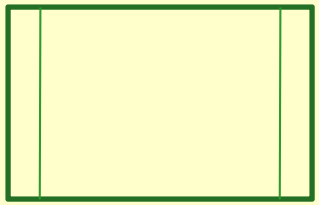
Connector



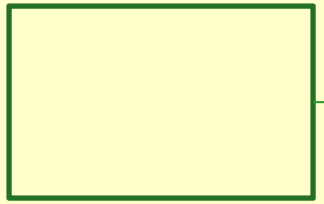
Processing



Off-Page



Predefined Processes



Annotation

Languages

- Low-Level Languages
  - Machine language instructions are intrinsically compatible with and understood by the computer's CPU
  - Assembly language uses mnemonic codes to specify the operations
    - Assembly is translated to machine language using an assembler
- High-Level Languages
  - The instructions attempt to resemble English
  - An interpreter or compiler translates high-level statements into machine language

Structured Programming

- Structured programming (or top-down programming, procedure-oriented programming, and GOTO-less programming)
  - Divides a procedure or algorithm into parts known as subprograms, subroutines, modules, blocks, procedures, functions, methods, etc.
- Recursive calls permit a program to call itself

Spreadsheets

- Spreadsheets are programs that provide a table of values arranged in rows and columns
  - Each value can have a predefined relationship to the other values
  - A cell is a particular element of the table identified by the row and column
    - An absolute cell reference will have a $ before the row and column designators, such as A1
    - A relative cell reference does not have the $ before the designators, and is dependent on the cell in which the reference resides

Fields and Records

- A collection of fields is known as a record
- Groups of records are stored in a file
- An index file is an ordered list of items with references to the complete record

Sorting

- Sorting routines place data in ascending or descending order
- Bubble sort requires approximately $n^2/2$ comparisons
- Insertion sort requires $n^2/2$ comparisons in the worst case, but $n^2/4$ comparisons on average
- Quicksort requires nlogn/log2 comparisons on average
- Heapsort requires nlogn/log2 comparisons in the worst case

Searching

- In the worst case, n comparisons will be required, though n/2 comparisons are required on average
- If the records are sorted, a binary search will only require logn/log2 comparisons

Hashing

- Hashing is a procedure used for determining the record number directly from a key for each record
- Most hashing algorithms use the modulus (remainder) function after dividing the key by the number of records n
  - If n is prime, excellent results are obtained
  - If n is a power of two, poor results are obtained

Artificial Intelligence

- Artificial Intelligence in a machine implies that the machine is capable of absorbing and organizing new data, learning new concepts, reasoning logically, and responding to inquiries
- Expert systems “learn” rules from sets of events that are entered whenever they occur

Sample Questions

- Which of the following terms is best defined as a formula or set of steps for solving a particular problem?
  - Program
  - Software
  - Firmware
  - Algorithm

- Which of the following is the computer language that is executed within a computer’s central processing unit?
  - DOS
  - High-level language
  - Assembly language
  - Machine language

- How many times will the second line be executed?
  - 8
  - 9
  - 10
  - 11

```
                    M=42
LOOPSTART           M = M – 1
                    P = INTEGER PART OF M/2
                    IF P > 15 GO TO LOOPSTART
                    OTHERWISE GO TO END
END                 PRINT DONE
```

- How many cells are in the range C5…Z30?
  - 575
  - 598
  - 600
  - 624