Introduction To Embedded System

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Course Information

Text books

- Jonathan W. Valvano, Embedded Systems: Introduction to Arm Cortex-M Microcontrollers, 3rd ed., 2012 (E-book: users.ece.utexas.edu/ valvano/Volume1/E-Book/)
- Jonathan W. Valvano, Embedded Microcomputer Systems: Real-Time Interfacing, 3rd ed., 2012.
- Jonathan W. Valvano, Real-Time Operating Systems for ARM Cortex-M Microcontrollers, 3rd ed., 2014
- A. McEwen and H. Cassimally, "Designing the Internet of Things", Wiley, 2013

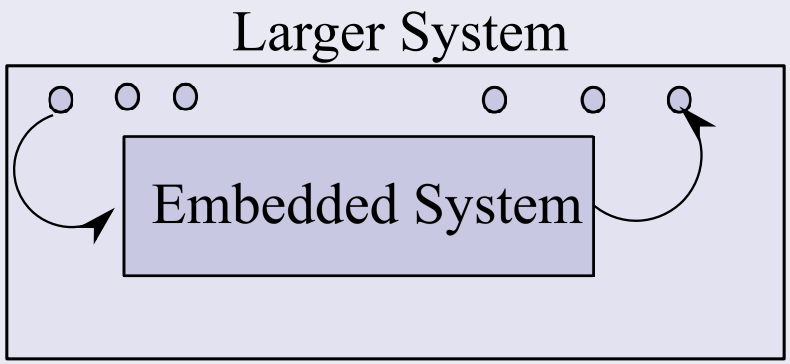
Course Contents

Syllabus

Contents of the course	Introduction to Embedded Systems: history and trends	(1)
	Elements of embedded systems such as GPIO, communication, interrupts, ADC, DAC	(10)
	Implementation of embedded systems: architecture, logic, timing, loading, protocols, and software	(3)
	Embedded systems design using ARM Cortex-M TM4C Launchpad IDE, and projects with sound, video games, and mobile robots	(6)
	Design methodologies, hardware-software co-design	(3)
	Introduction to advanced concepts such as real-time interfacing and operating systems	(5)
	Rapid prototyping of embedded systems with open source microcontrollers and Arduino shields	(9)
	IOT systems design using open source hardware (Intel and Microsoft kits)	(8)

Embedded System

- Embedded system is a system where a microcontroller based or microprocessor based programmable system is embedded in a larger system.



Varient of embedded system

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Cyber Physical System

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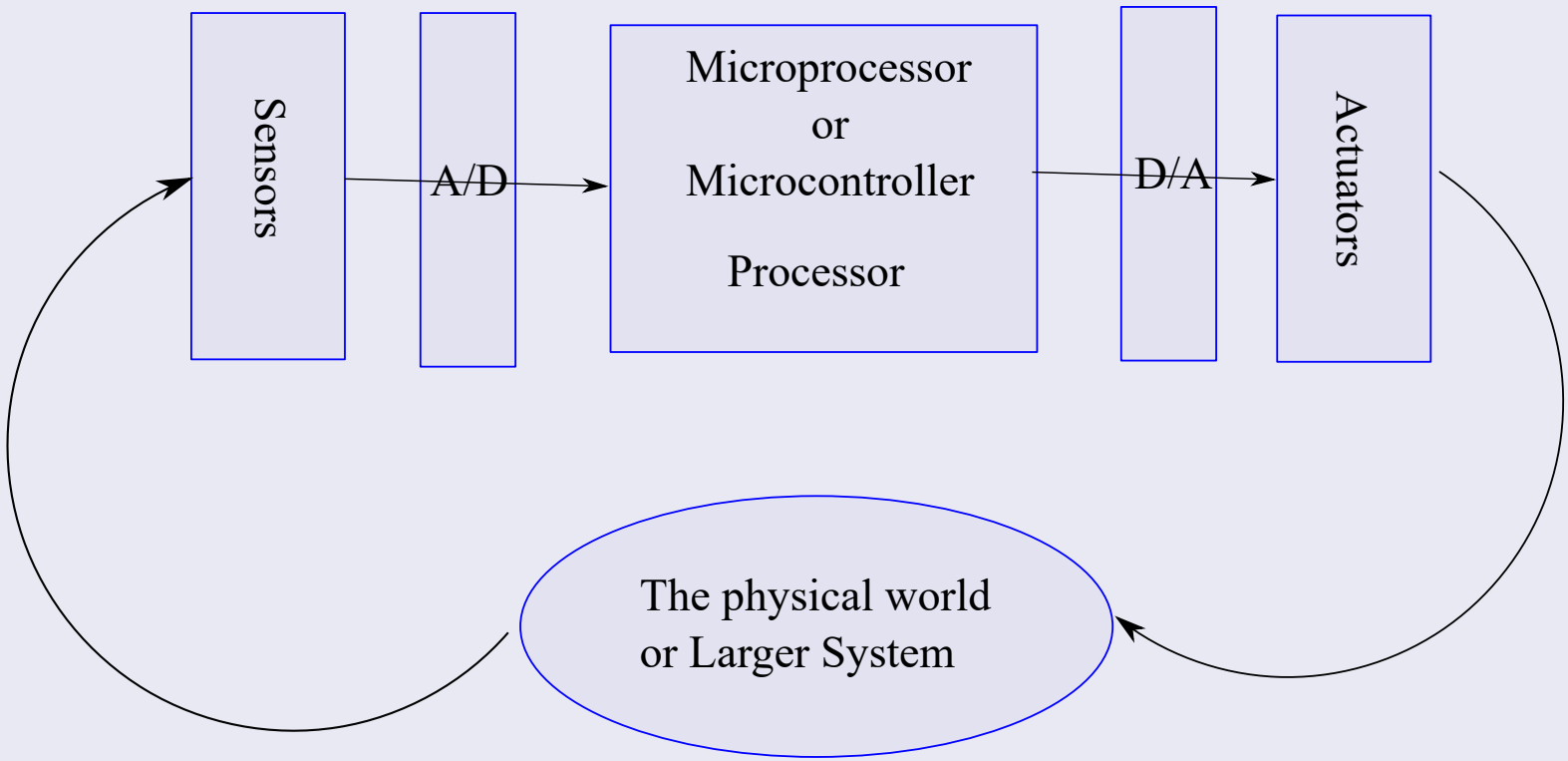
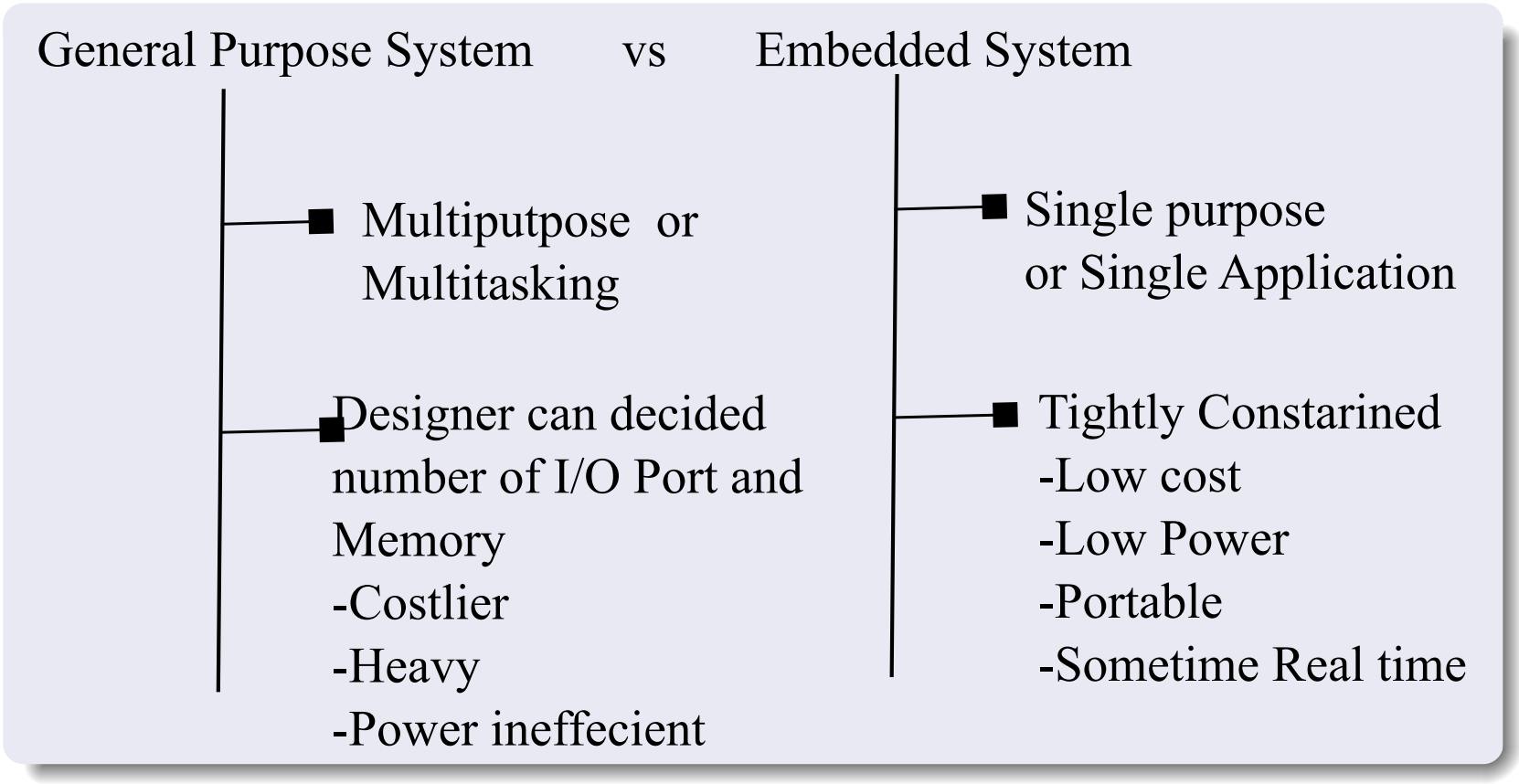
IOT

Embedded System

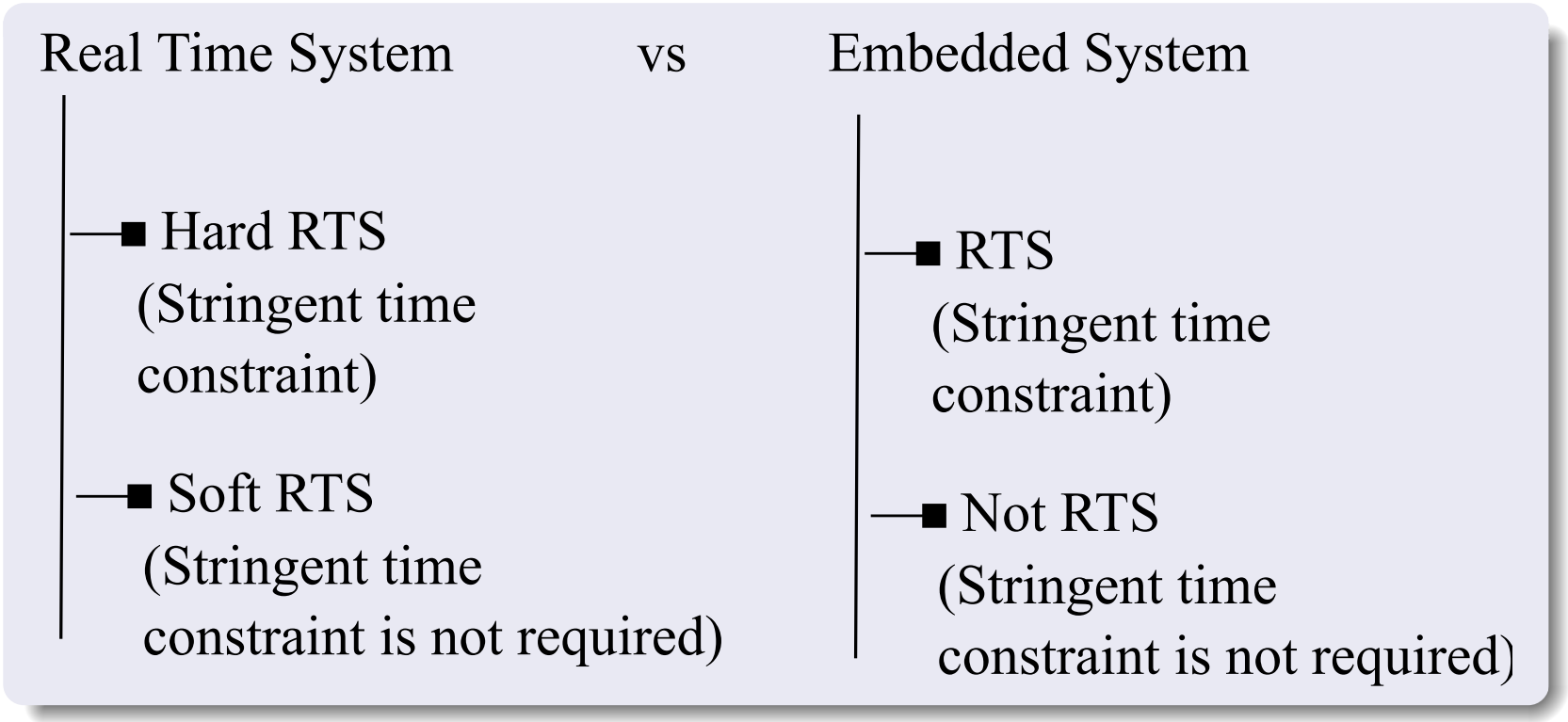
- Embedded system collection of subsystems



How embedded system differ from general purpose system



Real time system vs Embedded System

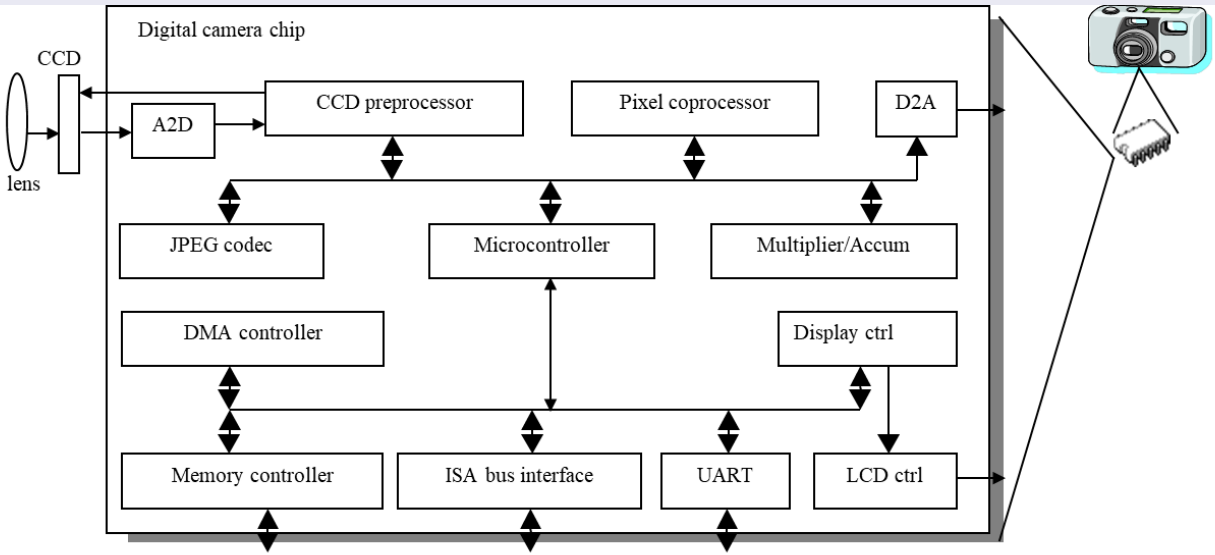


Failure of Real time System

- The hard real-time definition considers any missed deadline to be a system failure. This scheduling is used extensively in mission critical systems where failure to conform to timing constraints results in a loss of life or property.
  - Air France Flight 447 crashed into the ocean after a sensor malfunction caused a series of system errors. The pilots stalled the aircraft while responding to outdated instrument readings. All 12 crew and 216 passengers were killed.
  - Mars Pathfinder spacecraft was nearly lost when a priority inversion caused system restarts. A higher priority task was not completed on time due to being blocked by a lower priority task. The problem was corrected and the spacecraft landed successfully.
  - An Ink-jet printer has a print head with control software for depositing the correct amount of ink onto a specific part of the paper. If a deadline is missed then the print job is ruined.

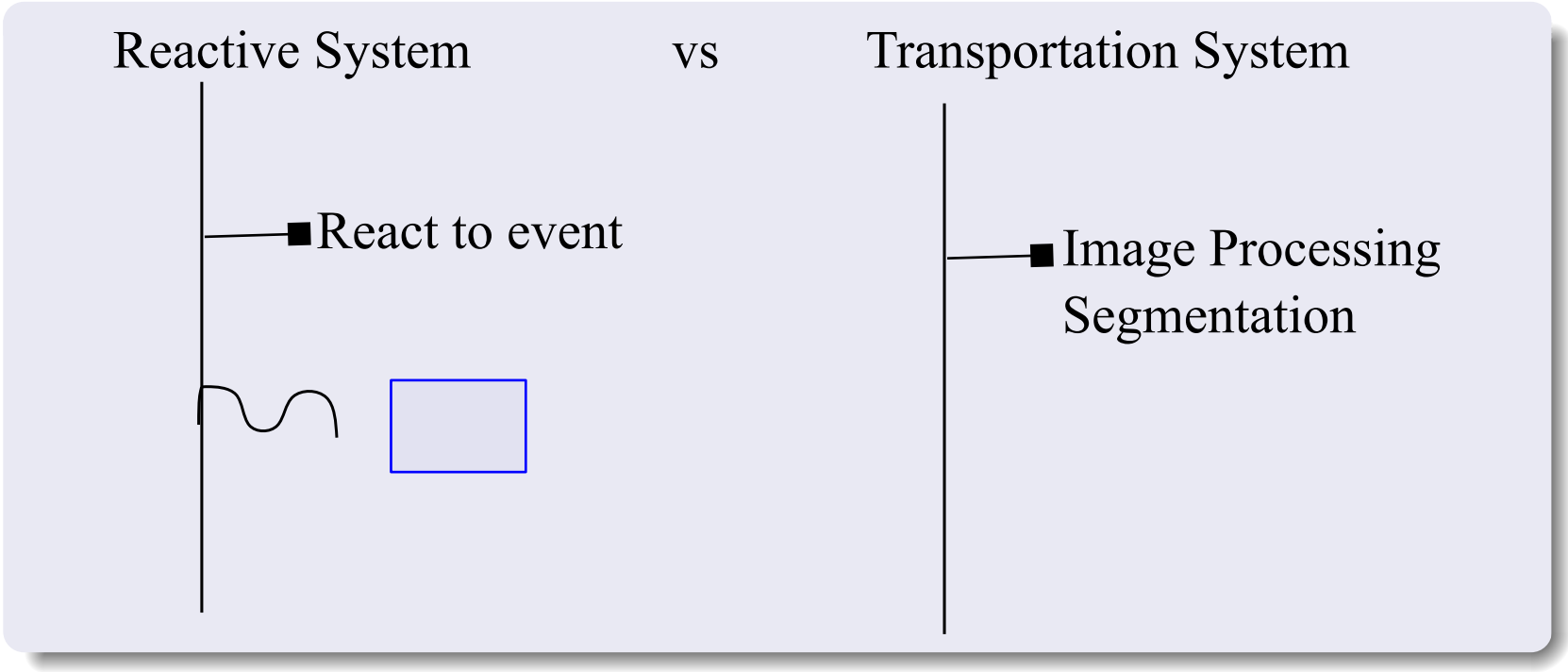
Embedded System Example

Embedded System

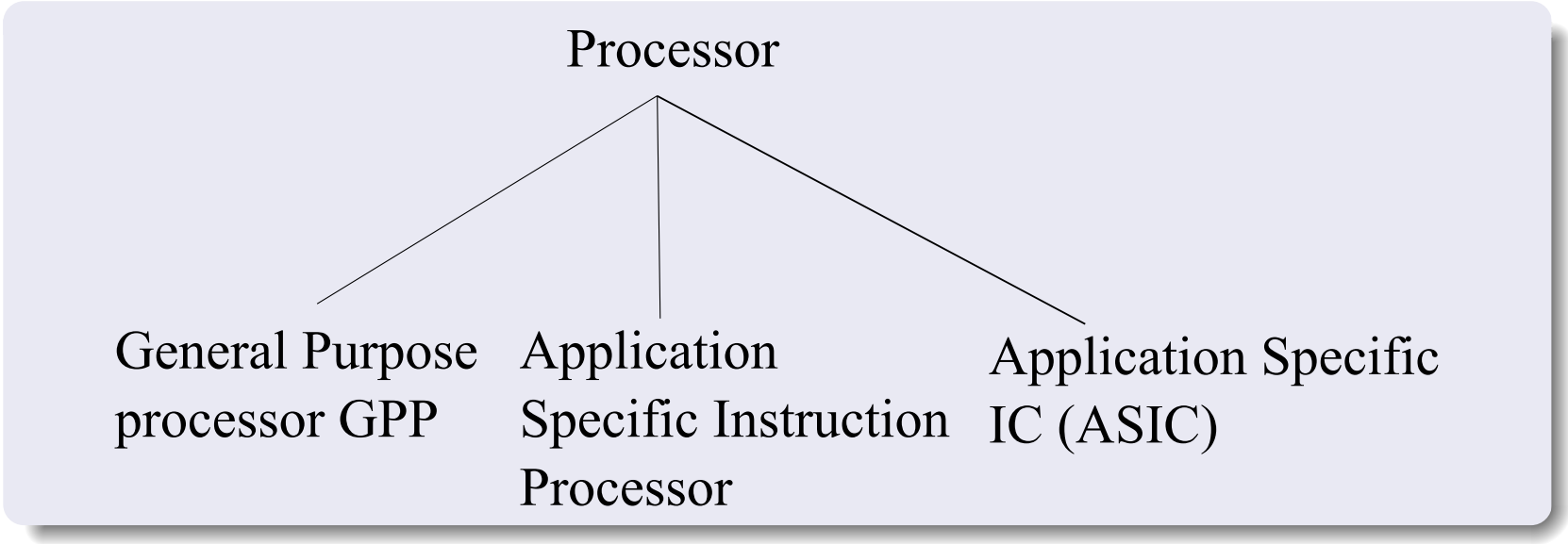


- Single-functioned -- always a digital camera
- Tightly-constrained -- Low cost, low power, small, fast
- Reactive and real-time -- only to a small extent

Reactive vs Transformation system

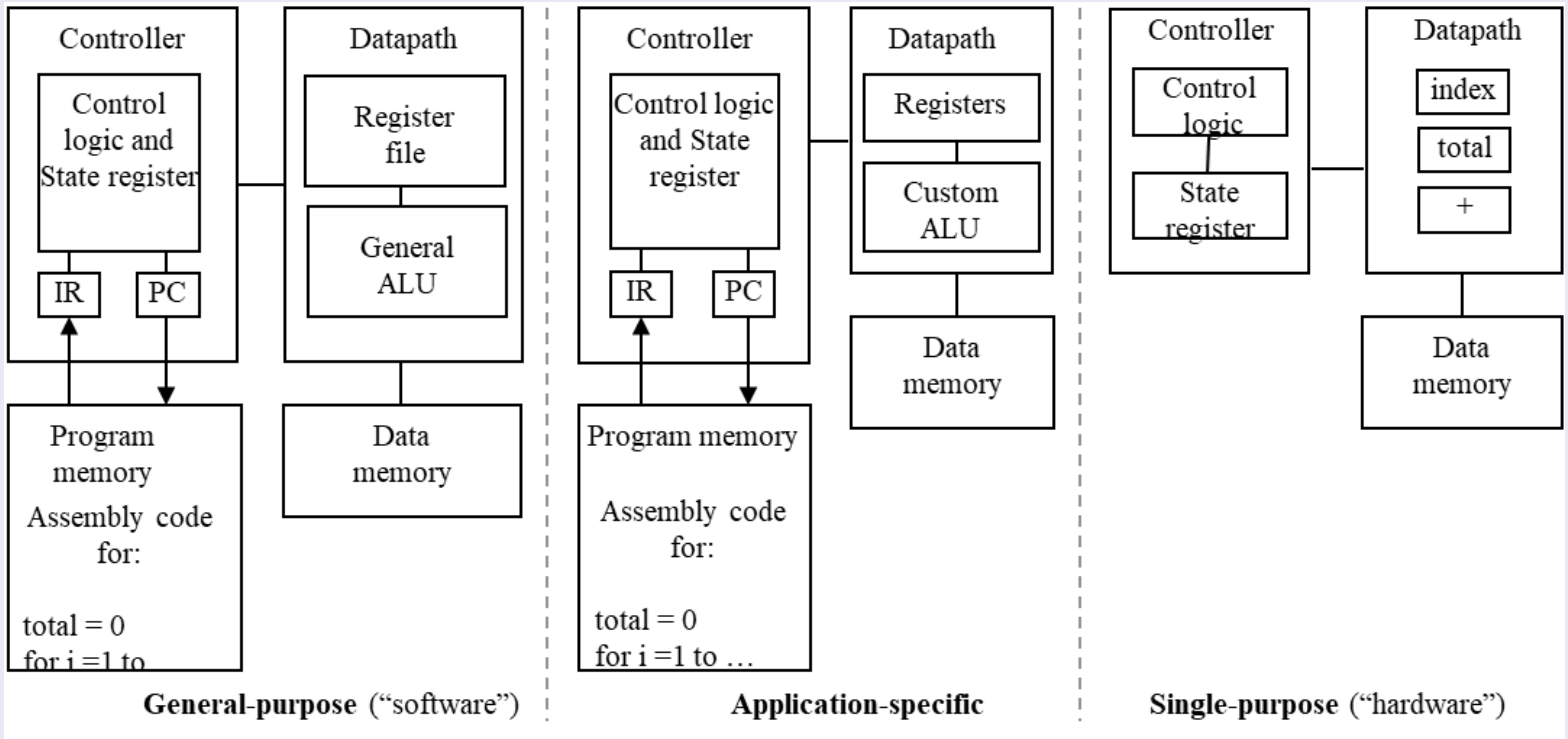


Types of Processors



Architecture of Processor

Von-Neumann & Hardward Architecture



Architectures of Processor

Von-Neumann Architecture

- Single memory to be shared by both code and data
- Processor needs to fetch code in a separate clock cycle and data in another clock cycle.
- Higher speed, thus less time consuming
- Simple in design

Harvard Architecture

- Separate memories for code and data.
- Single clock cycle is sufficient, as separate buses are used to access code and data
- Slower in speed, thus more time-consuming
- Complex in design

How Processor Differ from each other

- Instruction Set Architecture (ISA)
- ISA define the Complexity of the Processor
- ISA differ in every processor
- ISA classified into two categorizes
  - Reduce instruction set Computer (RISC)
  - Complex Instruction Set Computer (CISC)

Instruction Set Computer

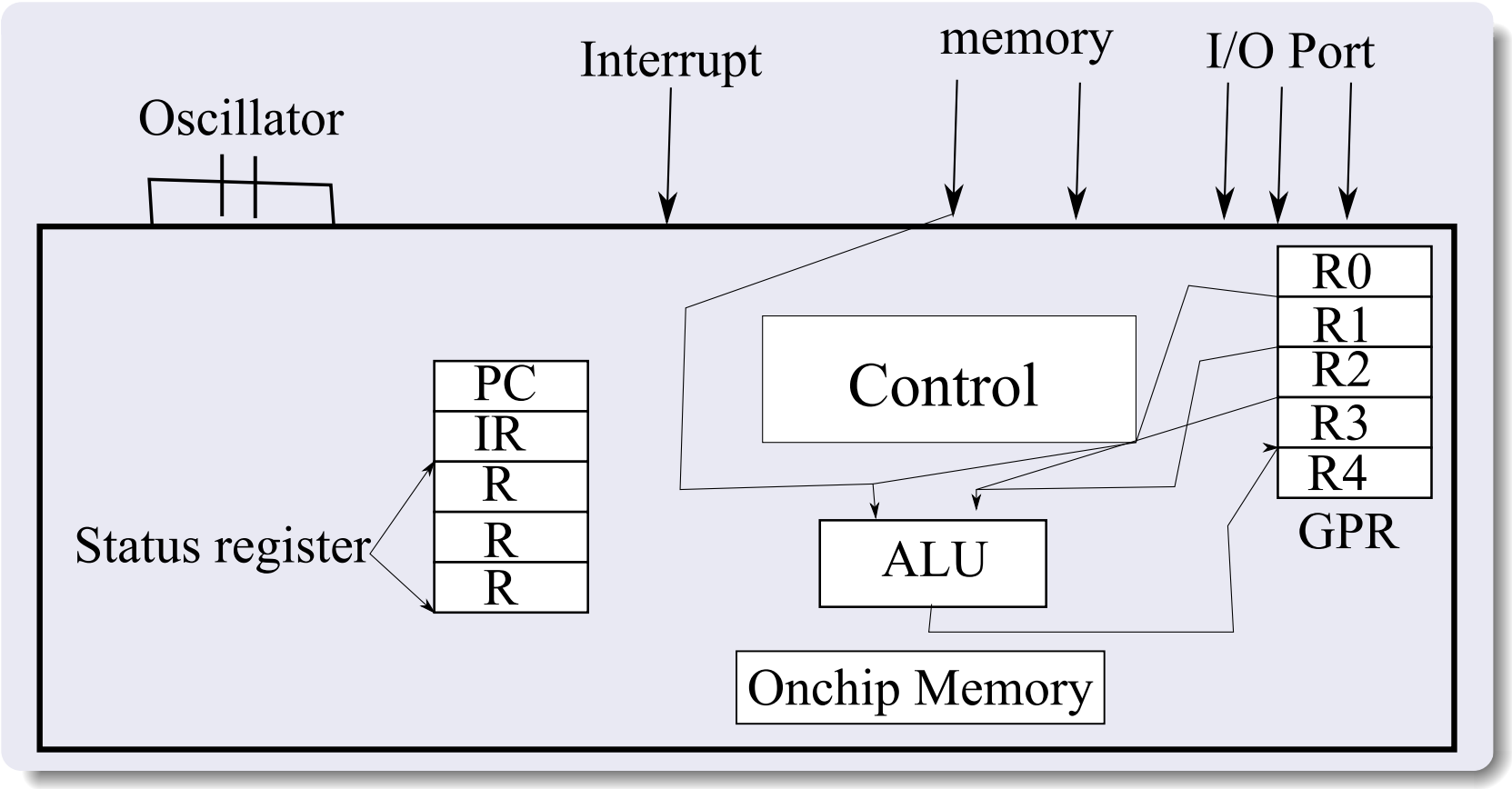
CISC

- Larger set of information, Easy to program
- Simpler design of compiler, considering larger set of instructions.
- Many addressing mode causing complex instruction formats
- Instruction length is variable.
- Higher clock cycle per second
- Pipelining is not possible

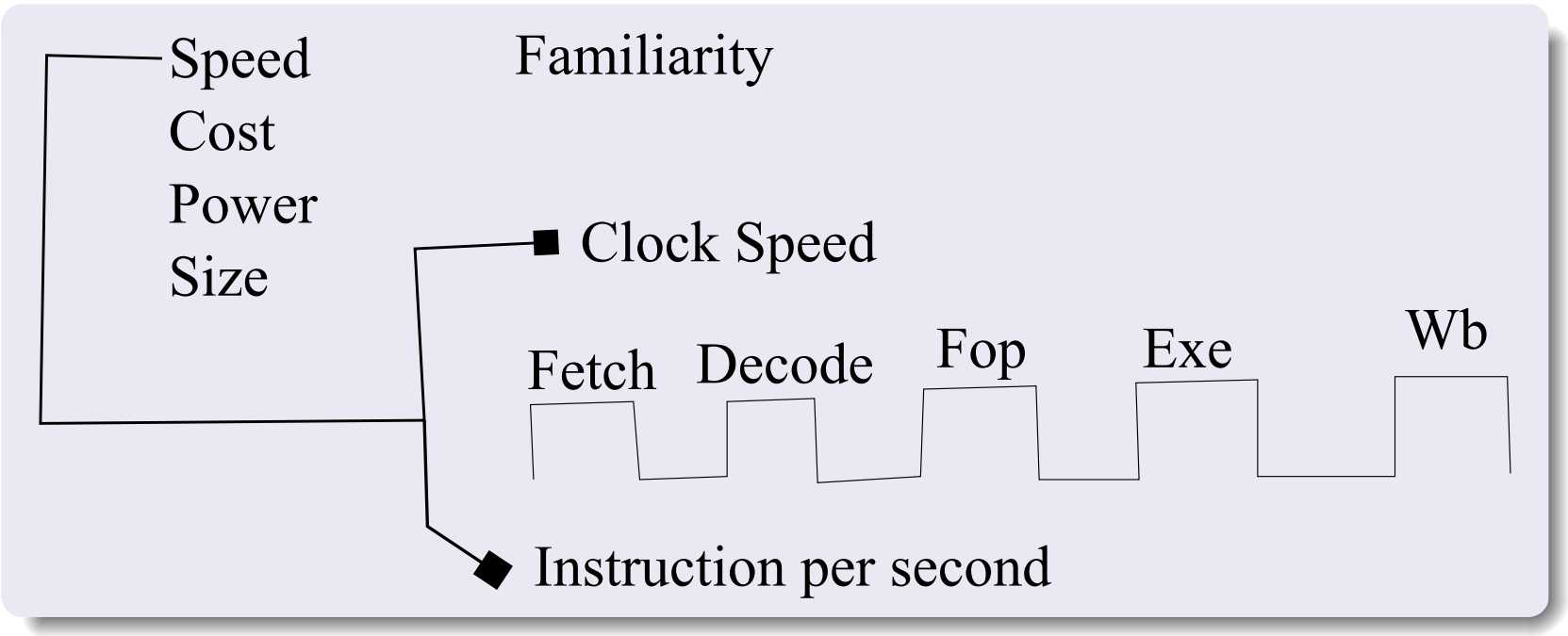
RISC

- Smaller set of instructions. Difficult to program
- Complex design of compiler
- Few addressing modes, fix instruction formate
- Instruction length varies
- Low clock cycle per second
- Faster execution, as each instruction to be executed by hardware
- Pipelining is possible

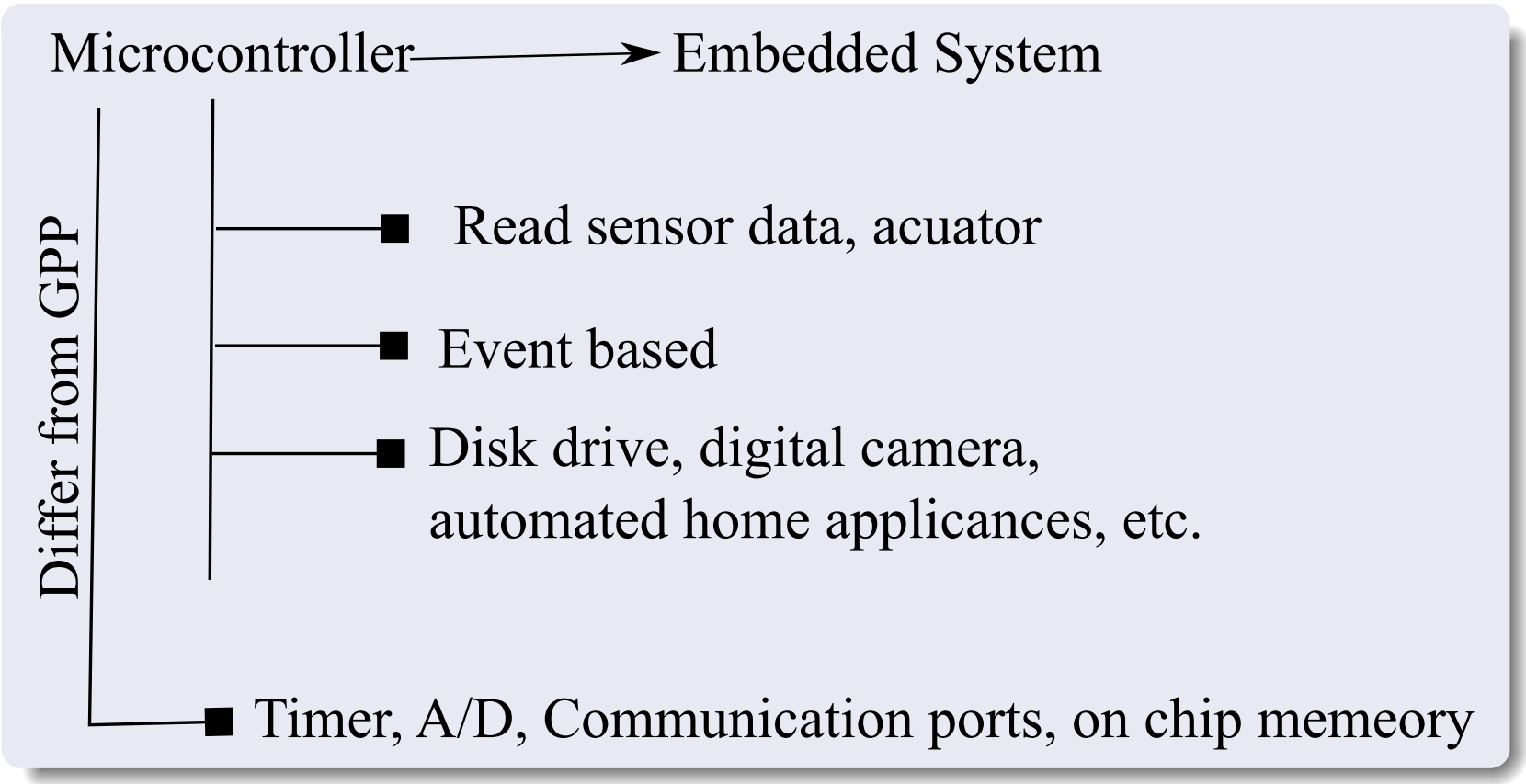
Microprocessor Architecture



How We do Select Microprocessor?



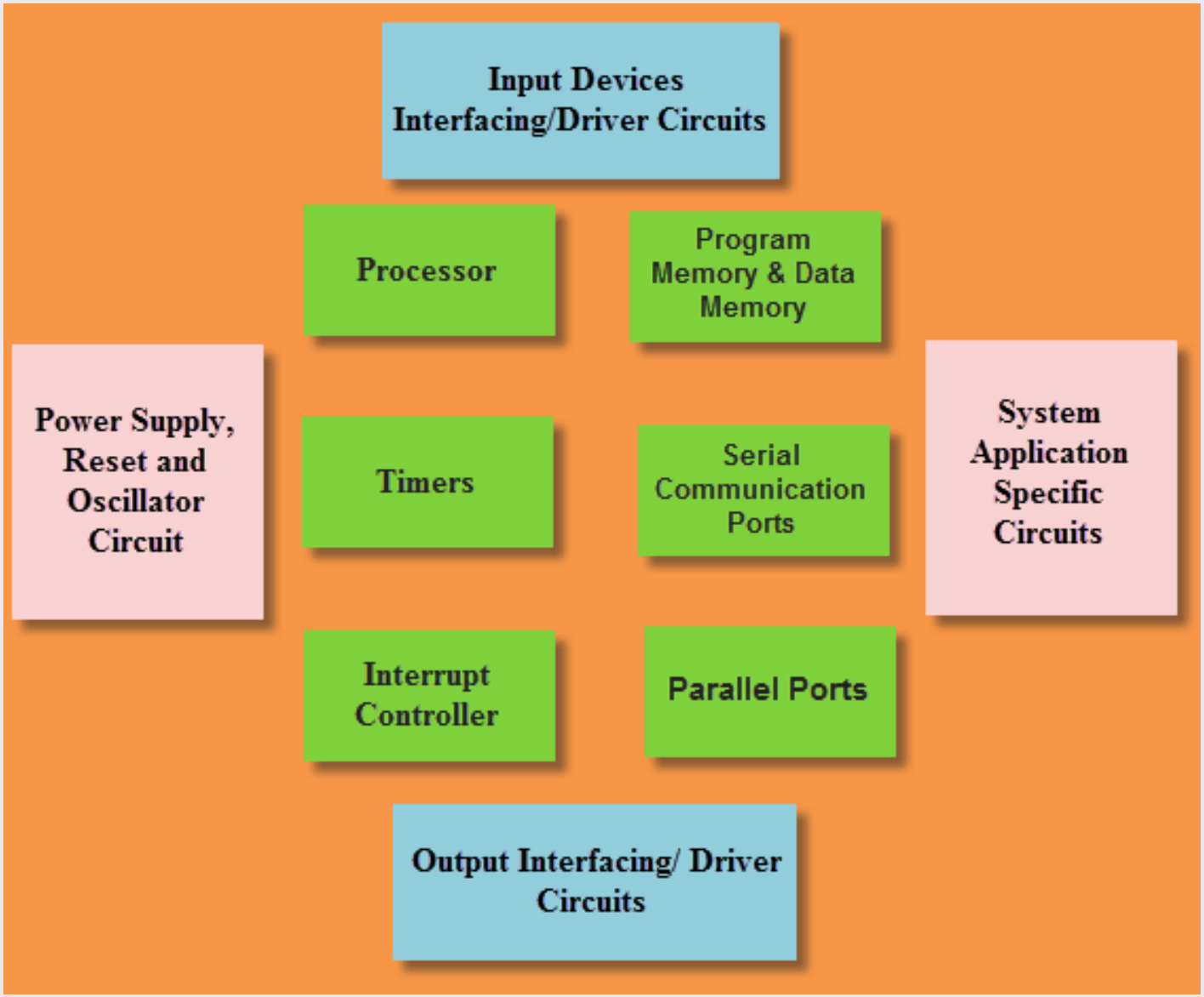
ASIP


Microcontroller
Embedded System
Differ from GPP
Read sensor data, acuator
Event based
Disk drive, digital camera,
automated home applicances, etc.
Timer, A/D, Communication ports, on chip memeory

Watch Dog Timer

- Watch dog timer is an event based timer
- Digital signal processor DSP:
- DSP Operations
  - Discrete Fourier Transform DFT
  - Fast fourier Transform FFT
  - Multiple Accumulate Instruction

Element of Embedded System



Classification of GPIO Ports

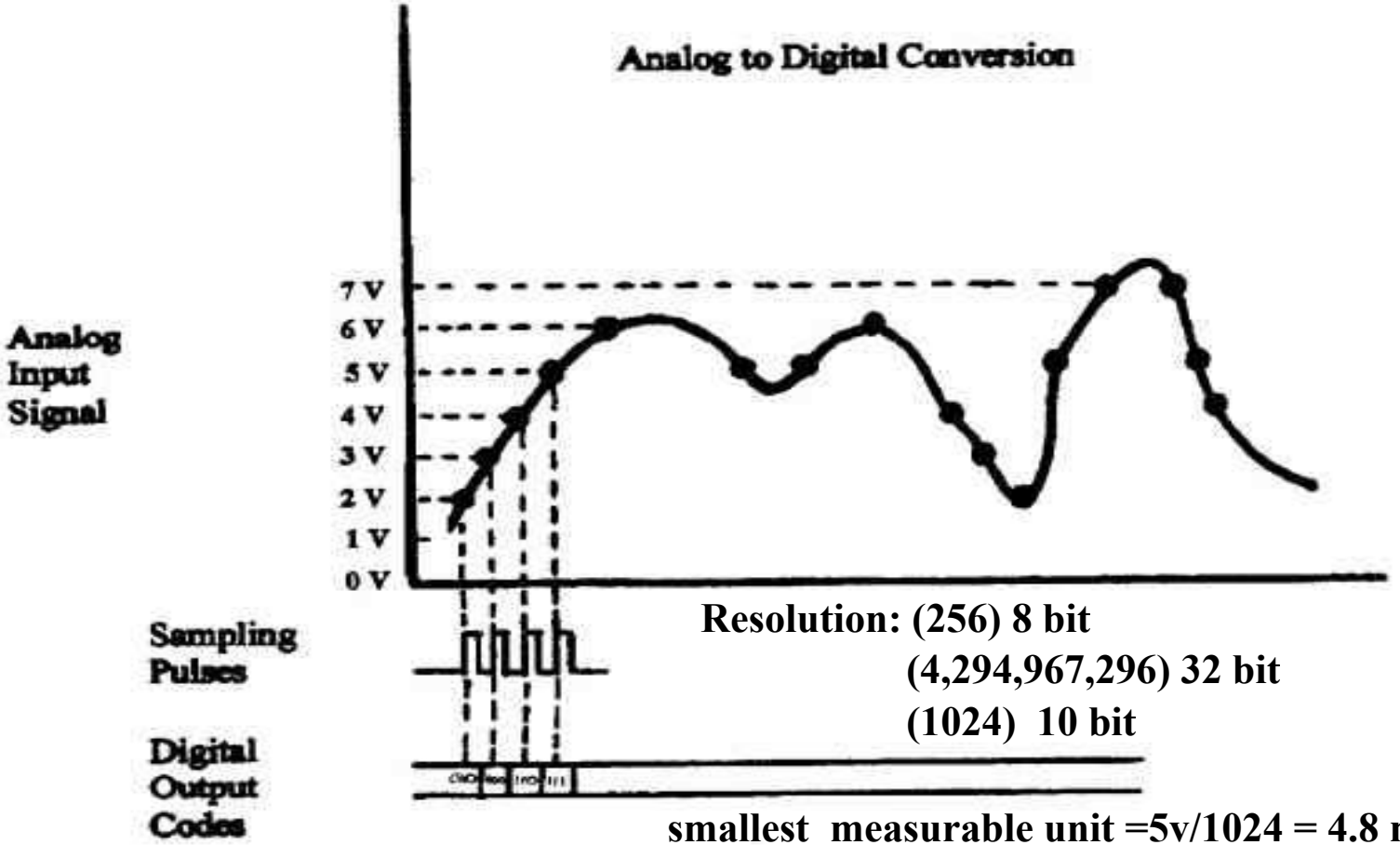
- In any embedded system, we normally have four types of ports
  - Digital I/O Ports
  - Analog Input Ports
  - Pulse width Modulation I/O Port
  - Serial Peripheral Interface I/O Ports

Digital I/O Ports

- The digital I/O ports normally used for controlling the digital devices
- The digital sensors and actuator attached with these ports
- Before use of digital I/O ports, we activate the clock gating at the specific port
- The clock gating signal activate the port memory for read and write operation
- Later, we set the direction of the port either input or output
- According to the direction, we set the port memory is read and write mode

Analog Input Ports

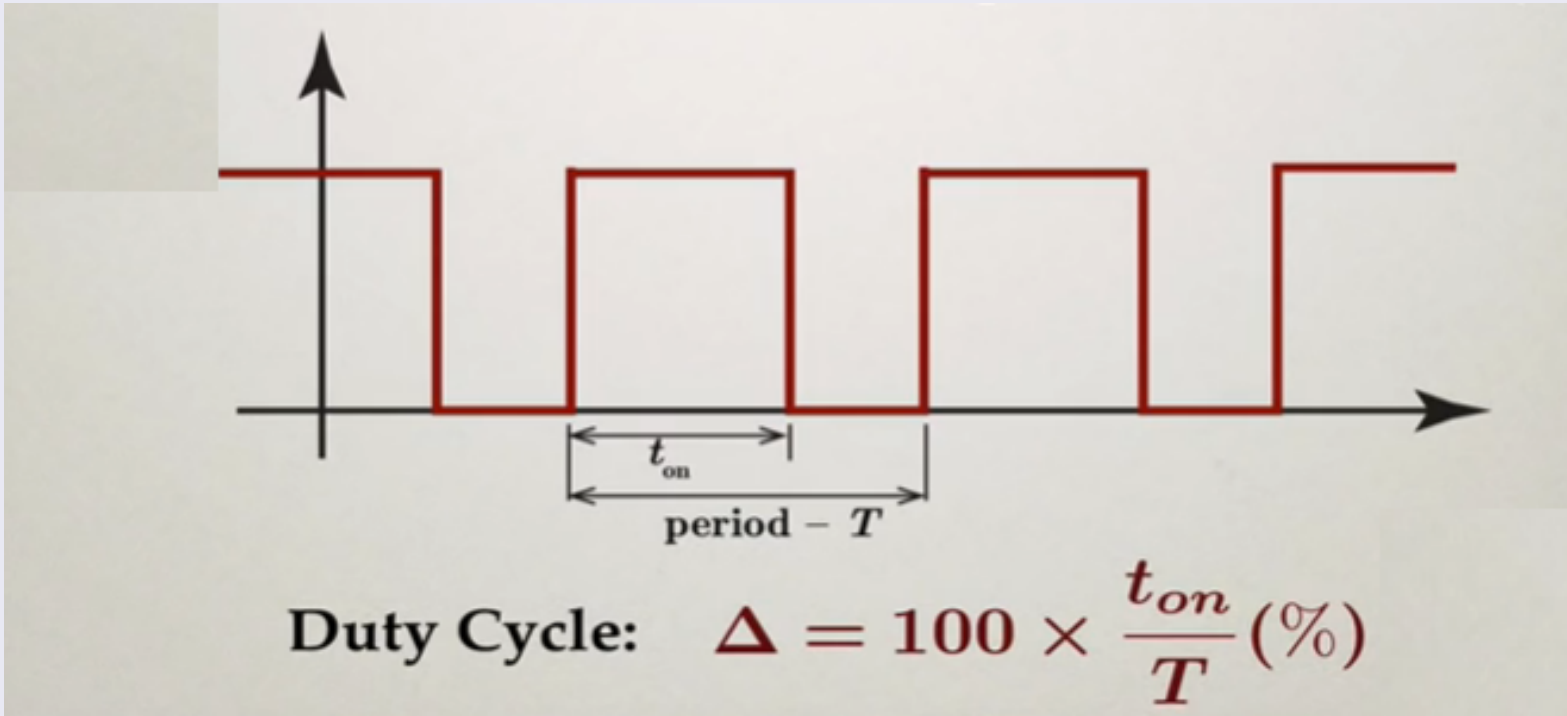
- The analog input port attached with analog sensors



Pulse Width Modulation (PWM)

Analog Output (PWM)

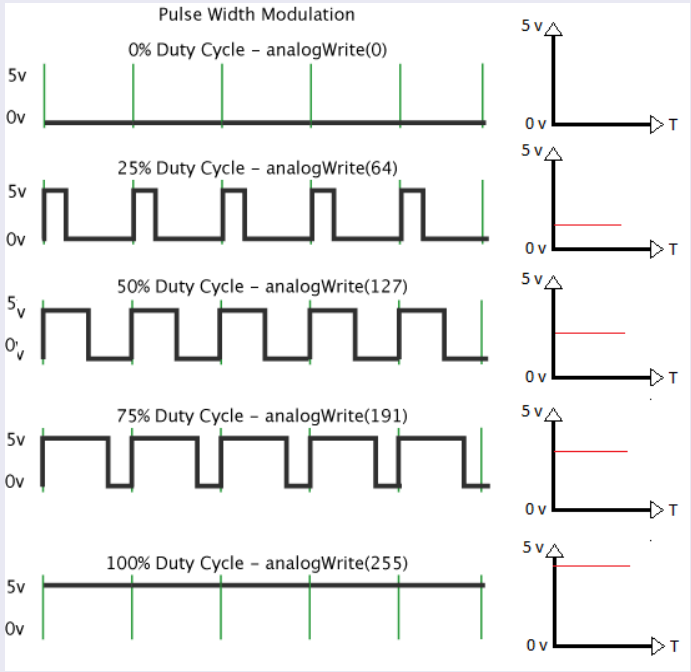
- PWM is defined in terms of its period and its duty cycle



Pulse Width Modulation (PWM)

Analog Output (PWM)

- PWM is used to simulate the analog output
- PWM is used to control the speed of DC motors
- PWM also used to change the brightness of the LED

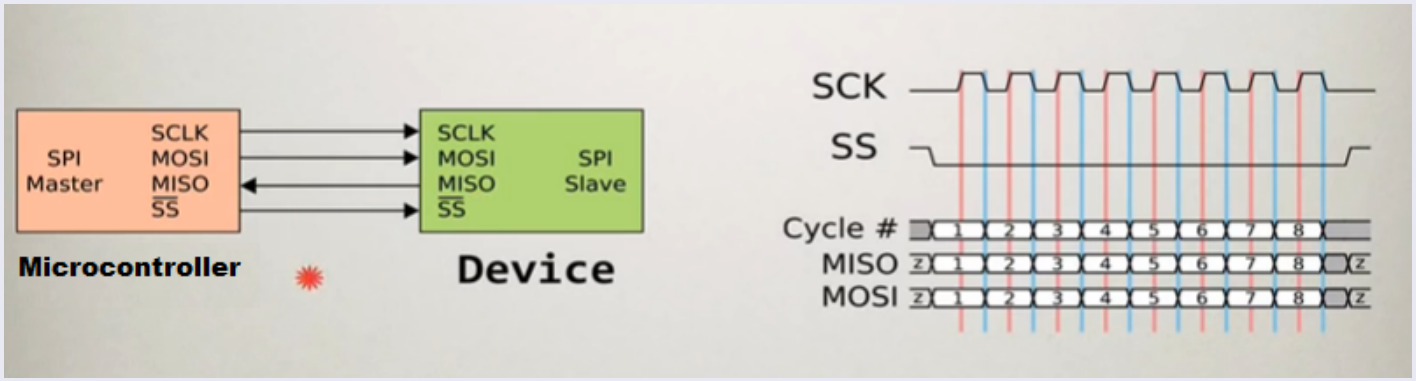


Output Voltage= Pulse on time/total period (on +off time)* 5 v

Serial peripheral Interface

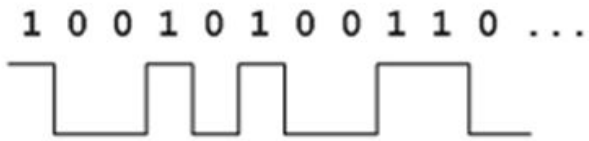
Serial peripheral Interface

- Another way of digital input and output is through SPI sensors device



Serial Communication

Serial Communication



Information passes between the computer and Arduino through the USB cable. Information is transmitted as zeros ('0') and ones ('1')... also known as **bits**!

todbot.com/blog/bionicarduino