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Embedded Computing Systems

Matthew N. O. Sadiku, Yonghui Wang, Suxia Cui, Sarhan M. Musa
Roy G. Perry College of Engineering, Prairie View A&M University, Prairie View, TX 77446
Email: sadiku@ieee.org; yowang@pvamu.edu; sucui@pvamu.edu; smmusa@pvamu.edu

Abstract : An embedded system is any computer that relies on its own microprocessor and is a part of a larger system. It is usually embedded as a part of a complete device that serves a more general purpose. Our society is increasingly depending on embedded computing systems such as robots, unmanned aerial vehicles self-driving cars, unmanned underwater vehicles, military and aerospace electronics. This paper provides a brief introduction on embedded computing systems.

Key Words: embedded computing systems

Introduction : The term "embedded system" is used for any electronic device that incorporates a computer. Embedded systems are dedicated to pre-defined tasks, rather than be a general-purpose computer for multiple tasks. Typical embedded systems have low power consumption, small size, rugged operating ranges, and low per-unit cost. Embedded systems range from portable devices such as digital watches and MP3 players, to large systems such as traffic lights, factory controllers, and hybrid vehicles [1]. Others include mobile phones, game consoles, digital still cameras, digital TV systems, Internet access, smart sensor pills, ATM machines, highway autopilot, and car navigation system.

Unlike a stand-alone, general-purpose computer, an embedded system is an inseparable part of a certain larger system. It serves a specific aim (such as monitoring, controlling, etc.) in this larger system through executing specific computation and communication processes required by its application. It is application-specific [2]. No one embedded system is suitable for all applications.

Basics Of Embedded Systems : Currently an embedded device consists of the hardware structure of the printed circuit board with the use of semiconductor components such as ASIC, microcontroller, and system on chip) (SoC). The application is implemented in software. As shown in Figure 1, a typical embedded system has the following components [3]:

- *Controller unit*: This takes total control of external I/O, data processing, user interface, and communication part.
- *Data processing unit*: This calculates high-level mathematical equations, searching, interpolation, and so on for the controller.
- *Storage unit*: Depending on application, this may use one form memory such as ROM (read only memory), flash memory, or RAM (random access memory).
- *User interface unit*: This displays input from users.

An embedded system may also be regarded as having three major parts [4]: (1) Hardware, which consists of the microprocessor or microcontroller, timers, interrupt controller, program and data memory, serial ports, parallel ports, input devices, interfaces, output devices, and power supply; (2) Application software that concurrently performs a series of tasks; (3) Real-time operating systems that supervise the application software.

Applications : Embedded systems are commonly used in domestic, industrial, automotive, medical, commercial, and military applications. They are used in telecommunications, consumer electronics, transportation, medical equipment, security, and fire safety [1].

- *Transportation*: Transportation systems from automobiles to airplanes use embedded devices for sensing and controlling. Sophisticated embedded systems are increasingly being used in defense, aerospace and avionic industries. They are used for control, collision avoidance, pilot assistance, target tracking, navigation, and communications. For example, a typical car today includes 70 to 100 microprocessor-based electronic control units, which control the engine, power, transmission, brakes, body, doors, dashboard, tires, and heating, ventilation, and air conditioning [5]. Modern high-speed trains have a large number of embedded controllers.

- *Telecommunications*: Embedded systems are employed in telephone switches and cell phones. Computer networks use them in routers and bridges.

- *Consumer electronics*: Household appliances, such as microwave ovens, DVD players, washing machines, and dishwashers employ embedded systems to provide flexibility and efficiency. Other electronic devices including mobile phones, videogames, digital video recorders, automobile collision-avoidance systems, GPS receivers, and printers routinely use embedded systems.

- *Medical equipment*: Embedded systems within medical equipment are often powered by industrial computers such as dialysis machines, infusion pumps, cardiac monitors, prosthetics, health monitors, and various medical imaging.

Other applications include aircraft electronics, military systems, navigation systems, telematics systems, high-definition digital television, health monitoring, smart manufacturing systems, smart roads, and habitat monitoring.

Challenges : The huge number of mobile devices has made embedded systems to become ubiquitous. This has made the task of managing their power consumption very challenging. Another challenge with embedded systems is delivering predictably good performance since many embedded systems have real-time requirements.

Designing software for embedded systems is always challenging because it needs to meet performance and power requirements as well as achieve functional correctness [6]. This may be coupled with the increasing system complexity, as well as relentless time-to-market pressure. This makes building embedded computing systems to be fundamentally hard.

Security poses a serious challenge in networked embedded systems. Security ensures that the system achieves the expected, predictable behavior in protecting sensitive and private data [7].

Conclusion : Embedded systems involve a wide range of disciplines, including computer architecture, compiler, operating system, and real-time systems. Modern technological advances have drastically improved the performance of embedded computing systems since they are
crucial enablers of the Internet of things. The trend is making embedded devices more consumable, programmable, and customizable by end users.

With embedded systems being the technological backbone for the world's digitalization, exposing students to this discipline is crucial. A course in embedded computing is found in many electrical and computer engineering curriculums in US [8]. A two-year graduate program is provided for engineering and computer science students in Europe [9].

For more information on embedded systems, one should consult several books on the topic available on Amazon.com.

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AUTHORS

Matthew N.O. Sadiku is a professor in the Department of Electrical and Computer Engineering at Prairie View A&M University, Prairie View, Texas. He is the author of several books and papers. His areas of research interest include computational electromagnetics and computer networks. He is a fellow of IEEE.

Yonghui Wang is currently an associate professor with the Department of Engineering Technology, Prairie View A&M University, Prairie View, TX. His research interests include digital signal processing, image and video coding, and wavelets.

Suxia Cui is an associate professor of Electrical and Computer Engineering Department at Prairie View A&M University. She has published journal and conference articles in the field of wavelets, image processing, and video coding. Her research interests include data compression, signal classification, image and video processing.

Sarhan M. Musa is a professor in the Department of Engineering Technology at Prairie View A&M University, Texas. He has been the director of Prairie View Networking Academy, Texas, since 2004. He is an LTD Spring and Boeing Welliver Fellow.

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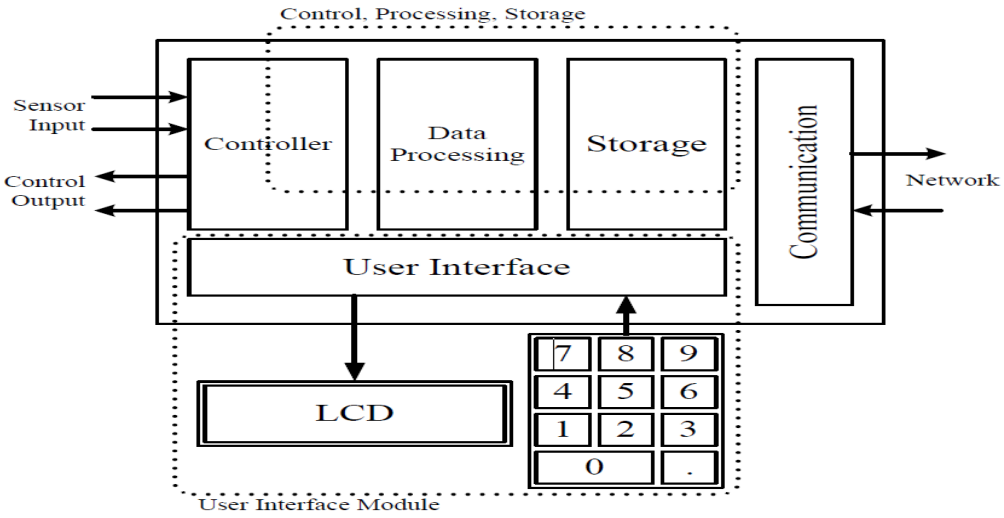

Figure 1 – A typical embedded system [3].