

Parallel Simulation of SystemC Loosely-Timed Transaction Level Models

Master of Science Thesis

Konstantinos Sotiropoulos
(kisp@kth.se)

KTH Royal Institute of Technology
Intel Sweden AB

Supervisor:	Björn Runåker (Intel Sweden AB)
Examiner:	Prof. Ingo Sander (KTH)
Academic advisor:	PhD student George Ungureanu (KTH)

Motivation

- This project stems from the work of Björn Runåker:
speeding up the simulation of 5G radio base stations.
- A **coarse-grained** approach was adopted:
multiple instantiations of SystemC's simulation engine.
- But motivated a **finer-grained** approach:
parallelism within a single instance?

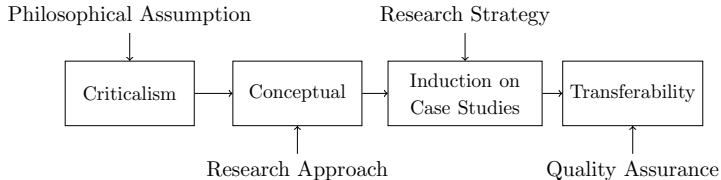
Problem Statement

- The verdict is categorical:
SystemC's Reference Simulation Environment
must be **bypassed**.
- Transaction Level Modeling in SystemC:
breaks the separation of concerns between
execution and communication.
- **Address the question:**
can we transform a SystemC TLM 2.0 LT model
into a parallel application?

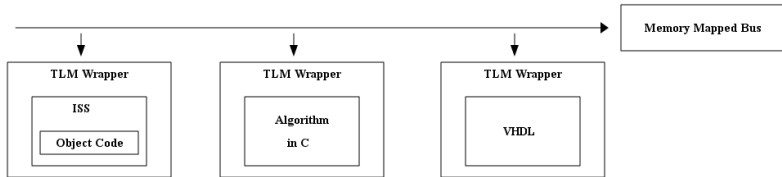
Purpose

- SystemC TLM 2.0 used to construct **Virtual Platforms**:
enabling hardware/software co-simulation.
- From SystemC Evolution Day 2016:
*"SystemC must embrace true parallelism
otherwise it will go down the same path
as the dinosaurs"*

Qualitative Research Methodology

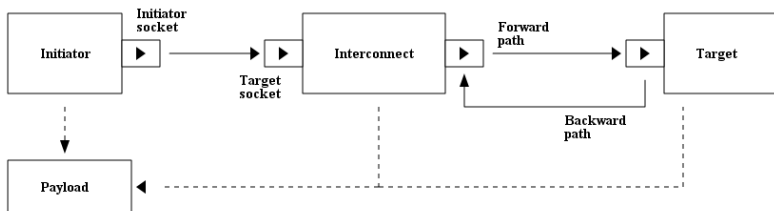


The Role of SystemC TLM 2.0



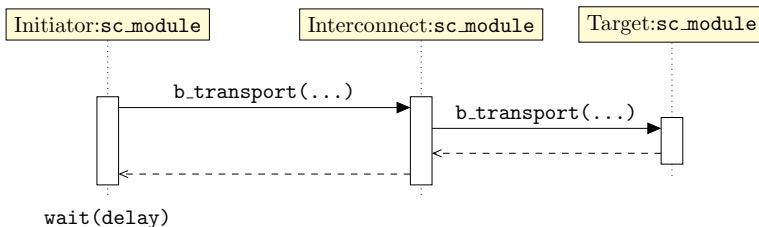
- SystemC TLM 2.0: a communication-centric API meant for **gluing** IP components

An example TLM



- An **initiator** initiates a transaction which is routed through **interconnect** components and eventually reaches the **target** component.

Communication in LT TLM

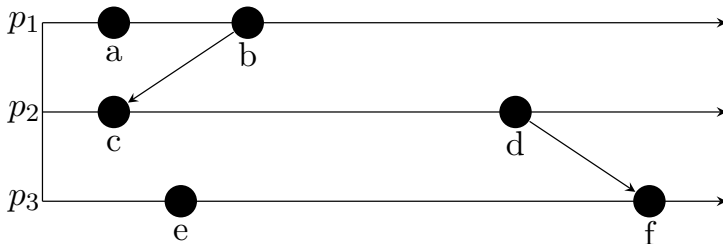


- Looks like a series of of **remote function calls**
No Channels!

The DE Model of Computation

- Provides the **operational semantics** of:
Electronic System-Level Design Languages.
- A model is a system of:
processes that **execute** and **communicate**
- Logic Time vs Real Time:
logic time is also relativistic.

The DE Manifold



- Execution:**

$$b = f(a) \implies a \propto b \implies a \sqsubset b$$

- Communication:**

$$c = g(b) \implies b \propto c \implies b \sqsubset c$$

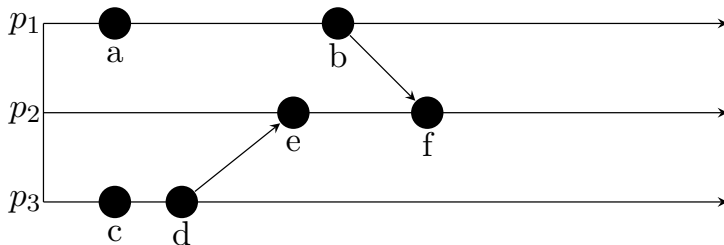
SystemC's DES

- A realization of the DE MoC:
is a **Discrete Event Simulator (DES)**.
- SystemC's DES:
uses **coroutines** to emulate space dimensionality.
- Enforces a global perspective on logic time:
since space is emulated.

Parallel DES

- A Parallel DES preserves spatial decomposition:
processes keep their own perspective of logic time.
- Communication is **Synchronization**:
a global perspective of logic time is realized
through communication.

Causality Hazard



- Event e might occur earlier in real time than f .
- Event e may causally affect event f .
- How can p_2 determine when it is safe to advance its logic time perspective?

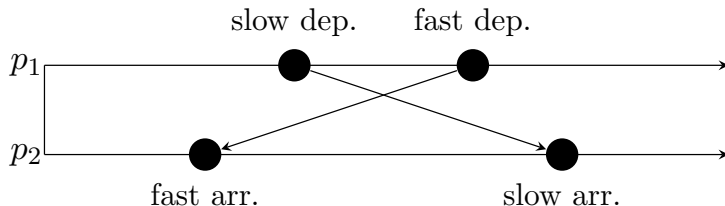
The CMB Synchronization Algorithm

- The **Chandy/Misra/Bryant** synchronization algorithm:
at the heart of the proposed PDES.
- **Block** a process until:
it gathers knowledge about other processes'
perspective of time.
- Implement in MPI:
unlimited **scalability**.

Proposed PDES Evaluation

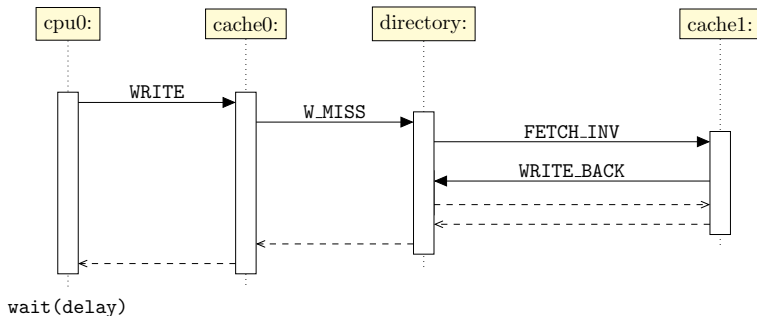
- Construct **two case** studies:
each with a sequential and parallel version.
- **Case Study 1:** airtraffic simulation
create a global log of departures/arrivals.
- **Case Study 2:** cache-coherent multiprocessor:
software is emulated by a memory trace.

Non-Monotonic Communication in Case Study 1



- Different airplane velocities

Non-monotonic Communication in Case Study 2



- A write-miss on an exclusive block

Verdict

- **Recoding** is deemed feasible:
but far from being fully automated.

Contributions

- A novel presentation of the DE MoC.
- An updated CMB implementation with new features introduced MPI 3.0.

Future Work

- An alpha version of a **recoding infrastructure**:
SystemC LT TLM → a parallel MPI application.

Questions?

Thank you for your time!

`github.com/kromancer/Thesis`