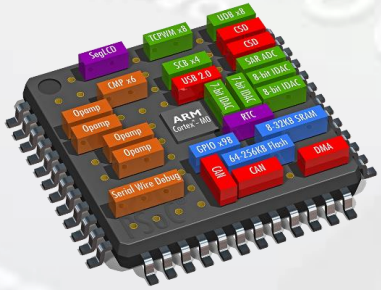
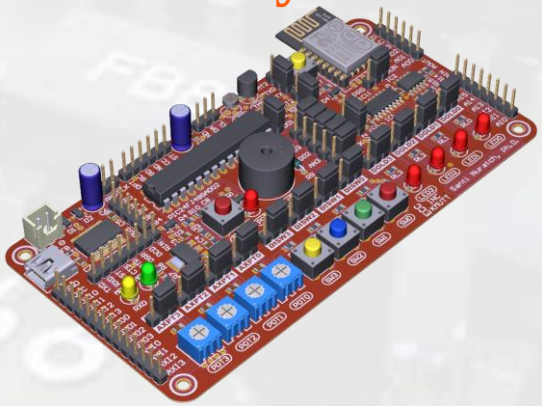
Week #01 - Introduction

INC 352:

Embedded Systems and Industrial Automation ApplicationsLaboratory





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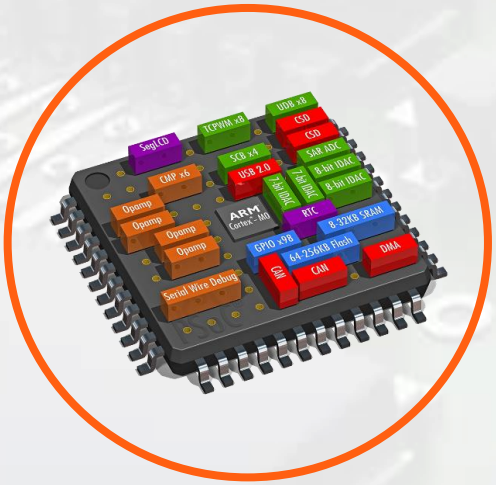
There are two main modules

Embedded Programming



Machine or System Controller

Graphical Programming

Computer-based Control and Monitoring

Embedded C Programming Techniques

Microcontroller Peripherals

Monitoring and Control Algorithms

Protocols and Communications

LabVIEW & Graphical Programming

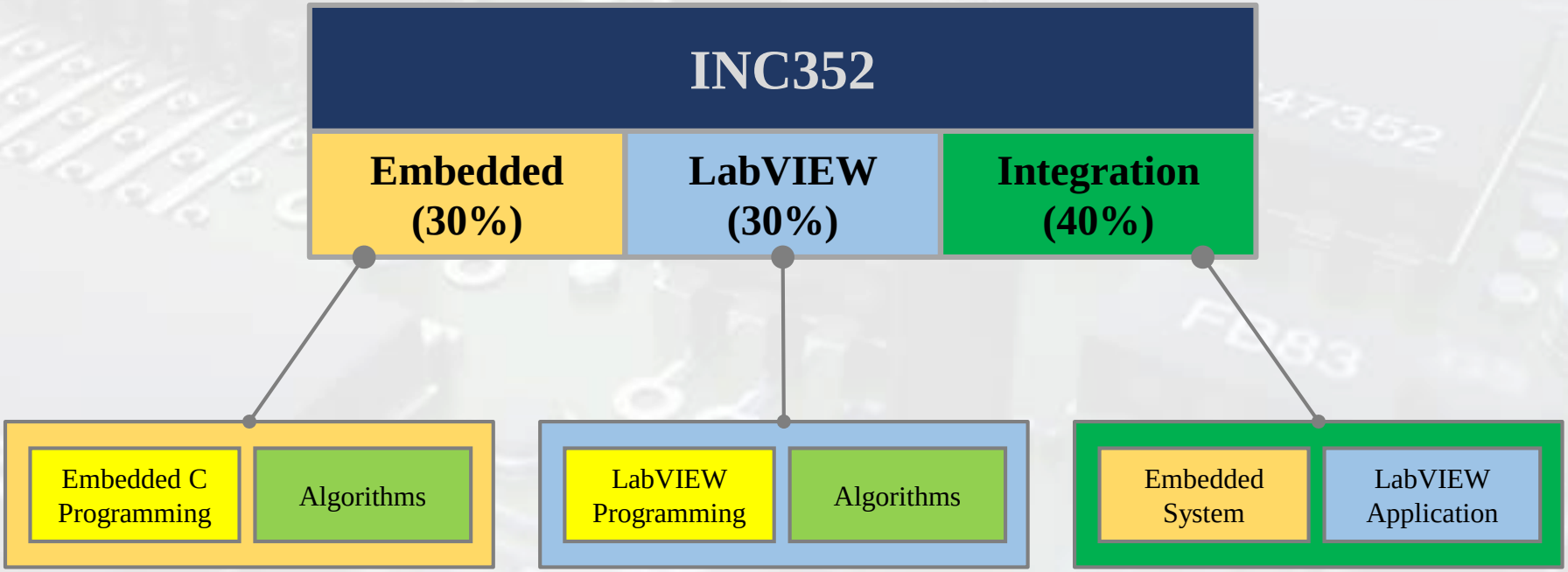
Event-Driven and FSM Techniques

Monitoring and Control Algorithms

Industrial Automation Applications

Self-learning	Assignments	Tests	Presentations	Teamwork

Three main important tasks, 100%



Thinking
Solving
Programming
Debugging

Thinking
Solving
Programming
Debugging

Knowledge and Usefulness
Engineering Design
Engineering Documents
Technical Presentation

Evaluation (score & grade)

Grades	Scores
A	80 - 100
B+	75 - 79
B	70 - 74
C+	65 - 69
C	60 - 64
D+	55 - 59
D	50 - 54
F	0 - 49

Weekly Quiz (60%)

- Embedded 30%
- LabVIEW 30%

System Integration (40%)

- Document 25%
- Presentation 15%

Once a Week Is Not Enough!!



Self-Study is better than Classroom Learning

Required Software Tools

Visual Studio Code

https://code.visualstudio.com/

https://www.labcenter.com/

MPLAB XC16 C Compiler

https://www.microchip.com/mplab/compilers

ecc-pic24-cli (Toolchain for PIC24 Development)

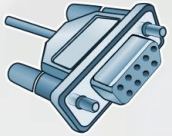
https://github.com/drsanti/INC352-2020

HTerm (Terminal for serial communication)

http://www.der-hammer.info/pages/terminal.html

Proteus (ISIS) (Circuit Simulator)

https://www.labcenter.com/



Virtual Serial Port Driver

https://www.virtual-serial-port.org/

LabVIEW 2019 (32-bit)

https://www.ni.com/

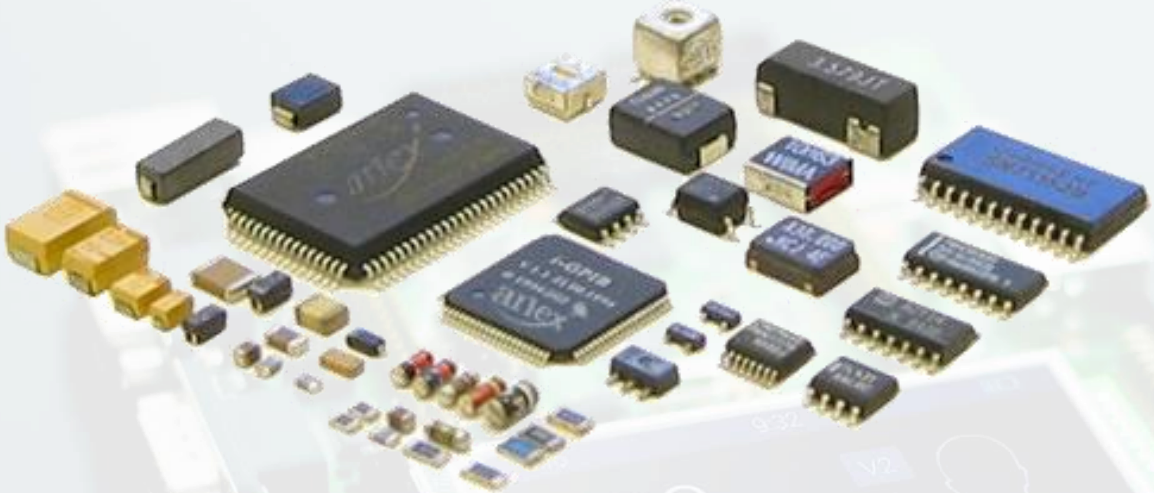
What is Embedded System?

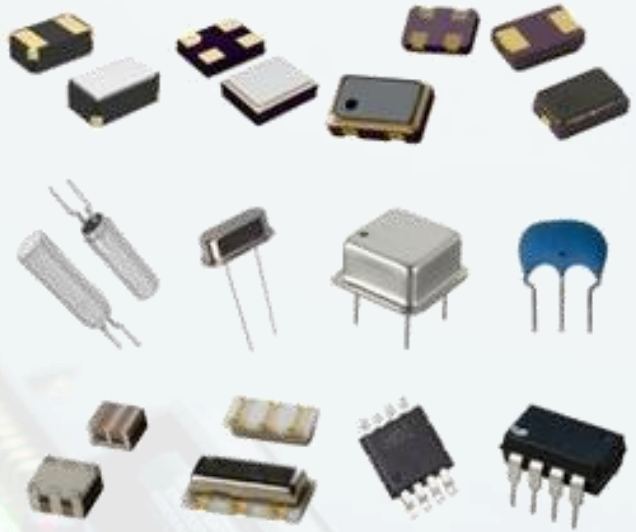
Electronic Devices

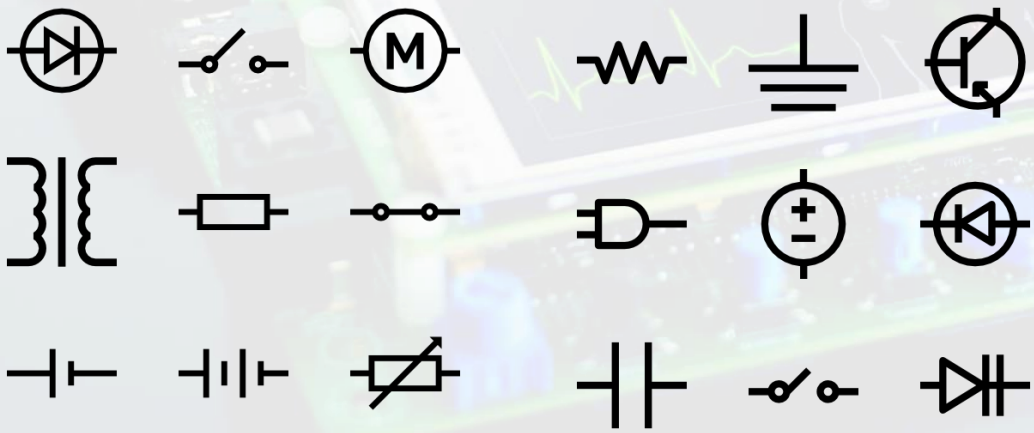
Most of electronic devices that we are using todays composed of microcontroller (a programmable computer). These devices are driven by the Embedded system.

What is Embedded System?

Electronic Components







Electronic components are not Embedded systems, but the Embedded systems are built from the electronic components

What is Embedded System?

General-purpose Computers

A general-purpose computers perform most common computing tasks. Personal computers, including desktops, notebooks, smartphones and tablets, are all examples of general-purpose computers.

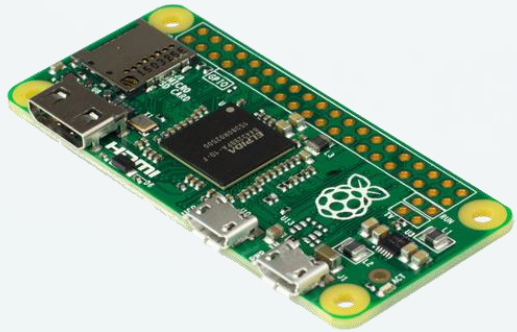
But there's another type of computing system, the Embedded Computing Systems

Personal computers have over 10 embedded processors. Graphics accelerator, mouse, keyboard, hard-drive, CD-ROM, bus interface, network card, etc.

What is Embedded System?

Embedded Computers





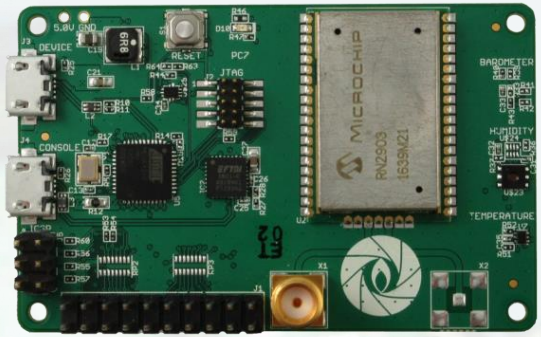
A single-board computer (SBC) is a complete computer built on a single circuit board, with microprocessor(s), memory, input/output (I/O) and other features required of a functional computer.



Industrial computers are primarily used for process control and/or data acquisition. In some cases, an industrial PC is simply used as a front-end to another control computer in a distributed processing environment.

What is Embedded System?

Single Board Microcontroller



A single-board microcontroller is a microcontroller built onto a single printed circuit board. This board provides all of the circuitry necessary for a useful control task: a microprocessor, I/O circuits, a clock generator, RAM, stored program memory and any necessary support ICs. The intention is that the board is immediately useful to an application developer, without requiring them to spend time and effort to develop controller hardware.

What is Embedded System?

A “short list” of Embedded Systems

Anti-lock brakes
Auto-focus cameras
Automatic teller machines
Automatic toll systems
Automatic transmission
Avionic systems
Battery chargers
Camcorders
Cell phones
Cell-phone base stations
Cordless phones
Cruise control
Curbside check-in systems
Digital cameras
Disk drives
Electronic card readers
Electronic instruments
Electronic toys/games
Factory control
Fax machines
Fingerprint identifiers
Home security systems
Life-support systems
Medical testing systems
Modems
MPEG decoders
Network cards
Network switches/routers
On-board navigation
Pagers
Photocopiers
Point-of-sale systems
Portable video games
Printers
Satellite phones
Scanners
Smart ovens/dishwashers
Speech recognizers
Stereo systems
Teleconferencing systems
Televisions
Temperature controllers
Theft tracking systems
TV set-top boxes
VCR’s, DVD players
Video game consoles
Video phones
Washers and dryers

Type of Embedded System

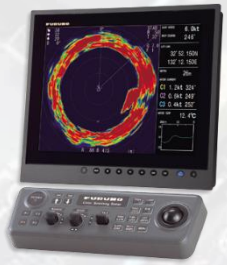
Four General Embedded System Types

General Computing

- Applications similar to desktop computing, but in an embedded package
- Video gams, set-top boxes, wearable computers, automatic tellers

Control System

- Closed-loop feedback control of real-time system
- Vehicle engine, chemical processes, nuclear power, flight control



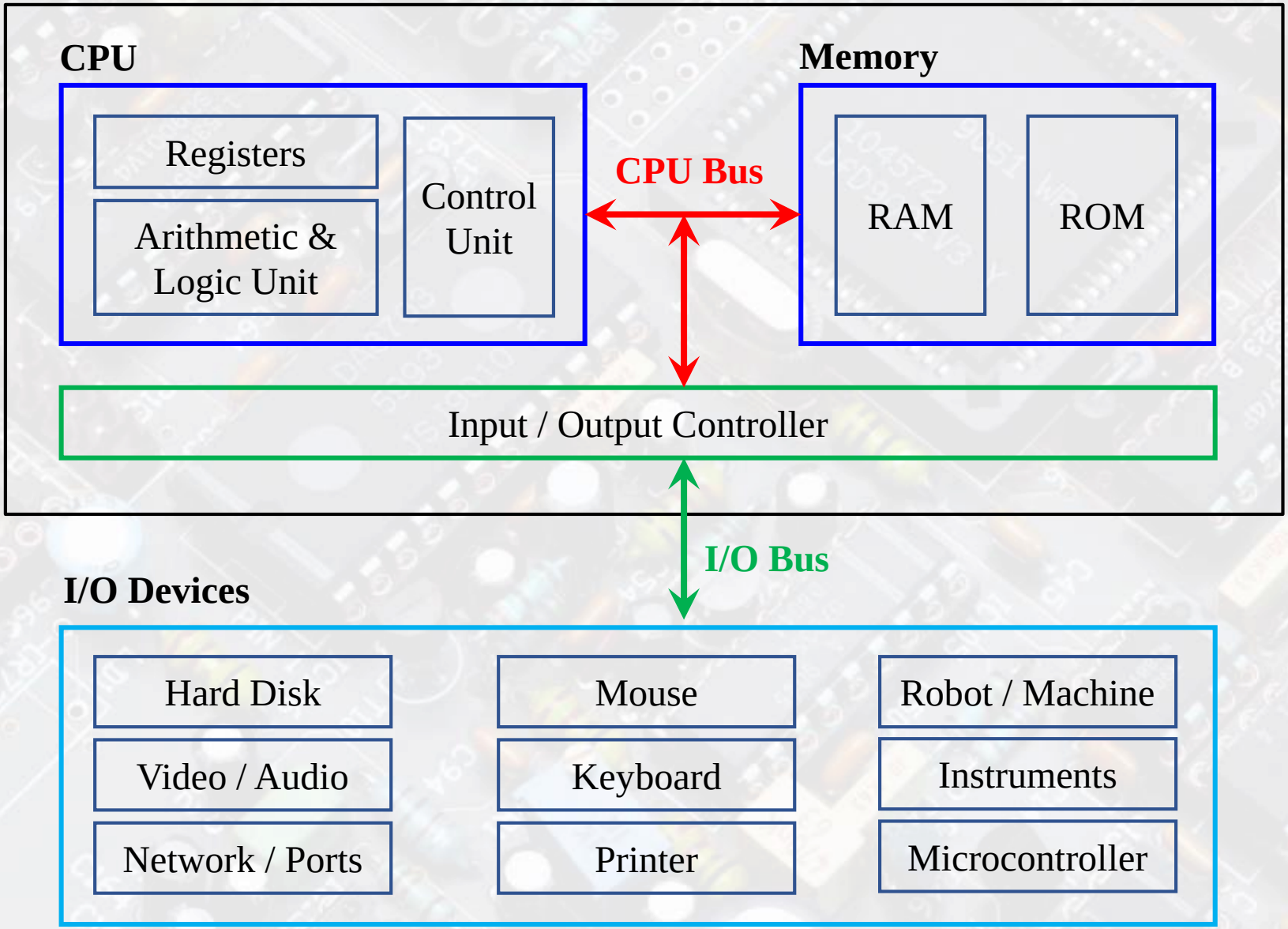
Signal Processing

- Computations involving large data streams
- Radar, Sonar, video compression

Communication and Networking

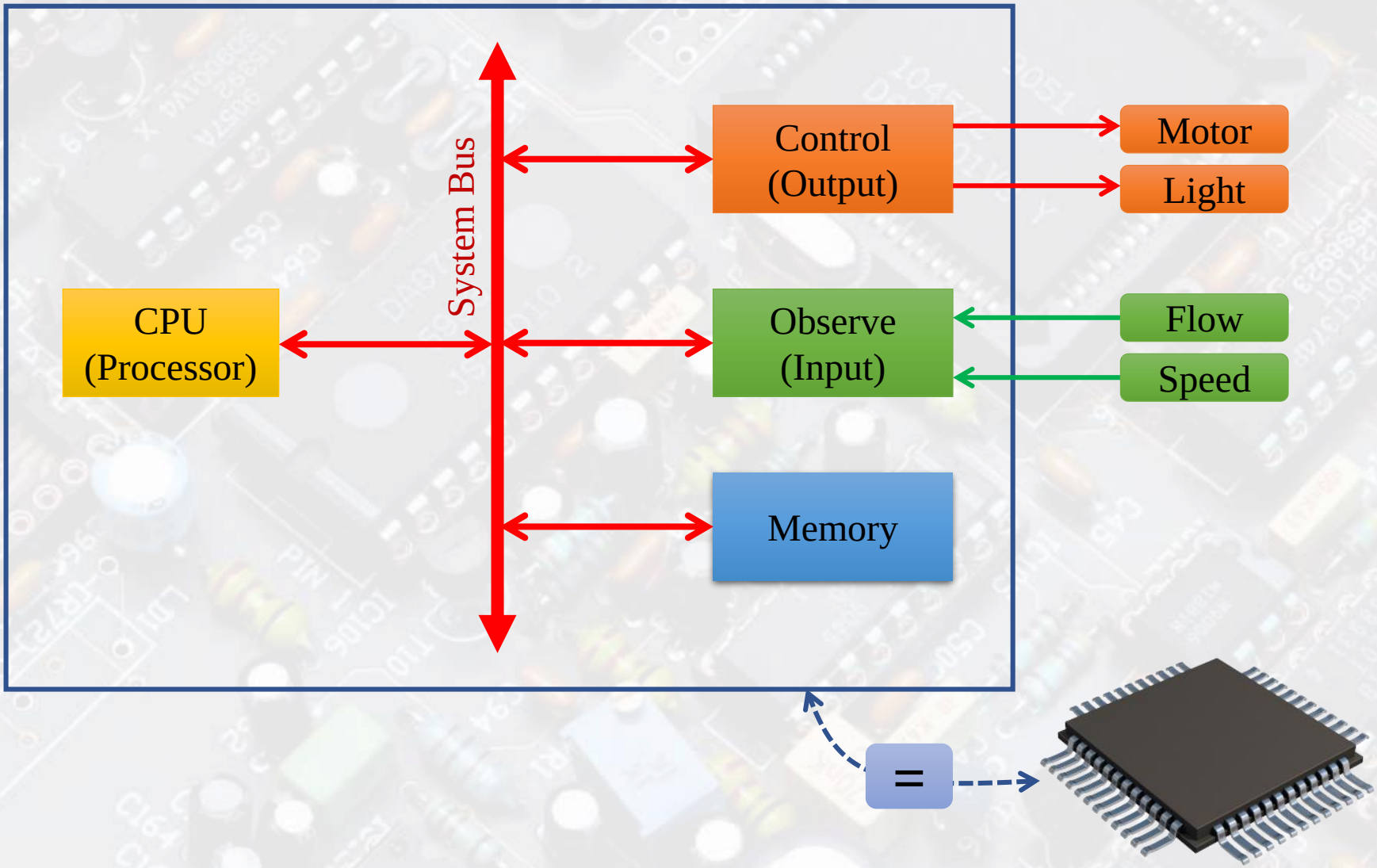
- Switching and information transmission
- Telephone system, Internet

Computer System Block Diagram

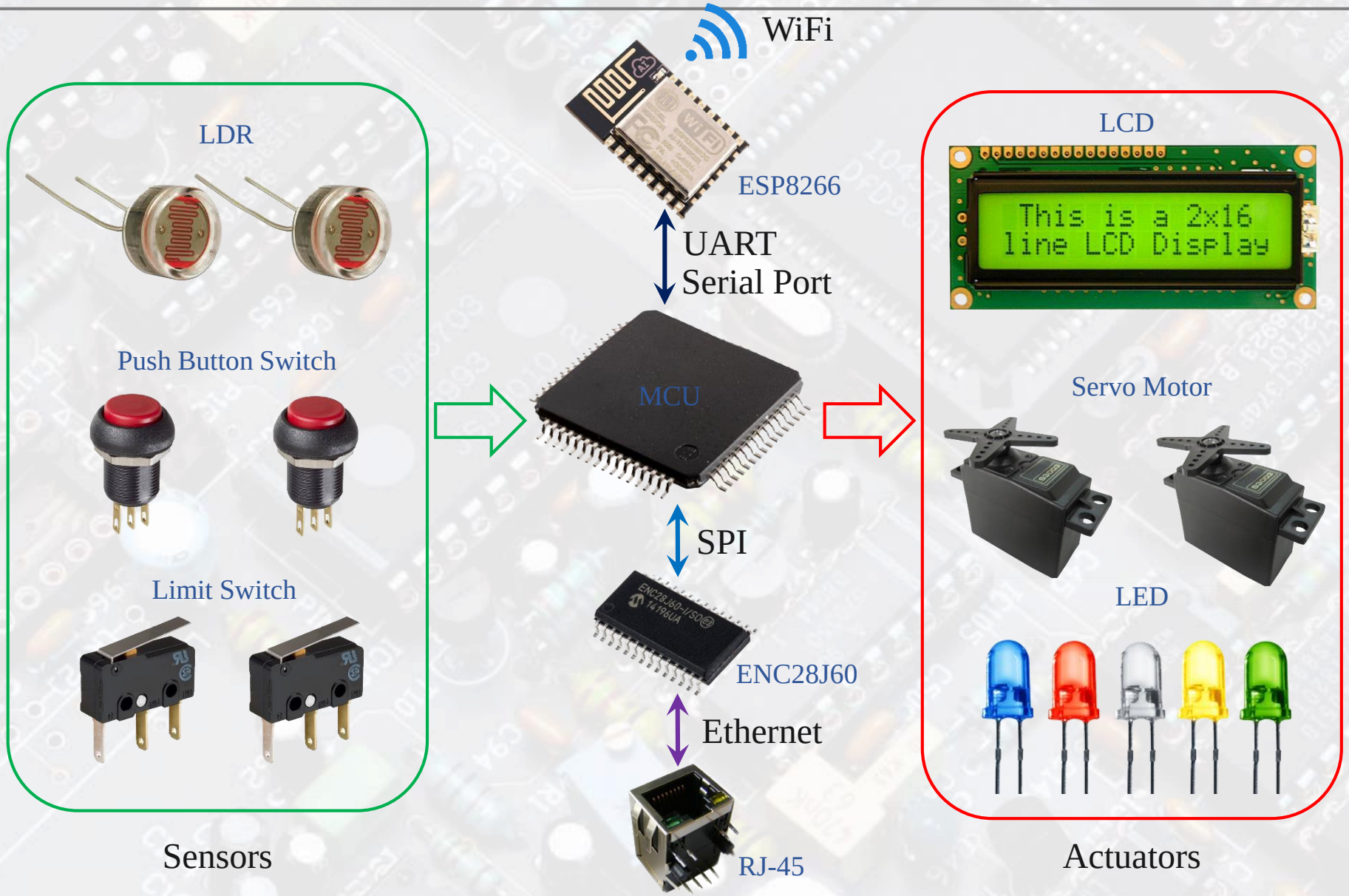


Embedded System Block Diagram

Simple Block Diagram of an Embedded System



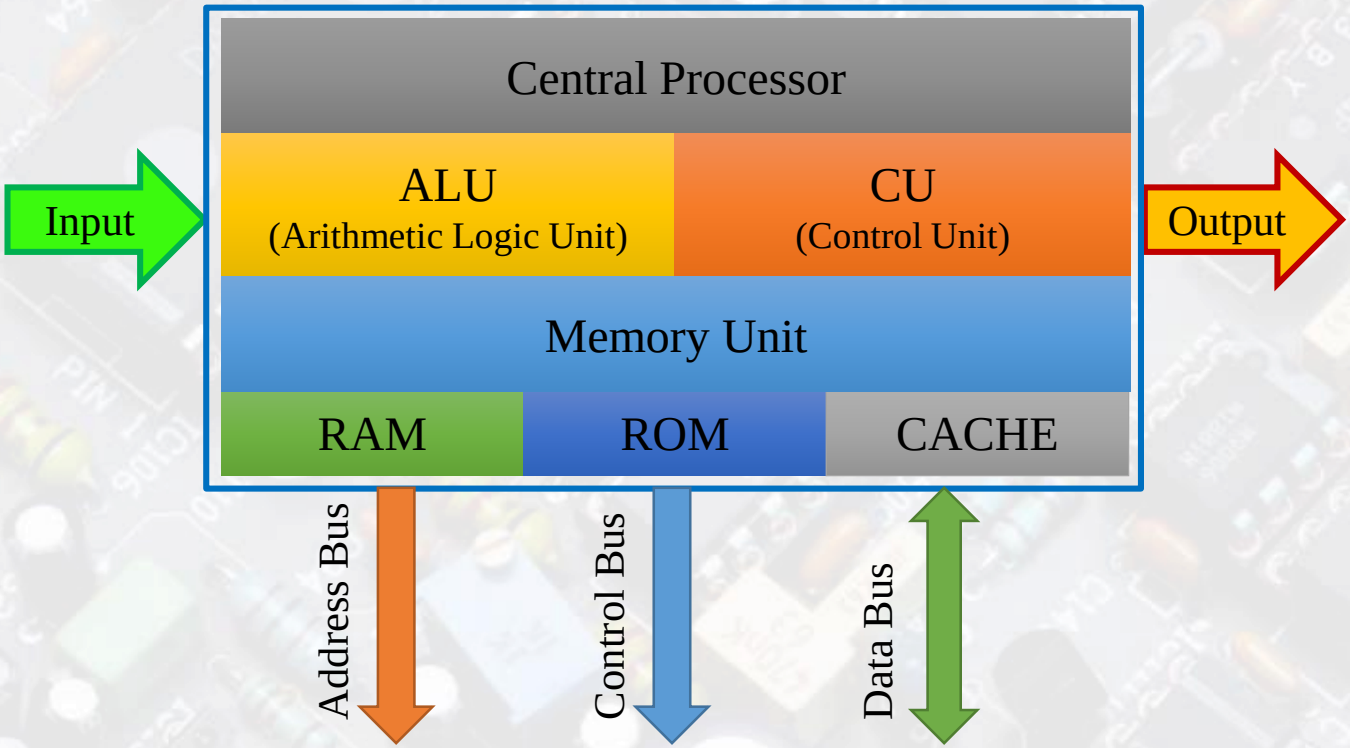
Embedded System Block Diagram



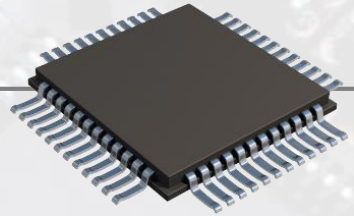
Processors

Computer's Processors

- A processor is the logic circuitry that responds to and processes the basic instructions that drive a computer. The four primary functions of a processor are fetch, decode, execute and write/read to/from memory.

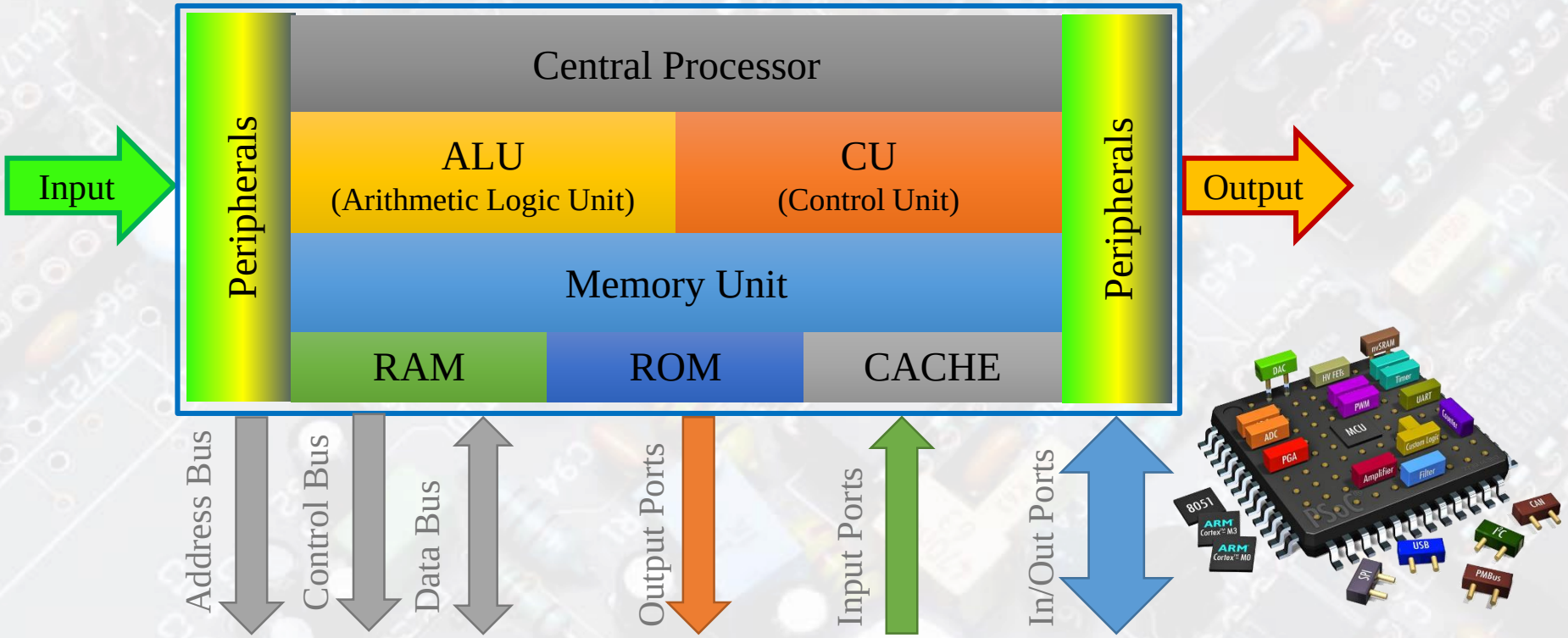


Processors



Embedded System's Processors or Microcontrollers

- A microcontroller (MCU) is a small computer on a single integrated circuit. In modern terminology, it is similar to, but less sophisticated than, a system on a chip or SoC; an SoC may include a microcontroller as one of its components. A microcontroller contains one or more CPUs (processor cores) along with memory and programmable input/output peripherals.



Types of Embedded Processors

Computational micros (32- or 64-bit)

- CPU of workstations, PCs, or high-end portable devices (PDAs)
- x86, PA-RISC, PowerPC, SPARC, etc.

Embedded general purpose micros (32-bit)

- Designed for a wide range of embedded applications
- Often scaled-down version of computational micros
- ARM, PowerPC, MIPS, x86, 68K, etc.

Microcontrollers (4-, 8-, or 16-bit)

- Integrate processing unit, memory, I/O buses, and peripherals
- Often low-cost, high-volume devices

Domain-specific processors (No of bits varies greatly)

- Designed for a particular application domain
- Digital signal processors, multimedia processors, graphics processors, network processors, security processors, etc.

Embedded System Design Constraints

Small Size, Low Weight

- Hand-held electronics
- Transportation application – weight costs money

Low Power

- Battery power for 8+ hours
- Limited cooling may limit power even if AC power available

Harsh Environment

- Heat, Vibration, Shock
- Power fluctuations, RF interference, lightning

Safety-Critical Operation

- **Must** function correctly
- **Must *not*** function ***in***correctly

Extrema cost Sensitivity

- $.05 adds up over 1,000,000 units

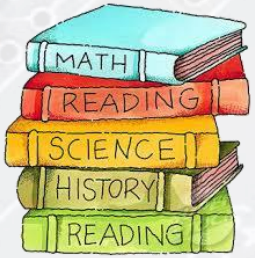
Embedded System Design Challenges

Does it really work?

- Is the specification correct?
- Does the implementation meet the spec?
- How do we test for real-time characteristics?
- How do we test on real data?

How do we work on the system?

- Observability, controllability?
- What is our development platform?



Are you an Embedded Engineer?

- **Hardware** (e.g.; Digital and Electronic Circuits) is your **life**
- **Software** (e.g.; C/C++ Programming for Embedded) is your **breath**

Embedded System Design Metrics

Unit cost: The monetary cost of manufacturing each copy of the system, excluding NRE cost

NRE cost (Non-Recurring Engineering cost): The one-time monetary cost of designing the system

Size: The physical space required by the system

Performance: The execution time or throughput of the system

Power: The amount of power consumed by the system

Flexibility: The ability to change the functionality of the system without incurring heavy NRE cost

Time-to-prototype: The time needed to build a working version of the system

Time-to-market: The time required to develop a system to the point that it can be released and sold to customers

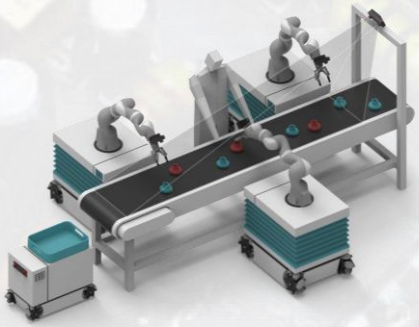
Maintainability: The ability to modify the system after its initial release

Real-Time Embedded System

What is Real-time Systems?

- Working correctly (functionally correct)
- Producing outputs **in time!**

(i.e. correct result(s) at the right time)



Real-Time Embedded System

Hard Real-time

- System designed to meet all deadlines
- A missed deadline is a **design flaw**, For examples: ABS brake, nuclear reactor monitoring systems
- System hardware (over) designed for worst-case performance
- System software rigorously tested
- Formal proofs used to guarantee timing correctness

Firm Real-time

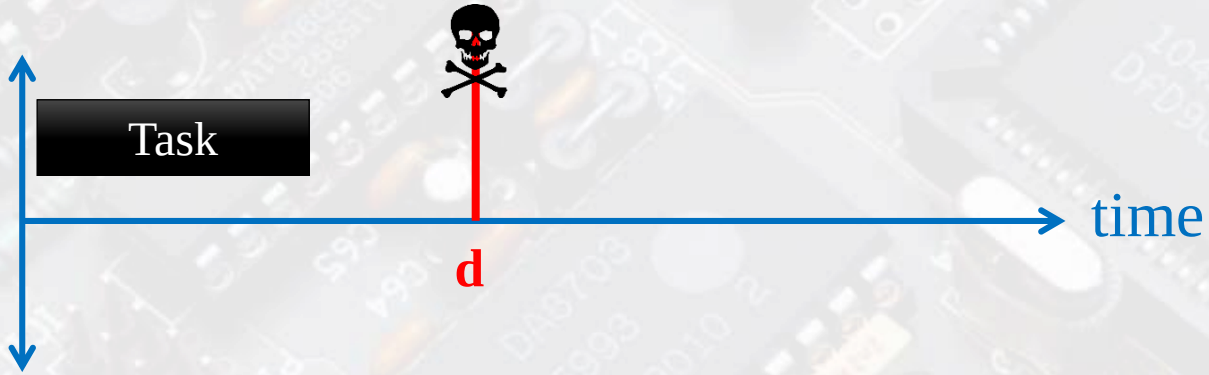
- System designed to **meet all deadlines**, but occasional missed deadline is allowed (< 5%), For examples: multimedia systems
- System hardware designed for average case performance
- System software tested under average (ideal) conditions

Soft Real-time

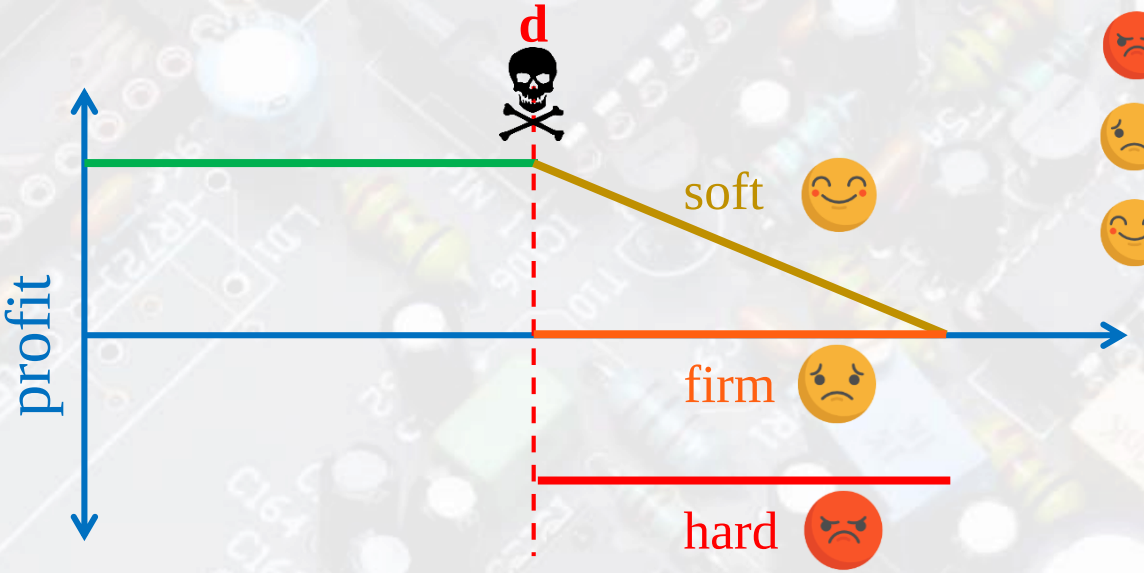
- System designed to **meet as many deadlines** as possible, For examples: network switch or router
- System hardware designed for average case performance
- System software tested under averaged (ideal) conditions

Real-time Systems Deadlines

Deadline: maximum time before a task must complete



The profit associated with execution of a task after the deadline:



Hard deadline: negative

Firm deadline: 0

Soft deadline: decreasing with time

It’s time to learn more and more!

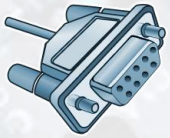
Learn by Doing

Excel Thru Experimentation

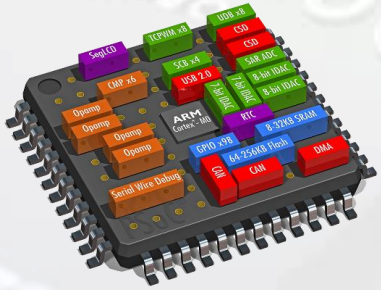
Lead by Example

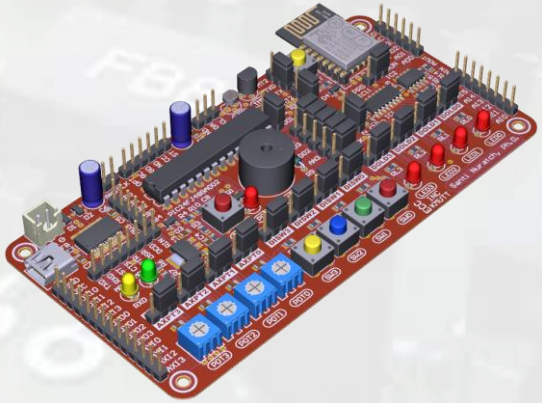
Acquire skills and get employed

Update skills and stay employed



THANK YOU!





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