EMBEDDED SYSTEM PROCESSOR TYPES, AND SELECTION

INTRODUCTION

- Overview of processors in embedded systems.
- Significance of processor selection in system design.
- Different types of processors used in embedded systems.
- Criteria for selecting the right processor.
- Goals of this presentation.

PROCESSOR TYPES OVERVIEW

- General-purpose Processors (GPPs)
- Microcontrollers (MCUs)
- Digital Signal Processors (DSPs)
- Application-Specific Integrated Circuits (ASICs)
- Field-Programmable Gate Arrays (FPGAs)

GENERAL-PURPOSE PROCESSORS (GPPS)

- Versatility across different applications.

  Examples: Intel, AMD processors.

- Support for complex operating systems.
- High computational power and performance.
- Used in desktops, servers, and complex embedded systems.

MICROCONTROLLERS (MCUS)

- Integration of CPU, memory, and peripherals on a single chip.

  Examples: ARM Cortex-M, PIC, AVR.

- Low power consumption for battery-operated devices.
- Cost-effective for mass production.
- Applications: Consumer electronics, automotive, home appliances.

DIGITAL SIGNAL PROCESSORS (DSPS)

- Optimized for real-time signal processing tasks.

  Examples: Texas Instruments TMS320, Analog Devices SHARC.
- Efficient handling of mathematical operations (e.g., FFT, filters).
- Commonly used in audio, video, and communication systems.
- High performance with specialized instruction sets.

APPLICATION-SPECIFIC INTEGRATED CIRCUITS (ASICS)

- Custom-designed for specific applications.
- High performance and low power consumption.
- Fixed functionality, not reprogrammable after manufacturing.
- Ideal for mass production with specific requirements.
- Used in mobile devices, gaming consoles, and specialized equipment.

FIELD-PROGRAMMABLE GATE ARRAYS (FPGAS)

- Reprogrammable hardware with flexibility in design.
- Parallel processing capabilities for high-performance applications.

  Examples: Xilinx, Altera (Intel).
- Used for prototyping and specialized embedded systems.
- Higher cost and power consumption compared to MCUs.

PROCESSOR SELECTION CRITERIA FOR AN EMBEDDED SYSTEM

- Performance Considerations
- Power considerations
- Peripheral Set
- Operating Voltage

PERFORMANCE CONSIDERATIONS

- The first and foremost consideration in selecting the processor is its performance. The performance speed of a processor is dependent primarily on its architecture and its silicon design.
- presence of cache reduces instruction/data fetch timing.
- Pipelining and super-scalar architectures further improves the performance of the processor.
- Multi-cores are the new direction in improving the performance.
- Rather than simply stating the clock frequency of the processor which has limited significance to its processing power,
- MIPS (Million Instructions Per Second) or MIPS/MHz was an earlier notation followed by Dhrystones and latest EEMBC's CoreMark.
- SIMD (Single Instruction/Multiple Data) set and Jazelle – Java acceleration can help in improving multimedia and JVM execution speeds.
- So size of cache, processor architecture, instruction set etc has to be taken in to account when comparing the performance.

POWER CONSIDERATIONS

- Increasing the logic density and clock speed has adverse impact on power requirement of the processor.
- A higher clock implies faster charge and discharge cycles leading to more power consumption.
- More logic leads to higher power density there by making the heat dissipation difficult.
- Techniques like frequency scaling – reducing the clock frequency of the processor depending on the load,
- voltage scaling – varying the voltage based on load can help in achieving lower power usage.
- Further asymmetric multiprocessors, under near idle conditions, can effectively power off the more powerful core and load the less powerful core for performing the tasks.
- SoC comes with advanced power gating techniques that can shut down clocks and power to unused modules.

PERIPHERAL SET

- Every System Design Needs, Apart From The Processor, Many Other Peripherals For Input And Output Operations.
- Since In An Embedded System, Almost All The Processors Used Are Socs, It Is Better If The Necessary Peripherals Are Available In The Chip Itself.
- This Offers Various Benefits Compared To Peripherals In External Ic's Such As Optimal Power Architecture, Effective Data Communication Using DMA, Lower Bom Etc.
- So It Is Important To Have Peripheral Set In Consideration When Selecting The Processor.

OPERATING VOLTAGES

- Each and every processor will have its own operating voltage condition.
- The operating voltage maximum and minimum ratings will be provided in the respective data sheet or user manual.
- While higher end processors typically operate with 2 to 5 voltages including 1.8V for Cores/Analogue domains, 3.3V for IO lines, needs specialized PMIC devices, it is a deciding factor in low end micro-controllers based on the input voltage.

Example: it is cheaper to work with a 5V micro-controller when the input supply is 5V and a 3.3 micro-controllers when operated with Li-on batteries

PROCESSOR SELECTION CRITERIA

Performance Requirements: Speed, real-time processing needs.

Power Consumption: Battery life vs. performance trade-offs.

Cost: Budget considerations and production volume.

Integration: Peripheral requirements and system complexity.

Development Tools: Availability of SDKs, compilers, and debugging tools.

CASE STUDY: SELECTING A PROCESSOR FOR A WEARABLE DEVICE

- \- Requirement Analysis: Low power, small form factor, and connectivity.
- \- Evaluation of Options: Comparing MCUs, FPGAs, and ASICs.
- \- Final Selection: MCU with integrated Bluetooth for power efficiency.
- \- Justification: Balance of performance, cost, and power consumption.
- \- Impact: Improved battery life and user experience.

CONCLUSION

- Recap of processor types and their applications.
- Importance of matching processor choice to application needs.
- Consideration of performance, power, cost, and tools in selection.
- Processor selection’s impact on the overall system design.
- Future trends in embedded system processors.