University of Dar es Salaam COICT

Department of Computer Science & Eng.

CS 602: Embedded Systems

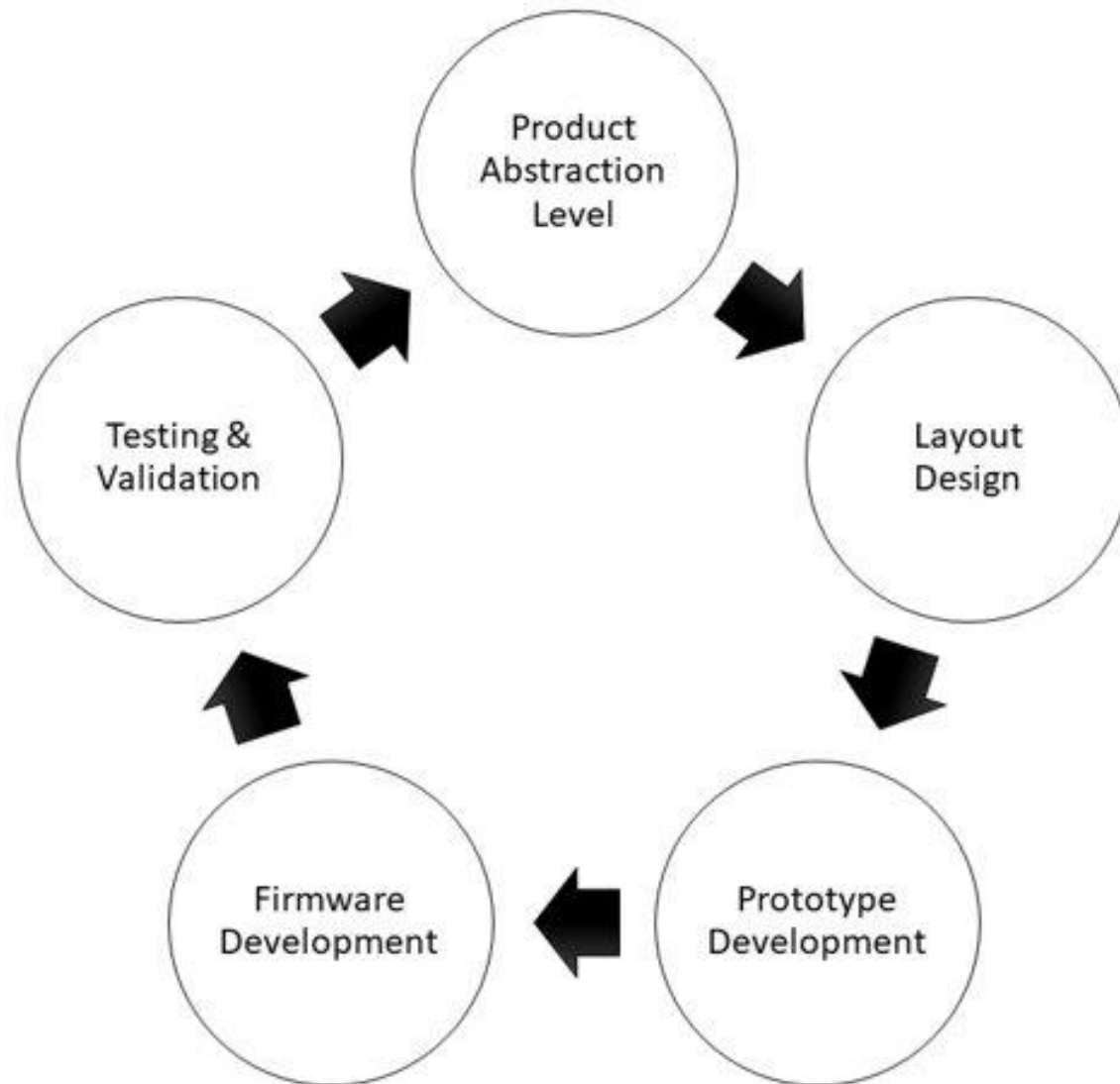Lecture 4: Embedded System Design

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The embedded system design Lifecycle

Product identification/Abstraction

- All It starts with requirement analysis:
  - **Analyzing product requirements and turning them into specifications**
  - The number of inputs/outputs and the logic diagram are not the only considerations but investigating usage and operating conditions aid in determining the appropriate specifications for the embedded system

Layout design/ Schematic

- The hardware design can begin building the schematic/blueprint once the requirements have been translated into specifications.

- At this stag of the design the appropriate microcontrollers is selected based on: power consumption, peripherals, memories, and other circuit components keeping in mind the cost factor.

Printed circuit board (PCB)

- The PCB is an assembly that employs copper conductors to link various components electrically and to support them mechanically.

- A printed circuit board design involves a brainstorming process in which best practices for features and capabilities, and reliability must be followed.

- When working with high-speed mixed-signal circuits, microprocessors, and microcontrollers it becomes more complicated. The common types of PCBs include single & double sided, multi-layer, flex, ceramic, etc..

Prototype development

- When creating a new product for a specific market segment, time is very essential and plays a crucial part.

- Creating a prototype allows you to identify flaws and design advantages early on.

- It aids in identifying design flaws earlier, allows ideas to be tested, determines product feasibility, and streamlines the design process.

Firmware development

- Writing code for embedded hardware (microprocessor, microcontroller, FPGA), as opposed to a full-fledged computer, is known as firmware development.

- Software that controls the sensors, peripherals, and other components is known as firmware.

- To make everything function, firmware designers must use coding to make the hardware come to life.

- Utilizing pre-existing driver libraries and example codes provided by the manufacturer will speed up the process.

Testing & validation

- Stringent testing must be passed before an embedded system design is authorized for production or deployment.

- The circuit must undergo reliability testing in addition to functionality testing, especially when operating close to its limitations.

Trends in embedded system

- Technology trends are accelerating, and devices have developed into distinctive qualities that fit in many categories and sectors, including embedded.

- Due to its outcomes being application-oriented and advance development areas in focus, embedded systems and devices will gain more popularity in the coming future while considering various business sectors and their applications.

- Let us see recent trends under embedded systems.

System-on-Chip Solution (SoC)

- System on chip solution is another new trend in embedded system technology.

- Many businesses provide SoC based embedded devices, and among these solutions is the market delivery of analog and mixed-signal integrated circuits as a popular one.

- ASIC with great performance, small size, low cost, and IP protection is one such solution.

- Due to their size, weight, and power performance, it is very popular for application specific system needs.

Wireless technology

- The primary goal of building wireless embedded software solutions is information transmission and reception.

- The wireless embedded system plays an important role where physical connections are impossible in any setting, and the use of IoT peripherals and devices becomes vital.

- With the technological advances in the areas of wireless solutions like Z-Wave, Bluetooth, Wi-Fi, and ZigBee the applicability of embedded wireless systems has drastically increased.

Automation

- Every system in use today is becoming more automated.

- Every sector of growth has some level of automation, largely due to developments in computers, robots, and advancement in intelligent technologies like AI & ML.

- The usage of embedded devices speeds up the connection of multiple storage components and can easily link up with cloud technology to power the device's quick expansion of cognitive processing.

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Automation - Cont'd

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- The applications based on facial recognition and vision solution offers benefits like image identification & capturing, image processing, post processing, etc, and alerting for security in real time.

- For example, a smart factory outfitted with IoT, and artificial intelligence can significantly boost productivity by monitoring operations in real time and allowing AI to make decisions that prevent operational errors.

Low power consumption

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- The optimization of battery-powered devices for minimal power consumption and high up-time presents a significant challenge for developers.

- For monitoring and lowering the energy usage of embedded devices, a number of technologies/modules and design techniques are currently being developed and these include Wi-Fi modules, enhanced Bluetooth that use less power at the hardware layer optimizing embedded systems.

Challenges in embedded systems design

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- Embedded system design is an important component and is rapidly evolving;

- However, certain challenges must be addressed, such as issues related to security & safety, updating system hardware and software, consumption of power, seamless integration, and verification & testing which plays a crucial part in improving the performance of the system.

Challenges in embedded systems design

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- When developing an embedded system, it is critical to avoid unexpected behaviour that could endanger users. It should be designed so that there are no problems with life-saving functionality in critical environments.

- Most of the time embedded device is controlled using mobile applications, where it is critical to ensure that there is no risk of data takeover or breach.

- Embedded technologies will continue to grow, manufacturers are now heavily relaying the usage of embedded devices starting from automobiles to security systems, consumer electronics to smart home

Embedded System Design Example

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- **Automatic Chocolate Vending Machine (ACVM)**

  - The design function of ACVM is to provide chocolate to the child whenever the child inserts a coin into ACVM.

- Design Steps:

  - The design steps mainly include the following

  - Requirements

  - Specifications

  - Hardware and software functioning.

Requirements

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- When a child inserts a coin into the machine and selects the particular chocolate that he wants to purchase.
- Inputs
  - Coins, user selection.
  - An interrupt is generated at each port whenever a coin is inserted.
  - A separate notification is sent to each port.
- Outputs
  - Chocolate
  - Refund
  - A message is displayed on LCD like date, time, welcome message.

Requirements- Cont'd

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- System Function

  - Using a graphical user interface, the child commands to the system which chocolate the child wants to purchase.

  - Where the graphical user interface has an LCD, keypad, touch screen.

  - The machine delivers the chocolate when the child inserts the coin if the coins inserted are excess than the actual cost of selected chocolate. The ACVM machine refunds the money back.

 - Using a Universal synchronous bus, the owner of the ACVM can keep track of client location.

Design metrics

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- Power Dissipation
- The design should be made as per display size and mechanical components.
- Process Deadline
  - Timer must be set, so that whenever the child inserts the coin the ACVM must respond within few seconds in delivering the chocolates and refunding if excess.
  - For example, if the response time is 10seconds, the ACVM should deliver the chocolate and refund the money if excess within 10 seconds as soon as the child inserts the coin and place a request for chocolate. .

Specification

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- From the below ACVM system, when the child inserts the coin.

- The coins get segregated according to the ports presented, Port1, Port2, Port5.

- On receiving coin an interrupt is generated by the port, this interrupt is sent to reading the amount value and increasing.
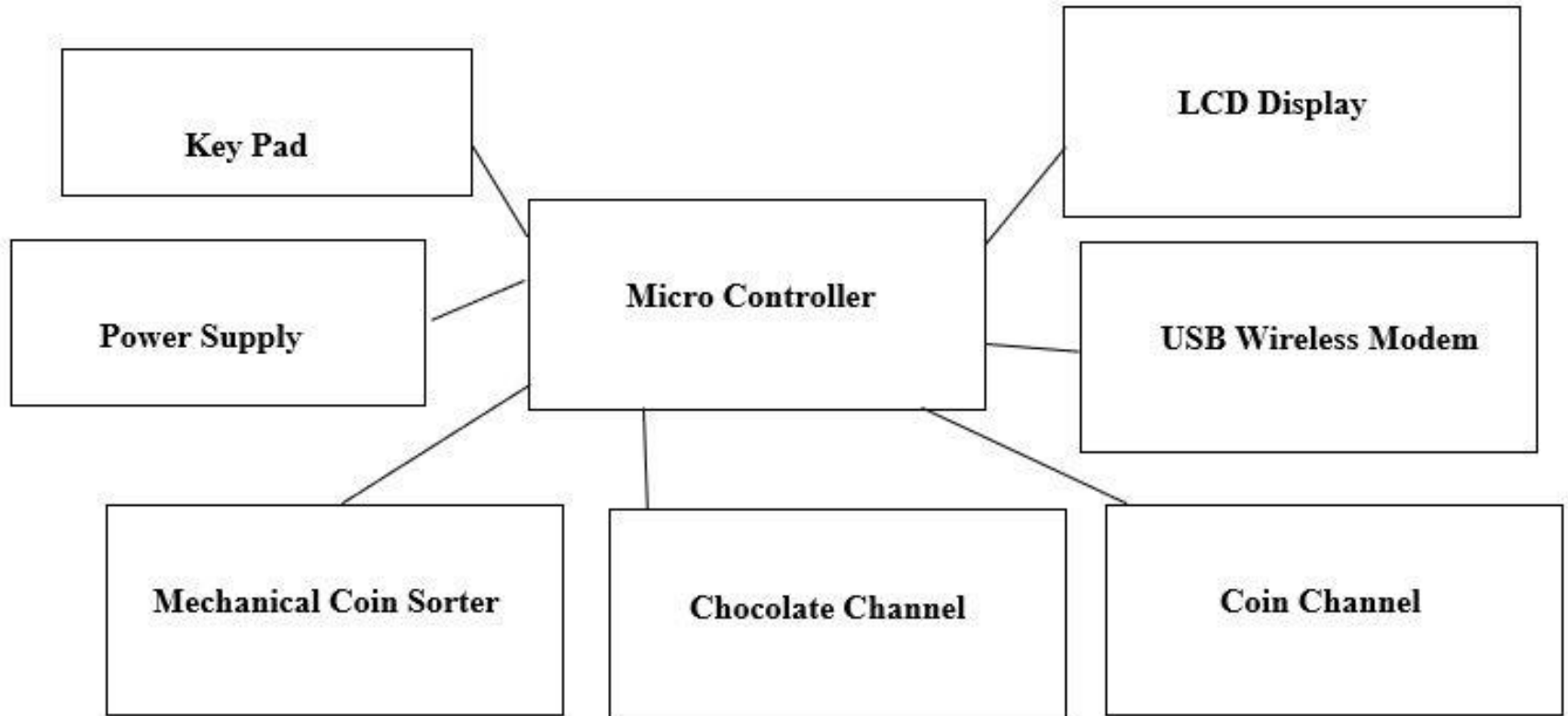
Automatic chocolate vending machine (ACVM)
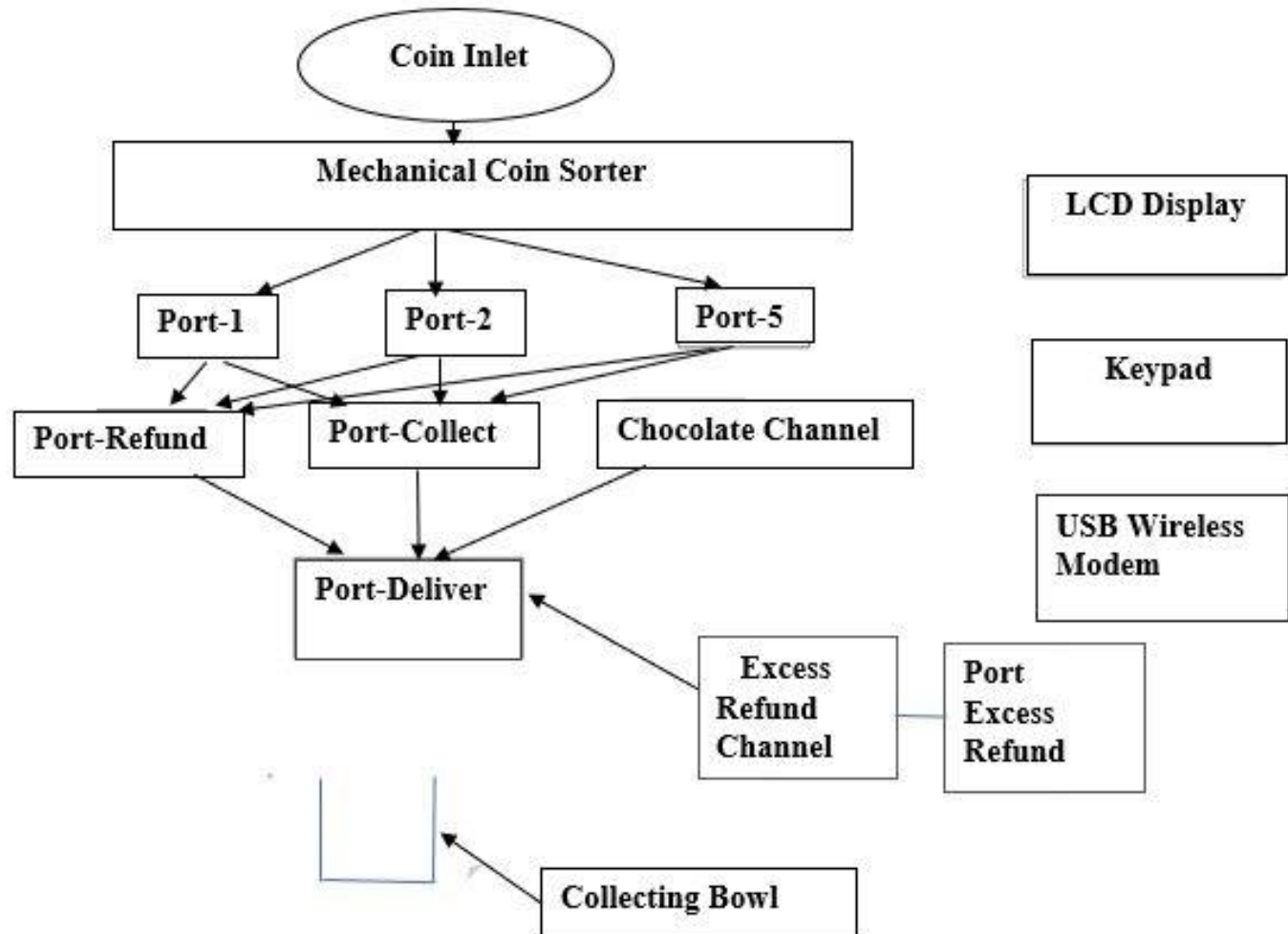
Hardware

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- ACVM hardware architecture has the following hardware specifications:

    - Microcontroller 8051

    - 64 KB RAM and 8MB ROM

    - 64 KB Flash memory

    - Keypad

    - Mechanical coin sorter

    - Chocolate channel

    - Coin channel

    - USB wireless modem

    - Power supply

ACVM - Architectural Diagram

ACVM Software

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- Many programs have to be written so that they can be reprogrammed when required in RAM /ROM like,

  – Increase in chocolate price

  – Updating messages to be displayed in LCD

  – Change in features of the machine.

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ACVM Software

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- An Embedded System is a combination of hardware + software to perform a particular function. There are of two types microprocessors and microcontrollers. While designing an embedded system certain design constraints and specifications are to consider, so that the developer can meet the customer expectations and deliver on time. An application of Embedded system design ACVM explained in this content. Here is a question what is the cause for environmental constraints while designing an embedded system?

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