

INTRODUCTION TO EMBEDDED SYSTEMS

COURSE INTRODUCTION

Getachew Teshome (Room 120-B)

Addis Ababa University, AAIT

School of Electrical and Computer Engineering

September, 2024

EMBEDDED SYSTEM

A computer System

Embedded within another system

to define/ control functionality of the embedding system.

WASHING MACHINE

Drum, Spin Motor,
heater, hot air
blower, Water
Dispenser, Soap dispenser,
pump, Sewage
valve, display, alarm, ...

Computer

WHAT IS AN EMBEDDED SYSTEM?



!

EXAMPLES

- Consumer: **Phone**, Camera, **TV**, **Game Console**
- Office: Printer, Copier, Fax, ...
- Home Appliance: Microwave, Refrigerator, AC
- Automotive: Car Engine, navigator, ...
- Aviation: Fly-by-wire, Entertainment, ...
- Industrial: Robots, Automation Units in Factories
- Military: Missile guidance, Drone



SMART

Every electronic device that is called “Smart” has an Embedded System in it:

- Smart Grids
- Smart Meters
- Smart Phones
- Smart TVs
- Smart Buildings ...

Attaching an Embedded System to an object makes it “Smart”!

Embedded systems in automobiles



Airbags



Navigation



Radio



Anti lock braking system



Automatic parking



Telematics



Adaptive cruise control



Drive through wire



Black Box

CHARACTERISTICS OF ES

- Single-functioned: executes one program repeatedly.
 - *A digital camera Vs Laptop Computer*
- Tightly constrained: have tight design constraints
 - cost, size, performance, and power
- Reactive and real-time: continually interacts with its environment and executes at-pace with environment
 - Brake control in a car Vs Keyboard input of desktop
- Dependable: Should work under all circumstances
- Dedicated user interface: no mouse, keyboard, screen
- Hybrid systems: analog + digital parts.

CHARACTERISTICS OF ES

- Must be Dependable,
 - Reliability $R(t)$ = probability of system working correctly at t provided that it was working at $t=0$
 - Maintainability $M(d)$ = probability of system working correctly d time units after error occurred.
 - Availability $A(t)$: probability of system working at time t
 - Safety: no harm to be caused
 - Security: confidential and authentic communication

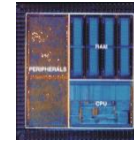


Even perfectly designed systems can fail!

CHARACTERISTICS OF ES

- Must be efficient **WHY?**

- Energy efficient
- Code-size efficient
(especially for systems on a chip)
- Run-time efficient
- Weight efficient
- Cost efficient



Dedicated Function

→ knowledge about behavior at design time can be used to minimize resources and to maximize robustness!

EMBEDDED VS GP

Embedded Systems

- Few applications that are known at design-time
- Not user programmable
- Fixed run-time requirements
- Important criteria
 - Cost
 - Power consumption
 - Predictability
 - ...

GP Systems

- Execute broad class of applications
- Programmable by the end user
- Faster is better
- Important criteria
 - Cost
 - Average speed

APPLICATION DOMAINS

- ▶ general purpose
 - PC, server, etc.
- ▶ embedded
 - consumer electronics
 - automotive
 - avionics
 - military

embedded	real time	safety critical	cost sensitive
-	-	-	-
x	x	-	x
x	X	x	x
x	X	x	-
x	X	x	-

TRENDS

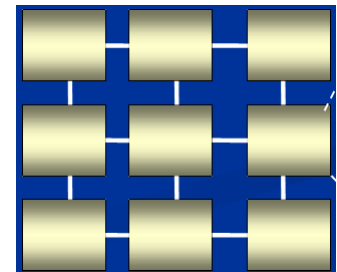
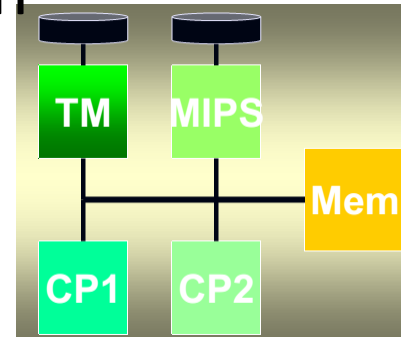
PAST

- Control Oriented Applications
 - Traffic lights control
 - Elevators control
 - Washing machines and dishwashers
- Simple Hardware Implementation
 - Sequential Circuit
 - m-controller

TRENDS

NOW - HARDWARE

- Network of Processors: Automobile, Airplane.
- Heterogeneous processors: run-time efficiency requirements, power efficiency *Vector, Power Mgmt*
- Higher Degree of Integration
 - Discrete
 - IC
 - μP , μC
 - SoC [*Processor + memory + I/O-units + communication structure*]
 - MPSoC, NoC, Co-P



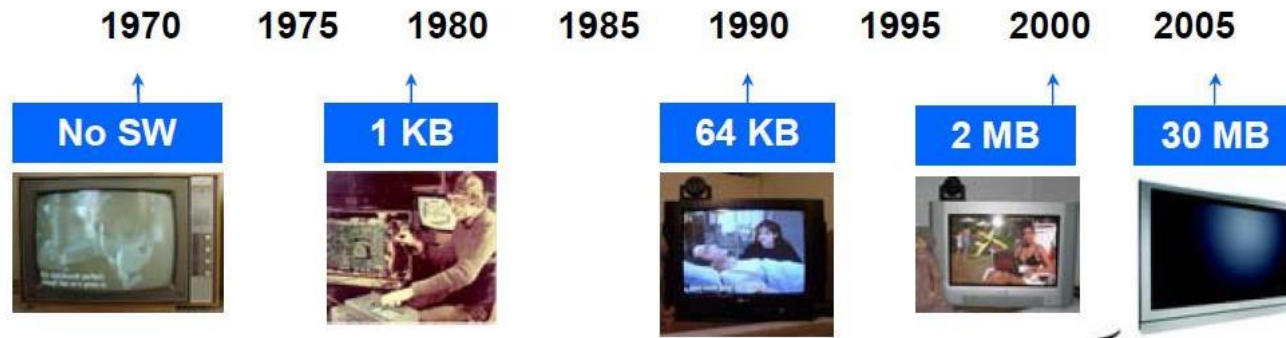
TRENDS

NOW – SOFTWARE

- TV, mobile phone, car: > 10 MLOC
- Code complexity is growing exponentially
- Number of bugs is growing exponentially
- Despite good SW eng'g ~10 bugs / KLOC
- 100 G\$ / yr on bug repair
- Embedded SW is difficult!
- Software dominates the total cost.
- Testing and validation dominates the SW cost

TRENDS

SOFTWARE – ORIENTED



NOW



TRENDS

NOW - MARKET

- Appear in every walk of life.
- 100 times PC market size.
- 25% annual growth.
- Accounts for 25-40% cost of a modern automotive.
(15 -60 ES per car)
- More affordable (GPS, VC)

TRENDS

- FUTURE

- Ubiquitous Computing, Pervasive computing, Ambient Intelligence
- Convergence
- Wearables
- Security

YOUR POSITION

?

EE
CE
CS
IT
IS

THE COURSE

- Introduction to Embedded Systems
- Embedded Systems Design
- Hardware Elements of Embedded System
- Embedded Programming
- State Machines
- Testing and Verification
- Selected Topics

LECTURE + LAB

- Lecture
- Assignments
- Paper review
- ✓ Class Activity,
- ✓ Final Exam`
- Lab Exercises
- Project (Group of 4)
- ✓ Attendance,
- ✓ Circuits & Codes,
- ✓ Report

ASSIGNMENT 1

- Investigate an Embedded System of your choice and write a short summary outlining
 - What it does, why it is an Embedded System
 - What it contains (Hardware and software components)
 - Its function described using Schematic diagrams and Flow chart
- 2-4 pages true content
- Submission : March 7, 2024. before 23:59.

END