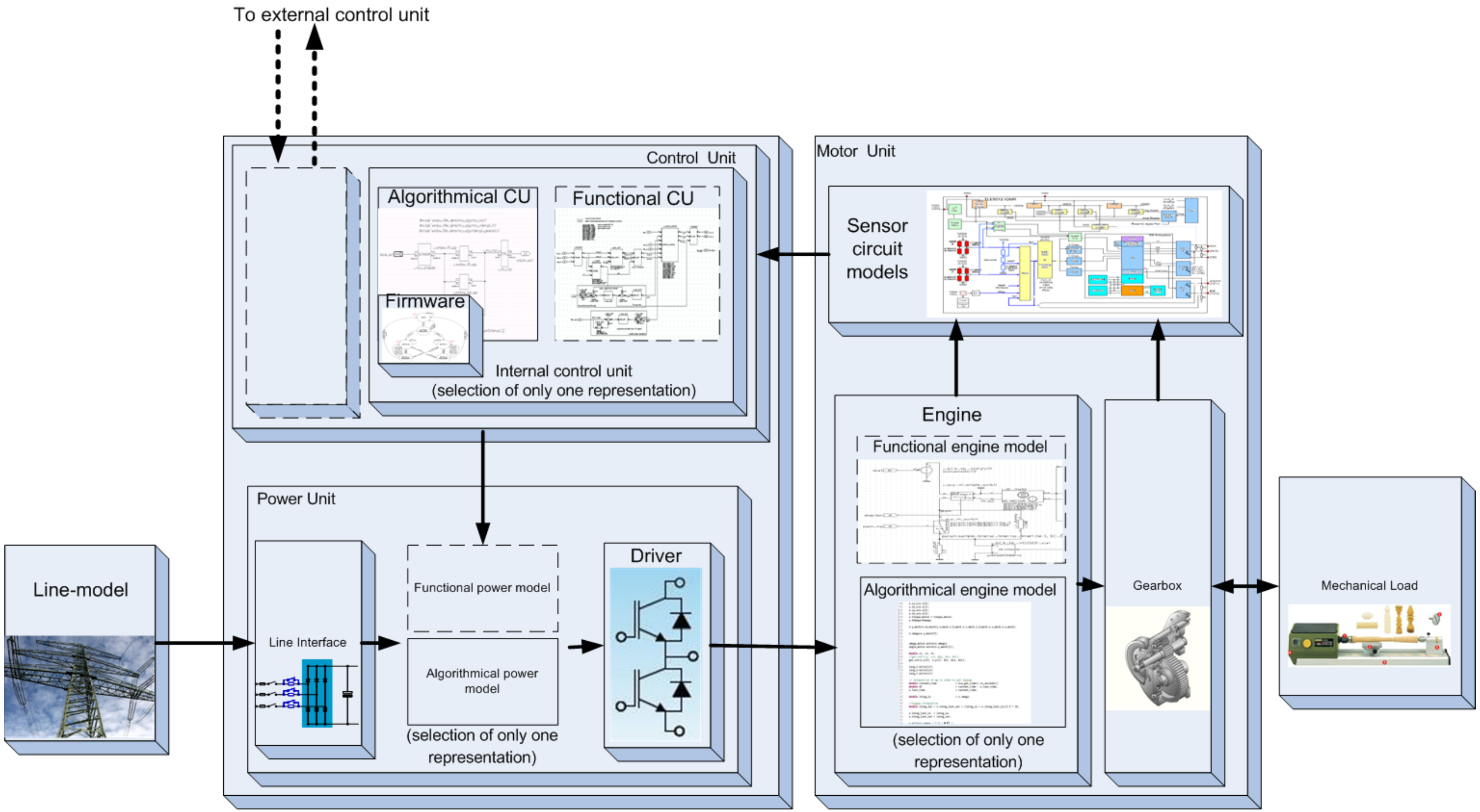
Heterogeneous Virtual Prototyping for IoT Applications

Paul Ehrlich, paul.ehrlich@coseda-tech.com
Karsten Einwich, karsten.einwich@coseda-tech.com
COSEDA Technologies GmbH
Mark Burton, mark.burton@greensocs.com
GreenSoCs
Luc Michel, luc.michel@antfield.fr
Antfield S.A.S

Agenda

- Introduction and Motivation
- Digital Platform integration
- Digital Analog Interface Modelling
- Physical domain Modelling
- Application Example

Heterogeneous Hard- Software System



Challenges for Virtual Prototyping of heterogeneous Systems

- Simulation Performance
- Highly configurable systems
- Combining different Modelling Domains
- Numerous application scenarios
- Hard-Software Codesign
- Closed loops

Digital Platform Modelling Requirements

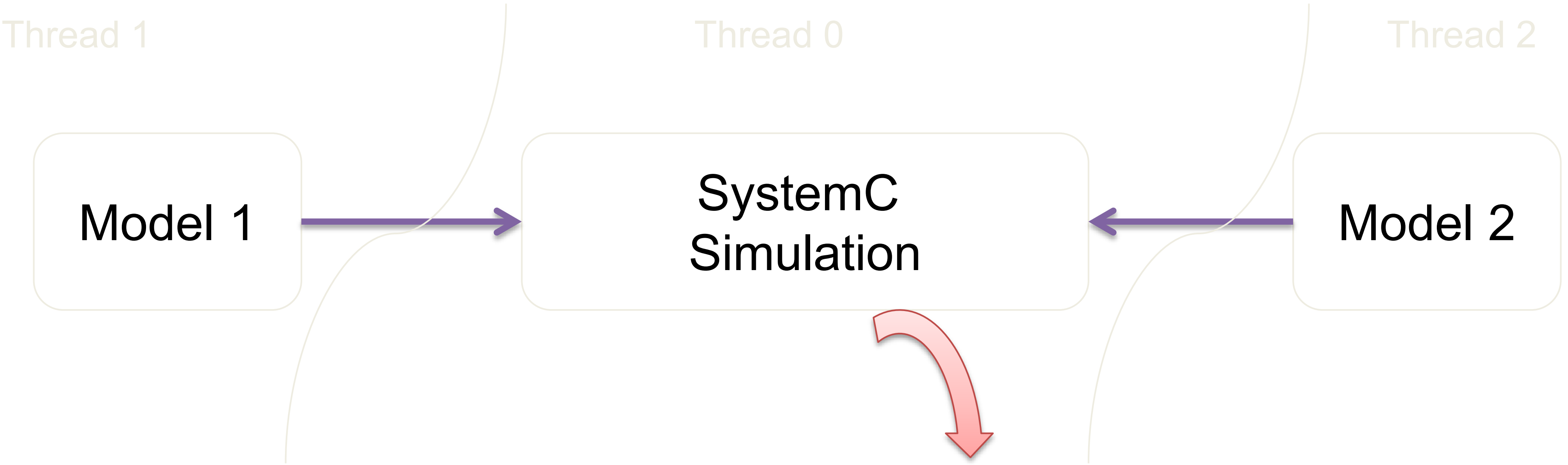
- Complex Multi Core / Multi Processor Networks
- Complex Bus Architectures and Arbitration Algorithm
- Tight Hardware/Software dependencies

- High simulation performance requirements regardless of complex processor architectures

Qemu SystemC Integration

- QEMU is a generic and open source machine emulator and virtualizer
- A wide variety of processor architectures and micro-controllers and boards are available (e.g. ARM, PPC, x86, Mips, MPCxxxx, etc…)
- Qbox uses Qemu to provide SystemC TLM 2.0 based CPU models
- Runs extremely fast : MULTI Thread Qemu
  - A massive speed improvement for Qemu to take advantage of multi-core hosts
  - Multiple CPU cores can run in separate threads
- Full SystemC/TLM integration (including DMI and Quantum support)
- Flexibly allow different parts of the system in Qemu or SystemC.

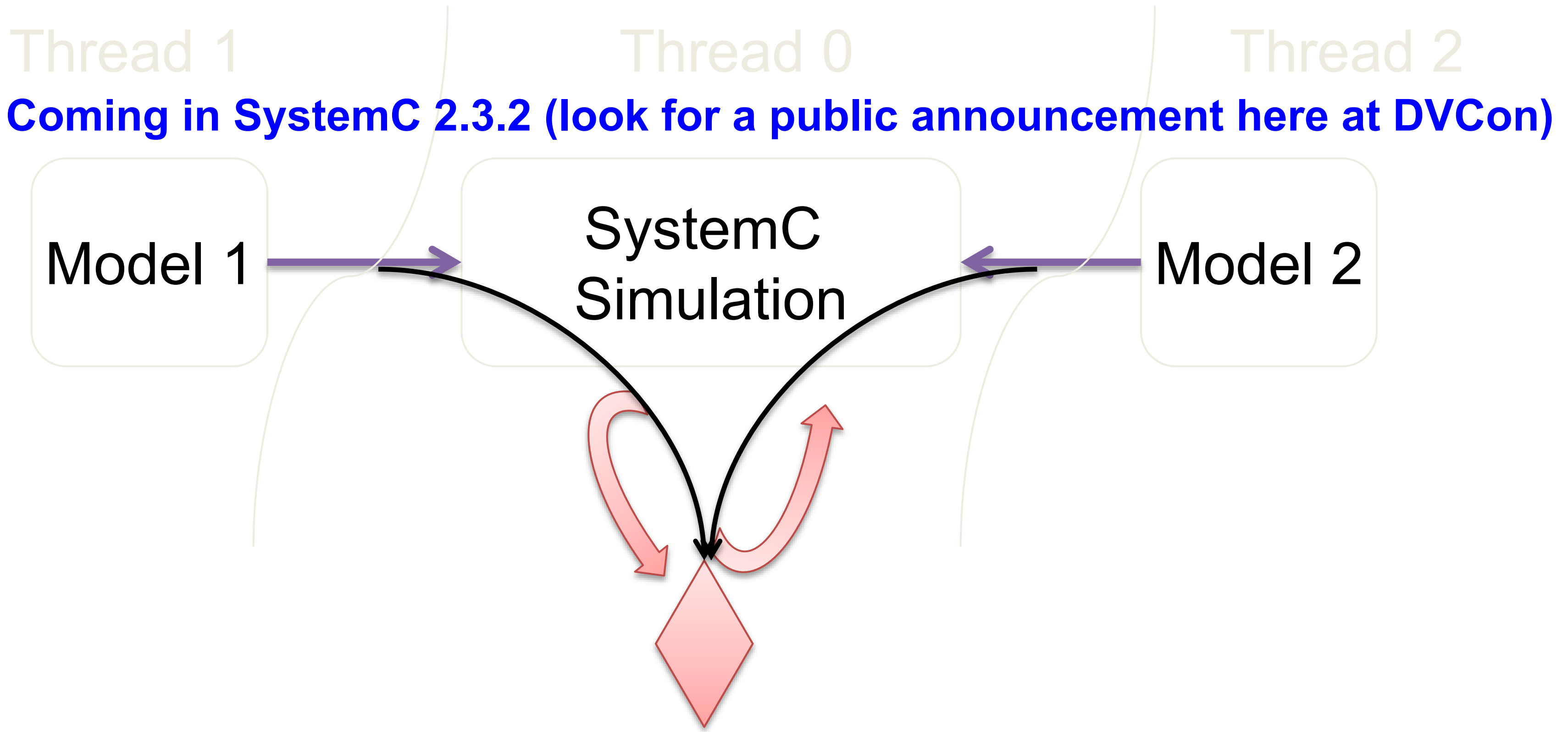
The problem multi-thread simulation in SystemC



SystemC runs out of events…
(even though model 1 and 2 are still active)

Simulation dies.

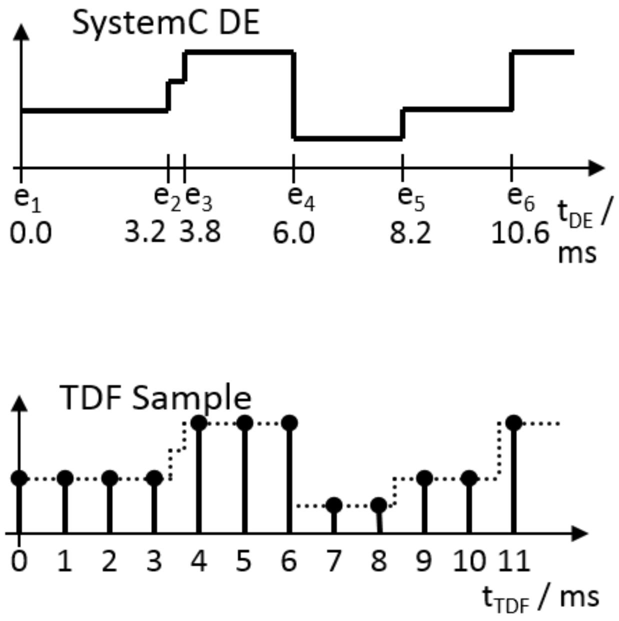
Synchronization of CPU core instances

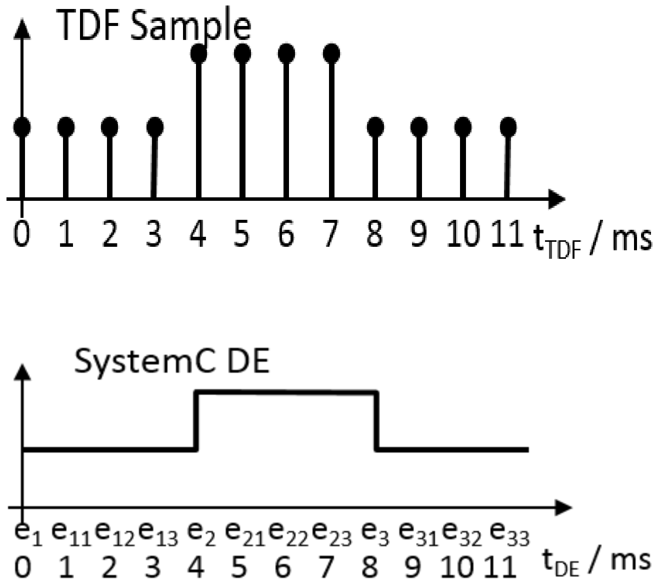


Single shared semaphore.
Triggered from async_request_update

Digital – Analog Interface

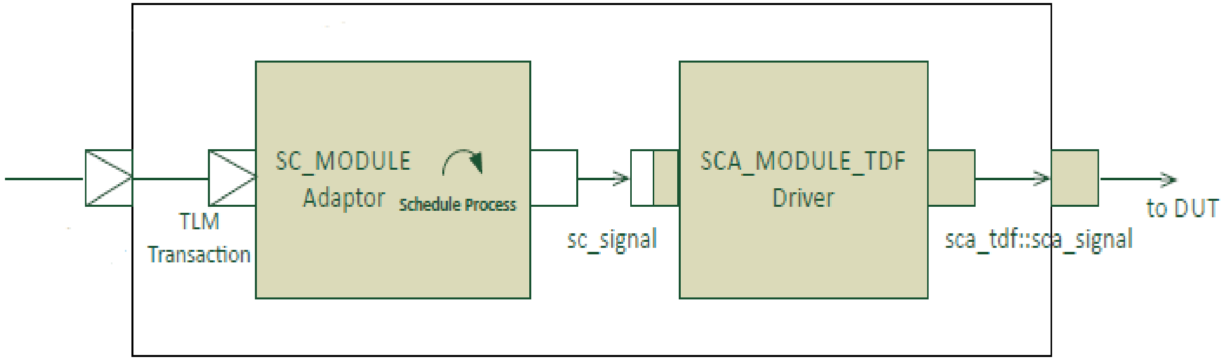
- Loosely coupled interaction





SystemC AMS – TLM Interaction

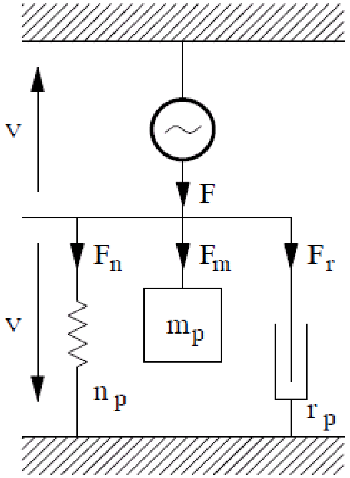
- Synchronization via method process



Physical Domain Modelling

- Using ELN elements as base classes
- ELN provides basis to describe any linear DAE system
- Equation setup based on Kirchoff's law
- Applying analogy relations

Analogy Relation

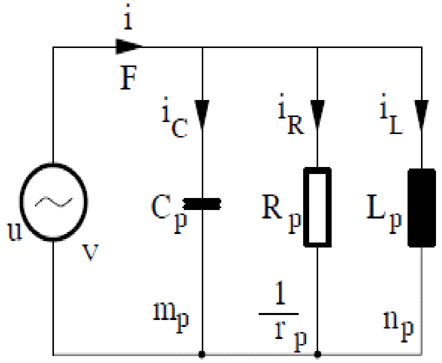


$$F_m + F_r + F_n = F$$

$$F_m = m * \dot{vel}$$

$$F_n = k * s = k * \int vel * dt$$

$$F_r = m * vel$$



$$i = C * \dot{v}$$

$$i = \frac{1}{L} * \int v * dt$$

$$i = \frac{1}{R} * v$$

Analogy Relation

- Direct mapping of physical components to electrical components possible
- Different analogy relations are possible
- It should be prevented to connect nodes of different physical properties
- The analogy relation should be selected in a way, that the wiring of the components remains

Analogy Relation – Realization within SystemC AMS

```
#include <systemc-ams>

class spring : public sca_eln::sca_l
{
public:
   spring(const char* nm,double k) : sca_eln::sca_l(nm,1.0/k)
   {}
};
```

```
namespace sca_ln
{
class sca_node_base : public sca_eln::sca_node
{…};

template<class PDOMAIN>
class sca_node :  public sca_ln::sca_node_base,
                  public sca_ln::sca_node_if<PDOMAIN>
{…};
}
```

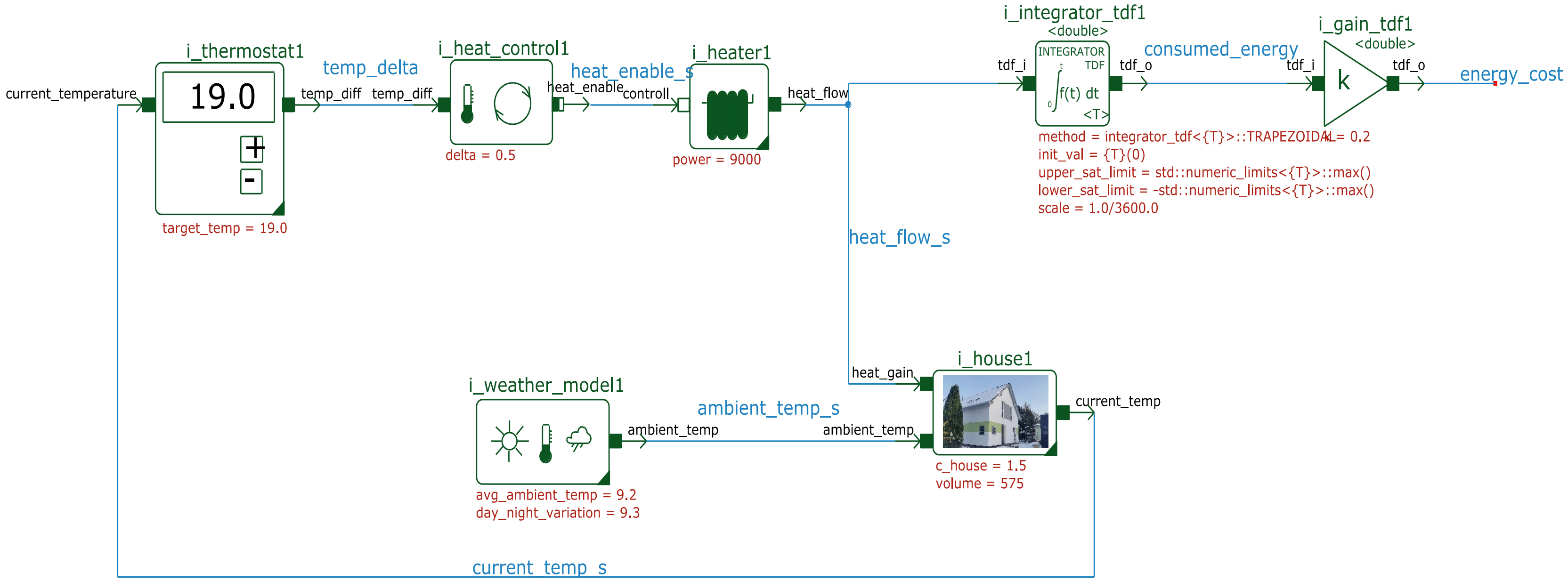
```
sca_ln::sca_node<sca_translational> mech_node;

class spring : public sca_eln::sca_l
{
public:
  sc_ln::sca_terminal<sca_translational>  t1;
    ...
};
```

Demonstrator

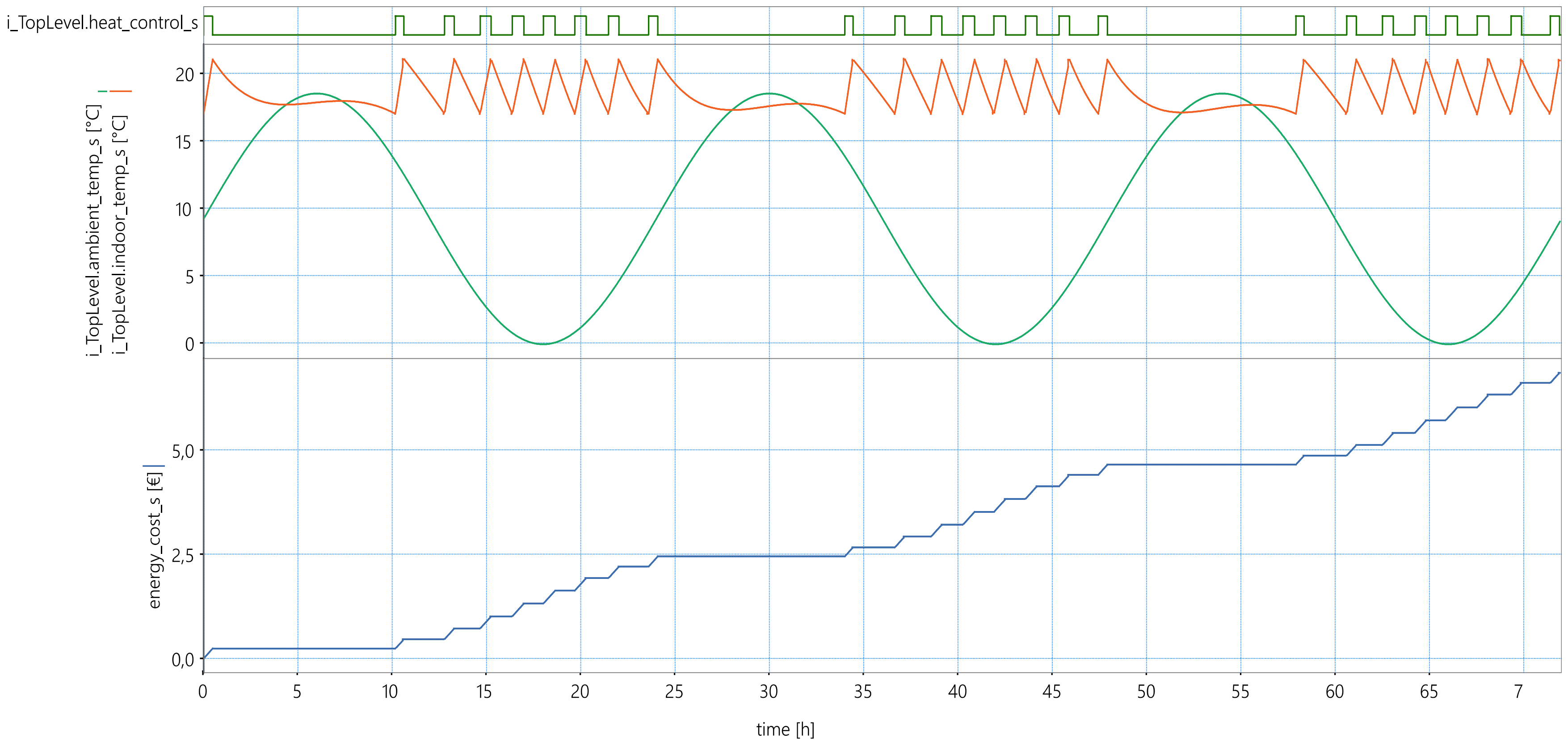
- Thermal house model
- Embraces digital hard- and software, electrical as well as thermic components
- Control unit is realized by an ARM CPU
- The dynamics of the electrical and thermal components are modelled

Demonstrator



Demonstrator - Results

3 days are simulated in 81 sec with simplified uC program



Summary

- More and more systems require embracing different domains
- Understanding the tight interaction is essential
- Qemu based processor integration enables fast hard- software debugging
- SystemC AMS can be used as a basis to create physical domain libraries
- Abstract modelling is the enabler to create virtual platforms which permit the simulation of application scenarious

Questions