Introduction to Embedded System Design

Lecture - 2: Modular Approach to Embedded System Design

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Key Parameters for a Successful Embedded System

- Time to Market (4 week delay can lead to 30% drop in revenues)
- Overall System Cost

Choosing the Right Microcontroller

- Time to Market
  - Is the Microcontroller easy to use?
  - High Level Language Supported?
- How Difficult to move to a different Device?
  - Does a compatible device with more/less memory exist?
- What about Development Tools?
  - assembler, compiler, debugger, emulators, eval kits?
- Support?

Choosing the Right Microcontroller-II

- Overall System Cost
  - Cost of Microcontroller + external components
  - Cost of PCB
- Does the Microcontroller offer higher Integration upgrade?
  - more software features could be accommodated
- Hidden Costs?
  - stocking multiple devices, turn-around time, upgrade?

Microcontroller Classification

1. Memory Architecture:
   - Von Neumann
   - Harvard
2. Bit Handling Capacity
   - 4, 8, 16, 32, 64-bits
3. Instruction Set Architecture
   - CISC: Complex Instruction Set Computing
   - RISC: Reduced Instruction Set Computing
   - MISC: Minimal Instruction Set Computer
   - VLIW: Very Large Instruction Word

Current Favorites – The 8-bitters

- 8051 family – more than 1000 variants, in varied packagings. Standard CISC
- Microchip's PIC – RISC architecture.
- Cypress Semiconductor PSoC. CISC, complete system on chip with programmable analog blocks (https://www.cypress.com/)
- Microchip's (ex-Atmel) AVR. RISC. 200+ chips

The 16-bitters

- Texas Instruments MSP430
- Microchip PIC24
- STMicroelectronics ST10
- NXP HC12 (Legacy), HC16

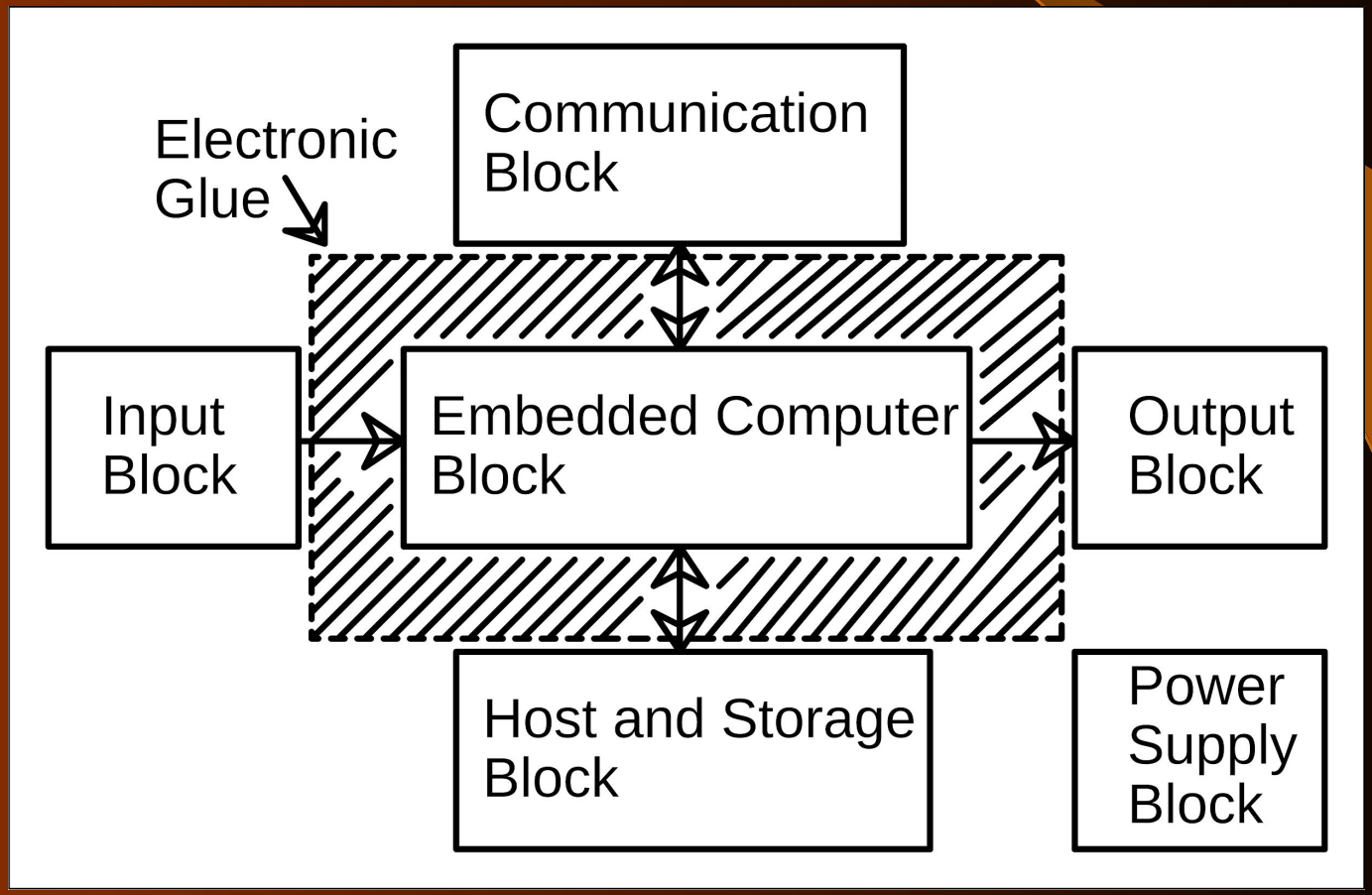
The 32-bitters

- 16/32-bit ARM family, 1000s of variants.
- Intel x86 family
- IBM’s PowerPC (used in telecom apps)

Modular Approach to an Embedded System Design

Six Box Model for Embedded System Design

Any embedded device correlates to this generic model



Input Block

- **User Input**
  Push Button, Toggle Switch, SPST/SPDT/MPMT selector switches, Switch Matrix, Capacitive touch, Resistive touch, Reed switch (with a magnet input)
- **Sound**
  Microphone, Ultrasonic
- **Magnetic Field**
  Hall Effect, Inductor, Reed switch, Magnetometer
- **Distance**
  Ultrasonic ranger, IR proximity sensor
- **Temperature**
  Thermistor, RTD, Thermocouple, Semiconductor Sensor
- **Light**
  LDR, Photodiode, LED as sensor
- **Strain/Force**
  Strain gauge, FSR, Piezo
- **Relative Position**
  Shaft encoder (Stepper Motor as a shaft encoder), Gyroscope, Optocoupler, Linear potentiometer, GPS
- **Image**
  Camera (CMOS or CCD), Linear CCD array
- **Time**
  RTC, Clock + Counter

Output Block

- **Light**
  LED, RGB LED, Laser, IR
- **Visual**
  Seven Segment/Alphanumeric Display, Character LCD, Graphics LCD, TV
- **Sound**
  Speaker, Buzzer, Ultrasound
- **Temperature**
  Heater, Peltier module
- **Position**
  Stepper Motor (Microstepping mode), DC Motor, Servo Motor, Servo mechanism, Solenoid
- **Flow**
  Valve, Pump
- **Haptic**
  Vibration (Motor + asymmetric load)
- **Print**
  Thermal printer, Dot-matrix printer

Power Supply Block

- Energy Source?
- Regulator: Linear or Switching?
- If Switching, then – Buck, Boost, Buck-Boost?
- Battery technologies?
- Supercapacitor?

Communication Links Block

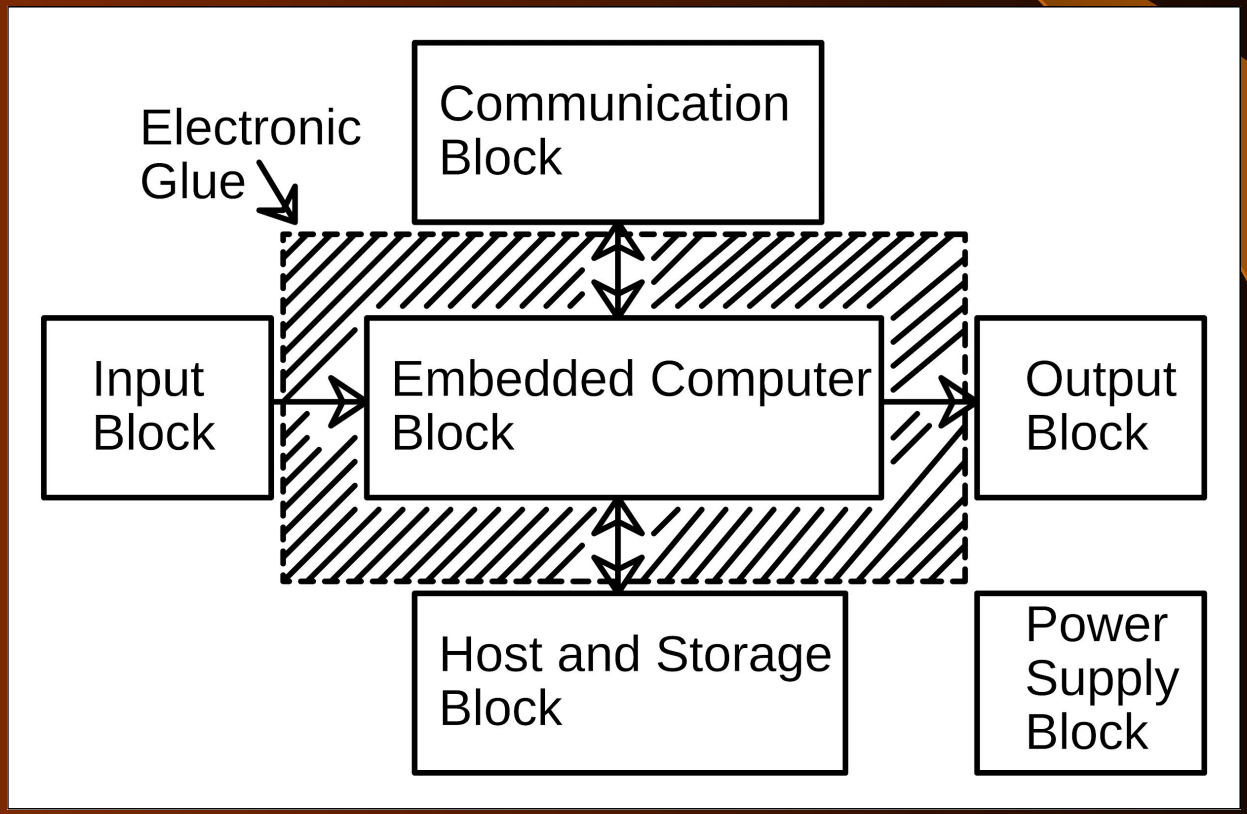
- Inter-device Vs Intra-device
- Intra-device: UART, SPI, I2C
- Inter-device: UART, LIN (Local Interconnect Network), CAN, WiFi, Ethernet, USB, Bluetooth

Host and Storage Block

- Serial E2PROM
- SD Card

Electronic Glue

- Analog front end: Amplifiers, filters.
- Output: Power Switching (Low, high and both side switching)



Lecture - 2 Summary

- Key parameters of Embedded System Design
- Time to market and cost.
- Microcontroller Classification based on memory access, ISA, data bus width (Example Microcontroller families (8-bit, 16-bit and 32-bit examples)), Memory technologies, Memory interface busses.
- Modular approach to Embedded System Design using a Six Box Model of an Embedded System: Input, Output, Processor, Power Supply, Communication, Host.

Thank you!