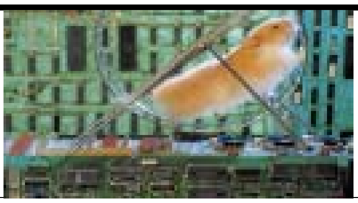

14 - Embedded processing

Ninety-eight per cent of the world's microprocessors are included in devices that are not designed nor sold as computers.[1]

The term "embedded processor" refers to the use of the microprocessor rather than any particular design aspect and is a general term that excludes desk-top computers or servers. Embedded processors are "programmable" rather than perform an application-specific function that is unchanging and these functions do not depend upon software.

Embedded microprocessors can be placed into one of three broad categories. These are:

Microprocessors – general-purpose integrated circuits that have a high-performance characteristic with little ability for integration with other devices.

Microcontrollers – integrated circuits that include memory characteristics and can communicate with other peripheral devices.

Digital signal processors – devices translate analogue signals into digital data streams and are used for sound, video and radio frequency applications.

The application of integrated circuits and microprocessors in an increasingly broad range of products would not surprise any reader within the industries covered by this Shared Technology Project. The use of microprocessors, microcontrollers and digital signal processors in new devices is presumed and therefore the relevance of the need for this chapter may be questioned.

The goal of this chapter is to provide an overview of the range of embedded processors so that a clearer understanding can be achieved as to how the integration of microprocessors and devices will affect the activities of operatives in these industries. When a technician is faced with the selection of a replacement product he or she will need to be able to intelligently assess the suitability of the new device. Those who are familiar with up-grading computer components will know that not all new devices will operate successfully with4 legacy equipment.

Technology

The architecture of integrated circuits may be divided into one of two broad areas. One is Complex Instruction Set Computing (CISC) and the other is Reduced Instruction Set Computing (RISC). See Box 14.1 - Microprocessor Architectures for a more detailed review.

Complex Instruction Set Computing (CISC) microprocessors are able to have more built-in functions and have a comparatively large memory. These processors are able to handle variable-sized data packets that are used in a Transmission Control Protocol / Internet Protocol (TCP / IP) transmission or in video data streams.

Reduced Instruction Set Computing (RISC) microprocessors are a more recent architecture development and are smaller and faster than CISC microprocessors. As these RISC are smaller and have a ‘reduced’ profile, they also draw less power.

Digital Signal Processors (DSPs)

Digital signal processors (DSPs) capture a variable-intensity analogue measure such as light, heat or movement and translate this measure into a digital signal. Within the Shared Technology Industries, this role is very important and the applications are seemingly endless. Without digital signal processors, advancement in these Shared Technology Industries would be limited to traditional analogue devices.

One of the differences between embedded DSPs and microprocessors or microcontrollers is that DSPs must function in real-time rather than respond to data. The DSP needs to be designed to respond in one processing cycle rather than spread processing across a number of cycles. Also as a DSP is operating in real-time there is no need to hold in memory any data and this frees the DSP to carry out the numerical-intensive calculations.[2] See Box 14.2 Digital Signal Processor Operations for more information.

As mentioned at the beginning of this chapter, there are many times more processors being embedded than are being used in desk-top computers. A broad distinction of DSP applications developing into either wireline network-connected devices (that is always connected to a power source) or mobile devices (that require low power usage). Power reduction is also important and processor manufacturers are seeking to combine both a DSP and other necessary microprocessors or microcontrollers on to a single silicon chip.[3]

BOX 14.1 - MICROPROCESSOR ARCHITECTURES

Application Specific Integrated Circuit *(ASIC) - This microprocessor is designed to accomplish a specific task. As a result it is able to undertake this task very quickly and efficiently. These microprocessors are expensive to develop but the designer can utilise a library of existing circuits to reduce costs.*

Complex Instruction Set Computing *(CISC) - This is the oldest architecture in microprocessor design. When originally developed, this design did not rely on system memory as memory was expensive. Also, the number of transistors that were able to be included was limited by manufacturing technology. This microprocessor uses variable-length instructions that take longer to execute by comparison to other designs.*

Reduced Instruction Set Computing *(RISC) - These microprocessors use fixed-length instructions that are faster to execute and can be grouped together to increase overall processing capabilities. This arrangement was considered to be superior to CISC microprocessors but performances are now relatively equal.*

Very Long Instruction Word *(VLIW) - A word is the data size of the instruction and can be 16 bits (2 bytes), 32 bits (4 bytes), 64 bits (8 bytes) and so on. Each word is processed within one clock cycle (MHz or GHz) and these microprocessors are able to process routine information quickly. As a result these types of microprocessors are used in multimedia, scientific and engineering programs particularly in high-speed digital signal processors.*

Explicitly Parallel Instruction Computing *(EPIC) - This architecture is the newest design that merges RISC and VLIW concepts. As named, the processor is able to define which instructions can be run parallel (rather than linearly) and is able to compile high-level programs more efficiently using a 128 bit register. This design is from a joint project with Hewlett Packard (HP) and Intel with the brand name Itanium.*

BOX 14.2 - DIGITAL SIGNAL PROCESSOR OPERATIONS

A Digital Signal Processor (DSP) converts analogue-to-digital and digital-to-analogue signals. A mobile telephone contains both types – one for the microphone and another for the speaker. The DSP is required to sample analogue signals within a fixed time period and convert these into a digital signal. The DSP performs this process using one or both of the following operations.

> ***Frequency-domain analysis*** *– this converts the time-based signal to a digital signal. By measuring the waveforms of the physical phenomena and calculating the sum of the sine waves a digital signal can be created.*
>
> ***Digital filtering*** *– any conversion process from analogue-to-digital will be imperfect. In order to reduce the error (or noise), a DSP can employ a filter to "clean" the digital signal. This can be accomplished using one of two calculation processes.*
>
> > *One is to feed back the calculation into the new time-based signal and this is termed infinite impulse response. This method provides for high-performance but can be unstable.*
> >
> > *The other method is to employ a coefficient to the signal (as does the infinite impulse response) and send the result forward. This second method is termed finite impulse response and provides for a stable computation but few performance characteristics.*

Applications of Embedded Processors

A complete list of all the applications of embedded processors within the Shared Technology Industries would be lengthy and soon be out of date. However there are a number of interesting advancements in embedded processing that can be outlined which will continue to be relevant.

Radio Frequency Integrated Circuits (RFIC)

These microprocessors are used to relay analogue radio frequency signals to a digital processor. Historically, the analogue digital signal processor was a separate processor to the rest of the device. These two devices were not able to be combined because radio frequency circuits suffer from interference caused by the other radio frequencies contained in the digital signal.

The goal of having a single chip or “system-on-a-chip” would reduce power consumption and speed the processing from analogue-to-digital signals. This development could reduce the cost of the microprocessor to one-tenth of the current costs by eliminating three-dimensional parts such as amplifiers, capacitors and oscillators. The manufacturer Intel is working on developing this type of microprocessor using a micro-electromechanical design.[4] (For more information on this topic, see Chapter 16 - Microelectromechanical Systems (MEMS).

Software Defined Radio

This technology allows for the re-configuration of radio-frequency devices such as a mobile computing device. Presently all radio frequency devices have hard-wired microprocessors to undertake the task of converting a specific analogue signal to a digital signal. However if the frequency that the microprocessor accesses is able to be determined by software rather than hardware then the flexibility of use of the device increases.

This function would be able to be accomplished through the development of a Radio Frequency Integrated Circuit (RFIC mentioned above) or through a Field Programmable Gate Array (See Chapter 15) microprocessor that is a re-programmable microprocessor. Hybrid designs are currently in progress that incorporate this technology.[5]

Microprocessor Microphones

In engineering, the new networks will allow for monitoring the vibration and frequency of sounds emanating from the equipment. As the vibration or frequency changes, engineers can predict the life-expectancy of a particular device. By incorporating digital signal processors into the equipment, self-diagnostic software can be used to provide for planned maintenance as in destruction testing of the equipment that will provide a database for maintenance engineering.

The company Akustica has produced a 2mm square microprocessor that contains 64 microphones on a single silicon chip. This development also allows an embedded processor to capture the sound frequencies and forward the signal for analysis. This development also has implications for mobile handsets and hearing aids.[6]

Summary

In Part 2 of this report, networking the interconnection of various devices is examined. The assumption within this Part is that each of the devices discussed here is networked and would contain embedded processors. These processors are either proprietary-based processors such as Echelon’s Neuron chip or a standard-compatible processor for open systems such as BACnet or Foundation Fieldbus.

The design, manufacture and marketing of these embedded processors may be undertaken by one or many companies. Some companies only design and others only manufacture. As advancements of microprocessors are increasing at a steady rate, it is reasonable to assume that the useful life a device will be limited. Technicians in the Shared Technologies Industries will need to keep pace with these changes in order to provide clients with accurate and timely information on strategies for equipment replacement and upgrade.

IMPLICATIONS FOR THE SHARED TECHNOLOGY INDUSTRIES

Automotive

One third of the embedded processors are used in the automotive industry. This use is expected to increase as automotive manufacturers employ more processing power within vehicles. The move to “fly-by-wire” where electric signals are sent from one device to another (as in accelerator control to the throttle) are expected to increase. The automotive technician of the future will be more of an electronics expert than mechanical.

Building and Construction

Within the networks created for building automation, the integration of system and the ability to have devices communicate directly with each other as well as through a control centre will increase with the continuing advances of embedded processors. Technicians in this area will need to be able to ensure that correct installation of security, emergency and environmental controls is properly commissioned.

Electrical

This industry will need to become more familiar with the capabilities of fitted devices. As the devices increase in number and capacity, operatives will need to ensure that issues regarding compatibility are resolved. Additionally, these technicians will need to be able to advise their clients in relation to the installation of new equipment. This will require continuing professional development.

Electronics

This industry will drive the design, implementation, commissioning and repair of these devices. Each person working in this area will be required to maintain an awareness of the merging of currently separate devices into single, compact microprocessors. This is likely to include more of a focus on radio frequency issues and network connectivity.

Engineering

Members of this industry will need to remain aware of the increasing availability of superior devices. The ability to create an integrated system with increased data recording capacity will be a challenge for those who have not engaged in professional development.

Information technology

As this industry is familiar with change and processing in general, few challenges other than continuing professional development will affect technicians working in this area.

Telecommunications

The next generation of microprocessors is likely to include more networking and wireless communications features. This increase will have an impact on the telecommunications industry and will continue place it within a software-defined industry.

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[1] PricewaterhouseCoopers. (2002). *Technology Forecast 2002-2004: Volume 2 – Emerging patterns of internet computing*, p. 112. Menlo Park, CA: Author.

[2] PricewaterhouseCoopers. (2002). *Technology Forecast 2002-2004: Volume 2 – Emerging patterns of internet computing*, p. 130. Menlo Park, CA: Author.

[3] PricewaterhouseCoopers. (2002). *Technology Forecast 2002-2004: Volume 2 – Emerging patterns of internet computing*, p. 130-131. Menlo Park, CA: Author.

[4] *Technology Review*, June, 2002. Radio-ready chips: All-silicon radios could make everything wireless, pp. 22-24. Also see Pawlowski, S. S. (2002). *CMOS radio: Expanding Moore's Law with ubiquitous, silicon-based wireless connectivity*. Santa Clara, CA: Intel. Available: http://www.intel.com/technology/ultrawideband/downloads/EML_radio.pdf Accessed: 20 April, 2003.

[5] PricewaterhouseCoopers. (2002). *Technology Forecast 2002-2004: Volume 2 – Emerging patterns of internet computing*, p. 457. Menlo Park, CA: Author.

[6] *Technology Review*, February, 2003. One-chip audio, p. 18.