C based Modelling of Embedded Mixed Signal Systems

Institut für
Computertechnik

ICT

Institute of
Computer Technology

Ch. Grimm[1], K. Einwich[2]

[1]TU Vienna
[2]Fraunhofer IIS/EAS Dresden

Motivations for C-Based approaches

- DSP methods include an increasing amount of control flow
  - SPUC, Ptolemy, …
  - HetSC, …
- DSP methods and AMS circuits are often functionally interwoven and can only be analyzed as a whole
  - MixSigC, ASC, SEAMS
  - SystemC-AMS

C based Modelling of Embedded Mixed Signal Systems

- **Before (or without) SystemC**
- **SystemC based**
- **What‘s next?**

Very early approaches …

- Many companies had in-house approaches, often starting in the 90s and maybe even earlier
- Motivation:
  - Simulator coupling backplane
  - Accelerated system simulation
- Example:
  AVSL [Meise et al.]

Signal Processing using C++ (SPUC, ´93-‘05)

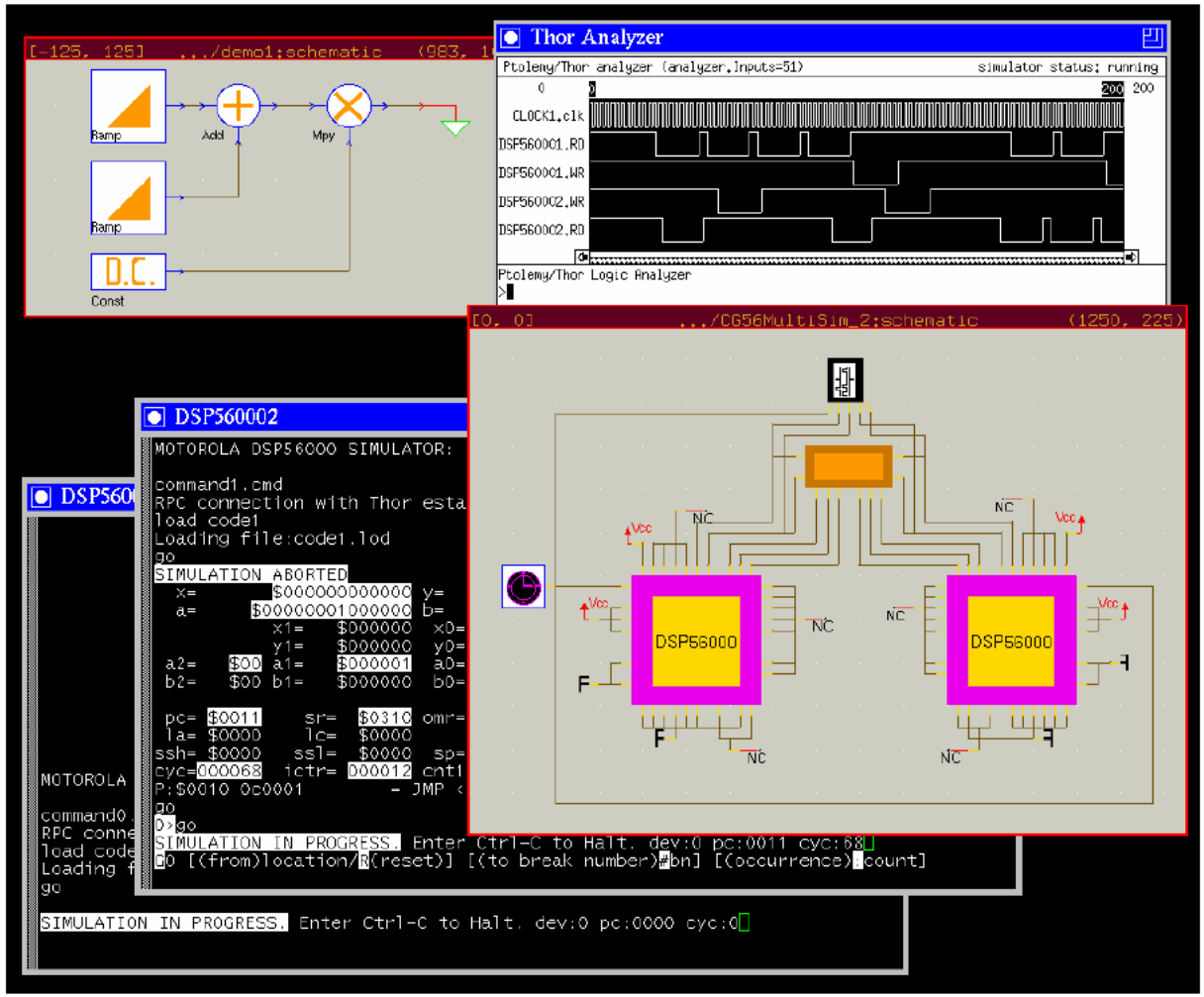
- From TI/HP stuff??? (Name of company has been removed …)
- Motivation
  - Faster System level simulation
  - Allows modelling of complex control flow in C/C++

- Open Source (sourceforge!)
- Most notably a DSP library in C/C++, no analog stuff
  - Modeling Digital Filter Functions, …

Ptolemy [Lee, Messerschmidt; ´90-´97]

- Used to study interaction of different simulators (MoC), Modelling/Simulation/Design of DSP systems
- Discrete-event, process networks, synchronous/reactive, and finite-state machine models of computation in C++
- Generates C-Code (or Assembler) for DSP realization
- Commercial Products: Agilent ADS, Cadence SPW
- → Ptolemy II

Ptolemy [Lee, Messerschmidt; UCB]



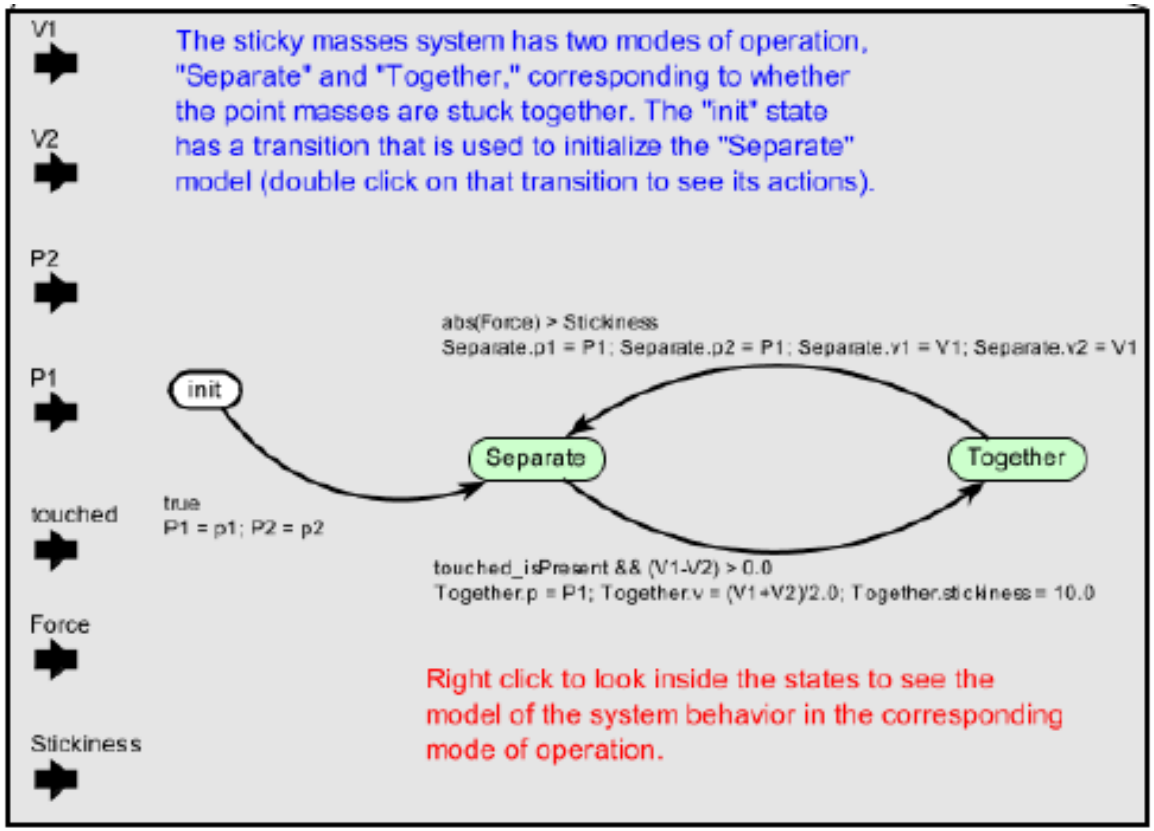
Ptolemy II [Lee et al, 1996-now]

- **Focus: Functional level modelling of DSP and other abstract heterogeneous systems**

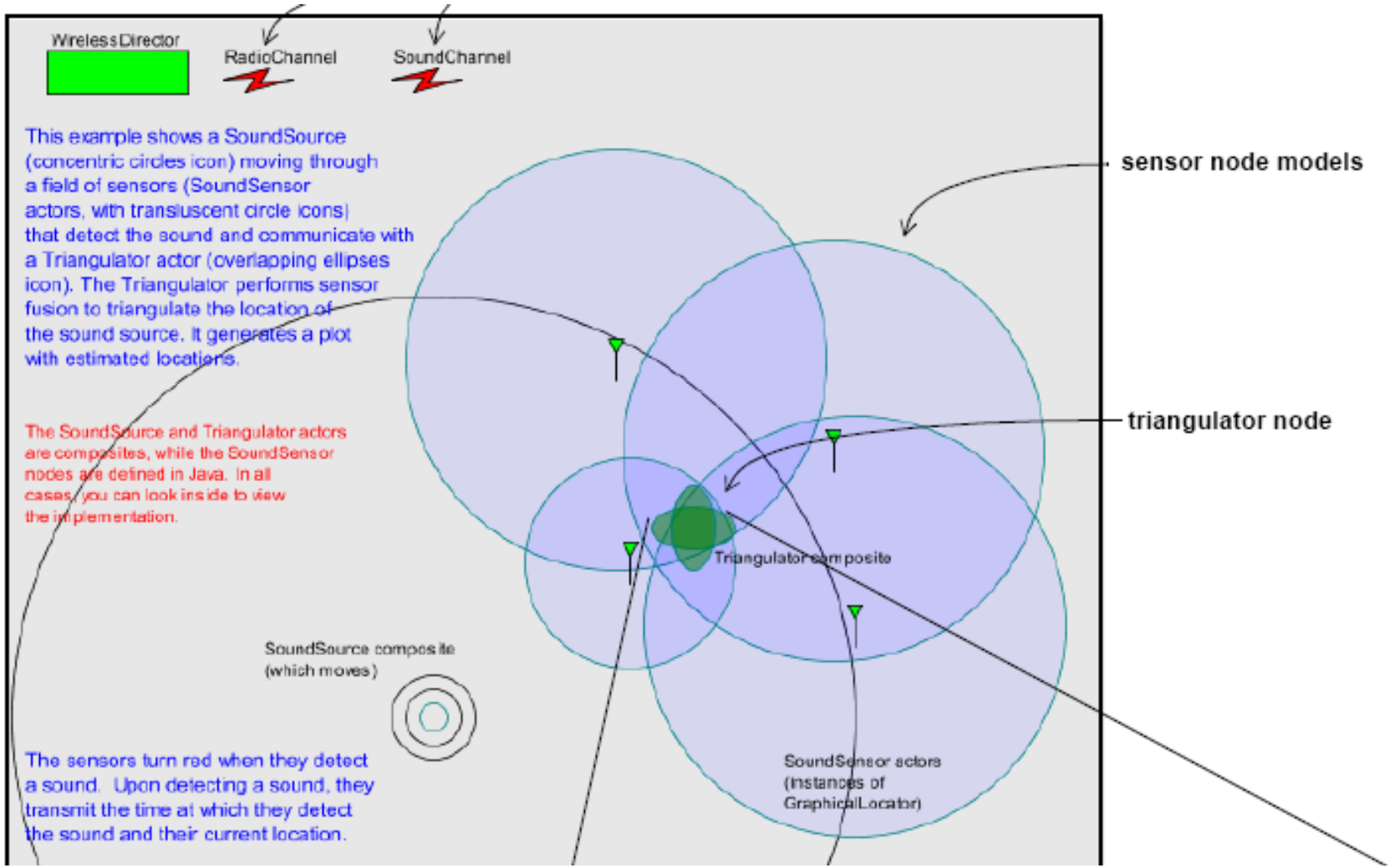
- Java based
- CT domain
  - DAE, interaction with DE and FSM domain

- Frequent use of polymorphism to allow use of components in different simulation scenarios

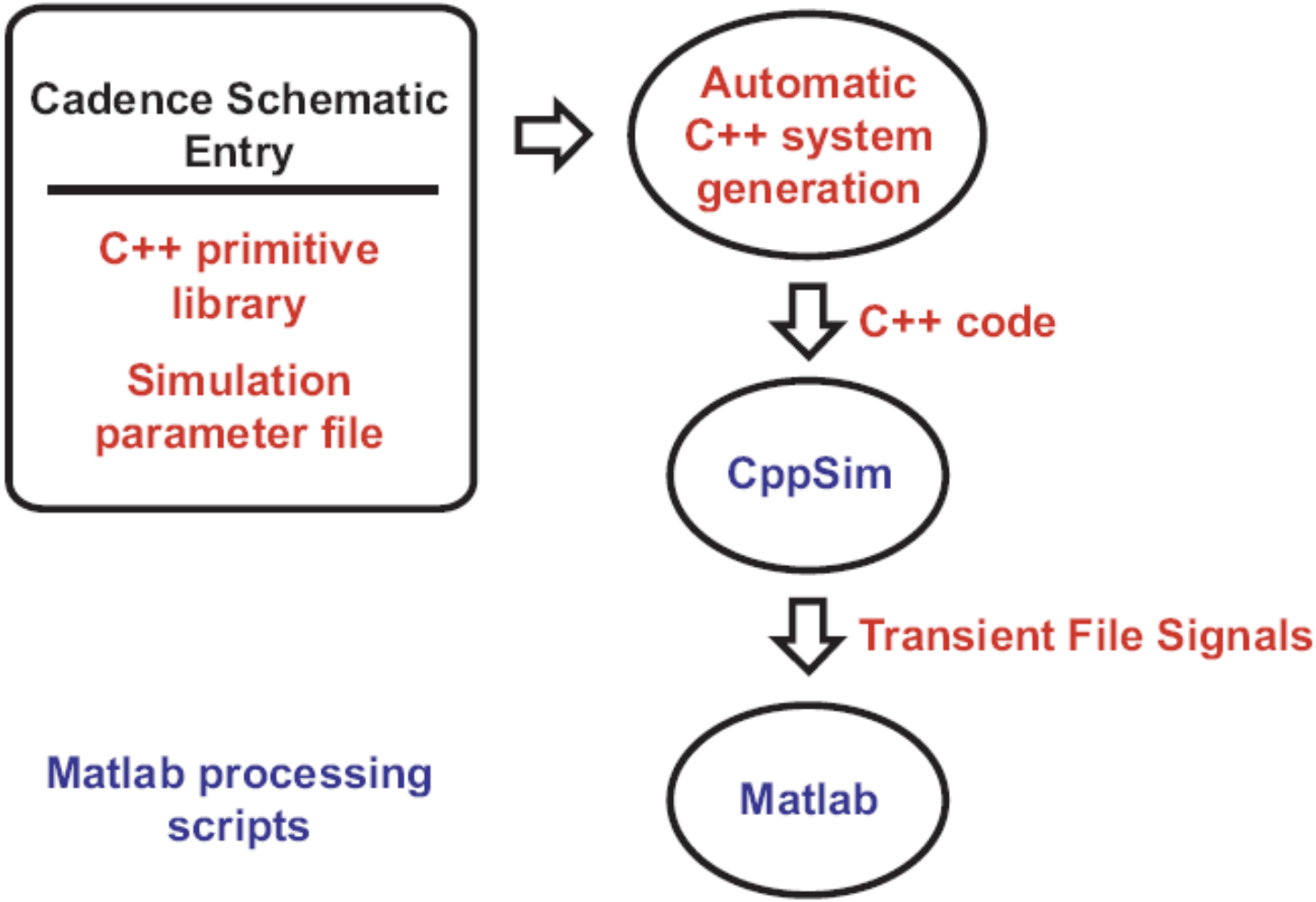
CT + „Mixed-Signal“ MoC in Ptolemy II …



„Wireless“ MoC in Ptolemy II



VPPsim [Perrot, 2006]



C based Modelling of Embedded Mixed Signal Systems

- **Before (or without) SystemC**
- **SystemC-based**
  - DE simulation kernel used
  - Extended kernel capabilities
- **What‘s next?**

Behavioral modeling and simulation of mixed-signal system-on-a-chip using SystemC [Bonnerud,Ytterda2001l]

- Purpose:
  Behavioural modelling of Mixed-Signal Systems
- No kernel extension

- Block diagrams with components for A/D Converter Design such as Sample & Hold, …
- No Netlists, transfer functions
- Use cases: Simulation of a A/D Converter

SystemC Kernel Extensions for Heterogeneous System Modeling [Patel, Shukla; 2002-2004]

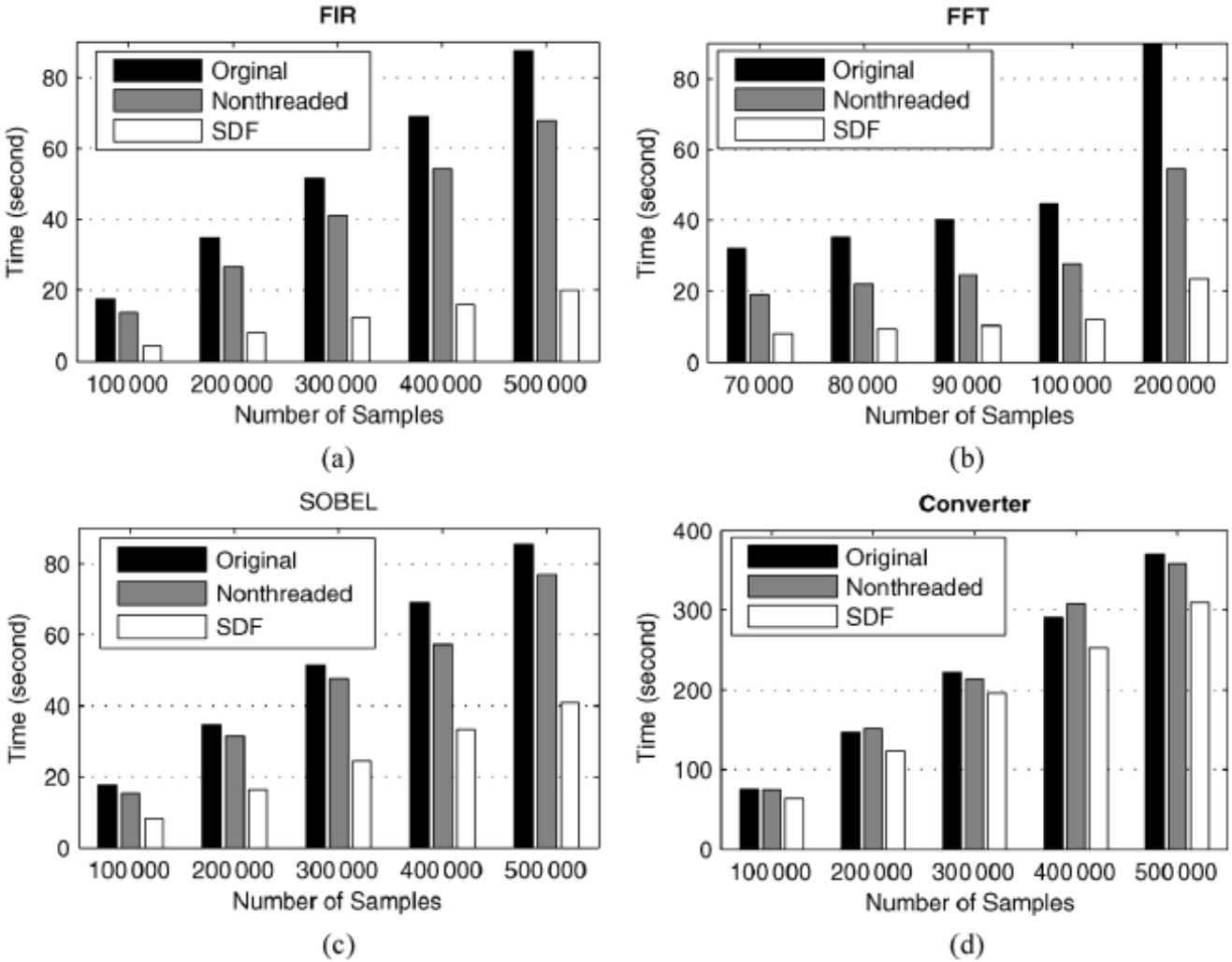
- Purpose: Scientific work …
- Extends SystemC kernel capabilities

- SDF, FSM, CSP MoC integrated in SystemC-AMS
- MoC can be structured hierarchically

- Lacks support for CT domain

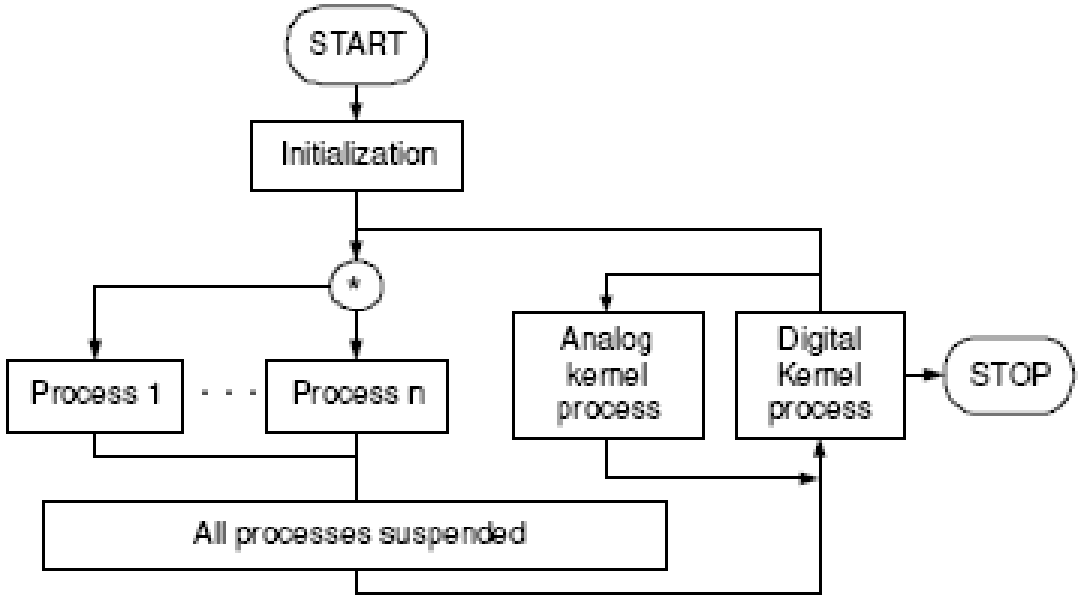
- **… interesting:** Comparison SDF with + without kernel extension (diophantine solver) →

Patel, Shukla / TCAD 8-2005



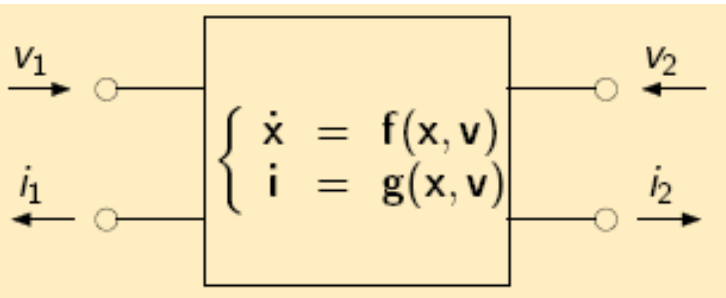
SEAMS [T. Kazmierski et al, 2004]

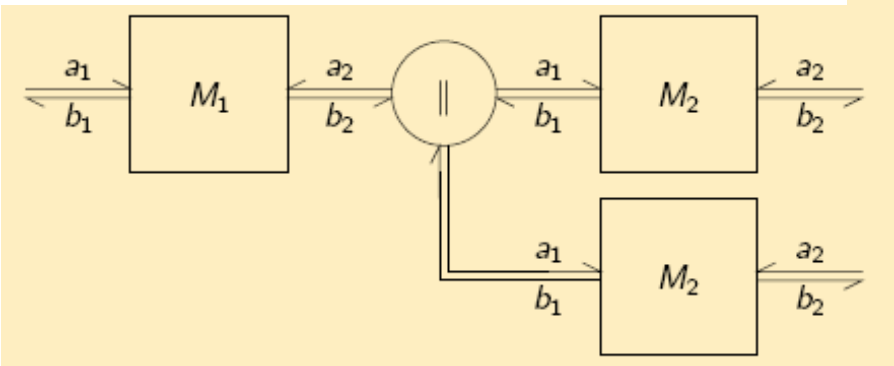
- Purpose: Modelling + Simulation of AMS systems
- SystemC Environment with integrated AMS solver
- Network elements, Nodes
- http://eprints.ecs.soton.ac.uk/9413/



SystemC-WMS [Orcioni,Conti, 2003-now]

- Hard to classify … distributed solver, mostly DE
- Two-ports connected via wavecannels solve equation systems in DE simulator.
- http://www.deit.univpm.it/systemc-wms/





HetSC [Herrera,Villar; 2003 - now]

- Application:
  - HW/SW Codesign, SW synthesis
- Class library of MoCs based on the DE MoC

- **DE MoC implements**
  - SDF, SR, DDF, … MoC

- Channels can convert MoCs where necessary

BeCom [Meise, Grimm, Waldschmidt]

- started 2001-2006, 2007-
- Symbolic preprocessing with MAPLE

  - reads SABER netlist
  - linearized equations in different workpoints
  - symbolically solves equation system
  - generates C-Code that
    - Computes output iff output signal is read
    - Computes states iff workpoint is left
  - Really fast …

ASC library [Grimm, Waldschmidt; 2001-2004]

- Analog/Mixed-Signal SystemC
  - Block diagrams, transfer functions, step width control + refinement of implicit control to control signals
  - Manual scheduling or 1 delay/block …
  - Focus:
    - Investigation of Refinement Methodology for AMS and multi MoC systems
    - OO-Design
      - Interface Classes allow designer to change MoC
      - Signals in this case adapt automatically (Polymorphic signals)

MixSigC [Einwich et al., 2000-2003]

- Cooperation Infineon + FhG-IIS/EAS Dresden
- SDF Engine + Linear Solver
- Mostly C-Based, no OO Design
- 2003 re-implementation with improved OO design, interface classes as evaluated in ASC
- ~2003 initial SystemC-AMS SG prototype
- 2005 submitted to OSCI

SystemC-AMS SG prototype

- Joint effort by SystemC-AMS SG
  - Base on re-implementation of MixSigC
  - New, innovative OO design with some features from ASC
- Starting point for SystemC-AMS WG effort

C based Modelling of Embedded Mixed Signal Systems

- Before or without SystemC
- SystemC-Based
- What‘s next?

Open issues (besides standardization …)

EMS Application

Function

Interaction
TLM / SystemC-AMS

Implementation