Week 3:

Embedded Systems

Learning Outcomes:

At the end of the discussion, the students will be able to:

1. Identify the uses of embedded systems.
2. Understand the key differences between computers and embedded systems; and
3. Identify various embedded systems platforms

Embedded Systems

An **embedded system** is a specialized computer system designed to perform specific functions within a larger mechanical or electrical system. Unlike general-purpose computers, which are designed to run a wide range of applications, embedded systems are dedicated to executing predefined tasks efficiently and reliably.

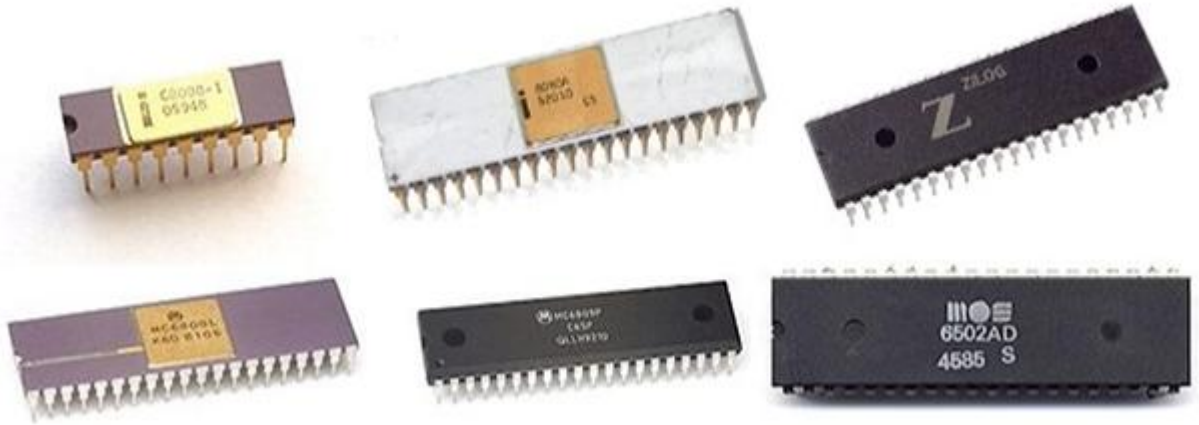
An embedded system can be thought of as a computer hardware system having software embedded in it.

History of Embedded System

- Embedded systems date back to the 1960s. **Charles Stark Draper** developed an Integrated Circuit (IC) in 1961 to reduce the size and weight of the Apollo Guidance Computer, the digital system installed on the Apollo Command Module and Lunar Module.
- The first computer to use ICs, it helped astronauts collect real-time flight data.

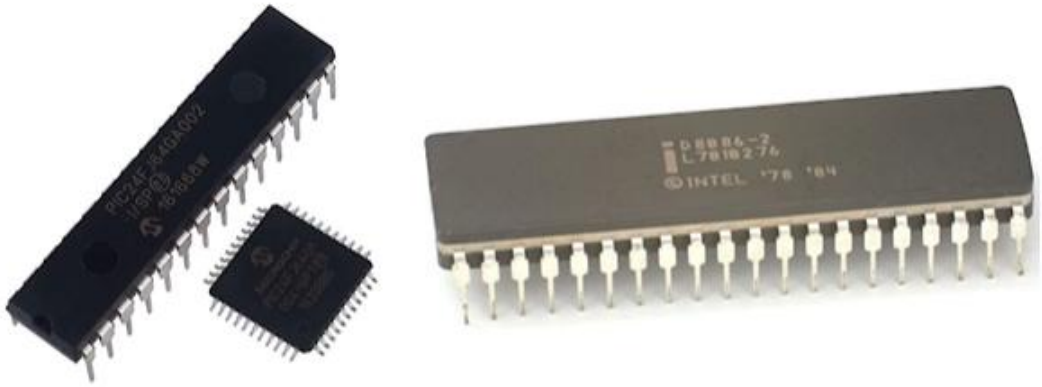
- In 1965, Autonetics, now a part of Boeing, developed the D-17B, the computer used in the Minuteman I missile guidance system.
- It is widely recognized as the first mass-produced embedded system.
- When the Minuteman II went into production in 1966, the D-17B was replaced with the NS-17 missile guidance system, known for its high-volume use of integrated circuits.
- In 1968, the first embedded system for a vehicle was released; the Volkswagen 1600 used a microprocessor to control its electronic fuel injection system.

1st Generations Embedded System



- Built around an 8-bit microprocessor or 4-bit controller
- Hardware circuit and firmware
- Single-chip computer processor

2nd Generations Embedded System

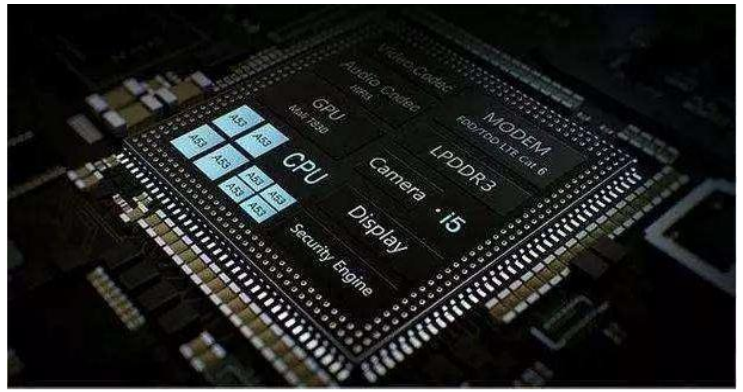


- Based on 16-bit microprocessors and 8 or 16 – bit microcontrollers
- Processors and controllers were significantly more complex and powerful than their predecessors.

3rd Generations Embedded System

- The possibility of using powerful 32-bit microprocessors and 16-bit microcontrollers
- Substantially more powerful and sophisticated than the second generation
- Integrates in Robotics and Embedded Networking

4th Generations Embedded System



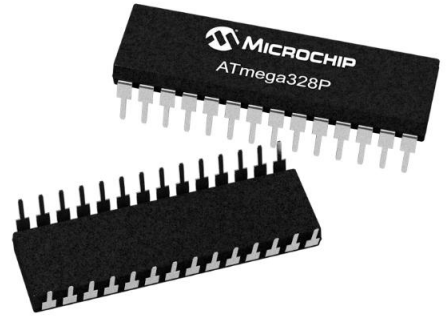
SoC chip

- The most recent generation
- Benefited from the introduction of new technologies
- Such as: System-on-Chip(SOC), Reconfigurable Processors, Multicore Processors

COMPONENTS OF EMBEDDED SYSTEMS

1. Microcontroller/Microprocessor:

Microprocessor	Microcontroller
Microprocessor is the heart of Computer system.	Micro Controller is the heart of an embedded system.
It is only a processor, so memory and I/O components need to be connected externally	Micro Controller has a processor along with internal memory and I/O components.



Microcontrollers are commonly used in embedded systems due to their low cost, low power consumption, and ease of use.

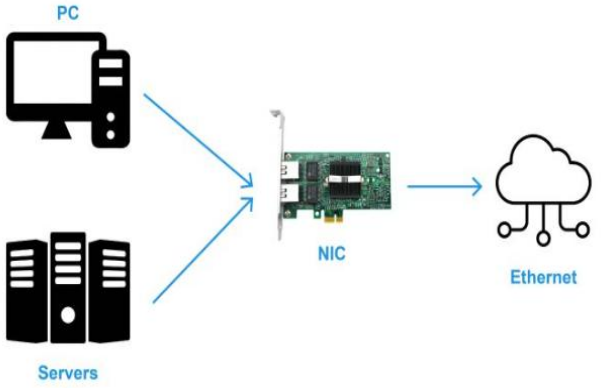
2. Memory

Embedded systems typically have limited memory compared to general-purpose computers. They may include ROM (Read-Only Memory) for storing firmware and program code, as well as RAM (Random Access Memory) for temporary data storage during program execution.

3. Sensors and Actuators:

Embedded systems interact with the physical world through sensors (inputs) and actuators (outputs). Sensors gather data from the environment, such as temperature, pressure, or motion, while actuators control physical processes, such as motors, valves, or displays.

4. Interfaces:



Embedded systems often feature various communication interfaces, such as Ethernet, USB (Universal Serial Bus), or wireless protocols like Wi-Fi, Bluetooth. These interfaces enable connectivity with other devices or systems.

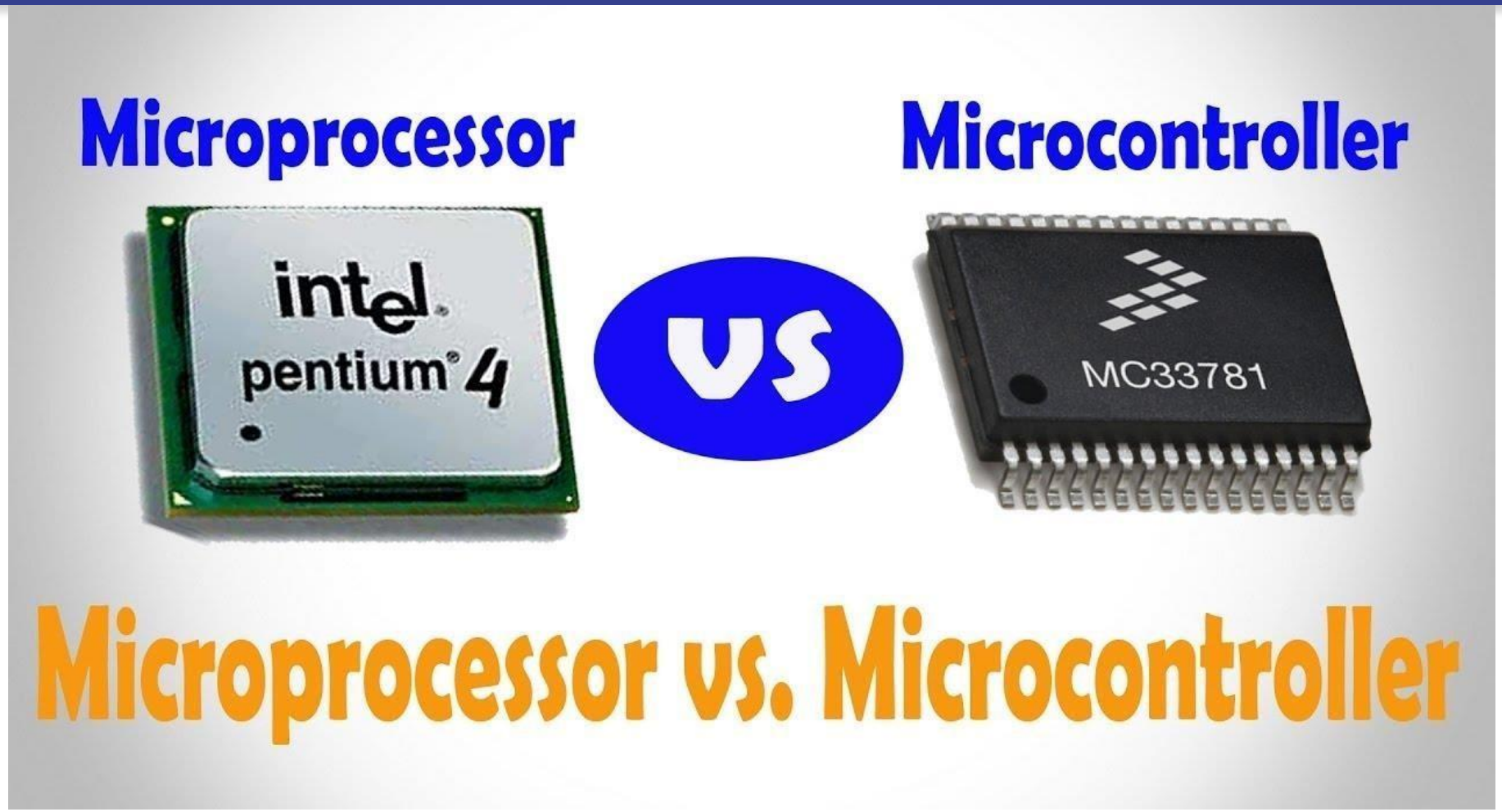
Embedded Systems vs Regular Computers

Embedded Systems

METRIC	REGULAR COMPUTERS	EMBEDDED SYSTEMS
Computing speed	High (GHz)	Low (KHz or MHz)
Working memory	High (GB)	Low (KB)
Secondary memory (non-volatile storage)	High (HDD)	Low (KB or flash memory)
Power Consumption	High (30 watts and above)	Low (Nanowatts or milliwatts)

Embedded Systems

METRIC	REGULAR COMPUTERS	EMBEDDED SYSTEMS
Software	Operating System (Microsoft, Mac OS, Linux) Applications (Office Suites, web browsers, games)	Firmware
Display	Video Connectivity	None provided nor needed, if required, these must be constructed and coded
User Input	Keyboard/mouse	None provided nor needed, if required, these must be constructed and coded
Expected useful lifespan for each unit	Obsolescence measured in months	Obsolescence measured in years or decades


Microprocessor
Microcontroller
intel
pentium 4
VS
MC33781
Microprocessor vs. Microcontroller

Embedded Systems

PARAMETERS	MICROPROCESSOR	MICROCONTROLLER
Function	Process the general task	Both process and control the specific task
Application	Gaming, web browsing, document creation etc.	Dedicated for specific tasks (Camera, washing machine etc.)
Internal Structure	Memory and I/O devices connected externally	CPU, memory and I/O are present internally
Architecture	Von Neumann (program and data stored in the same memory)	Harvard (program and data stored in different/ separate memory)
Cost	High	Low
Memory (RAM)	512 MB to up to 32 GB	2KB to up to 256 KB
Complexity	Large no. of instructions More complex	Lesser number of instructions Less complex
Power Consumption	High	Low
Storage (ROM)	Hard Disk (128 GB to up to 2 TB)	Flash memory (32 KB to 2 MB)

What makes a device an **EMBEDDED SYSTEM**?

Embedded Systems

Embedded systems are computers that are placed into things that don't look like typical computers and are programmed to perform specific tasks that can be broad and varied.

Embedded systems are everywhere in our everyday lives.

Examples of Embedded Systems

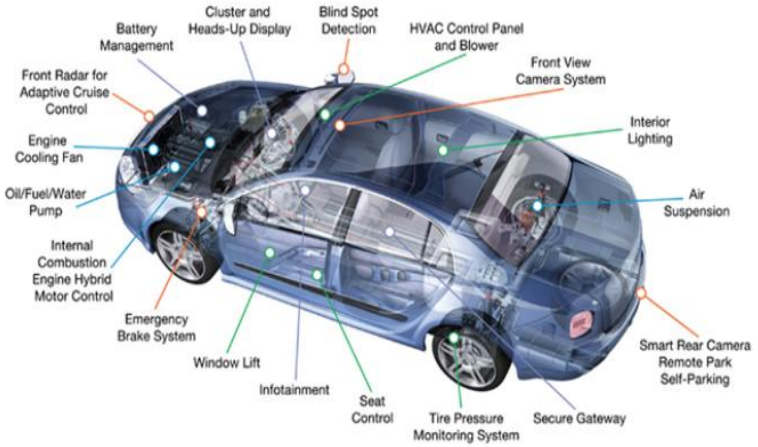
1. Smartphones

Smartphones are perhaps the most familiar example of embedded systems. They incorporate a multitude of sensors (e.g., accelerometer, gyroscope, GPS) for location tracking, motion sensing, and user interaction.

Examples of Embedded Systems

2. Automotive Systems:

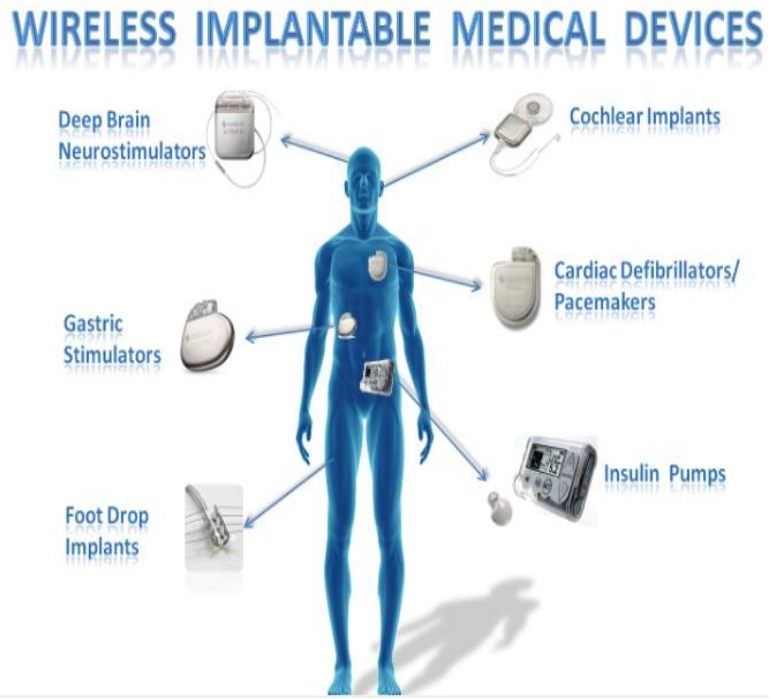
Modern vehicles are equipped with numerous embedded systems for engine management, anti-lock braking, airbag deployment, climate control, entertainment, and navigation.



Examples of Embedded Systems

3. Medical Devices:

Embedded systems play a critical role in medical devices, such as pacemakers, insulin pumps, and patient monitoring systems. These devices rely on embedded controllers to regulate physiological functions, administer medication, and collect vital signs data for healthcare professionals.

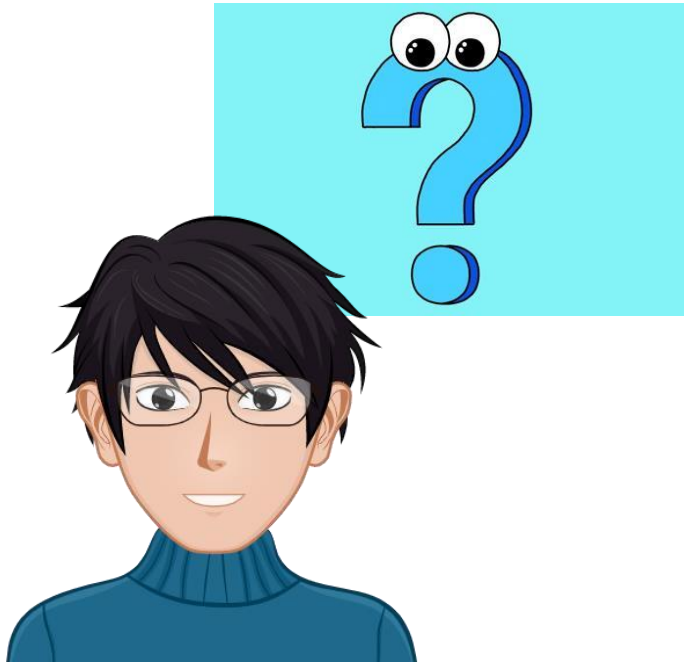


4. Industrial Automation:

Industrial automation systems use embedded controllers to control manufacturing processes, robotics, and machinery. Embedded systems monitor sensors to detect defects, regulate production parameters, and ensure the safe and efficient operation of factories and assembly lines.

Examples of Embedded Systems

CAN YOU GIVE MORE EXAMPLES?



Examples of Embedded Systems

PEMBEDS

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PEMBEDS

Examples of Embedded Systems

PEMBEDS

Comparison: Internet of Things (IoT) vs Embedded Systems

Feature	Embedded System	Internet of Things (IoT)
Definition	A specialized computing system designed for a specific task within a larger system.	A network of interconnected devices that communicate and exchange data over the internet.
Connectivity	Works independently or with minimal communication.	Requires internet/cloud connectivity for remote access and control.
Data Handling	Processes data locally within the device.	Collects, analyzes, and transmits data to cloud or other devices.
Examples	Digital Camera, Washing Machine, ABS in Cars.	Smart Home Devices (Alexa, Google Nest), Smart Agriculture, Smart Cities.
Functionality	Performs dedicated real-time tasks, often without internet connectivity.	Enhances device intelligence through remote monitoring, automation, and AI-based decision-making.
User Interaction	Limited or no direct interaction with the user.	Allows remote control via apps, voice assistants, or dashboards.
Components	Microcontroller/Microprocessor, sensors, actuators.	Embedded system + Cloud connectivity, AI, Big Data.

Comparison: Internet of Things (IoT) vs Embedded Systems

Examples & Functions

1. Embedded System Example: Digital Camera

- **Function:** Captures and processes images using an image sensor and a microcontroller.
- **Connectivity:** Works independently, no internet required.

2. IoT Example: Smart Security Camera (Ring, Arlo)

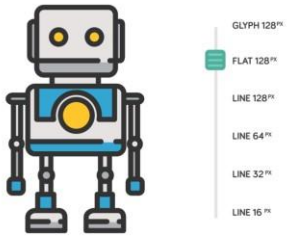
- **Function:** Captures video footage and sends alerts to users via a mobile app.
- **Connectivity:** Requires Wi-Fi to stream footage and send notifications.

Comparison: Internet of Things (IoT) vs Embedded Systems

Key Takeaways

- All IoT devices contain embedded systems, but not all embedded systems are IoT devices.
- IoT enhances embedded systems by enabling remote access, cloud processing, and automation.
- Embedded systems are task-specific, while IoT focuses on connectivity and smart data utilization.


Any
Questions?


GLYPH 128PX
FLAT 128PX
LINE 128PX
LINE 64PX
LINE 32PX
LINE 16PX

PEMBEDS

END OF SLIDES

THANK YOU!