"Fresh Air": The Emerging Landscape of Design for Networked Embedded Systems

Radu Marculescu
Carnegie Mellon University
Department of ECE
Pittsburgh, PA 15213, USA
radum@ece.cmu.edu

Borivoje Nikolic
University of California
Department of EECS
Berkeley, CA 94720, USA
bora@eecs.berkeley.edu

Alberto-Sangiovanni Vincentelli
University of California
Department of EECS
Berkeley, CA 94720, USA
alberto@eecs.berkeley.edu

ABSTRACT

As implementation architectures for complex systems evolve towards heterogeneous multiprocessing, let this be on a single chip or on a geographically distributed area, the importance of communication has reached unprecedented peaks. Indeed, due to the complex nature of interaction among its components, any complex system has behaviors that may be highly unpredictable. Dealing with such behaviors requires a deep understanding of various ways to enable communication and account for complex traffic patterns among different components of the system.

So far, successful design of many integrated systems has been primarily based on algorithms and design methodologies meant to work under deterministic conditions where communication is considered in an ancillary role. However, in the light of emerging systems and applications (e.g. networked cars and buildings, smart surfaces and dense networks for health monitoring, and multi-core chips at nanoscale) this deterministic, computation-centered mindset no longer offers an appropriate approach. Indeed, such systems are highly distributed and heterogeneous, unreliable and redundant, so new approaches, distributed and stochastic in nature, need to be developed. Consequently, we need to move from a deterministic, computation-centered to a probabilistic, communication-based design paradigm to compensate for the lack of predictable behavior which used to be the norm in traditional systems. We need to consider optimization strategies that work in distributed collaborative networks and find new ways to model communication and traffic distributions in cars, buildings, or chips.

Starting from these overarching ideas, this special session is meant to address the concept of probabilistic, communication-centric design in a variety of contexts and identify specific design principles and optimization techniques that are poised to redefine the landscape of system design in the near future.

The first talk by A. Sangiovanni-Vincentelli addresses distributed embedded systems, with particular attention to automotive electronic systems and intelligent buildings. The importance of selecting the communication protocols and architecture is underlined. The design criteria will be examined. The problem of distributing a complex application on a number of networked processing elements that may subjected to faults caused by harsh environments will be analyzed. The talk presents a unified approach to the design of these networks of embedded systems and the recent advances in automatic selection of protocols, topologies and architectures with examples in the automotive and intelligent building domain.

The second talk by B. Nikolic addresses challenges in communications systems presented by the way radio spectrum is being shared today. It presents scenarios for the spectrum reuse on a dynamic basis, to achieve a more robust system for massive deployment of wireless terminals. Allocated, but unused portions of the spectrum are used by secondary, cognitive, basis. The ideas of packet multi-hop and spatial multiple-input, multiple-output (MIMO) systems will be discussed in this context.

The third talk by R. Marculescu focuses on systems designed at nanoscale. The emphasis of presentation is on probabilistic modeling and optimization of emerging systems where communication happens via the NoC approach. Instead of taking the classical path of using queuing models for network optimization, this talk argues in favor of a substantial paradigm shift in network design based on adopting a quantum-like approach to model the information exchange and buffer behavior in NoC platforms.

Categories and Subject Descriptors

J.6 [**Computer-Aided Engineering**]: Computer-Aided Design, C.2.1 [**Computer-Communication Networks**]: Network Architecture and Design, B.7.1 [**Integrated Circuits**]: Types and Design Styles.

General Terms

Algorithms, Performance, Design, Reliability, Verification.

Keywords

Embedded systems, distributed systems, low-power, wireless communication, multi-core chips.

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