Embedded Multiprocessors

Scheduling and Synchronization

Sundararajan Sriram
Shuvra S. Bhattacharyya

Signal Processing and Communications Series

Embedded Multiprocessors

Signal Processing and Communications

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To my parents, and Uma

Sundararajan Sriram

To Arundhati

Shuvra S. Bhattacharyya

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SERIES INTRODUCTION

Over the past 50 years, digital signal processing has evolved as a major engineering discipline. The fields of signal processing have grown from the origin of fast Fourier transform and digital filter design to statistical spectral analysis and array processing, and image, audio, and multimedia processing, and shaped developments in high-performance VLSI signal processor design. Indeed, there are few fields that enjoy so many applications—signal processing is everywhere in our lives.

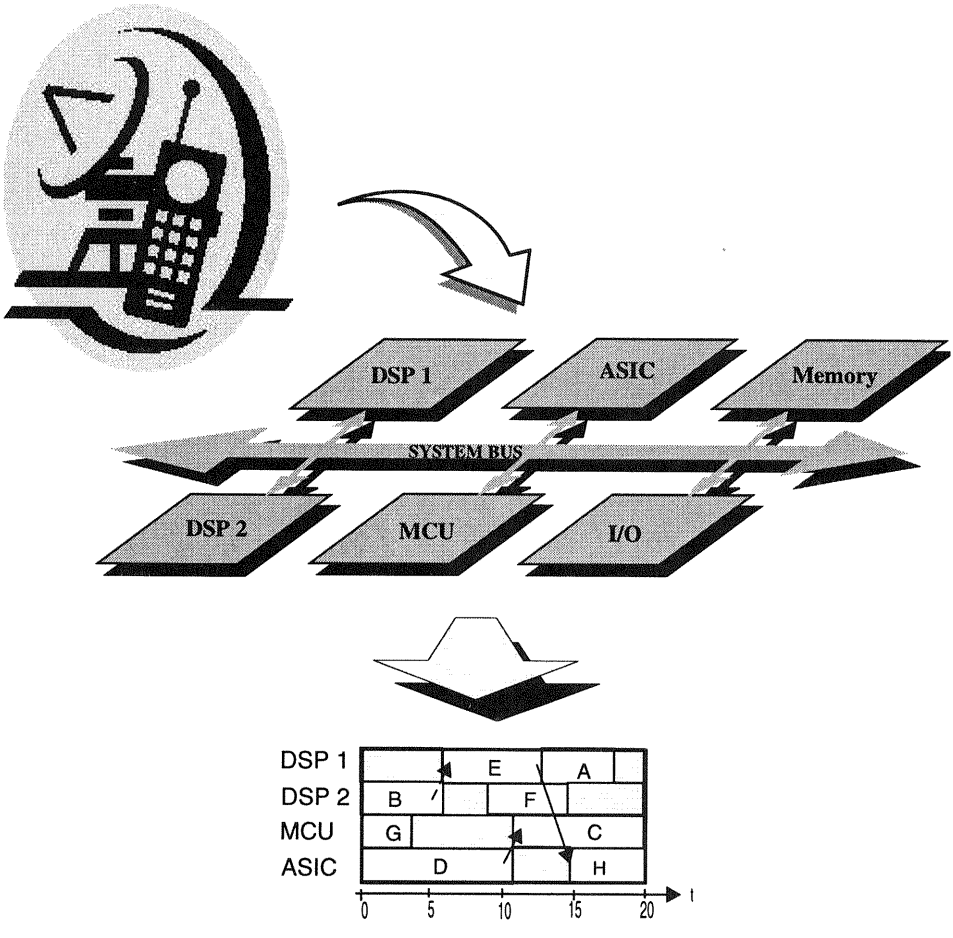
When one uses a cellular phone, the voice is compressed, coded, and modulated using signal processing techniques. As a cruise missile winds along hillsides searching for the target, the signal processor is busy processing the images taken along the way. When we are watching a movie in HDTV, millions of audio and video data are being sent to our homes and received with unbelievable fidelity. When scientists compare DNA samples, fast pattern recognition techniques are being used. On and on, one can see the impact of signal processing in almost every engineering and scientific discipline.

Because of the immense importance of signal processing and the fast-growing demands of business and industry, this series on signal processing serves to report up-to-date developments and advances in the field. The topics of interest include but are not limited to the following:

- Signal theory and analysis
- Statistical signal processing
- Speech and audio processing
- Image and video processing
- Multimedia signal processing and technology
- Signal processing for communications
- Signal processing architectures and VLSI design

I hope this series will provide the interested audience with high-quality, state-of-the-art signal processing literature through research monographs, edited books, and rigorously written textbooks by experts in their fields.

K. J. Ray Liu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FOREWORD

Embedded systems are computers that are not first and foremost computers. They are pervasive, appearing in automobiles, telephones, pagers, consumer electronics, toys, aircraft, trains, security systems, weapons systems, printers, modems, copiers, thermostats, manufacturing systems, appliances, etc. A technically active person today probably interacts regularly with more embedded systems than conventional computers. This is a relatively recent phenomenon. Not so long ago automobiles depended on finely tuned mechanical systems for the timing of ignition and its synchronization with other actions. It was not so long ago that modems were finely tuned analog circuits.

Embedded systems usually encapsulate domain expertise. Even small software programs may be very sophisticated, requiring deep understanding of the domain and of supporting technologies such as signal processing. Because of this, such systems are often designed by engineers who are classically trained in the domain, for example, in internal combustion engines or in communication theory. They have little background in the theory of computation, parallel computing, and concurrency theory. Yet they face one of the most difficult problems addressed by these disciplines, that of coordinating multiple concurrent activities in real time, often in a safety-critical environment. Moreover, they face these problems in a context that is often extremely cost-sensitive, mandating optimal designs, and time-critical, mandating rapid designs.

Embedded software is unique in that parallelism is routine. Most modems and cellular telephones, for example, incorporate multiple programmable processors. Moreover, embedded systems typically include custom digital and analog hardware that must interact with the software, usually in real time. That hardware operates in parallel with the processor that runs the software, and the software must interact with it much as it would interact with another software process running in parallel. Thus, in having to deal with real-time issues and parallelism, the designers of embedded software face on a daily basis problems that occur only in esoteric research in the broader field of computer science.