RADIO VIRTUAL MACHINE

VIRTUAL MACHINE FOR RECONFIGURABLE RADIO

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OUTLINE

• Radio Computing and RVM Semantics
• Radio Virtual Machine
• RVM Applications
  • Reconfigurable Radio
  • Dynamical Certification
  • Communication Platform Co-Design
RADIO COMPUTING

Definition

• Radio Computing considers wireless communications as a domain-specific embedded computing which has deal with algorithms specific for wireless communications and related to radio waves processing. It assumes the radio computer interacts with external world (radio spectrum) and is capable to receive and to emit radio waves.

Main Objectives

• Defining notion of software for communication platforms

• Building effective, according to given criteria, a Radio Computer as a holistic entity by combining jointly optimized hardware and software.
# Radio Computing vs. General Purpose Computing

<table>
<thead>
<tr>
<th>Radio Computing</th>
<th>General Purpose Computing</th>
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</thead>
<tbody>
<tr>
<td>Application specific computations</td>
<td>Any type of computations</td>
</tr>
<tr>
<td>Computation are composed from basic block of different granularity specific for selected application area</td>
<td>Computation are composed from basic arithmetic and logic operations;</td>
</tr>
<tr>
<td>True concurrent heterogeneous MoC</td>
<td>MoC with interleaving concurrency</td>
</tr>
<tr>
<td>Computer interact with real world</td>
<td>Isolated computations</td>
</tr>
<tr>
<td>Targeted on heterogeneous hw platforms</td>
<td>Targeted mostly on homogenous hw platforms</td>
</tr>
<tr>
<td>Real-time computations</td>
<td>Mostly non-real time computations</td>
</tr>
</tbody>
</table>
RVM SEMANTICS

- Data – 0-transition
- Operators – 1-transition
- Concurrency relation $p_1 \# p_2 \iff s(p_1) \cap s(p_2) = \emptyset$ & $t(p_1) \cap t(p_2) = \emptyset$
- A scheme $N$ is a tuple $(Q_0, Q_1, \lambda, \#)$.
- If $p_1 \# p_2 \# \ldots \# p_K$ then $<p_1, p_2, \ldots, p_K>$ - K-transition
- $N$-transition $\iff$ $N$-cube
- A scheme $N = (Q_0, Q_1, \lambda, \#)$ is a cubical set.

Pipeline Processing

Geometry of Pipeline Processing
**SPECIFIC RVM**

- includes modules of different granularity;
- modules are taken from Radio Lib or assembled from Radio Lib elements;
- concurrent and data-driven execution;
- static or dynamic unrolling;
- modules are composed from configcodes executed on RVM.

802.11a TX
EXAMPLE 1: CONVOLUTION

2-order FIR filter

Specific RVM for 2-order FIR
RADIO VIRTUAL MACHINE
UNIVERSAL RVM

[Diagram of eRVM with arrows and blocks labeled Basic operations, Program memory, Control Unit, Abstract switch fabric, APE, data, status, and External ports.]
EXAMPLE 2: PIPELINE

Specific RVM

Universal RVM
APPLICATION 1: RECONFIGURABLE RADIO SYSTEM ARCHITECTURE

Radio App \textit{source code} \rightarrow \text{RadioApps Storage} \rightarrow \text{Target platform} \rightarrow \text{Radio Operating System} \rightarrow \text{Radio Computer}

\text{Design time} \rightarrow \text{Run time}

Radio App \textit{configcode} \rightarrow \text{RadioApps configcode} \rightarrow \text{Radio Operating System}

\text{Compiler}

\text{RadioApp configcode}

\text{Radio Lib}

\text{BE Compiler}

\text{RVM}

\text{HW Platform}

\text{RadioComputer}

\textit{Radio Application}: is software which enforce RVM or particular RP to generate or receive radio waves
RECONFIGURABLE RADIO: VENDOR’S CLOUD SERVICE
1. The initial certification of the RE:
   • similar to the conformity testing and declaration of conformity certification for non-reconfigurable RE;
   • Certification of RF part.

2. 3rd party configcodes certification:
   • certified execution of RadioApp on RVM.

3. Self-certification:
   • verification of downloaded RadioApp against reference execution on RVM
APPLICATION 3: PLATFORM CO-DESIGN

Design Phases

**Base Phase**
- Reference Radio Library mapping

**Phase 1 (application model)**
- rApp Exploration: rApps to FUs mapping

**Phase 2 (arch model)**
- System-Level Architecture Exploration: rApps to Arch Template mapping

**Phase 3**
- System Level Refinement
CONCLUSION

• We proposed vision on wireless communications as domain-specific Radio Computing;

• Radio Virtual Machine plays fundamental role for Radio Computing providing domain-specific abstract machine and defines semantic of computations

• We shown 3 applications of RVM:
  1) Reconfigurable Radio Architecture definition and solution of the configuration portability problem
  2) Solution of the dynamical certification problem
  3) Communication platform co-design
THANK YOU!

Questions?