INTRODUCTION TO EMBEDDED SYSTEMS

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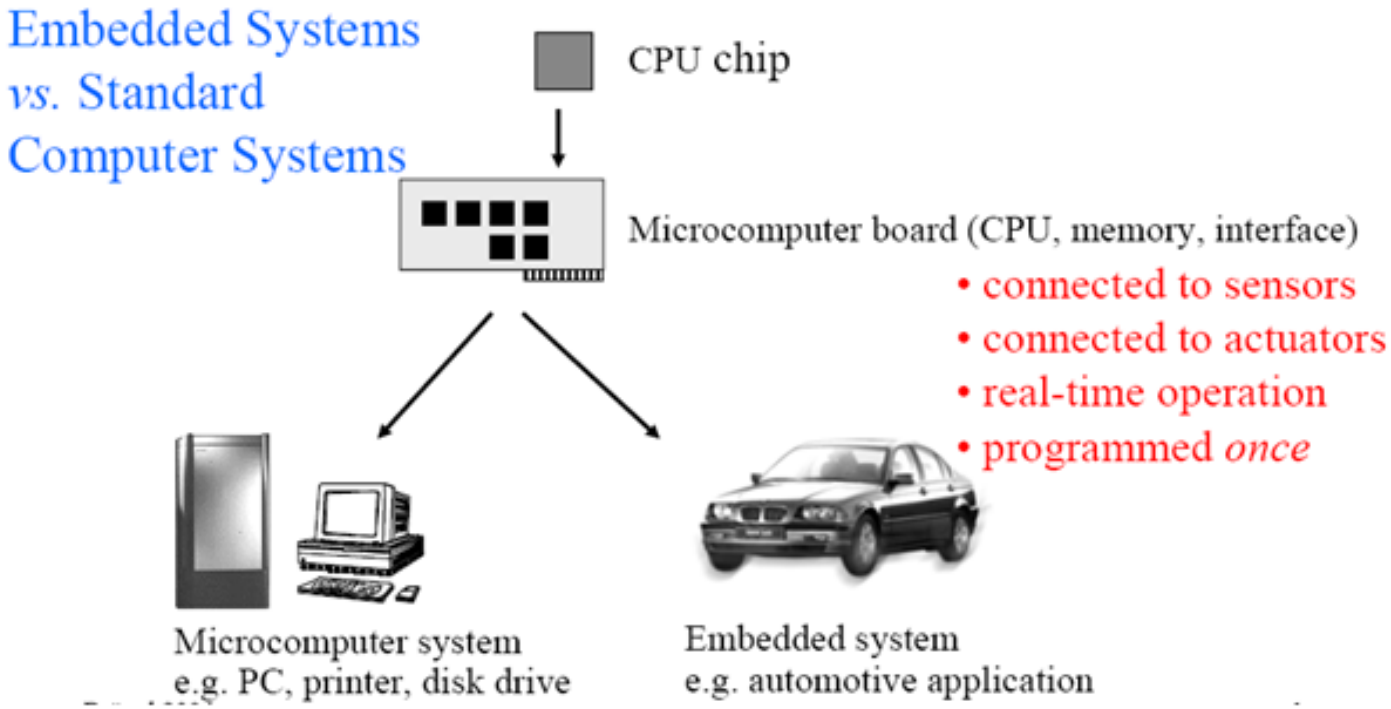
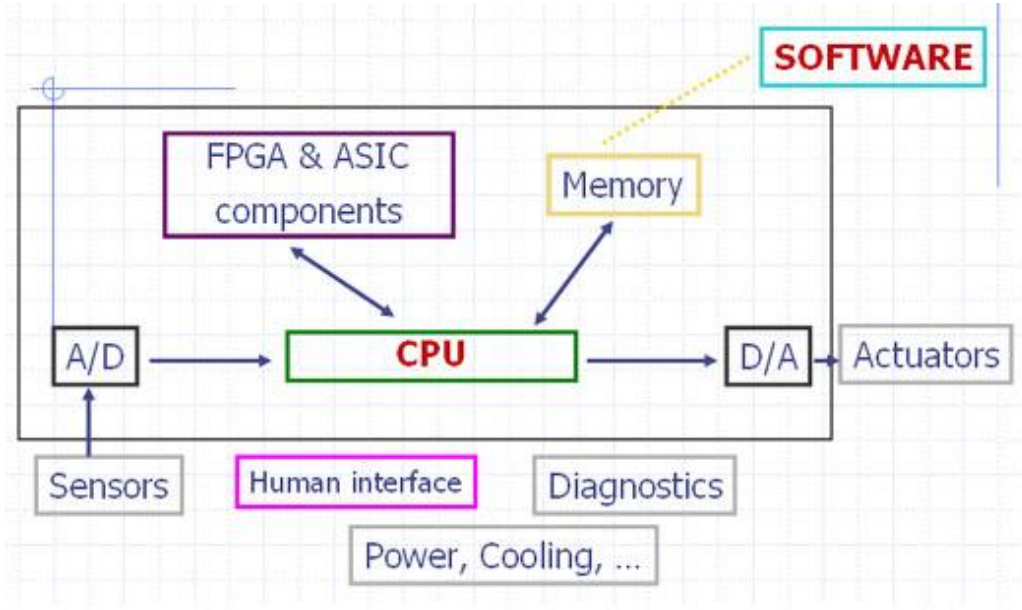
EMBEDDED SYSTEMS

- *An embedded system is a system designed to perform a specific function and is a combination of both hardware and firmware (software)*
- *An embedded system is designed to run on its own without human intervention, and may be required to respond to events in real time.*



GENERIC EMBEDDED SYSTEM

- Performs one or a few pre-defined tasks
- Very specific requirements
- Task-specific hardware and mechanical parts
- Often mass-produced



GENERAL COMPUTING SYSTEMS VS. EMBEDDED SYSTEMS

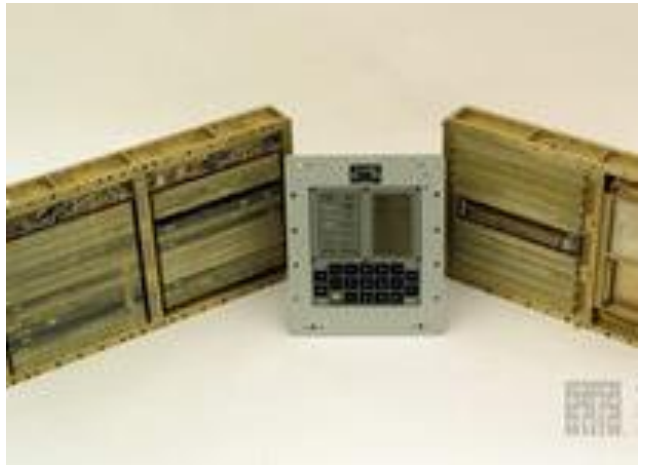
GENERAL COMPUTING SYSTEMS	EMBEDDED SYSTEMS
A system which is a combination of a generic hardware and a General Purpose Operating System for executing a variety of applications	A system which is a combination of special purpose hardware and embedded OS for executing a specific set of applications
Applications are alterable (programmable) by the user	The firmware is pre-programmed and it is non-alterable by the end-user
Less / not all tailored towards reduced operating power requirements, options for different levels of power management.	Highly tailored to take advantage of the power saving modes supported by the hardware and the operating system
Response requirements are not time–critical	Response time requirement is highly critical
Need not be deterministic in execution behaviour	Execution behaviour is deterministic

EMBEDDED SYSTEMS VS. GENERAL COMPUTING SYSTEMS

General Purpose Computing System	Embedded System
• A system which is a combination of a generic hardware and a General Purpose Operating System for executing a variety of applications	• A system which is a combination of special purpose hardware and embedded OS for executing a specific set of applications
• Contains a General Purpose Operating System (GPOS)	• May or may not contain an operating system for functioning
• Applications are alterable (programmable) by the user	• The firmware of the embedded system is pre-programmed and it is non-alterable by the end-user
• Performance is the key deciding factor in the selection of the system. Always, 'faster is Better'	• Application-specific requirements (like performance, power requirements, memory usage, etc.) are the key deciding factors
• Less / not all tailored towards reduced operating power requirements, options for different levels of power management.	• Highly tailored to take advantage of the power saving modes supported by the hardware and the operating system
• Response requirements are not time–critical	• Response time requirement is highly critical
• Need not be deterministic in execution behaviour	• Execution behaviour is deterministic

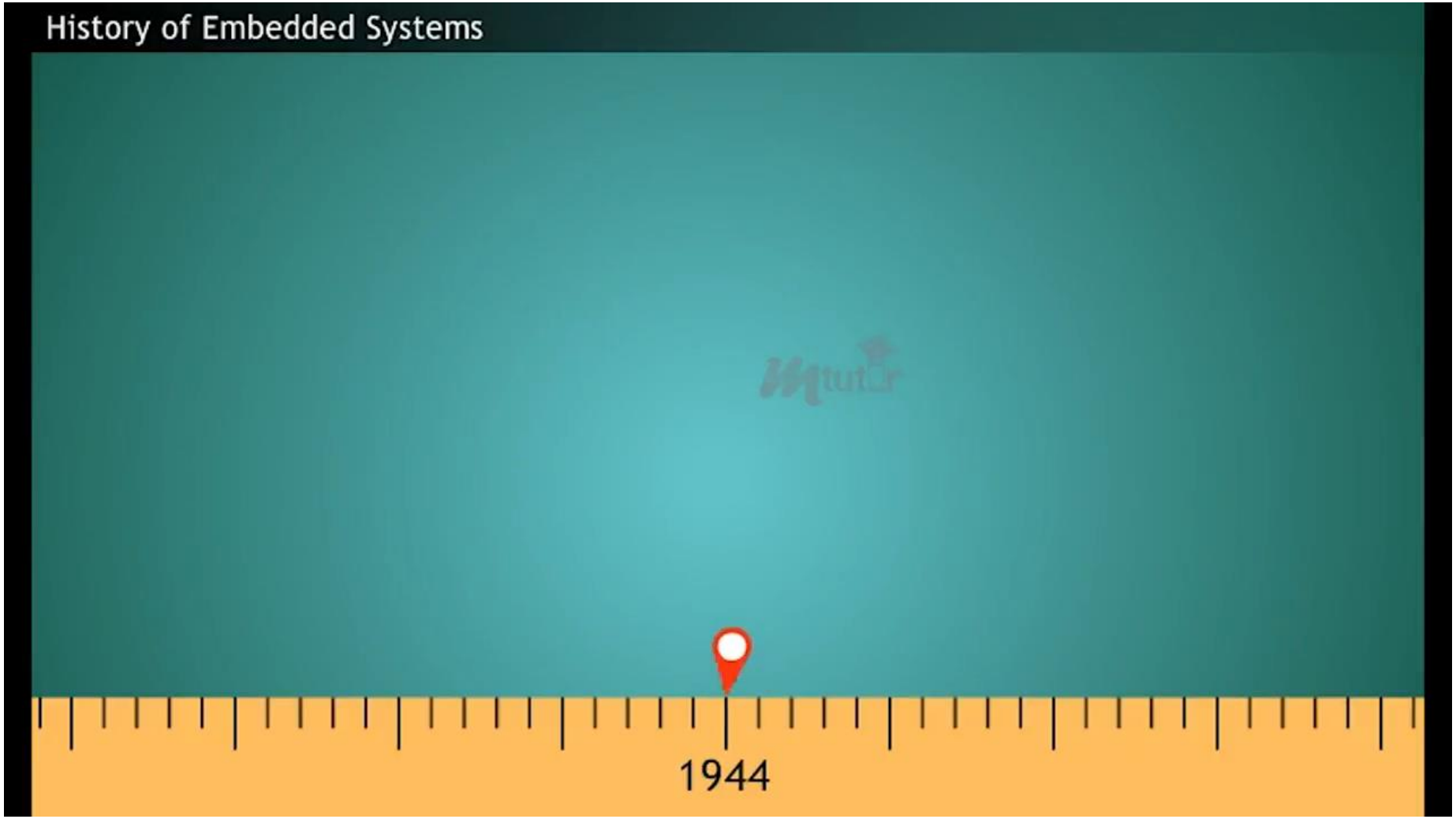
HISTORY OF EMBEDDED SYSTEMS

Apollo Guidance computer



- The Apollo Guidance Computer, the first recognizable modern embedded system developed by ***Charles Stark Draper*** at the MIT Instrumentation Laboratory
- Lunar Module and its crew were designed to go down to the moon surface and land there safely
- 36K ROM, 2K RAM
- Clock frequency 1.024 MHz
- Around 5000 ICs

HISTORY OF EMBEDDED SYSTEMS



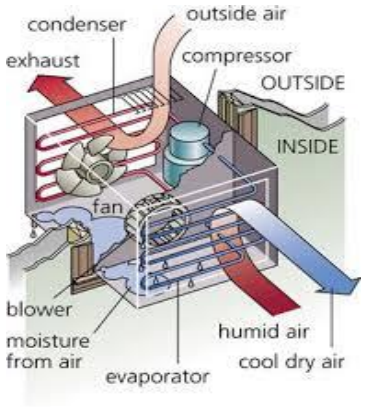
https://www.youtube.com/watch?v=Xyn0Oh5jlTc&ab_channel=MobileTutor

CLASSIFICATION OF EMBEDDED SYSTEMS
(BASED ON GENERATION)

First Generation	Second Generation	Third Generation	Fourth Generation
8 bit μP and 4 bit μC	16 bit μP and 8 or 16 bit μC	32bit μP and 16bit μC	System on Chips (SoC), reconfigurable processors and multicore processors
Firmware in Assembly code	Instruction set were much more complex	Instruction pipelining	High performance, tight integration and miniaturization
	May contained embedded operating systems	Real time operating systems	High performance real time embedded operating systems
Digital telephone keypads, stepper motor control	Data Acquisition Systems, SCADA systems	Robotics, media, industrial process control	Smart phone devices, mobile internet devices

CLASSIFICATION OF EMBEDDED SYSTEMS
(BASED ON COMPLEXITY AND PERFORMANCE)

Small–Scale Embedded Systems	**Medium–Scale Embedded Systems**	**Large–Scale Embedded Systems / Complex Systems**
Performance requirements are not time critical	Slightly complex in hardware and firmware	Highly complex hardware and firmware
Low performance and low cost 8 or 16 bit microprocessors / microcontrollers	Medium performance, low cost 16 or 32 bit microprocessors / microcontrollers or digital signal processors	High performance 32 or 64 bit RISC processors
May or may not contain an operating system	Contain an embedded operating system	High performance Real Time Operating Systems (RTOS)



PURPOSE OF EMBEDDED SYSTEMS

- Data collection / Storage / Representation
- Data communication
- Data (signal) processing
- Monitoring
- Control
- Application specific user interface

Core Of The Embedded System

General purpose and domain specific processors

- Microprocessors
- Microcontrollers
- Digital Signal Processors

Application Specific Integrated Circuits (ASICs)

Programmable Logic Devices (PLDs)

Commercial off-the-shelf Components (COTS)