Chapter 5: Units of Measure

Thomas Holt Russell, M.Ed., Hon. D. (Cybersecurity)

Overview

What We Will Cover:

- Bits and Bytes
- Data Storage Units
- Data Throughput
- Processor Speed
- Key Concepts and Real-World Applications

Bits — The Smallest Unit of Data

- A **bit** (binary digit) is the smallest unit of data.
- Represents either **0** or **1** (on/off state).
- Computers use bits to represent and process data.

Key Points:

- **1 byte = 8 bits**
- **1 kilobit (Kb)** = 1,000 or 1,024 bits (depending on context).
- Used in transmission rates like **Mbps (megabits per second)**.

Bytes — A Basic Unit of Digital Storage

- A **byte** consists of **8 bits** and can represent 256 possible values.
- Often used to store characters in encoding schemes like **ASCII**.

Key Points:

- **1 KB (kilobyte)** = 1,024 bytes (binary system).
- **1 MB (megabyte)** = 1,048,576 bytes.
- **1 GB, 1 TB, and beyond** measure larger storage units.

- **Example:** The letter "A" in ASCII is stored as **01000001 (binary)**.

Bits vs. Bytes in Real Life

Bits: Used to measure data transfer rates (e.g., 100 Mbps internet).

Bytes: Used to measure data storage (e.g., a 500 GB hard drive).

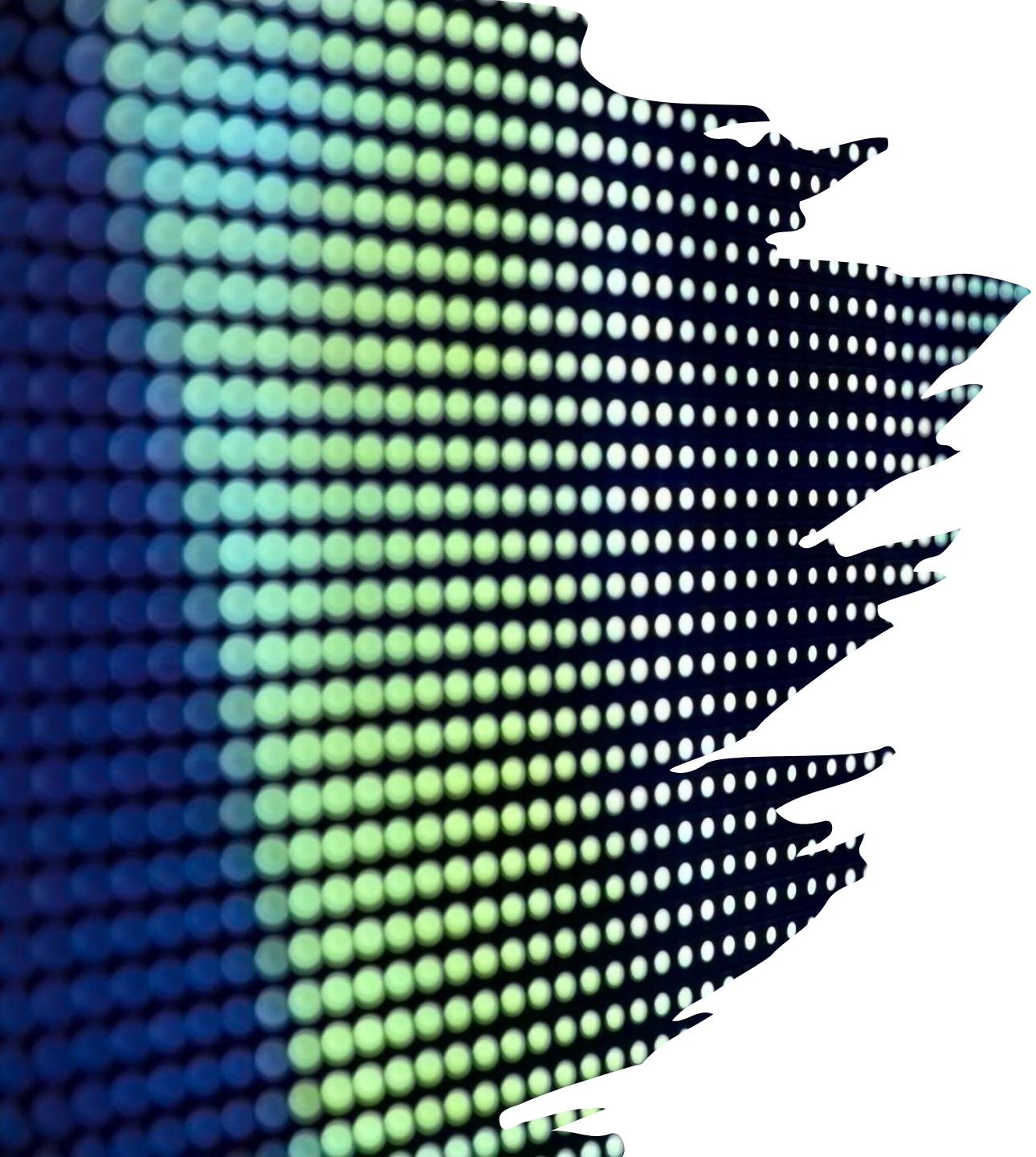
Binary Combinations

2 Bits: 4 possible values (00, 01, 10, 11)
3 Bits: 8 possible values (000 to 111)

Data Storage Units

Example:
A 500 GB hard drive can store approximately **500 billion bytes** of data.

Unit	Number of Bytes
Byte	1 - one
Kilobyte (KB)	1,000 - one thousand
Megabyte (MB)	1,000,000 - one million
Gigabyte (GB)	1,000,000,000 - one billion
Terabyte (TB)	1,000,000,000,000 - one trillion
Petabyte (PB)	1,000,000,000,000,000 -one quadrillion



Data Throughput — Measuring Data Transfer

- **Definition:** Throughput refers to how much data is transferred over a given time.

Common Units:

- **bps (bits per second)**: Network speeds.
  - **Kbps** = 1,000 bps
  - **Mbps** = 1,000,000 bps
  - **Gbps** = 1 billion bps
- **Bps (bytes per second)**: Used for file transfers or disk I/O.
  - **KBps**, **MBps**, **GBps**

Where Throughput is Measured

- **Network throughput:** Data transferred across a network.

Example: **1 Gbps** fiber internet connection.

- **Disk throughput:** Read/write speed of storage devices.

Example: **500 MBps** disk write speed.

- **System throughput:** Overall performance combining CPU, memory, and disk.

Factors Affecting Data Throughput

1. **Bandwidth:** The maximum data rate of a medium.
2. **Latency:** Delay in data transmission.
3. **Network congestion:** Competing traffic reduces speed.
4. **Protocol overhead:** Data used for headers, error correction, etc.

- **Throughput Formula:**

$$\text{Throughput} = \frac{\text{Total Data Transferred}}{\text{Time Taken}}$$

Example Calculation

Problem: If 10 GB of data is transferred in 500 seconds, what is the throughput?

Calculation:

$$\text{Throughput} = \frac{10 \times 1,000\,\text{MB}}{500\,\text{s}} = 20\,\text{MBps}$$

Convert to bits:

$$20\,\text{MBps} \times 8 = 160\,\text{Mbps}$$

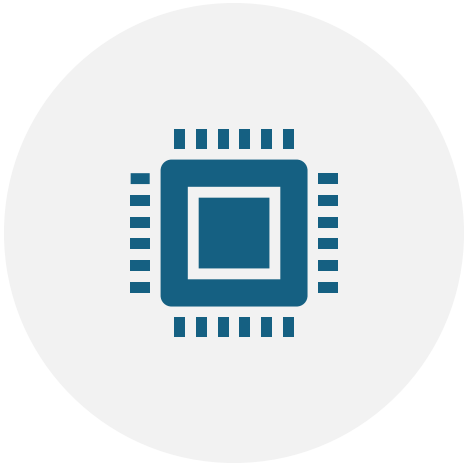
Processor Speed — What Is It?

- **Processor speed** (clock speed) measures how many cycles a CPU can execute per second.
- Measured in **Hertz (Hz)**

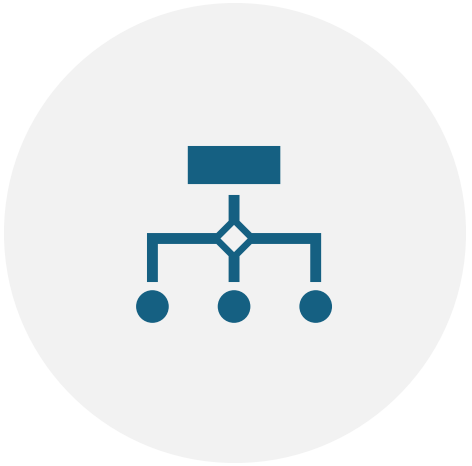
Common Units:

- **MHz (Megahertz)**: 1 million cycles per second.
- **GHz (Gigahertz)**: 1 billion cycles per second.
- **Example:** A **3.5 GHz** CPU can execute 3.5 billion cycles per second.

What Do Clock Cycles Represent?



1 CLOCK CYCLE: THE CPU FETCHES, DECODES, AND EXECUTES AN INSTRUCTION.



MODERN CPU'S CAN PERFORM MULTIPLE INSTRUCTIONS PER CYCLE USING PARALLELISM.

Does Higher Clock Speed Mean Faster Performance?

Not always! Other factors also matter:

Cores and threads: Multi-core processors handle tasks simultaneously.

Architecture: Better design improves instruction execution.

Cache memory: Faster data retrieval boosts performance.

Thermal throttling: Heat can limit CPU speed.

Real-World Applications

Speed Range	Common in…	Example Tasks
1-2 GHz	Low-power devices, smartphones, IoT devices	Web browsing, lightweight apps
2-3 GHz	Laptops, budget desktops	Office work, light multitasking
3-5 GHz	High-performance desktops, servers	Gaming, video editing, coding, simulations
5+ GHz	Overclocked CPUs, specialized hardware	Heavy computing, rendering, scientific tasks

Summary of Key Terms

Storage Unit: How much digital data a device can store.

Throughput Unit: How fast data is transferred.

Processor Speed: How quickly the CPU processes instructions.

Helpful Resources and Videos

Bits and Bytes | What and Why?
Watch on YouTube

Khan Academy: Binary and Data
Watch on YouTube

CPU Clock Speed Explained
Watch on YouTube

Questions?

SEMtech!

Student Engagement & Mentoring in Technology

Thomas Holt Russell, M.Ed., Hon. D. (Cybersecurity)