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Embedded Systems: Challenges and opportunities

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I INTRODUCTION

An Embedded system can be defined as any sort of device which includes a programmable computer but itself is not intended to be a general-purpose computer. An Embedded System is a System that has software embedded into hardware, which makes a system dedicated for an application (s) or specific part of an application or product or part of larger system. It is also collection of several interdependent parts for a specific application (s). Embedded System are the electronics systems that contain a microprocessor or microcontroller used for specific applications. The microprocessor is a programmable device, which has all the functions of a CPU of a Computer as to access an information, to store that information, to process that information and to give the result in desired form. The microcontroller is an embedded function of all the circuits like Ports, Timers, Memories, Serial Controllers and various other functions available in a Single Chip with inbuilt microprocessor in it. Almost all the microcontrollers use RISC type of architecture. The average middle-class home may have 40 to 50 embedded processors in it like Microwave, washer, dryer, dishwasher, TV, VCR, stereo, hair dryer, coffee maker, remote control, humidifier, heater, toys, etc. The Luxury cars have over embedded processors for Brakes, steering, windows, locks, ignition, dashboard displays, transmission, mirrors, etc. Also Personal computers have over embedded processors like Graphics accelerator, mouse, keyboard, hard-drive, CD1ROM, bus interface, network card, etc.

II HARDWARE COMPONENTS OF EMBEDDED SYSTEM

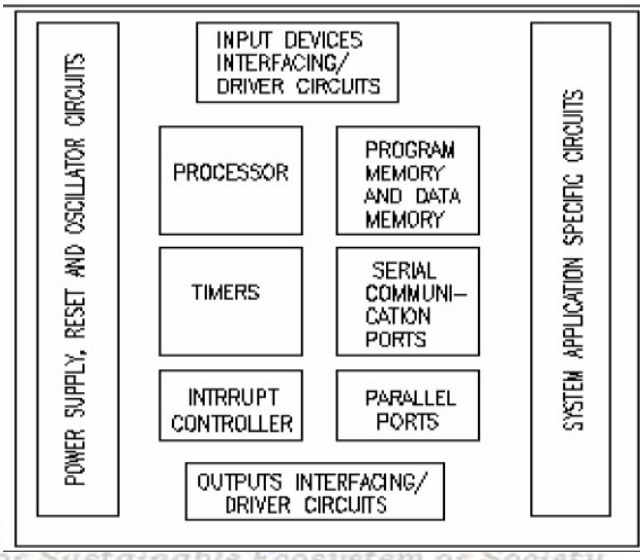

Fig 1. Hardware components of Embedded System

As shown in the schematic diagram (Fig 1), the generalized embedded system includes various hardware components such as I/O Devices, Memories, Ports, Timers, Serial controllers, Interrupt controllers and Processor. It also includes power supply with clock circuits for proper functioning of specific application. There are mainly three types of processors available with an advent of microprocessors technology as,

a. General-purpose processors
b. Single-purpose processors
c. Application-specific processors

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The general purpose processors are also known as microprocessors, which includes general ALU, register file and Program Memory. The single purpose processors can be coprocessors designed for intended aspect. The application specific processors are optimized for a particular class of applications having common characteristics. It is actually Compromise between general-purpose and single-purpose processors. The growing demand of embedded processors is shown in Fig 2. The market sales for processors is expected to increase by roughly 15% each year. The semiconductor industry association (SIA) roadmap for processor technology predicts the progress to go on continuously day by day for several years. The number of transistors on chips are aslo increased, which is proving Moore's law by developing products in 90 nm, 45 nm or able to realize 10 nm and smaller geometrics which would produce more transistors on the same area.

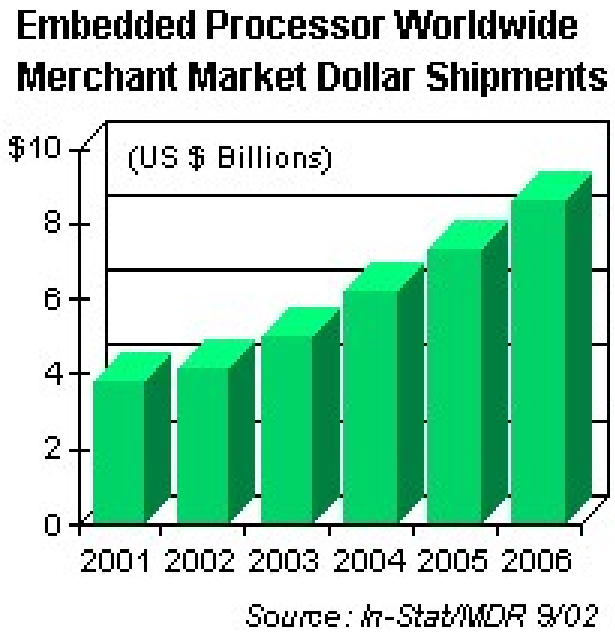

Fig.2:Demand

III CHARACTERISTICS OF EMBEDDED SYSTEMS

There are following characteristics for Embedded system may be expected as,

a. Single-functioned
– Executes a single program, repeatedly
b. Tightly-constrained
– Low cost, low power, small, fast, etc.
c. Reactive and real-time
– Continually reacts to changes in the system's environment

– Must compute certain results in real-time without delay
d. Application-specific functionality – specialized for one or one class of applications
e. Deadline constrained operation – system may have to perform its function(s) within specific time periods to achieve successful results
f. Resource challenged – systems typically are configured with a modest set of resources to meet the performance objectives
g. Power efficient – many systems are battery-powered and must conserve power to maximize the usable life of the system.
h. Form factor – many systems are light weight and low volume to be used as components in host systems
i. Manufactural – usually small and inexpensive to manufacture based on the size and low complexity of the hardware.

This Embedded system is similarly observed with various design constraints and challenges as size, weight, power, environment, safety and cost. Further the design challenge includes correct specifications, testing on real time with real data and optimizing the design metrics. The common metrics for embedded system includes,

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a. Unit cost: the monetary cost of manufacturing each copy of the system, excluding NRE cost

b. NRE cost (Non-Recurring Engineering cost): The one-time monetary cost of designing the system

c. Size: the physical space required by the system

d. Performance: the execution time or throughput of the system

e. Power: the amount of power consumed by the system

f. Flexibility: the ability to change the functionality of the system without incurring heavy NRE cost

The other design constraints include,

Reliability: probability of system working correctly provided that it worked at time.

Maintainability: probability of system working correctly on time units after error occurred.

Timing correctness and safety

IV THE FUTURE EMBEDDED SYSTEM

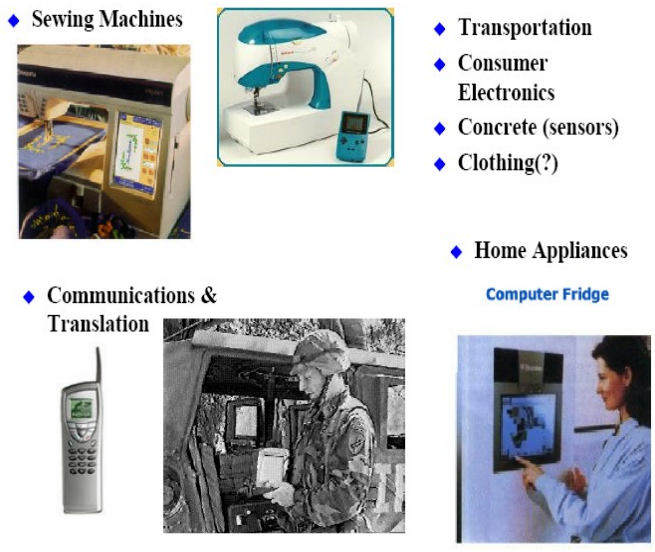

Fig. 3: The future embedded system

The challenges with future embedded system will be,

- More complexity (people expect more functions and higher performance from their electronic products)
- This leads to more complex software
- Which requires better design process

- More importantly, thorough testing for safety critical systems (diagnostics codes of engine ECUs is half of its total software codes)
- Hardware – to improve performance (sensors and actuators), verification, etc.
- Software – reusability, testing, verification, OS, etc.
- Network – higher connectivity between systems (e.g. smart homes link many systems together, standardized protocols, etc.
- Security – protection against attacks

- Design – improved methodology, more automation, formal verification

V FUTURE TRENDS FOR ESD (EMBEDDED SYSTEM DESIGN)

Embedded systems are on the rise as the technology paves the way for the future of smart manufacturing across a range of industries.

Microcontrollers — the hardware at the center of embedded systems are improving quickly, allowing for better machine control and monitoring.

The key characteristics of embedded systems include speed, security, size, and power. The future trends for Embedded System would include,

- ***Improved Security for Embedded Devices***
- ***Cloud Connectivity and Mesh Networking***
- ***Reduced Energy Consumption***
- ***Visualization Tools with Real Time Data***
- ***Deep Learning Applications***

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The embedded systems market is shaping up for simplified cloud connectivity, improved security tools, real-time visualizations, lower power consumption, and deep learning solutions with innovations. There are 10 predictions made for the world in 2030 as shown in Figure 4.

Fig. 4: The world in 2030 predictions

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