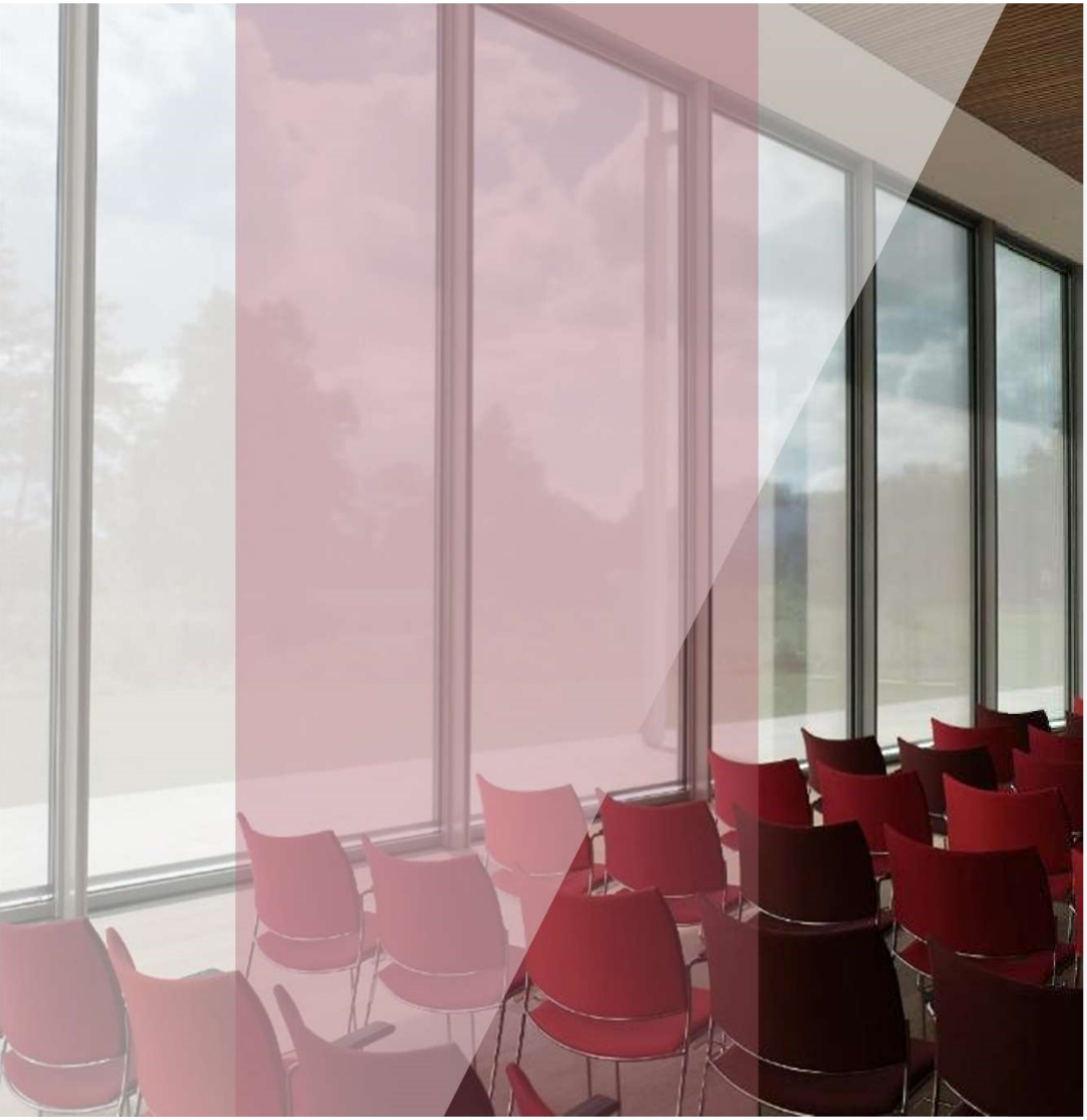
Embedded Systems
4th Stage

Assist Prof. Dr. Yasir Amer Abbas

Computer Engineering Department

2022



Content

Course Protocol Explanation
Syllabus Explanation
Course Learning Objectives
Embedded Systems Overview
What is an embedded system?
Examples of embedded system?
How embedded system is different from General computer system ?

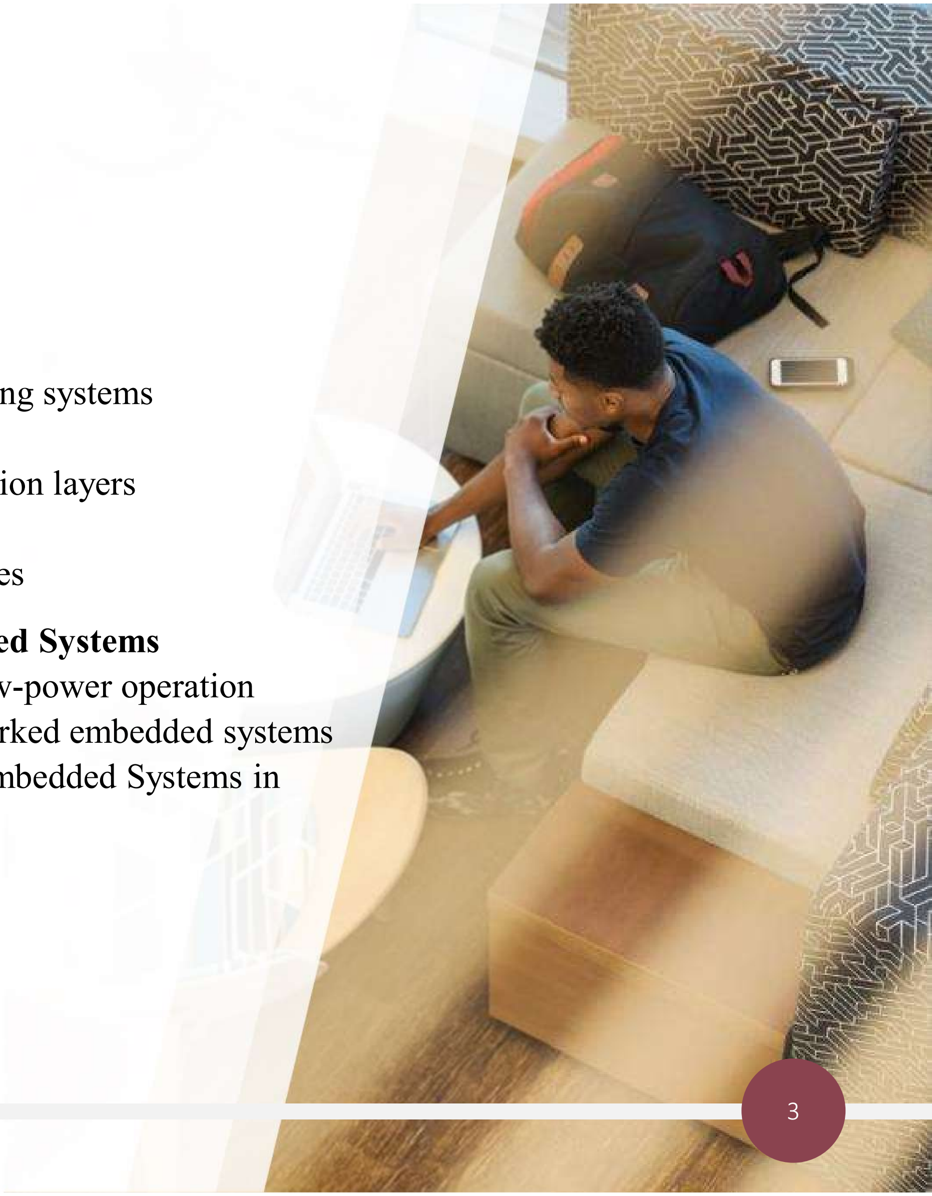
Syllabus

1.Embedded Systems Overview
1.1 What is an embedded system?
1.2 Embedded Systems Vs General Computing Systems
1.3 Embedded Systems Classification
1.4 Characteristics and Quality Attributes of Embedded Systems
1.5 Embedded System Design Process

2. **Embedded system hardware**
2.1 Typical Architecture
2.2 Input Components
2.3 Communication
2.4 Processing Units (Overview of Processors & Microcontrollers)
2.5 Memories
2.6 Output Components
2.7 Secure hardware

3. **System software**
3.1 Embedded operating systems
3.2 ERIKA
3.3 Hardware abstraction layers
3.4 Middleware
3.5 Real-time databases

4. Complex Embedded Systems
4.1 Techniques for low-power operation
4.2 Mobile and networked embedded systems
4.3 Applications of Embedded Systems in Modern Life



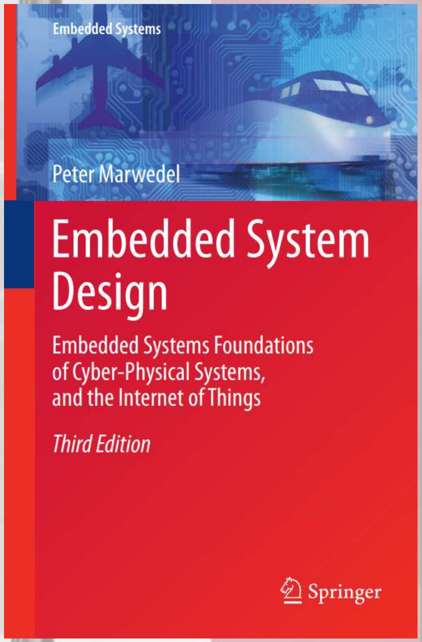
Course Protocol

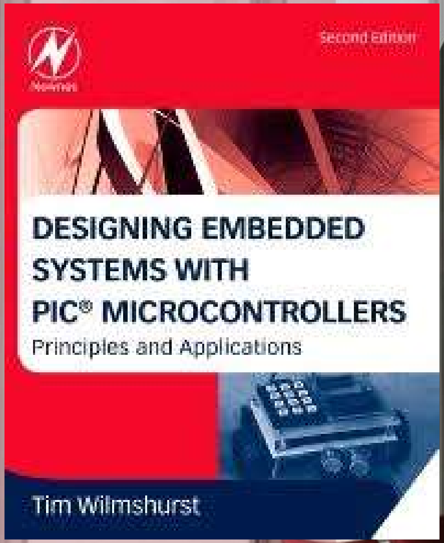
Exam (Two)	02*10= 20
Homework (Four)	04*02= 10
Quiz	03*02= 06
Attendance	= 4
Lab	=10

Total Marks 50
Final Exam   50

Course Timing

Tuesday Day Morning	Tuesday Day Evening
08:30 AM To 10:30 AM	02:00 PM -4:00 PM


Embedded Systems
Peter Marwedel
Embedded System Design
Embedded Systems Foundations of Cyber-Physical Systems, and the Internet of Things
Third Edition
Springer


Second Edition
Newnes
DESIGNING EMBEDDED SYSTEMS WITH PIC® MICROCONTROLLERS
Principles and Applications
Tim Wilmshurst

Test Book

Peter Marwedel, “Embedded System Design”, Springer, Third Edition 2018.

Tim Wilmshurst, “Designing Embedded Systems with PIC Microcontrollers Principles and applications”, Second Edition 2010.

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Embedded Systems

Lecture One
Embedded Systems Overview

Assist. Prof. Dr Yasir Amer

2022

Embedded Systems Overview

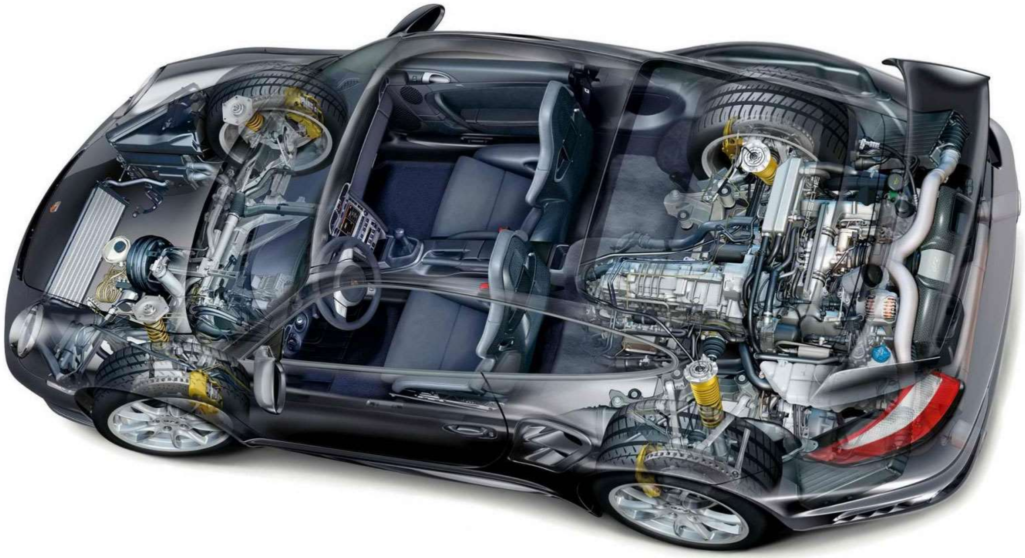
1.1 What is Embedded System?

1.2 Example of embedded systems

1.3 Embedded Systems Vs General Computing Systems

Embedded Systems Overview

- An embedded system can be thought of as a computer hardware system having software embedded in it. An embedded system can be an independent system or it can be a part of a large system.
- An embedded system is a microcontroller or microprocessor based system which is designed to perform a specific task.



HISTORY OF EMBEDDED SYSTEM

- The first mass-produced embedded system was guidance computer for the Minuteman-I missile in 1961.
- In the year 1971 Intel introduced the world's first microprocessor chip called the 4004, was designed for use in business calculators. It was produced by the Japanese company Busicom.

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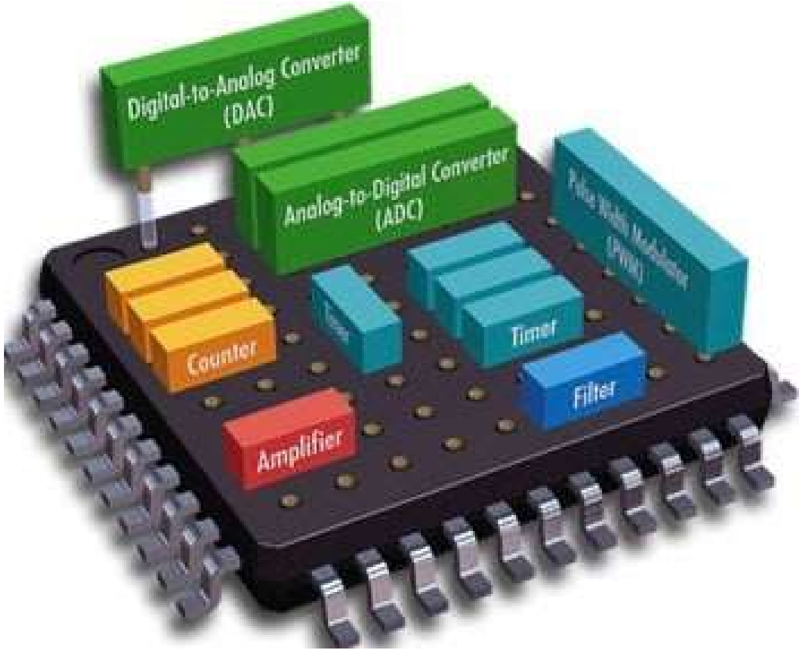
What is an embedded system?

DEFINITION OF AN EMBEDDED SYSTEM

An embedded system is a combination of 3 things:

- Hardware
- Software
- Mechanical Components

And it is supposed to do one specific task only.


Digital-to-Analog Converter (DAC)
Analog-to-Digital Converter (ADC)
Pulse Width Modulator (PWM)
Counter
Timer
Filter
Amplifier

What is an embedded system?

- **Embedded System:**

  "Embedded" means hidden inside so one can't see it.

  "System" means multiple components interfaced Together for a common purpose.

What is an embedded system?

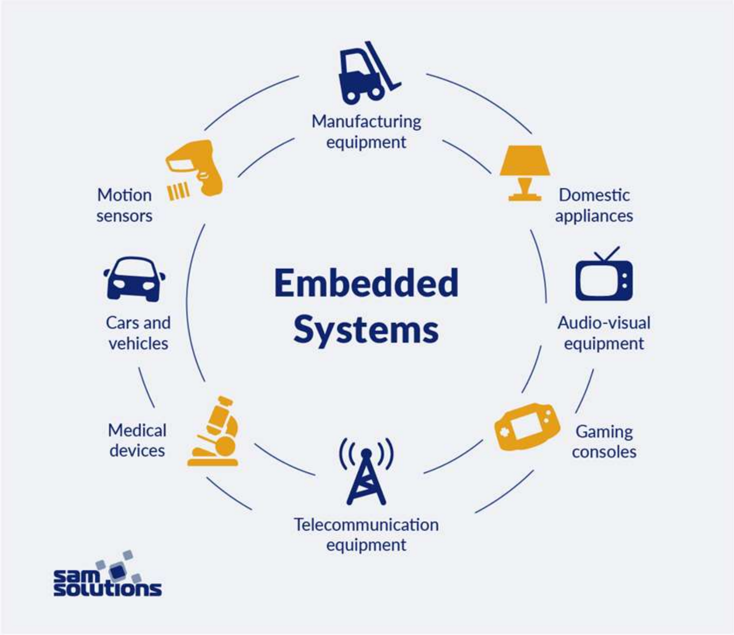
Embedded systems are usually single function applications. Various functional constraints associated with embedded systems are low cost, single-to-fewer components, low power, provide real-time response and support of hardware software co-existence.

A general methodology used in designing an embedded. The decision on the kind of digital platform to be used takes place during the system architecture phase as each embedded application is linked with its unique operational constraints. Some of the constraints of a digital controller of embedded system hardware include the following:

- Real-time update rate
- Power
- Cost
- Single chip solution
- Ease of programming
- Portability of code

Major Application Areas of Embedded Systems

- **Consumer Electronics:** Camcorders, Cameras etc.
- **Household Appliances:** Television, DVD players, washing machine, Fridge, Microwave Oven, etc.
- **Home Automation and Security Systems:** Air conditioners, sprinklers, Intruder detection alarms, Closed Circuit Television Cameras, Fire alarms etc.
- **Automotive Industry:** Anti-lock breaking systems (ABS), Engine Control, Ignition Systems, Automatic Navigation Systems etc.
- **Telecom:** Cellular Telephones, Telephone switches, Handset Multimedia Applications etc.
- **Computer Peripherals:** Printers, Scanners, Fax machines etc.
- **Computer Networking Systems:** Network Routers, Switches, Hubs, Firewalls etc.
- **Health Care:** Different Kinds of Scanners, EEG, ECG Machines etc.
- **Measurement & Instrumentation:** Digital multi meters, Digital CROs, Logic Analysers PLC systems etc.
- **Banking & Retail:** Automatic Teller Machines (ATM) and Currency counters, Point of Sales (POS)
- **Card Readers:** Barcode, Smart Card Readers, Hand held Devices etc

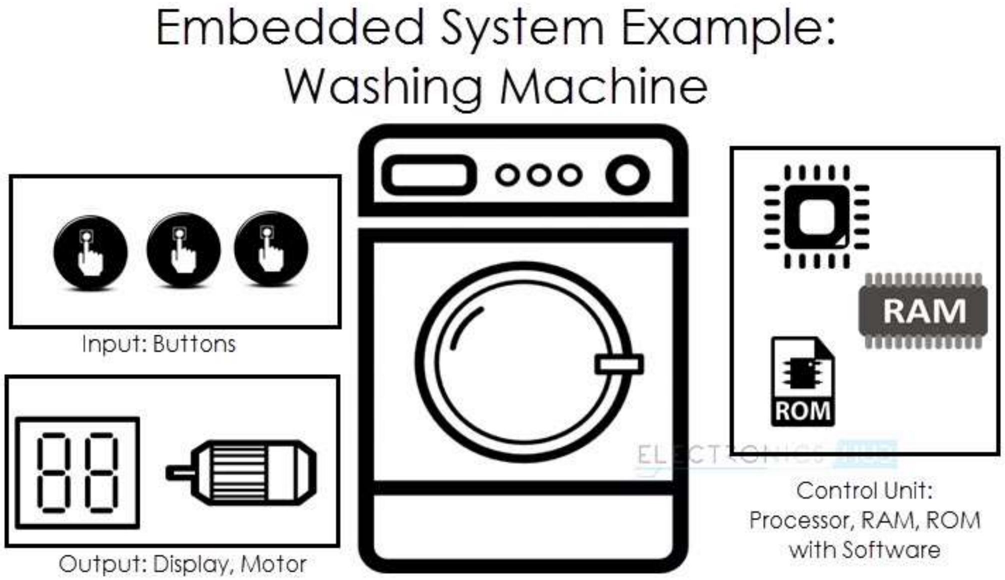


Example of Embedded Systems

Example 1: Washing Machine

A washing machine from an embedded systems point of view has:

- Hardware: Buttons, Display & buzzer, electronic circuitry.
- Software: It has a chip on the circuit that holds the software which drives controls & monitors the various operations possible.
- Mechanical Components: the internals of a washing machine which actually wash the clothes control the input and output of water, the chassis itself.

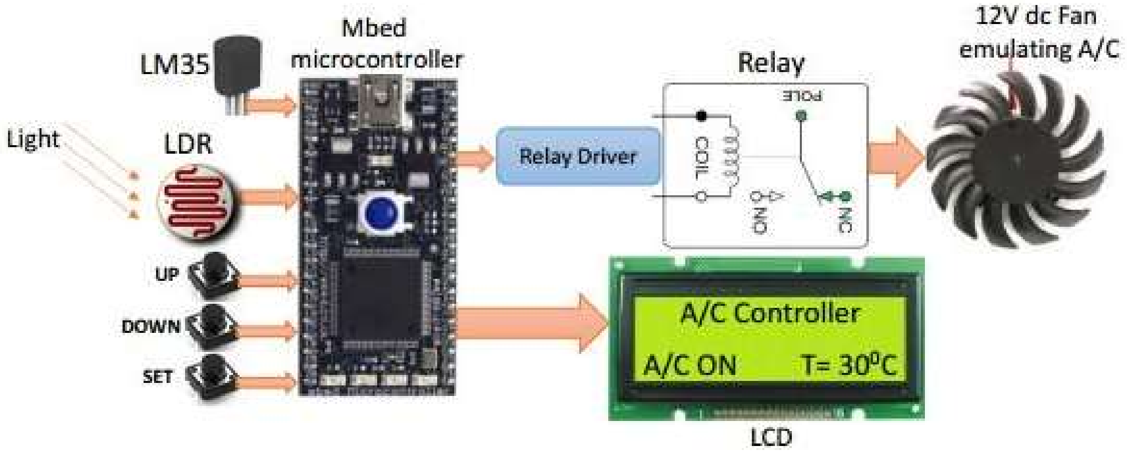


Example of Embedded Systems

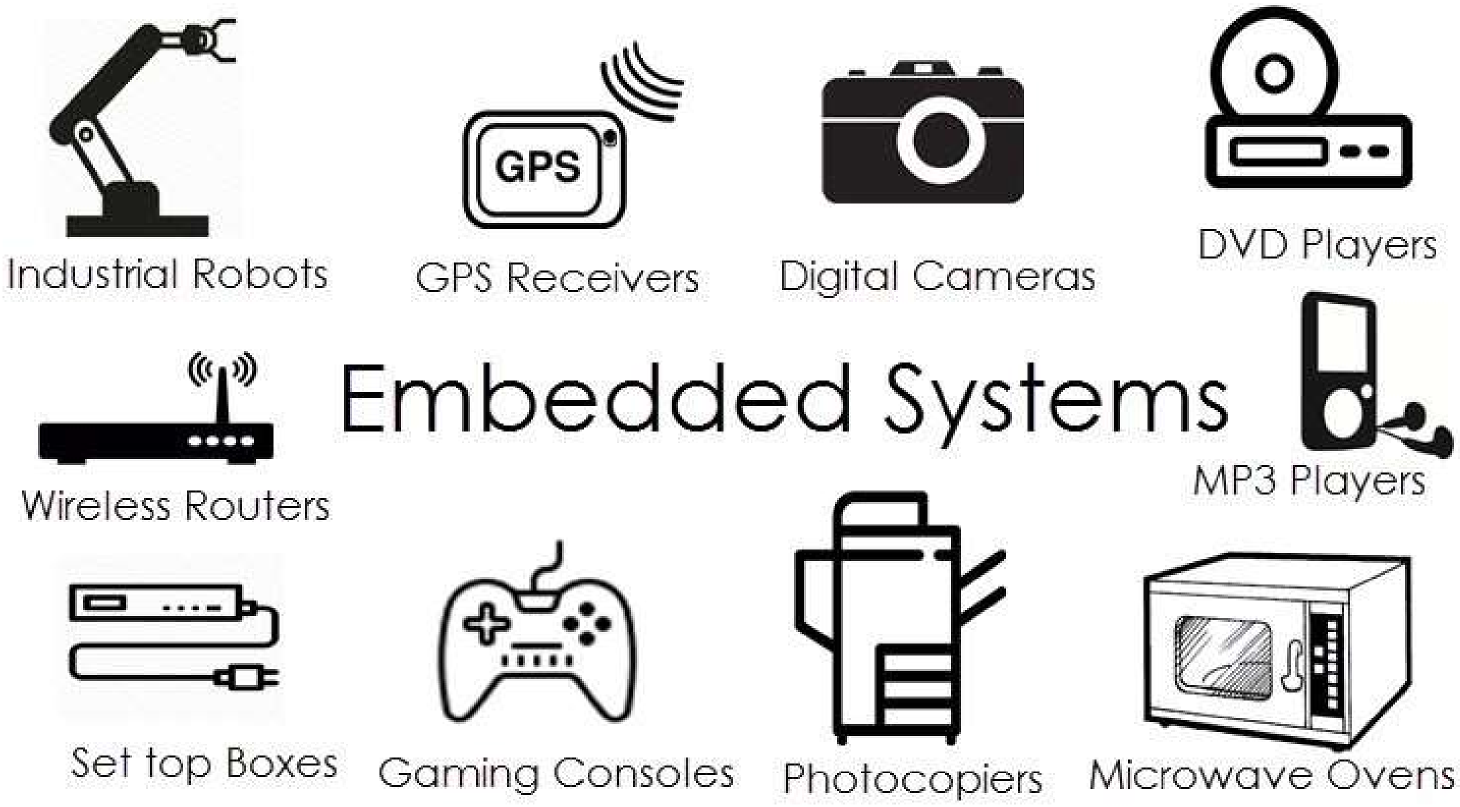
Example 2: Air Conditioner

An Air Conditioner from an embedded systems point of view has:

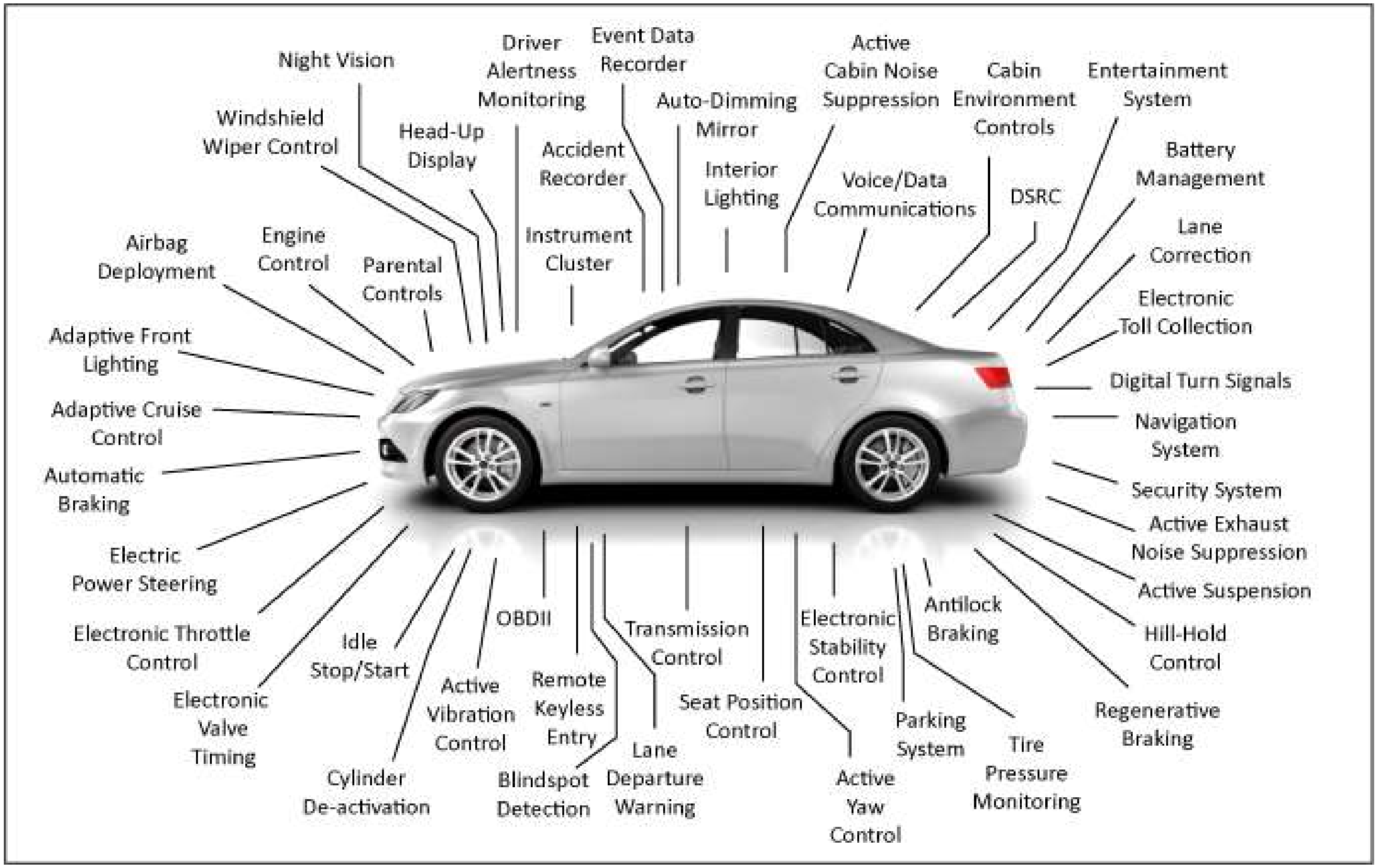
- Hardware: Remote, Display & buzzer, Infrared Sensors, electronic circuitry.
- Software: It has a chip on the circuit that holds the software which drives controls & monitors the various operations possible. The software monitors the external temperature through the sensors and then releases the coolant or suppresses it.
- Mechanical Components: the internals of an air conditioner the motor, the chassis, the outlet, etc



Example of Embedded Systems



Example of Embedded Systems



Example of Embedded Systems

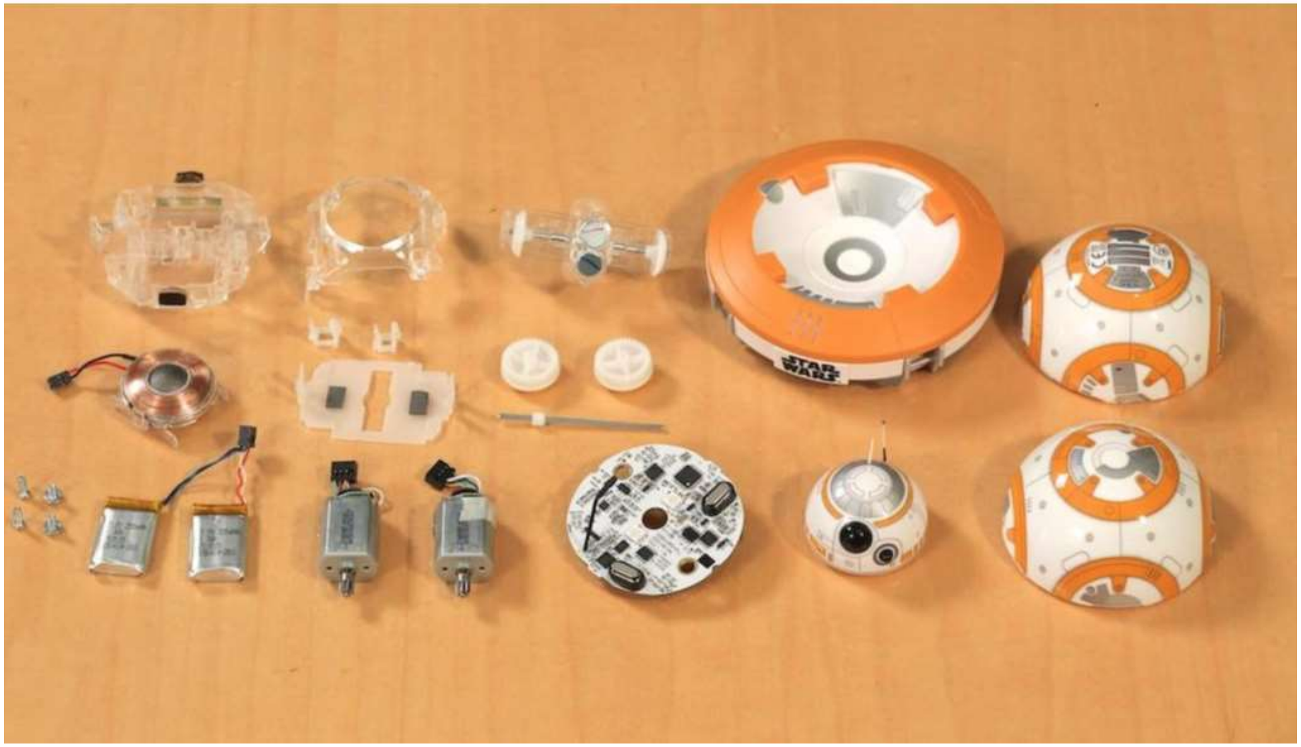
- NASA's Twin Mars Rovers.
- Microprocessor: Radiation Hardened 20MHz PowerPC From **IBM**
- Commercial Real-time OS.
- Software and OS was developed during multi-year flight to Mars and downloaded using a radio link.

Examples of Embedded Systems

- Sphero BB-8
- ARM Cortex-M4 core 32bit From ST

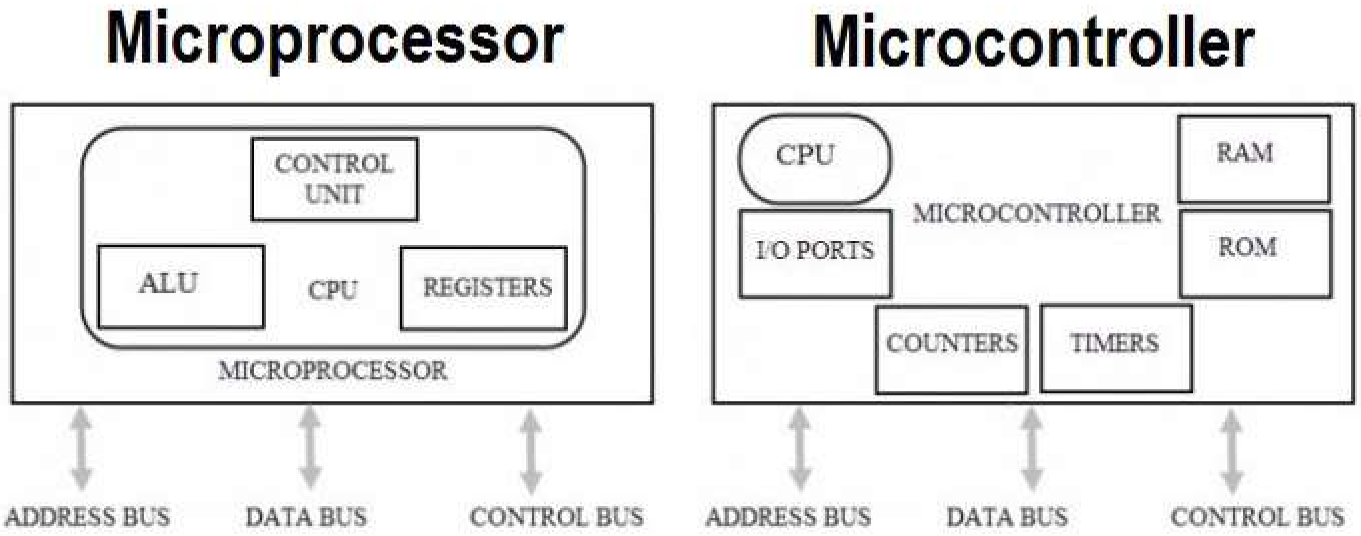
Examples of Embedded Systems

Sphero BB-8 From inside



Microprocessor and Microcontroller

- An embedded system is designed to do a specific job only. Example: a washing machine can only wash clothes, an air conditioner can control the temperature in the room in which it is placed.
- The hardware & mechanical components will consist all the physically visible things that are used for input, output, etc.
- An embedded system will always have a chip (either microprocessor or microcontroller) that has the code or software which drives the system.



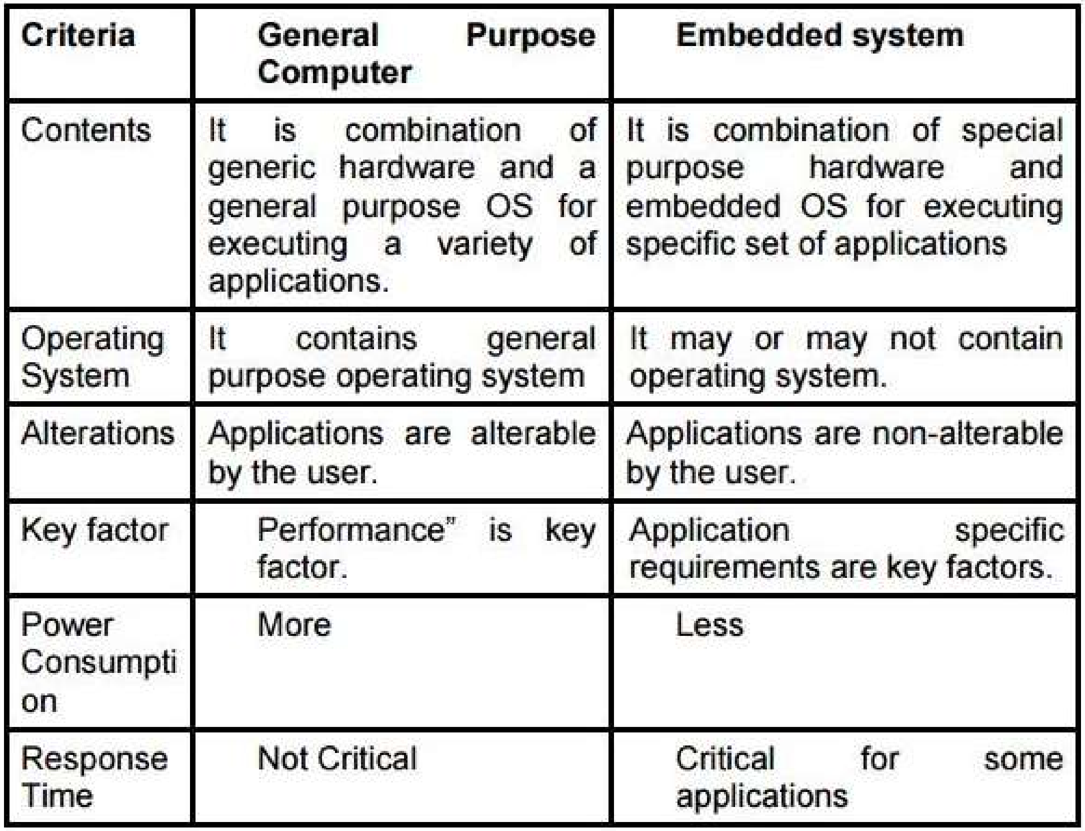
EMBEDDED SYSTEM & GENERAL PURPOSE COMPUTER

The Embedded System and the General purpose computer are at two extremes.

The embedded system is designed to perform a specific task whereas as per definition the general purpose computer is meant for general use.

It can be used for playing games, watching movies, creating software, work on documents or spreadsheets etc.

Following are certain specific points of difference between embedded systems and general purpose computers:



Criteria	General Purpose Computer	Embedded system
Contents	It is combination of generic hardware and a general purpose OS for executing a variety of applications.	It is combination of special purpose hardware and embedded OS for executing specific set of applications
Operating System	It contains general purpose operating system	It may or may not contain operating system.
Alterations	Applications are alterable by the user.	Applications are non-alterable by the user.
Key factor	Performance" is key factor.	Application specific requirements are key factors.
Power Consumption	More	Less
Response Time	Not Critical	Critical for some applications

Key factors to consider when choosing a microcontroller

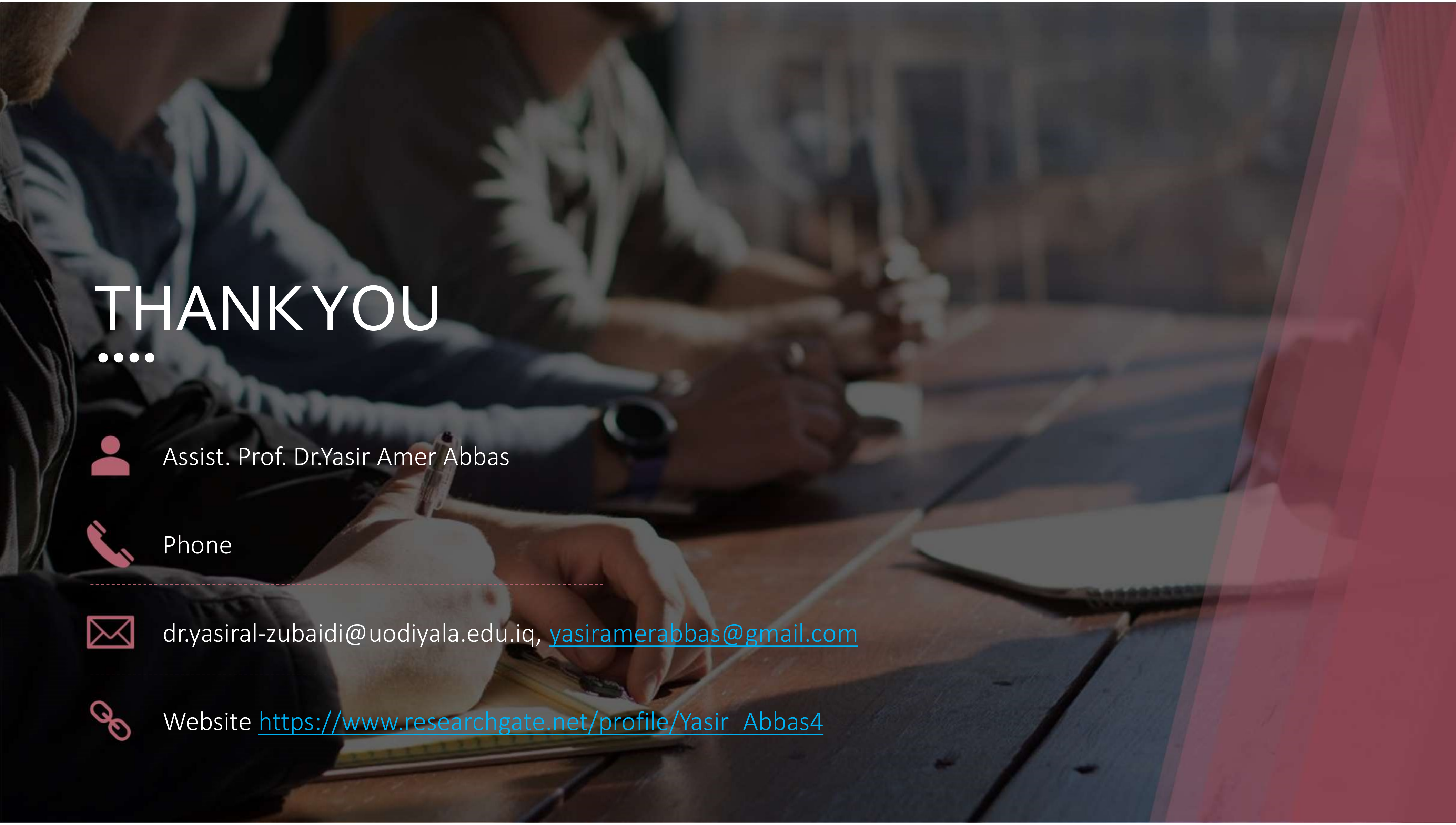
- Power efficiency. There is a trade-off between processing performance and power consumption:
- a device with higher processing power will consume more energy. Therefore, if your microcontroller is wireless and running on a rechargeable battery, you need to weigh sacrificing power efficiency against getting more processing power, or vice versa. Some power-efficient microcontrollers include STMicroelectronics' STM32 series, NXP's Kinetis L series, Renesas' H8 Super Low Power series, Cypress' PSoC 6 series, Microchip's eXtreme Low Power PIC series, and Texas Instruments' MSP430 series.
- Temperature tolerance. Depending on the environment in which your microcontrollers operate, you may want devices that withstand extreme temperature. There will be a trade-off between temperature tolerance and cost. Some temperature-tolerant microcontrollers include STMicroelectronics' STM32F103 series, NXP's Kinetis EA series, Renesas' RX24T and RX24U, Infineon's XMC series and AURIX™ series, Microchip's: PIC and AVR microcontrollers, and Texas Instruments' MSP430F2619S-HT.

Key factors to consider when choosing a microcontroller

- Security. Hacking which targets IoT devices is rising, a threat that is especially relevant to microcontrollers used in automobiles. In response, microcontroller makers are implementing layers of security such as cryptography and physical security. Now, users can purchase microcontrollers that have been certified to the latest security standards or use MCUs with on-chip secure hardware. Companies that offer stand-alone security MCUs include STMicroelectronics (ST33 series), Renesas (AE-5 and RS-4 series), Infineon (OPTIGA Trust and OPTIGA TPM), Cypress (PSoC 64), Microchip (32-bit and 16-bit MCUs for Security), and Texas Instruments (MSP430 series). Companies that offer on-chip security hardware include NXP (Kinetis series) and Infineon (AURIX).
- Hardware architecture. A microcontroller's packaging directly influences its size and performance. Dual in-line packaging is the most common type. Small-outline transistors have a small footprint, and quad flat packs take up more areas but less vertical space. Wafer level chip-scales are much smaller and pack in more processing power but are more expensive to manufacture. Flat no-lead packages are better in heat diffusion. Ball grid arrays (BGAs) have high performance due to the compact package but also cost more to fabricate.
- Some of the smallest footprint microcontrollers include Microchip's (formerly Atmel's) ATtiny20-UUR, Cypress' PSoC 4000, NXP's LPC1102UK, STMicroelectronics' STM32F042T6Y6, and Texas Instrument's MSP430G2252.

Key factors to consider when choosing a microcontroller

- Processing power. How much processing power do you require for the task, will a single core processor suffice, or do you need a dual-core? A multicore processor will be significantly faster, but it will also consume more energy. Also, will a graphics processing unit (GPU) be necessary?
- Memory. The amount of memory (RAM and ROM) you need will depend on the programs you will be running. More programs need more random access memory (RAM). In addition, a GPU will require not only more RAM but faster read/write time as well.
- Hardware interface. The nature of the task will dictate the need for hardware interfaces such as USB, Wi-Fi, Bluetooth, audio, video, or camera.
- Software architecture. Some microcontrollers are operable on multiple OSs, and others are not. If you need to scale, it is better to use the same software architecture to increase interoperability.
- Cost. Microcontrollers fall within a wide price range, from a hundred units for a few dollars to a few dollars per unit. If you want to scale, you need to consider the overall cost versus the individual performance power of a microcontroller.



THANK YOU

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