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What are the Embedded Systems

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Abstract:- Embedded systems have become the cornerstone of modern technology, powering everything from intelligent buildings to autonomous vehicles. These unique computer systems made to carry out particular functions inside larger systems, enhance efficiency and functionality across various industries. As we delve into the world of embedded systems, we will explore their applications, essential components, distinctive characteristics, and the challenges associated with their design. Specifically, we will focus on optimizing design metrics and discussing the three key technologies that underpin embedded system development.

I. INTRODUCTION

A specialized computer system created to carry out a particular function inside a larger apparatus or system is called an embedded system. Contrary to multipurpose computers, which are versatile and can handle a wide range of tasks, embedded systems are optimized for their particular function. This specialization enables engineers to minimize size, weight, and power consumption, making them ideal for applications where resource constraints are paramount. Embedded systems are often mass-produced, further driving down costs through economies of scale. Their ubiquity in modern devices, from smartphones to automobiles, underscores their critical role in shaping our technological landscape.

II. EMBEDDED SYSTEM OVERVIEW

Specialized computer systems called embedded systems are made to carry out certain functions inside bigger systems. Usually, they are composed of a microprocessor or microcontroller, memory, and input/output peripherals, operating under dedicated software. Unlike general-purpose computers, embedded Systems are tuned to maximize effectiveness, minimize power usage, and real-time performance, often lacking a user interface. Ubiquitous in modern life, embedded systems can be found in a wide range of applications.

While the term "embedded system" might seem abstract, it encompasses a vast array of devices that have become integral to our daily lives. Their prevalence and versatility underscore their importance in shaping the technological landscape.

➢ *An "Initial Roster" of Embedded Systems*

brakes with anti-lock	cameras with autofocus
Automated Tellers	Toll-automated systems
automated switching	Avionics systems
chargers for batteries	Recorders
Mobile phones	Base stations for cell phones
phones without cords	cruise control
Systems for curbside check-in	digital photography
Drives	Electronic tools
Electronic games and toys	manufacturing command
Fax machines	fingerprint readers
Security systems for homes	mechanisms that sustain life
Systems for medical testing	Computers
MPEG decoders	Cards for networks
Network switches/routers	Navigation on-board
Pagers	Copier/photo
Point of sale programs	Video games on a portable device
Inkjets	satellite-based phones
Scanners	Smart dishwashers and ovens
speech recognition software	stereos
Systems for teleconferencing	temperature controllers for
televisions	Systems for tracking theft
TV set-top boxes	DVD players and VCRs
systems for playing video games	phones with videos
dryers and washers	And the list is endless.
Card readers with electronic devices	

➢ *The use of Embedded Systems*

- Consumer electronics, like video cameras as well as camcorders.
- Washing machine and refrigerator are examples of household appliances.
- Automotive sector: engine control, anti-lock braking system (ABS).
- Fire alarms, sprinklers, and air conditioners are signs of home automation and security systems.
- Communication: mobile phones, landlines.
- Computer accessories, such as printers and scanners.
- Computer networking systems consist of switches and routers.
- Medical devices: EEG and ECG machines.
- Banking and retail: point of sale systems, automated teller machines (ATMs).
- Barcode and smart card readers are available.

➢ *Principal Elements*

Embedded processors, embedded software, embedded boards, and embedded memory make up its three main sections.

- The three segments of embedded processors are digital signal processor (DSP), microprocessor (MPU), and microcontroller (MCU).
- Embedded memory comprises different kinds of flash memory, programmable read-only memory (PROM), and random-access memory (RAM).
- Embedded software, encompassing portable and real-time operating systems (RTOS), is used for embedded applications.

➢ *Embedded Systems' Common Characteristics*

- Single-functioned: Runs a single program repeatedly.
- Strictly limited: inexpensive, low-power, compact, quick, etc.
- Reactive and instantaneous: Constantly responds to modifications in the system's surroundings & Needs to compute certain outcomes instantaneously.

III. DESIGN DIFFICULTY - IMPROVE DESIGN METRICS

- Creating an implementation with the desired functionality is the obvious design aim.
- The main design problem is to optimize multiple design metrics at once
- Design metrics are quantifiable aspects of a system's implementation, and one of the main challenges is optimizing them.

➢ *Common Metric*

- Unit cost: the overall cost of production, without including NRE costs, for each system copy.
- The one-time financial expense associated with system design is known as the NRE cost, or non-recurring engineering cost.
- Dimensions: the amount of physical space needed for the system.
- Results: the system's flow or time to execute.
- Power: the quantity of power that the system uses.
- Adaptability: the capacity to modify the system's operation without having to pay a high amount of NRE.

➢ *Common Metrics (Engaged)*

- Period-to-market: the amount of time needed to develop a system to the point where it can be made available to the public for purchase.
- Period-to-prototype: the amount of time needed to construct a functioning version of the system.
- Service: the capacity to make changes to the system after it has been released, along with accuracy, security, and many other aspects.

IV. EMBEDDED SYSTEM TECHNOLOGIES THREE ESSENTIAL

Technology is a means of achieving an objective, particularly through the application of technical procedures, methods, or expertise.

A. Technology of Processors

The computing engine's architecture that carries out the intended functionality of a system. It is not necessary for a processor to be programmable. A processor is not the same as a general-purpose processor. The degree to which processors are customized for the given challenge varies.

➢ *Processors with a General Purpose*

Programmable gadget with a wide range of uses Another name for a "microprocessor" Features include program the memory, a general ALU, and a generic data path with a huge register file. Benefits for the user include: High flexibility, low time-to-market and NRE costs. Obviously, Pentium is the most well-known, but hundreds more exist.

➢ *Processors with a Single Purpose*

A digital circuit, often known as a coprocessor, accelerator, or peripheral, is made to run just one program.

- Features: No program memory; only the parts required to run a single program are there.
- Benefits: Compact, quick, and low power consumption.

➢ *Processors Tailored to a Certain Application*

A programmable processor is a hybrid of a general-purpose and single-purpose processor, designed to balance performance and features for a certain class of applications. Features include Special functional units, optimized data path, and program memory. Advantages include size, power, outstanding performance, and some adaptability.

B. IC Technology

The process of mapping an IC to a digital (gate-level) representation;

- IC stands for "integrated circuit," or "chip."
- How an IC technology is tailored to a design varies.
- ICs are made up of many layers—possibly ten or more.
- IC technologies vary in terms of who constructs each layer and when.

C. Three Types of IC Technologies;

➢ *Completely customized/VLSI*

Every layer is tailored to the specific digital implementation of an embedded system.

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- Wire routing, transistor placement, and transistor sizing.

- *Advantages*

✓ Compact design, high performance, low power consumption.

- *Cons:*

✓ High time-to-market and high NRE costs (e.g., $300k).

➢ *Semi-custom ASIC*

Lower strata are constructed entirely or partially. The only tasks left for designers are to route cables and possibly place some blocks.

Benefits include good size, good performance, and lower NRE costs compared to a full-custom solution (maybe between $10k and $100k).

- Cons: still take several weeks or months to mature.

➢ *Programmable Logic Device, or PLD*

Every layer is pre-existing; designers can buy integrated circuits (ICs); connections on the IC can be made or broken to get desired functionality; FPGAs are quite popular. Benefits include low NRE costs and nearly instantaneous IC availability.

- Cons: larger, more costly (about $30 per unit), power-hungry, slower.

➢ *Technology of Design*

How we translate our idea of ideal system functionality into reality. An exponential rise in design productivity. exponential growth during the last several decades. The ladders of co-design The technology used to develop hardware and software were considerably different in the past.

The unification of hardware and software is made possible by the recent maturity of synthesis. "Code sign" of hardware and software.

There is no fundamental difference in what hardware and software can implement; instead, the choice of hardware versus software for a given function is just a tradeoff among many design parameters, like performance, power, size, NRE cost, and especially flexibility.

➢ *Separation between IC and Processor Technologies*

A simple trade-off. Normal versus unique. In terms of processor or integrated circuit technology, the two are distinct fields.

➢ *Design-Productivity Disparity*

Over the past few decades, designer output has increased at an astounding rate; yet, the rate of progress has not kept up with the capacity of chips.

➢ *The Fabled Month of Men*

The productivity gap underrepresents the severity of the situation. Theoretically, a team comprising designers completes projects faster. In actuality, the difficulties in managing a team and communicating with one another cause a decline in designer output. Known as "the mythical man-month" in the software community (Brooks 1975). Can eventually cause a delay in the project's completion! "There are too many cooks."

V. CONCLUSION

Systems with embedded components are poised to revolutionize the technological landscape, with their market experience rapid expansion worldwide. The increasing integration of these systems across various industries, coupled with adoption of multicore processor technology in military application, is driving substantial growth. The burgeoning market for wearable devices and the raising demand for embedded systems healthcare equipment further contribute to this trend. Moreover, the internet of thing (IoT) has already transformed the consumer application industry, paving the way for a future where Embedded systems are essential to the development of our globalized society.

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