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Recent Trends in Platforms of Embedded Systems

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ABSTRACT

In today's advanced world lots of innovative applications in embedded system are built on single board based technologies namely platforms of embedded system and more are being developed. Therefore embedded based technology can be used in several areas. Hence, in this paper, we present about latest platforms available in embedded system and several applications of embedded platforms in various fields. The embedded systems industry was born with the invention of microprocessors and microcontrollers, now a day various platforms of embedded system like Arduino, Raspberry pi, Beagle Bone Black are implemented in market. These embedded platforms provide IoT, SoC, more flexibility for interfacing communication protocols to real world device. Also provide ISP, on system hardware and software debugging tools, thus using these platforms creating newer opportunities and challenges to develop different types of future advanced embedded system applications.

Keywords: Embedded system, IoT (Internet on Thing), SoC (System on Chip), Arduino, Raspberry pi, ISP (In System Programming).

1. INTRODUCTION

Recent development in the areas of embedded system detonated the emergence of new platforms. These platforms are based on computer and embedded system to control and monitor all the matters without human's direct involvement. Embedded systems have become an integral part of daily life. Be it a cell phone, a smartcard, a music player, a router, or the electronics in an automobile these systems have been touching and changing modern lives like never before. An embedded system is a combination of computer hardware, software, and additional mechanical or other technical components, designed to perform a dedicated function. Most of the embedded systems need to meet realtime computing requirements.[1,3]

The major building blocks of an embedded system are listed below:

- Microcontrollers / digital signal processors (DSP)
- Integrated chips
- Real time operating system (RTOS) - including board support package and device drivers
- Industry-specific protocols and interfaces
- Printed circuit board assembly.

Usually, an embedded system requires mechanical assembly to accommodate all the above components and create a product or a complete embedded device.

2. PERIPHERAL STANDARDS AND PROTOCOL IN EMBEDDED SYSTEM PLATFORMS:

Embedded systems communicate with the outside world via their peripherals using following communication standards and protocols are used:

- Serial Communication Interfaces (SCI) like RS-232, RS-422, RS-485, etc.
- Synchronous Serial Communication Interface like I2C, SPI, SSC, and ESSI
- Universal Serial Bus (USB)
- Multi Media Cards (SD Cards, Compact Flash, etc.)
- Networks like Ethernet, Lan Works, etc.
- Field buses like CAN-Bus, LIN-Bus, PROFIBUS, etc.
- Timers like PLL(s), Capture/Compare and Time Processing Units.
- Discrete IO aka General Purpose Input / Output (GPIO)
- Analog to Digital/Digital to Analog (ADC/DAC)
- Debugging like JTAG, ISP, ICSP, BDM Port, BITP, and DP9 ports.

3. LATEST TRENDS IN EMBEDDED SYSTEM

Overview of the emerging technological trends and implications in the development of embedded systems.

3.1 System-on-Chip (SoC)

It represents a revolution in integrated circuit (IC) design, enabled by advances in process technology, which allow the integration of the main components and subsystems of an electronic product onto a single chip or integrated chipset. This development has been embraced by designers of complex chips because it permits the highest possible level of integration, resulting in increased performance, reduced power consumption, and advantages in terms of cost and size. These are very important factors in the design process, and the use of SoC is arguably one of the key decisions in developing real-time embedded systems.[3]

SoC can be defined as a complex integrated circuit, or integrated chipset, that combines the main functional elements or subsystems of a complete end product in a single entity. Nowadays, the most challenging SoC designs include at least one programmable processor, and very often a combination of at least one RISC (reduced instruction set computing) control processor and one digital signal processor (DSP). They also include on-chip communications structures processor bus, peripheral buses and sometimes a high-speed system bus. A hierarchy of on-chip memory units, as well as links to off-chip memory, is especially important for SoC processors.

For most signal-processing applications, some degree of hardware based accelerating functional unit is provided, offering higher performance and lower energy consumption. For interfacing to the external world, SoC design includes a number of peripheral processing blocks consisting of analogue components as well as digital interfaces (for example, to system buses at board or backplane level). Future SoC may incorporate MEMS-based (micro electro-mechanical system) sensors and actuators, or chemical processing.[3,4]

All interesting SoC designs comprise both hardware and software components. These include programmable processors, real-time operating systems, and other elements of hardware dependent software. Thus, the design and use of SoCs not only concerns hardware it also involves system level design and engineering, hardware software tradeoffs and partitioning, and software architecture, design and implementation.[2,5]

3.2 Internet of Things (IoT):

The Internet of Things (IoT) is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. IoT has evolved from the convergence of wireless technologies, micro-electromechanical systems (MEMS), micro services and the internet. The convergence has helped tear down the silo walls between operational technology and information technology, allowing unstructured machine-generated data to be analyzed for insights that will drive improvements.[9]

3.3 Wireless:

For a long time, embedded devices were mostly operating as stand-alone systems. However, with the advent of wireless connectivity, the scenario has changed. Both, short-range wireless protocols like Bluetooth, Zigbee, RFID, near field communications (NFC) and long-range protocols such as, wireless local area network (WLAN), WiMAX, long term evolution (LTE) and cellular communications are bound to witness more widespread applications in the near future. The recent trends in wireless for use in embedded systems are in the areas of IoT and system-on-chip (SoC) architecture, reduced power consumption and application of short range protocols.[3,4,11]

3.4 Multi-core Processors

A lot functionalities being added, the need for high performance in embedded systems has become inevitable and so developers are increasingly leaning towards multicore processors in their systems design decision. While this range of new applications also demands low thermals in small form factor setting, the mechanicals and packaging is also becoming a sub specialization of its own. Conventionally, chip manufacturers developed faster single core processors to meet the ever increasing performance requirements. Today most of the gaming consoles are multicore and so are smart phones, which are indeed getting 'smarter'. While this multicore paradigm offers benefits, there is also ample opportunity for the engineers to relearn on this new design space, architecture, design, programming, debugging and testing so that they are well informed and are aware about the optimal use of new power that a multicore offers.[4,12]

Multicore processors offer a solution to the need for mixing new features with legacy code and combining multiple operating environments on the same system. Compared to traditional embedded systems composed of multiple subsystems, a highly integrated system can be constructed with real-time software components and human-directed elements running on separate cores in a single processing system, decreasing system manufacturing and maintenance costs by eliminating redundant hardware.

In the near future, there could be a need to migrate the existing systems to multi-core platforms so that a genuine multi-processing ability can be realized by the systems. These are still early days for the widespread deployment of multi-core processors in embedded computing. Adoption of these processors will depend how fast the entire ecosystem responds to the standardization of technology in terms of debuggers, RTOS, compilers, integrated development environment (IDE) vendors and programming methodologies.[4,11]

3.5 Power consumption

Another key parameter that is used as a differentiator among the available products is ultra-low power consumption. Zigbee-based applications require battery life to extend up to more than two years. In this case, smart scheduling of transmission and reception will only help to a certain extent. The onus is on the device manufacturers to reduce the power consumption, particularly during the time interval in radio communication. The device should remain in sleep mode the rest of the time. The current consumption during a radio interface is typically 30–35 mA.[4,5, 11]

3.6 Operating systems in embedded system:

Traditionally embedded systems did away with an operating system (OS), it had lightweight control program to offer limited input/output and memory services, however, as the systems became complex, it was inevitable to have OS which offered low latency real-time response, low foot print both in time and space and give all traditional functionality such as memory protection, error checking and transparent inter process communication, which can be applied to communications, consumer electronics, industry controls, automotive electronics and aerospace, national defense. Emerging multicore also needs multimission, multithread, multiprocess, multiprocessor, multiboard debugging and has to operate on open source tool chains such as eclipse etc, most of the new designs today are moving away from proprietary OS and tool chains and are more and more opting for open source platforms both of development and deployment as the key market differentiator for them is cost. Today many new handhelds and smart phones are used android operating system.[4,5]

4. TODAY`S MICROCONTROLLERS AND MICROPROCESSORS

4.1 ARM:

ARM, originally Acorn RISC Machine, later Advanced RISC Machine, is a family of reduced instruction set computing (RISC) architectures for computer processors, configured for various environments. ARM products that implement one of those architectures including systems-on-chips (SoC) that incorporate memory, interfaces, and radios. It also designs cores that implement this instruction set.

ARM support a 32-bit address space and 32-bit arithmetic and ARMv8-A architecture, adds support for a 64-bit address space and 64-bit arithmetic. Instructions for ARM Holdings' cores have 32-bit fixed-length instructions, but later versions of the architecture also support a variable-length instruction set that provides both 32- and 16-bit instructions for improved code density.ARM is the most widely used instruction set architecture in terms of quantity produced. Currently, the widely used Cortex cores, older "classic" cores, and specialized. [2]

The ARM architecture has evolved a lot from its first version ARM1 to the latest ARM11 Processor core.ARM1, ARM2, ARM3, ARM4 & 5, ARM6, ARM7, ARM8, Strong ARM, ARM9, ARM10 and ARM11 are the product families from ARM since its introduction to the market. [3]

A RISC-based computer design approach means processors require fewer transistors than typical complex instruction set computing (CISC) x86 processors in most personal computers. This approach reduces costs, heat and power use. These characteristics are desirable for light, portable, battery-powered devices including, smart phones, laptops and tablet computers, and other embedded systems. For supercomputers, which consume large amounts of electricity, ARM could also be a power-efficient solution. [2,3]

4.2 AVR

AVR stand for Advance Virtual RISC is a modified Harvard architecture, 8-bit RISC, single chip microcontroller. The AVR was one of the first microcontroller families to use on-chip flash memory for program storage, as opposed to OTP ROM, EPROM or EEPROM used by other microcontrollers at that time. An AVR microcontroller is a type of device manufactured by Atmel, which has particular benefits over other common chips. AVR provides the intelligence, RAM and EEPROM memories and interfaces to rest of system, like serial ports, disk drives and display interfaces.AVR microntrollers come in different packages, some designed for through-hole mounting and some surface mount. AVRs are available with 8-pins to 100-pins, although anything 64-pin or over are surface mount only. Most people start with a DIL (Dual In Line) 28-pin chip like the ATmega328 or the 40-pin ATmega16 or ATmega32. [3,12]

4.3 PIC

PIC is a family of microcontrollers made by Microchip Technology.PIC stand for Peripheral Interface Controller. The hardware capabilities of PIC devices range from 6-pin SMD, 8-pin DIP chips up to 100-pin SMD chips, with discrete I/O pins, ADC and DAC modules, and communications ports such as UART, I2C, CAN, and even USB. Low-power and high-speed variations exist for many types.[3] The first generation of PICs with EPROM storage is almost totally replaced by chips with Flash memory. Similarly, the original 12-bit instruction set of the PIC1650 and its direct descendants has been old-fashioned by 14-bit and 16-bit instruction sets. Microchip still trades OTP (one-time-programmable) and windowed (UV-erasable) versions of some of its EPROM based PICs. [3,14]

Various processors for different fields are also available in the market,

- DSP Processors
- Media Processor
- Graphic Processor Unit
- Multiprocessor Systems using GPPs
- System-on-a-Chip (SoC).
- Application Specific System Processor (ASSP)
- Application Specific Instruction Processors (ASIPs)
- GPP core(s) or ASIP core(s) on either an Application Specific Integrated Circuit (ASIC) or a Very Large Scale Integration (VLSI) circuit.

5. LATEST PLATFORM IN EMBEDDED SYSTEM

5.1 Arduino

Arduino was born at the Ivrea Interaction Design Institute as an easy tool for fast prototyping, aimed at students without a background in electronics and programming. As soon as it reached a wider community, the Arduino board started changing to adapt to new needs and challenges, differentiating its offer from simple 8-bit boards to products for IoT applications, wearable, 3D printing, and embedded environments. All Arduino boards are completely open-source, empowering users to build them independently and eventually adapt them to their particular needs. The software, too, is open-source, and it is growing through the contributions of users worldwide.

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Over the years Arduino has been the brain of thousands of projects, from everyday objects to complex scientific instruments. A worldwide community of makers - students, hobbyists, artists, programmers, and professionals has gathered around this open-source platform, their contributions have added up to an incredible amount of accessible knowledge that can be of great help to novices and experts alike.

It is a single-board microcontroller, proposed to make the application of interactive objects or environments more manageable. The hardware consists of an open-source hardware board designed around a 32-bit Atmel ARM or an 8-bit Atmel AVR microcontroller. Current models an 8-bit Atmel AVR microcontroller, a USB interface, as well as 14 digital I/O pins which allow the user to attach numerous extension boards. [8]

There are many other microcontrollers and microcontroller platforms available for physical computing. Parallax Basic Stamp, Netmedia's BX-24, Phidgets, MIT's Handyboard, and many others offer similar functionality. All of these tools take the messy details of microcontroller programming and wrap it up in an easy-to-use package. Arduino also simplifies the process of working with microcontrollers.[3,8]

Arduino offers some advantage for teachers, students, and interested amateurs over other systems:

- Inexpensive - Arduino boards are relatively inexpensive compared to other microcontroller platforms.
- Cross-platform - The Arduino Software (IDE) runs on Windows, Macintosh OSX, and Linux operating systems. Most microcontroller systems are limited to Windows.
- Simple, clear programming environment - The Arduino Software (IDE) is easy-to-use for beginners, yet flexible enough for advanced users to take advantage of as well. For teachers, it's conveniently based on the Processing programming environment, so students learning to program in that environment will be familiar with how the Arduino IDE works.
- Open source and extensible software - The Arduino software is published as open source tools, available for extension by experienced programmers. The language can be expanded through C++ libraries, and people wanting to understand the technical details can make the leap from Arduino to the AVR C programming language on which it's based.

- Open source and extensible hardware - The plans of the Arduino boards are published under a Creative Commons license, so experienced circuit designers can make their own version of the module, extending it and improving it. [3,8,11]

5.2 Raspberry Pi

Raspberry Pi on the other hand is an amazing device that really started the microprocessor revolution. The Raspberry Pi is single-board computers developed in the United Kingdom by the Raspberry Pi Foundation to promote the teaching of basic computer science in schools and developing countries. The Raspberry Pi hardware has evolved through several versions that feature variations in memory capacity and peripheral-device support. Several generations of Raspberry Pi has been released. The first generation (Raspberry Pi 1 Model B) was released in February 2012. It was followed by a simpler and inexpensive model Model A. In 2014 the foundation released a board with an improved design in Raspberry Pi 1 Model B+. The model laid the current "mainline" form-factor. Improved A+ and B+ models were released a year later. A cut down "compute" model was released in April 2014, and a Raspberry Pi Zero with smaller size and limited input/output (I/O), general-purpose input/output (GPIO), and abilities released in November 2015. The Raspberry Pi 2 which added more RAM was released in February 2015. Raspberry Pi 3 Model B released in February 2016 is bundled with on-board Wi-Fi and Bluetooth. As of 2016, Raspberry Pi 3 Model B is the newest mainline Raspberry Pi.

All models feature a Broadcom system on a chip (SoC), which includes an ARM compatible central processing unit and an on chip graphics processing unit. CPU speed ranges from 700 MHz to 1.2 GHz for the Pi 3 and on board memory range from 256 MB to 1 GB RAM. Secure Digital (SD) cards are used to store the operating system and program memory in either the SDHC or Micro SDHC sizes. Most boards have between one and four USB slots, HDMI and composite video output, and a 3.5 mm phone jack for audio. Lower level output is provided by a number of GPIO pins which support common protocols like I²C. The B-models have an 8P8C Ethernet port and the Pi 3 has on board Wi-Fi 802.11n and Bluetooth.

Models A, B, A+, and B+. Model A, A+, and the Pi Zero lack the Ethernet and USB hub components. The Ethernet adapter is internally connected to an additional USB port. In Model A, A+, and the PI Zero, the USB port is connected directly to the system on a chip (SoC). On the Pi 1 Model B+ and later models the USB/Ethernet chip contains a five-point USB hub, of which four ports are available, while the Pi 1 Model B only provides two. On the Pi Zero, the USB port is also connected directly to the SoC, but it uses a micro USB (OTG) port.[6]

5.3 Beagle Bone Black:

The high-performance, low-power world with the tiny, affordable, open-source Beagles. Putting Android, Ubuntu and other Linux flavors at your fingertips, the Beagle family revs as high as 1GHz with flexible peripheral interfaces and a proven ecosystem of feature-rich "Cape" plug-in boards. The Beagle Bone Black is a relative newcomer to the world of easy to use microprocessor breakouts, however, what it missed out on in time-to-market, the Beagle Bone Black has more than made up for in capability. The Beagle Bone Black has evolved out of the long lineage of Beagle Board products into the current version; a small form-factor, very powerful, and extremely expandable product that allows builders, makers, artists, and engineers the ability to create truly innovative projects. The Beagle Board family was originally designed to provide a relatively low-cost development platform for hobbyists to try out the powerful new system-on-a-chip (SOC) devices that were essentially capable of performing all the duties of a computer on a single chip.

The Beagle Bone Black is an affordable single-board credit card sized computer. It has a powerful ARM Cortex A8 CPU, a full Linux OS, and allows for easy access to external sensors. It is an open platform targeting students and hobbyists who want hardware focused alternative to the Raspberry PI[8].

6. MAJOR APPLICATION AREAS OF EMBEDDED SYSTEMS

Industrial Controls: Smart sensors, special purpose controllers.
Automotive Electronics: networking, process controls, Electronic control units used in chassis, body electronics, security, power train, in-vehicle entertainment, and infotainment systems.
Military / Aerospace: Satellite systems, radar, sonar, navigation, weather systems, flight control systems, aircraft management systems.
Telecom: Routers, switches, bridges, cellular phones, smart devices, networking gateways.
Automation: Copier, Fax machines, printers, scanners, multi-function peripherals, point of sale terminals, storage devices, smart cards.
Consumer Electronics:
Music players, digital cameras, DVD players, set-top boxes, PDAs, videogames, GPS receivers, home appliances.
Medical Electronics: Patient monitoring, surgical systems, diagnostic equipment, imaging, electronic stethoscopes.
Remote Automation: Building automation e.g. heating, ventilation, air-conditioning (HVAC), home automation, utility meters.[1,2,3,9,11]

7. FUTURE SCOPE AND CHALLENGES

Lastly, the future of embedded lies in how faster people adapt latest embedded platforms to the changes offered by their daily life applications and develop advanced embedded system platforms based applications that advance the society and human needs.

The challenge is to implement different communication protocols, software and hardware tools that efficiently utilize the new platforms of embedded system. Many opportunities also arising from the efficient and error-free design of SoC, IoT.

8. CONCLUSION

Platforms of embedded have been gradually bringing a sea of technological changes in our daily lives, which in turn helps to making our life simpler and more comfortable, though various advance technologies and applications. We need to build standard protocols and different communication standards to interface real world device with platforms of embedded system. Let us hope future better platforms of embedded system.

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