A novel hierarchical and parallel model for wireless network simulations and its design using Ptolemy II infrastructure

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• Background and Problem Statement
• Approach
• Analysis
• Design
• Results and Conclusions

Background
Modeling a Radio Access Network

Reality  -->  Model

Physical time, real world actions  -->  Dynamic Analysis  -->  Dynamic Design (Simulation Engine)

Static Analysis  -->  Static Design (object oriented class library)

Done

Simulation Engine: Problems

- Stochastic, discrete, and dynamic simulations
- State of the art: discrete event simulations
  - Sequential (slow, but simple scheduling)
  - Parallel/Distributed (PDES)
    - Complicated synchronization algorithms
- Speed up in radio access network simulations depends on: partitioning vs. multiple access scheme
- Known partitioning strategies not usable with CDMA networks
**Starting Point / Approach**

- **known** Static Design
  - UML
  - A Meta Language (Tagged Signal Model)

- **unknown** Model of Computation
  - Mathematics
  - Dynamic Analysis

- **goal** Dynamic Design (Simulation Engine)
  - UML

**Static Design: 3 Key Elements**

- **Network Element Activation**
- **Transmission Channel**
- **Network Element**
Dynamic Analysis

Example: Global Interactions

- Time resolution: $z$
- Time slot or time frame of duration $d$

$$\text{Channel} \quad \text{Activation} \quad \text{Network Element}$$

- Channel: repeated interactions at: $h_{CA} = z \cdot d, N = \{z, 1 \leq z < n, z \in N\}$

$$E_{CA} = (E_{CA1} \uplus E_{CA2} \uplus E_{CA3} \uplus E_{CA4}), \forall z \in N$$

- Activation: random interactions at: $h_{AA} = \lambda_a, M = \{a, 1 \leq a < m, a \in N\}$

- Set of all interactions: $E_{\text{global}} = E_{CA} \uplus E_A$

- Set of all time stamps: $H_{\text{global}} = H_{CA} \uplus (H_A \setminus H_{CA})$
Dynamic Analysis: Results

synchronization = rendezvous

Dynamic Design: Theory
**Dynamic Design on Ptolemy II**

Interactions in Ptolemy II

- **novel domain for rendezvous interactions**
- **network element type partitioning**
- **sequential method calls**
- **rendezvous interactions**
- **global time**
- **discrete events**
- **local time**
Conclusions: PDES of CDMA Radio Access Networks

• **Synchronization algorithms**
  • mathematical analysis of interactions proves unordered interactions: *parallelism possible*
  • a-priori knowledge about interactions' course allows novel, tailored, and very simple „pessimistic“ synchronization using rendezvous interactions

• **Partitioning, especially for CDMA networks**
  • hierarchical design
  • partitioning strategy: types of network elements

• **Speed up vs. sequential**
  • on multi processor workstation about 1.2 ... 1.6