Data Representation

1.1 Number Systems

Understanding Binary: Computers use binary (base 2) because electronic components have two states: on (1) and off (0), making it efficient for processing data.

Number Systems:

- **Denary:** Base 10, uses digits 0-9.
- **Binary:** Base 2, uses digits 0 and 1.
- **Hexadecimal:** Base 16, uses digits 0-9 and letters A-F.

Conversions:

- **Denary to Binary:** Divide by 2 repeatedly, noting remainders. Read remainders from bottom to top. Example: Convert 25 to binary. Result: 11001.
- **Denary to Hexadecimal:** Divide by 16 repeatedly, converting remainders greater than 9 to hexadecimal. Example: Convert 257 to hexadecimal. Result: 101.
- **Hexadecimal to Binary:** Convert each hex digit to its 4-bit binary equivalent. Example: Convert A5 to binary. Result: 10100101.

Binary Addition: Add corresponding bits, carry over if sum exceeds 1. Overflow occurs when binary addition exceeds register capacity.

Binary Shifts:

- **Left Shift:** Multiplies by 2.
- **Right Shift:** Divides by 2. Bits shifted out are lost.

Two's Complement: Represents negative numbers in binary by inverting all bits of the positive number and adding 1.

1.2 Text, Sound, and Images

Text Representation:

- **Character Sets:** ASCII (7-bit) for English, Unicode for multiple languages and symbols. Unicode uses more bits per character than ASCII.

Sound Representation:

- **Sampling:** Converts sound waves to digital by taking samples at regular intervals.
    - **Sample Rate:** Affects quality and file size.

    - **Sample Resolution:** Affects dynamic range and file size.

Image Representation:

- **Pixels:** Images are made of pixels, each with binary data.
- **Resolution:** Affects detail and file size.
- **Color Depth:** Number of bits per pixel for color accuracy and file size.

1.3 Data Storage and Compression

Data Storage Units:

- Units: Bit, nibble, byte, kilobyte (KB), megabyte (MB), gigabyte (GB), etc.
- **Calculations:** File size depends on image resolution, color depth, sound sample rate, and duration.

Data Compression:

- **Purpose:** Reduces file size for storage and transmission.
    - **Lossless:** No data loss (e.g., RLE).
    - **Lossy:** Removes data (e.g., reducing resolution).

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2. Data Transmission

2.1 Types and Methods of Data Transmission:

- **Packets:** Data transmitted in packets with headers, payloads, and trailers.
- **Packet Switching:** Breaks data into packets for efficient travel, but can cause packet loss.
- **Modes:**
    - **Simplex:** One-way (e.g., radio).
    - **Half-duplex:** Bidirectional but not simultaneous (e.g., walkie-talkie).
    - **Full-duplex:** Simultaneous bidirectional (e.g., telephone).
- **Data Transmission:** Serial (bit by bit) or parallel (multiple bits). USB is a high-speed serial interface.

2.2 Methods of Error Detection:

- **Parity Check:** Extra bit for odd/even number of 1s.
- **Checksum:** Mathematical calculation appended to data.
- **Echo Check:** Data sent back for comparison.
- **Check Digit:** Extra digit based on an algorithm.
- **ARQ:** Receiver acknowledges data, retransmits if errors occur.

2.3 Encryption:

- **Symmetric Encryption:** Single key for encryption and decryption.
- **Asymmetric Encryption:** Public key for encryption, private key for decryption.

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3. Hardware

3.1 Computer Architecture:

- **CPU:** Executes instructions and processes data.
  - **ALU:** Performs calculations and logical operations.
  - **CU:** Manages CPU operations and fetch-decode-execute cycle.
  - **Registers:** Temporary high-speed storage.
  - **Buses:** Data pathways.
- **Fetch-Decode-Execute Cycle:** Fetches instruction from memory, decodes it, and executes.
- **Performance Factors:** Cores, cache size, and clock speed.
- **Embedded Systems:** Specialized for specific tasks.

3.2 Input and Output Devices:

- **Input Devices:** Capture data (e.g., keyboard, mouse).
- **Output Devices:** Display or produce information (e.g., monitor, printer).
- **Sensors:** Convert physical stimuli to electrical signals.

3.3 Data Storage:

- **Primary Storage:** RAM (volatile) and ROM (non-volatile).
- **Secondary Storage:** Non-volatile, includes magnetic (hard drives), optical (CDs/DVDs), and solid-state (SSDs, flash drives).
- **Virtual Memory:** Uses hard drive space as additional RAM.
- **Cloud Storage:** Remote servers accessible via the internet.

3.4 Network Hardware:

- **NIC:** Connects to a network, each device has a MAC address.
- **IP Address:** Numerical label for devices.
- **Routers:** Direct data packets.
- **IP Versions:** IPv4 and IPv6 (larger address space).

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4. Software

4.1 Types of Software and Interrupts:

- **System Software:** Manages hardware and provides a platform for applications.
    - **OS:** Controls hardware and provides UI.
    - **Utility Software:** Performs maintenance tasks.
- **Application Software:** Specific user tasks (e.g., word processors).
- **Interrupts:** Signals that pause the current process for urgent tasks, handled by an Interrupt Service Routine (ISR).

4.2 Programming Languages:

- **High-Level Languages:** Easier to write (e.g., Python, Java).
- **Low-Level Languages:** Closer to machine code (e.g., assembly language).
- **Translators:**
    - **Compilers:** Translate code to executable form.
    - **Interpreters:** Translate code line by line.
- **IDEs:** Integrated Development Environments for coding, debugging, and compiling.

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5. The Internet and Its Use

5.1 The Internet and the World Wide Web:

- **Internet:** Global network of interconnected computers.
- **WWW:** System of interconnected documents accessible via the internet.
- **URL:** Address of a webpage, includes protocol, domain name, and file path.
- **HTTP/HTTPS:** Protocols for transferring web pages.
- **Web Browsers:** Access and render web pages.
- **Cookies:** Track user information and preferences.

5.2 Digital Currency:

- **Digital Currency:** Virtual currency operating independently of central banks.
- **Blockchain:** Decentralized ledger for tracking digital transactions.

5.3 Cyber Security:

- **Threats:** Hacking, malware, phishing, pharming, DoS attacks, brute-force attacks, data interception.
- **Protection Measures:** Anti-malware, firewalls, strong passwords, software updates, privacy settings, secure connections, backups, user education.

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6. Automated and Emerging Technologies

6.1 Automated Systems:

- **Automation:** Uses sensors, microprocessors, and actuators for tasks with minimal human intervention.
- **Advantages:** Increased efficiency, accuracy, productivity.
- **Disadvantages:** Setup costs, job displacement, technology reliance.

6.2 Robotics:

- **Robotics:** Field of creating and using robots for various tasks (e.g., manufacturing, healthcare).
- **Components:** Mechanical structure, sensors, microprocessors, actuators.
- **Advantages:** Precision, endurance, handling hazardous tasks.
- **Disadvantages:** Cost, maintenance, job displacement.

6.3 Artificial Intelligence (AI):

- **AI:** Creates intelligent systems capable of reasoning, learning, and adaptation.
- **Components:** Knowledge base, rule base, inference engine.
- **Expert Systems:** Apply knowledge to solve specific problems.
- **Machine Learning:** Systems learn from data to improve performance.

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