Current Challenges in Embedded Communication Systems

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ABSTRACT

This article defines and analyses key challenges met in future embedded systems in networked multimedia and communication applications. Self-awareness, interoperability and embedded security are used to characterize different aspects of designing and implementing next generation embedded systems. The dynamic nature of applications and implementations as well as possible technological faults and variations need to be considered in system verification and modeling. A new design layer needs to be added to current NoC platforms in order to build procedures that take into account dynamic system reconfigurations, fault-tolerance aspects and flexible portability. Increased modularity and networked implementations create a need for trust management mechanisms between system components and technology for analyzing validity and correctness of received application and system configuration information.

Keywords: Data Security, Design Verification, Embedded Systems, Fault-Tolerant Systems, Modular Design, Networking, Processors, System Modeling, Telecommunications

INTRODUCTION

Technological evolution towards the nanoregime has lead to remarkable improvements in capacity and performance of embedded systems. Processing capacity has increased a thousand-fold since the early days of embedded systems, allowing their penetration to completely new application areas. The focus has changed from the simple control oriented tasks via peripheral circuitry to mobile and personal high-speed multimedia processing, often with network interfaces. Many of these applications may even require continuous access to very high speed networks everywhere. The changes in the roles of and the tasks performed by embedded systems create new challenges to be solved during the design process. The derivation of these challenges for embedded systems is presented in detail in Figure 1.

The implementations of future nanoscale electronic systems can be based either on advanced CMOS-style technologies ranging between 0.1 – 0.05 µm, or completely new, emerging technology approaches. In either case, the strategic issue is scalability towards and beyond gigascale integration in three domains:

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a. Architectural and system scalability with respect to complexity
b. Performance scalability with respect to geometrical scaling in underlying device and circuit structures
c. Design effort scalability with respect to increased functionality

Very high-speed access networks approaching gigabit speeds and providing continuous network access provide also a new dimension to system scalability. A system implementation can be composed of multiple networked embedded systems instead of being limited to a single network node. Scalability in all the three perspectives and a demand for networked multiparty connections define the key characteristics required of the platform solution. Thus, the platforms need to provide extensive parallel processing power with seamless network support. In order to benefit from such platforms properly, the system and algorithm level solutions need to provide extensive support for concurrency of operations.

Although quite many systems are basically sequential by their nature, their parallelism can still be increased at the system architecture level. In addition to different types of parallel techniques, also distributing the system functionality into modular self-contained components is vital in order to decrease the complexity of the design phase and to provide splitting of the system into multiple processing units and network nodes. Typically, system components are highly diverse by their functionality and interconnections, yet they must together compose coherent system functionality. Similarly, network nodes and their communication infrastructures might differ from each other heavily. They are often dynamic and time-dependent. Even parallel platforms themselves are seldom highly homogenous by structure. System reconfigurability is necessary to provide support for programming that is targeted to decreasing these dissimilarities and making the platform suitable for multiple applications, thus further increasing product life-times and design economy.

In the development towards more computer-like mobile communication devices, that is, embedded communication systems, the system-level design process and the design of hardware and software components of the system are facing brand new challenges: despite the small size and reliance on battery power, the devices
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