

# Computing Concepts for Information Technology

*Bob Brown*

0. How We Got Here
  - 0.1. Computing in the 21<sup>st</sup> Century
  - 0.2. Vannevar Bush and the MEMEX.
  - 0.3. Alan Turing
  - 0.4. The von Neumann Architecture
  - 0.5. Moore's law
  - 0.6. The Development and Importance of Standards
  - 0.7. The "Phone" – Smaller, Faster, More Connected
  - 0.8. The "Cloud" – Bigger, Faster, More Connected
  - 0.9. Summary
  - 0.10. References
  
1. Numbers, Number Systems, and Representing Data
  - 1.1. Numbers as Abstractions
  - 1.2. Positional Number Systems – The Decimal Number System
  - 1.3. Other Bases
  - 1.4. Binary Numbers
    - 1.4.1. Binary Integers
    - 1.4.2. Why binary?
    - 1.4.3. Converting Decimal to Binary
    - 1.4.4. Finite-Precision Arithmetic – How High Can We Count?
    - 1.4.5. Binary Arithmetic – Addition
    - 1.4.6. Negative Numbers – Twos Complement
    - 1.4.7. Binary Fractions
    - 1.4.8. Hexadecimal Numbers as Shorthand
  - 1.5. Very Large and Very Small Numbers
    - 1.5.1. Scientific Notation
    - 1.5.2. Floating Point Numbers
    - 1.5.3. Normalized Numbers
    - 1.5.4. Precision of Floating Point Numbers
    - 1.5.5. Special Values in IEEE 754
  - 1.6. Representing Symbols – Encoding Systems
    - 1.6.1. ASCII and ISO 8859
    - 1.6.2. Unicode
    - 1.6.3. UTF-8
  - 1.7. Sound, Images, and Video
    - 1.7.1. Sound
    - 1.7.2. Images
    - 1.7.3. Video
  - 1.8. Summary
  - 1.9. References
  
2. Digital Logic

- 2.1. Boolean Algebra: the Logic of True and False
  - 2.2. Truth Tables
  - 2.3. Functions of One Variable and the NOT Function
  - 2.4. Functions of Two Variables
  - 2.5. Boolean Algebra, Switches, and Claude Shannon's Master's Thesis
    - 2.5.1. Electric Circuits, Switches, and Transistors
    - 2.5.2. Digital Logic Gates
  - 2.6. Digital Logic Building Blocks: Combinational Circuits
    - 2.6.1. Adders
    - 2.6.2. Combinational Circuits and Gate Delay
    - 2.6.3. Decoders, Multiplexors, and Other Building Blocks
    - 2.6.4. Shifters
  - 2.7. NAND and NOR: Circuit Equivalence and Functional Completeness
  - 2.8. Sequential Circuits and Memory
    - 2.8.1. The S-R Latch
    - 2.8.2. The Clocked D-latch
    - 2.8.3. Edge-Triggered Devices
  - 2.9. Clocks and Synchronous Circuits
  - 2.10. Registers
  - 2.11. Summary
  - 2.12. References
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3. The CPU and Memory
    - 3.1. The von Neumann Architecture
      - 3.1.1. Instruction Set Architecture
      - 3.1.2. Microarchitecture
    - 3.2. The "Little Man Computer"
      - 3.2.1. The Instruction Cycle
      - 3.2.2. Programming the Little Man Computer
      - 3.2.3. Problems with the Little Man Computer
    - 3.3. Let's Build a CPU – The Tiny Binary Computer
      - 3.3.1. Architecture of the TBC
      - 3.3.2. A One-Bit Arithmetic-Logic Unit
      - 3.3.3. Functions of the ALU
      - 3.3.4. Testing the ALU Output
      - 3.3.5. The Registers and Datapath
      - 3.3.6. The TBC Datapath Cycle
    - 3.4. Instruction formats and Addressing Modes
      - 3.4.1. Instruction Formats
      - 3.4.2. Addressing Modes
    - 3.5. Memory
      - 3.5.1. Memory Technology
      - 3.5.2. Memory Organization and Addressing
      - 3.5.3. Error Detection and Correction
      - 3.5.4. Cache Memory
      - 3.5.5. Stacks and the Stack Pointer

- 3.6. Modern Computer Architecture
  - 3.6.1. RISC Computers
  - 3.6.2. Pipelined Execution
  - 3.6.3. Many Registers
  - 3.6.4. Superscalar Architecture
  - 3.6.5. Multiple Cores
  - 3.6.6. High-Performance Computing
- 3.7. Summary
- 3.8. References
  
- 4. Input and Output
  - 4.1. Computer Peripheral Concepts
    - 4.1.1. Input, Output, and Storage
    - 4.1.2. Programmed I-O
    - 4.1.3. Interrupt-Driven I-O
    - 4.1.4. DMA I-O
    - 4.1.5. Scheduling and Device Priority
      - Includes cycle-stealing and bus contention
  - 4.2. Storage Devices
    - 4.2.1. Hierarchy of Storage – Access Time and Transfer Rate
      - Includes sequential vs. direct access
    - 4.2.2. Magnetic Disks
    - 4.2.3. Solid-State Disks and Flash Drives
    - 4.2.4. CD and DVD Devices
    - 4.2.5. Magnetic Tape
    - 4.2.6. Redundancy – RAID and ZFS
  - 4.3. Displays and Printers
  - 4.4. Other Devices
    - Includes keyboards, mice, touch screens, scanners, cameras, etc.
  - 4.5. Summary
  - 4.6. References
  
- 5. Data Communications and Networks
  - 5.1. Messages, Protocols, and Connections
    - 5.1.1. Circuit Switching and Packet Switching
    - 5.1.2. Reliable and Unreliable Protocols
  - 5.2. Protocol Stacks and the OSI Model
  - 5.3. Ethernet, Local Networks and the Data Link Layer
    - 5.3.1. Transmission Characteristics, Data Link Layer Addressing
    - 5.3.2. Collisions and Switching
  - 5.4. TCP /IP and the Internet Model
    - 5.4.1. The Data Link Layer
      - Address Resolution Protocol
    - 5.4.2. The Internet Protocol Layer
      - IPv4
      - IP v6

- 5.4.3. The Transport Layer
  - TCP
  - UDP
  - SCTP
  - QUIC
- 5.4.4. The Application Layer
  - The Domain Name System
- 5.5. Physical Transmission
  - 5.5.1. Transmission media (Wired, fiber optic, radio)
    - Includes attenuation and noise
  - 5.5.2. Network Topologies, Physical and Logical
  - 5.5.3. Signaling Mechanisms – Amplitude, Frequency, and Phase.
  - 5.5.4. Analog vs. Digital Signaling
  - 5.5.5. Baseband and Broadband Circuits
- 5.6. Summary
- 5.7. References
  
- 6. Programming and Computer Software
  - 6.1. Application software and software development.
    - 6.1.1. Software Engineering
    - 6.1.2. Programming Languages
  - 6.2. Operating Systems
    - 6.2.1. Functions of the Operating System
    - 6.2.2. Process Dispatching
    - 6.2.3. Interrupts and Concurrent Operation
    - 6.2.4. Hardware Support and Privileges Instructions
      - What the software needs from the hardware: Privileged instructions, protected memory, timer interrupts.)
    - 6.2.5. File Management
    - 6.2.6. Memory Management and Virtual Memory
    - 6.2.7. Limits on Throughput
  - 6.3. Virtualization
  - 6.4. Summary
  - 6.5. References
  
- 7. Computer Security
  - 7.1. What Does “Secure” Mean?
  - 7.2. Properties of a Secure System
    - 7.2.1. Confidentiality
    - 7.2.2. Integrity
    - 7.2.3. Availability
    - 7.2.4. Properties, States, and Controls: the McCumber Model
    - 7.2.5. Other “Properties”
  - 7.3. Goals of an Information Security Program
  - 7.4. Policy, Procedures, and Controls
  - 7.5. Assets, Risks, and Risk Management

- 7.5.1. Identifying Assets and Threats
    - 7.5.2. Risk Management
  - 7.6. Identification, Authentication, and Access Control
  - 7.7. Cryptography
    - 7.7.1. Symmetric Key Cryptography
    - 7.7.2. Asymmetric Key Cryptography
    - 7.7.3. Cryptographic Hashes and Digital Signatures
  - 7.8. Summary
  - 7.9. References
- 8. Computing in the Twenty-First Century
  - 8.1. Artificial Intelligence and Machine Learning
  - 8.2. Device Automation and Robotics
  - 8.3. Internet of Things
  - 8.4. Data Science
    - 8.4.1. How Data are Used (Discuss nominal, ordinal, interval, and ratio)
    - 8.4.2. Very Large Data Sets
  - 8.5. Quantum Computing
  - 8.6. Summary
  - 8.7. References