Work in Progress - Under Development

AP Computer Science Principles

Unofficial Summary

Following the Outline of Code.org

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Contents

1 Digital Information

The foundation of computing lies in how computers represent and process information digitally. This unit explores how data is represented using binary and the implications of digital representation.

Learning Objectives

Binary Numbers (2.1)

- **DAT-1.A**: Explain how data can be represented using bits
- **DAT-1.B**: Explain the consequences of using bits to represent data
- **DAT-1.C**: Calculate and compare binary numbers

Data Compression (2.2)

- **DAT-1.D**: Compare data compression algorithms in context

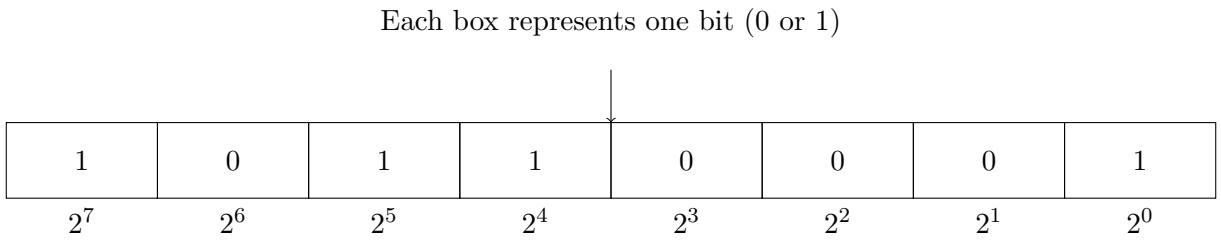
Legal and Ethical Concerns (5.5)

- **IOC-1.F**: Explain how computing raises legal and ethical concerns

Essential Knowledge

Binary and Data Representation

- **Basic Concepts**
  - A bit (binary digit) is the smallest unit of data, representing either 0 or 1
  - A byte consists of 8 bits
  - Computing devices represent all data digitally using bits at their lowest level
  - Data values can be stored in variables, lists, or constants and can be used as input/output for procedures
- **Data Abstraction**
  - Abstraction reduces complexity by hiding irrelevant details while bringing together useful ones, allowing focus on the main idea
  - Bits are grouped to represent higher-level abstractions like numbers, text, and colors
  - The same bit sequence can mean different things in different contexts (e.g., the same bits might represent a number or a letter)
- **Digital vs. Analog**
  - Analog data has values that change smoothly over time (e.g., pitch and volume of music, colors in a painting, position of a runner)
  - Digital data approximates analog data through sampling - measuring values at regular intervals to determine the bits needed for storage



$$1 \cdot 2^7 + 0 \cdot 2^6 + 1 \cdot 2^5 + 1 \cdot 2^4 + 0 \cdot 2^3 + 0 \cdot 2^2 + 0 \cdot 2^1 + 1 \cdot 2^0$$
$$= 128 + 0 + 32 + 16 + 0 + 0 + 0 + 1$$
$$= 177_{10}$$

Figure 1.1: Converting binary to decimal: Each bit's value is multiplied by its position value (powers of 2)

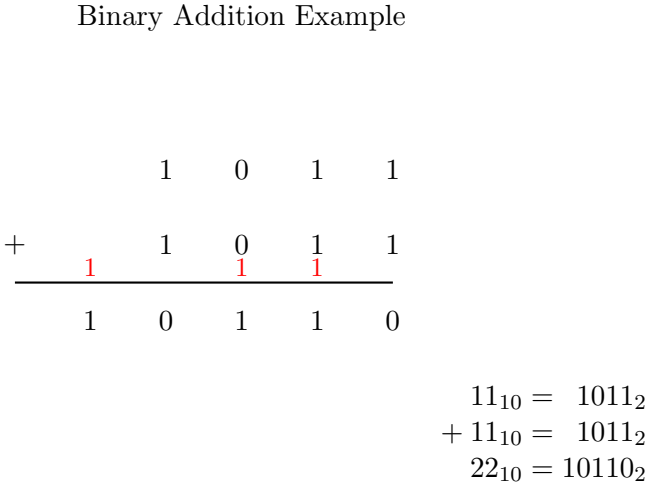


Figure 1.2: Binary addition example showing carry bits in red

Number Systems

- **Binary Numbers**
  - Binary (base 2) uses only 0s and 1s
  - Decimal (base 10) uses digits 0-9
  - A bit's position determines its value - multiply the bit (0 or 1) by the place value
  - Place values are powers of 2, starting from right (2^0) and increasing leftward
- **Limitations**
  - Fixed-size integers in many programming languages have limited range, which can cause overflow errors
  - Some languages allow unlimited integer size, limited only by computer memory
  - Real numbers often have limited precision, leading to round-off errors when stored or calculated

Data Compression

- **Basic Concepts**
  - Data compression reduces the number of bits needed for data storage/transmission
  - Fewer bits doesn't always mean less information
  - Compression effectiveness depends on data redundancy and the algorithm used
- **Types of Compression**
  - Lossless: Guarantees exact reconstruction of original data
  - Lossy: Creates approximation of original data, typically achieving better compression ratios
- **Choosing Compression**
  - Use lossless when exact reconstruction is crucial (e.g., text documents, program files)
  - Use lossy when minimizing size/transmission time is priority (e.g., streaming video, music)

Legal and Ethical Considerations

- **Intellectual Property**
  - Digital content is the intellectual property of its creator or organization
  - Digital distribution makes intellectual property concerns more complex
  - Proper safeguards should protect intellectual property
  - Using others' work without attribution is plagiarism with legal consequences
- **Legal Usage**
  - Creative Commons: Public license enabling free distribution of copyrighted work
  - Open source: Programs freely available for redistribution and modification
  - Open access: Research output free of access restrictions
  - All borrowed material must be properly cited
- **Broader Impact**
  - Computing can affect social and political issues
  - Digital divide raises ethical concerns about computing access
  - Ethical concerns include biased algorithms, data collection privacy, and digital media access

2 The Internet

The Internet is a global network of interconnected computer networks that use standardized communication protocols. This unit covers core concepts about how the Internet works and its impact on society.

Learning Objectives

The Internet (4.1)

- **CSN-1.A**: Explain how devices communicate in a network.
- **CSN-1.B**: Understand the structure and functionality of the Internet.
- **CSN-1.C**: Explain data transmission via packets.
- **CSN-1.D**: Differentiate between the Internet and the World Wide Web.

Fault Tolerance (4.2)

- **CSN-1.E**: Understand and describe fault tolerance in networks.

Digital Divide (5.2)

- **IOC-1.C**: Describe issues that contribute to the digital divide.

Essential Knowledge

The Internet (4.1)

- **Computing Devices and Networks**
  - **Computing Device**: Physical tools (e.g., computers, routers) capable of running programs.
  - **Computing System**: A collaborative group of devices and programs with a common purpose.
  - **Computer Network**: Interconnected devices that can send and receive data, like the Internet.
  - **Network Path**: Route taken by data between two devices in a network, involving a series of directly connected devices.
  - **Routing**: The process of selecting a path for data in a network from sender to receiver.
  - **Bandwidth**: The maximum data volume that can be sent over a network in a given time, usually measured in bits per second.
- **Internet Structure and Protocols**
  - **Internet**: A global network of interconnected networks that communicate using standardized, open protocols.

  - **Protocol**: Agreed-upon rules that dictate how data is transmitted; open protocols allow for easy connectivity and interoperability of devices.
  - **Dynamic Routing**: Internet paths are flexible and often change based on network conditions.
  - **Scalability**: The Internet's design allows it to grow and adapt to meet increasing demand.

- **Data Transmission Through Packets**
  - **Data Stream**: Continuous flow of data transmitted as a series of packets.
  - **Packet**: A small unit of data that includes payload (data) and metadata (information for routing and reassembly).
  - **Packet Protocols**: Common protocols include IP, TCP, and UDP, which manage data routing and delivery.

- **Internet vs. World Wide Web**
  - **World Wide Web (WWW)**: A system of interconnected pages and files accessible via the Internet.
  - **HTTP Protocol**: The protocol that enables communication on the Web.
  - **Relationship**: The Web relies on the Internet to operate but is a separate service layer.

Fault Tolerance (4.2)

- **Fault Tolerance**: The Internet is designed to withstand failures, maintaining functionality when parts of the network fail.
- **Redundancy**: Extra components, like alternate paths, ensure data can reroute around issues, enhancing reliability.
- **Resilience**: Redundancy enables fault tolerance, allowing the network to continue operating despite failures.

Digital Divide (5.2)

- Refers to differing access to computing devices and the Internet based on socioeconomic, geographic, or demographic characteristics
- Access varies between countries and demographic groups
- Affects both groups and individuals
- Raises issues of equity, access, and influence globally and locally
- Influenced by actions of individuals, organizations, and governments

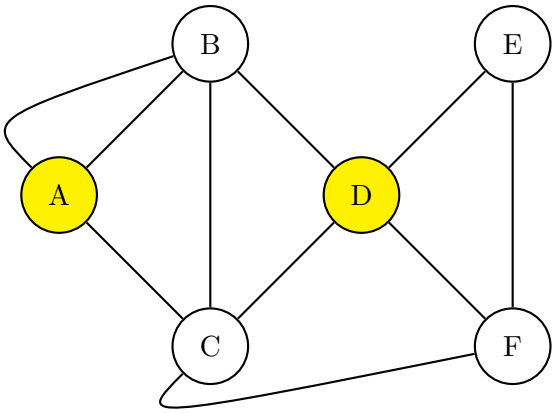


Figure 2.1: This network diagram demonstrates key concepts in network design:
• Path: A route data can take from one node to another. Here, multiple paths connect nodes **A** and **D**.
• Redundancy: Multiple paths between nodes (like from **A** to **D** via **B** or **C**) provide backup routes.
• Fault Tolerance: If one path breaks, the network still works because of backup paths.
Nodes **A** and **D** are highlighted to show an example of endpoint devices in a network path.

Other Topics on Code.org

- **Net Neutrality**: Principle that Internet Service Providers should treat all Internet traffic equally, without discriminating based on content or source
- **Internet Censorship**: Government or organizational control over Internet access and content, which can limit free speech and information flow

3 Variables, Conditionals, and Functions

Categories

- **Logical Operators**
- **Relational Operators**
- **Numbers, Strings, Variables (neutral)**
- **Parentheses**

Logical Operators

Symbol	AP Symbol	Meaning
`&&`	AND	Logical AND
`||`	OR	Logical OR
`!`	NOT	Logical NOT

Relational Operators

Symbol	Meaning
`==`	Equal to
`!=`	Not equal to
`>`	Greater than
`<`	Less than
`>=`	Greater than or equal to
`<=`	Less than or equal to

Examples

- *Example 1:*

  x > 10 AND y < 20

- *Example 2:*

  NOT (a == b)

Side by Side Comparison

JavaScript	AP Pseudocode
Assignment: x = 5	Assignment: x ← 5
Logical OR: a || b	Logical OR: a OR b
Logical AND: a && b	Logical AND: a AND b
Logical NOT: ! a	Logical NOT: NOT a