MICS_MOBILE_INFORMATION_AND_COMMUNICATION_SYSTEMS

IP9 Communicating Embedded Systems

Reconfigurable Hardware in Wireless Networks

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Advantages of Reconfigurable Hardware

IP 9 deals with the design of Communicating Embedded System (CES) such as Terminodes. This work investigates reconfigurable hardware in wireless network nodes.

Project Goal

A Terminode is ...
- a heterogeneous device
- a terminal to user (audio- and video coding, sensor data processing, ...)
- a network node (store and forward, QoS routing, cryptography, ...)

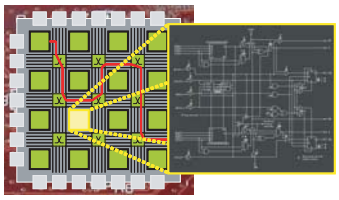
Terminodes require ...
- occasionally a high amount of local processing power
- flexibility to reprogram and update

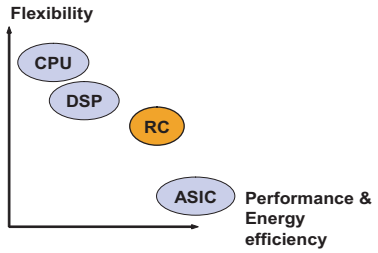
Performance / Flexibility Trade-Off

Goal: Design of Flexible Terminode Platform for High Performance Streaming Applications

Advantages of Reconfigurable (RC) Hardware

Predominant device: FPGA





RC most efficient for:
- regular and parallelizable operations
- bit-level operations
- custom bitwidths

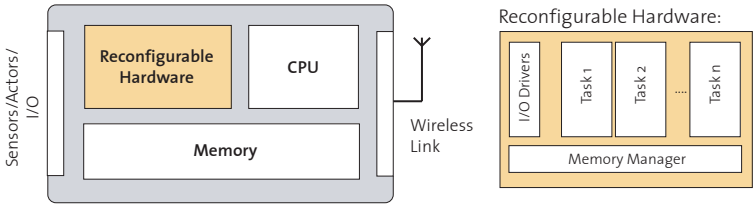
→ **DSP, Crypto, Communication**

Examples:
Mencer et al [ICASSP'98]: IDEA encryption:

Type	Device	Mbit/s	Mbit/Ws
CPU	StrongARM SA-110	32.0	32.0
DSP	TI TMS320C6x	53.1	8.9
FPGA	Xilinx XC4020XL	528.0	167.6

Research Issues

Target Hardware Architecture

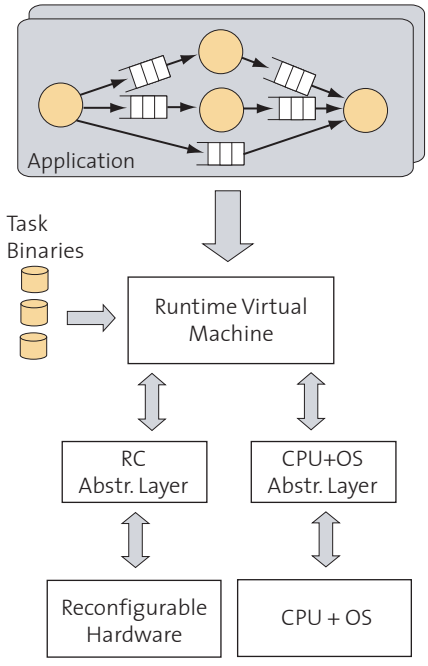


Prototyping Platform

CPU + OS, IPAQ h3970:
- Intel xScale @ 100-400 MHz
- PocketPC 2003 (WinCE 4.1) real-time operating system
- integrated Bluetooth IF
- optional WLAN

Reconfigurable Hardware:
- Xilinx Spartan II FPGA (200k Gates)
- CPLD, 1Mbit SRAM, 8Mbit Flash

Programming Model - Virtual Machine



Model of Computation:
- Focus on stream-based applications, specified as Process Networks.
- Task coordination language:
  - in interpretable format
  - clear semantics to check real-time properties

HW/SW Tasks:
- Task implementations are platform optimized: -> *no performance loss*
- downloadable over wireless network

Abstraction Layer:
- Virtualization of reconfigurable logic
- provides a common interface to the virtual machine

Publications / Related Work

Publication:
- Plessl,-C. et al.: *The case for reconfigurable hardware in wearable computing,* Personal and Ubiquitous Computing, Springer-Verlag, Vol. 7, No. 5, pages 299-308, Oktober, 2003.

Wireless Network Nodes and Virtual Machine:
- Levis,-P.; Culler,-D.: *Mate: a tiny virtual machine for sensor networks,* SIGPLAN-Notices. Oct. 2002; **-> difference to this work**: focus on code size minimization, assembler-like code, not suited for high performance tasks.
- Liu,-T.; Martonosi,-M.: *Impala: A Middleware System for Managing Autonomic, Parallel Sensor Systems,* PPoPP'03; June 2003; **-> difference to this work**: focus on remote update, no task coordination.
- Henzinger,-T.-A.; Kirsch,-C.-M.: *The Embedded Machine: Predictable, Portable Real-time Code*, PLDI'02, May 2002; **-> difference to this work:** designed for control applications, not suited for streaming applications, synchronization by explicit driver calls.

Reconfigurable Computing:
- Yajun,-H. et al.: *A hardware virtual machine for networked reconfiguration,* RSP'00, June 2000; **-> difference to this work:** direct byte code interpreter for FPGA circuits, virtualization of FPGA-routing -> performance loss.
- Nollet, V. et al.: *Designing an operating system for a heterogeneous reconfigurable SoC,* IPDPS'03, April 2003; **-> difference to this work:** no specific model of computation.