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Towards the Integration of UPPAAL for Formal Verification of EAST-ADL Timing Constraint Specification

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Presentation Outline

- Background
- Objectives and methodology
- Base technologies
  - EAST-ADL
  - UPPAAL
- Transformation scheme
- Results and Conclusions

Background

- Automotive system development
  - Paradigm shift
- Software and distributed computing
  - Innovations and features
  - Increased safety and performance
- Increased complexity
  - Life Cycle
    - Maintenance, product variability, information exchange across domains and enterprises
  - Run-time
    - Modes, dependencies …

Background (Contd.)

- Technologies for system specification(UML, SysML, EAST-ADL, AADL, AUTOSAR etc.)
  - Requirements,
  - Functions, software / hardware
  - Behavior and non-functional constraints
  - Variability
  - Verification and validation
- Different views, concerns, scope
  - Consistency
  - Communication
  - Automation
- Tools and tool integration

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Objectives

- To investigate
  - The support for formal verification of execution timing constraints by external tools
  - Automation possibilities
- To identify possible transformation scheme and challenges

Approach

- Case studies
  - Emergency Braking Assistant
  - Brake-by-wire
- Base technologies
  - EAST-ADL
  - UPPAAL
- Prototype transformation
  - MDWorkBench (MQL)
- Results

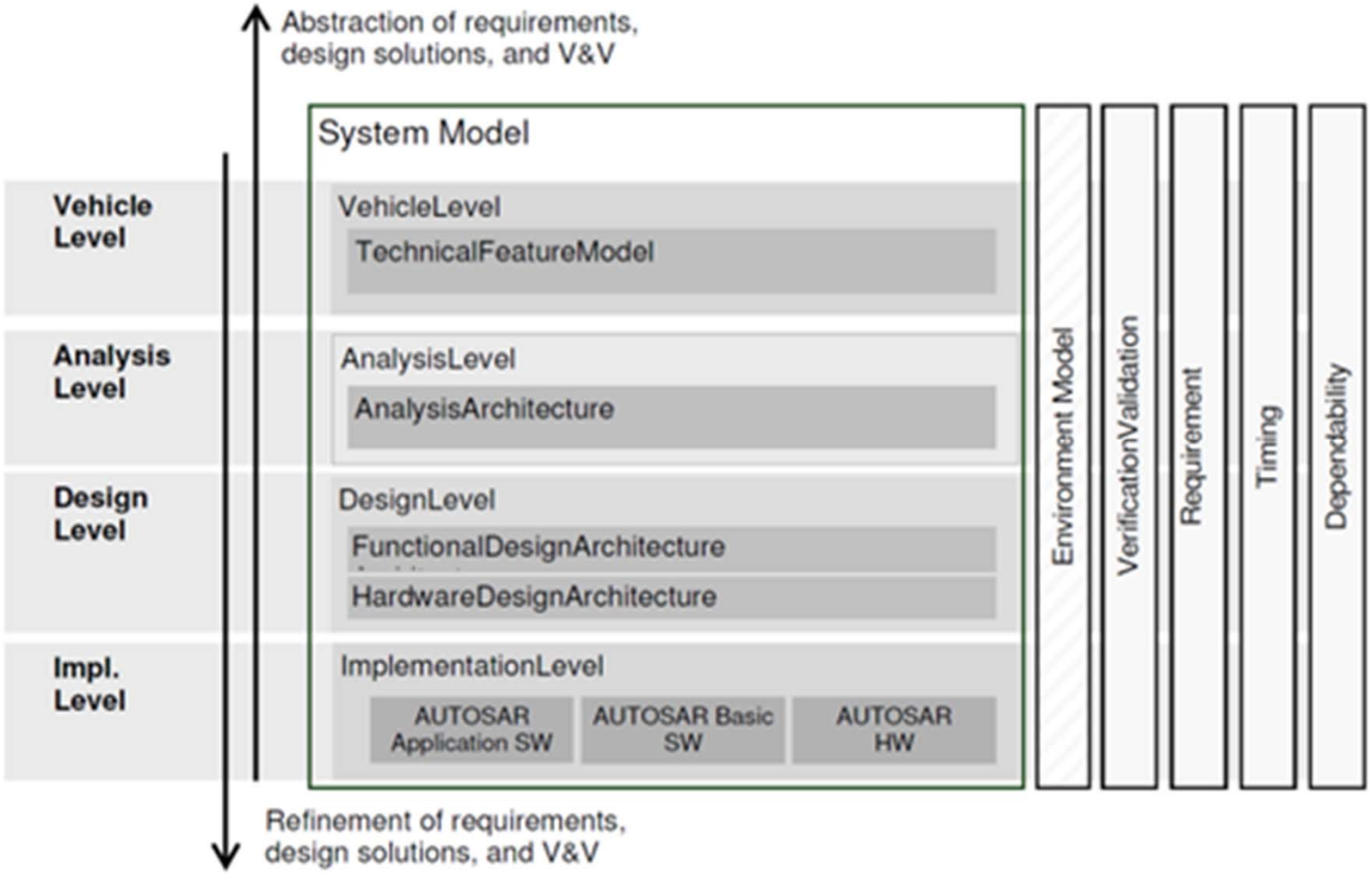
Behavior taxonomy

- Application logic and interaction
- **Execution and timing**
- **Nominal** vs. error
- **Required** vs. provided
- Discrete vs. continuous time

EAST-ADL

- Electronics Architecture and Software Technology – Architecture Description Language (2001 – present)
  - Addresses current industrial needs
  - Embraces de-facto standards
  - Complement best industrial practices
  - Tool Support
    - Specification tools (e.g. PapyrusUML)
    - External analysis tools (e.g. HIP-HOPS)

EAST-ADL (Contd.)



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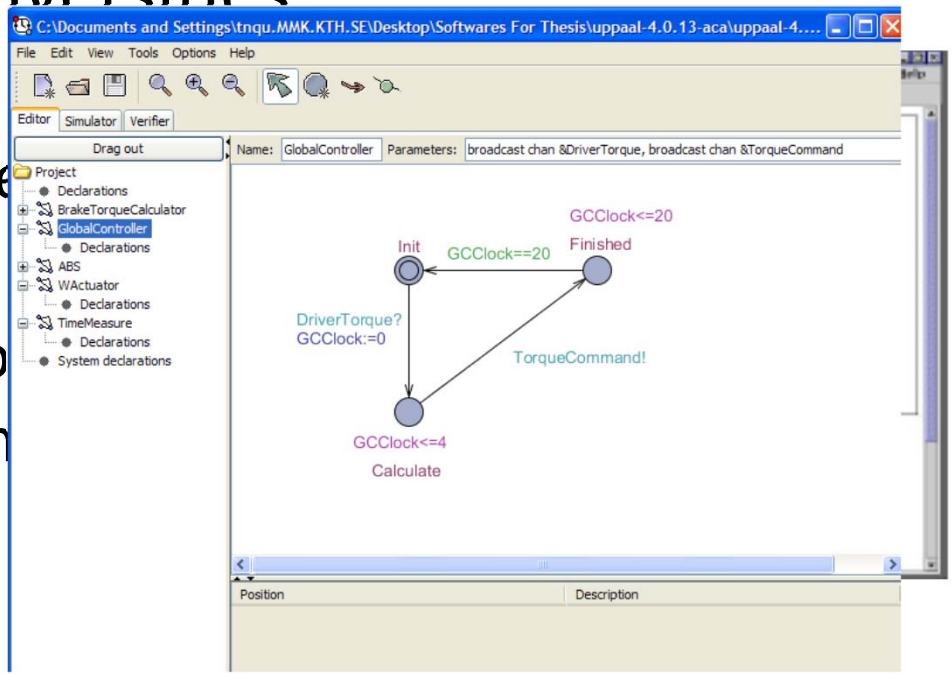
UPPAAL

- Uppsala and Aalborg Universities
- Industrial usage
  - Philips audio protocol, Ge
- Timed Automata
  - Quantitative treatment o
  - Easy and flexible modelin
- Formal verification
  - Modeling
    - Graphical and C like syntax
  - Simulation
    - Non-exhaustive analysis
  - Verification (Query Language)
    - CTL



A[] (ECU.TaskFinished *imply* ECU.Timer <= Deadline)

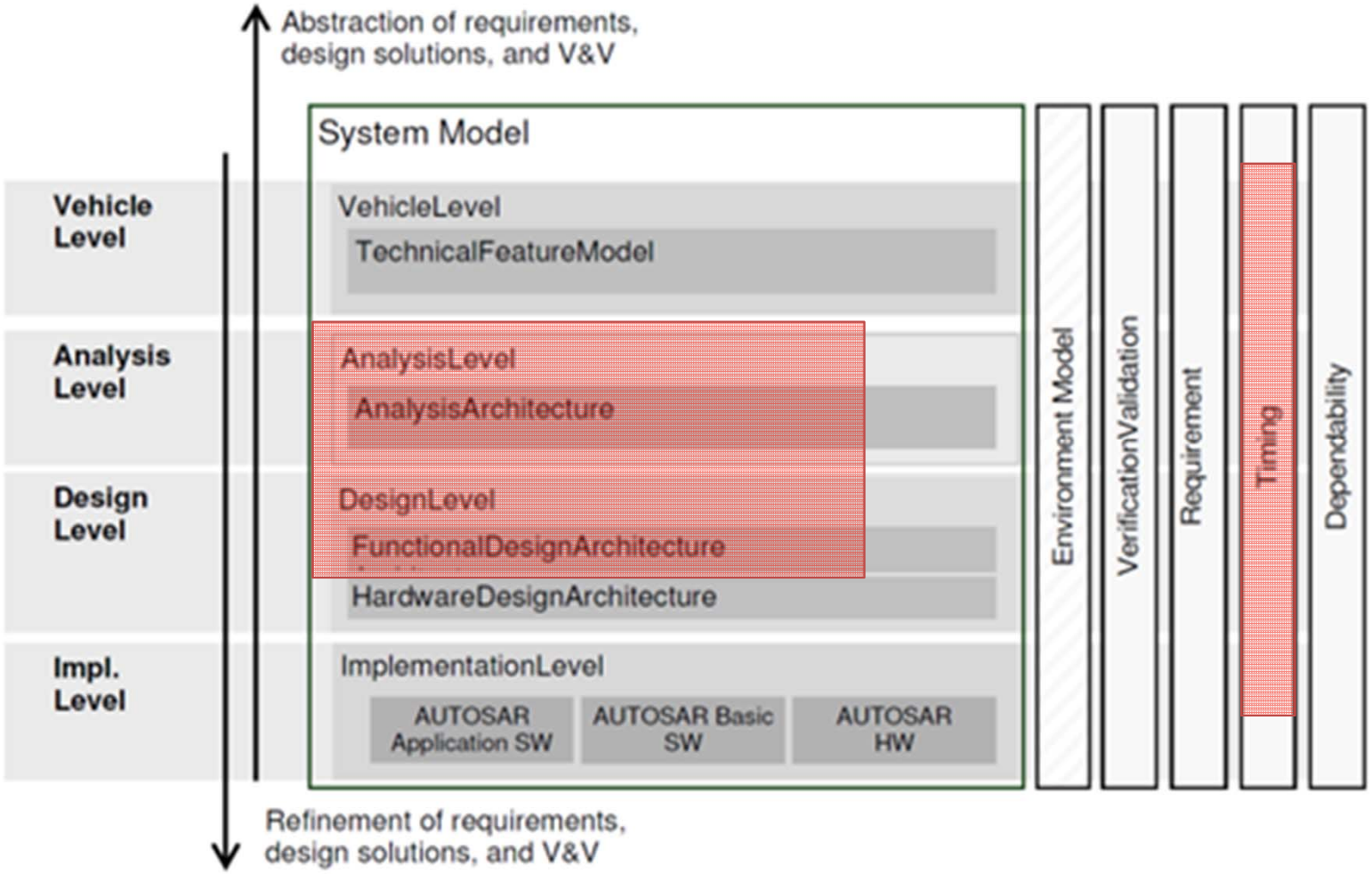
EAST-ADL vs. UPPAAL

UPPAAL	EAST-ADL
Template	Function type
Process	Function prototype
States	*Implicit*
Transitions	*Implicit*
Channels	*Implicit through connectors, execution events*
Time guards and clocks	Timing constraints

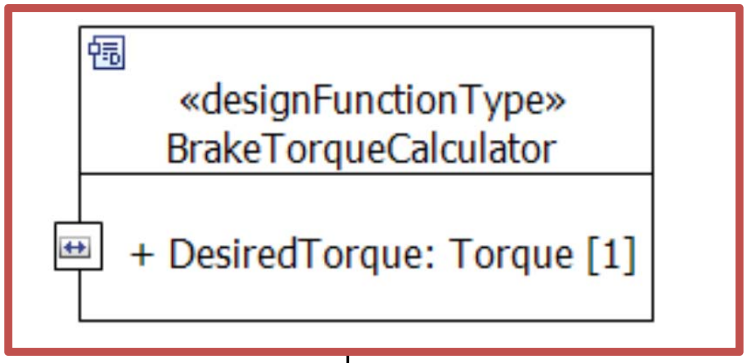
Contribution:
Make explicit transformation

Result:
Transformation algorithm
Semi-automated transformation

EAST-ADL vs. UPPAAL



Transformation Scheme - I



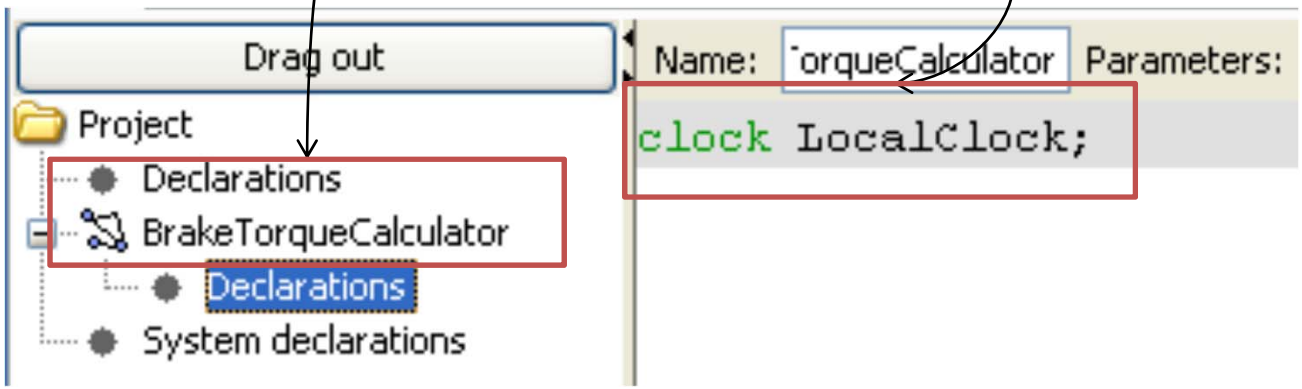
EAST-ADL::Design Function Type

-->

UPPAAL::Template

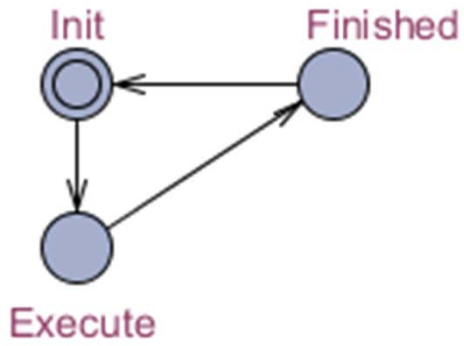
Define a clock in the declaration of the new template.

clock LocalClock;

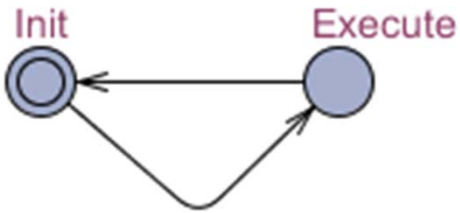


Transformation Scheme - II

- Create standard locations and transitions
  - Periodic

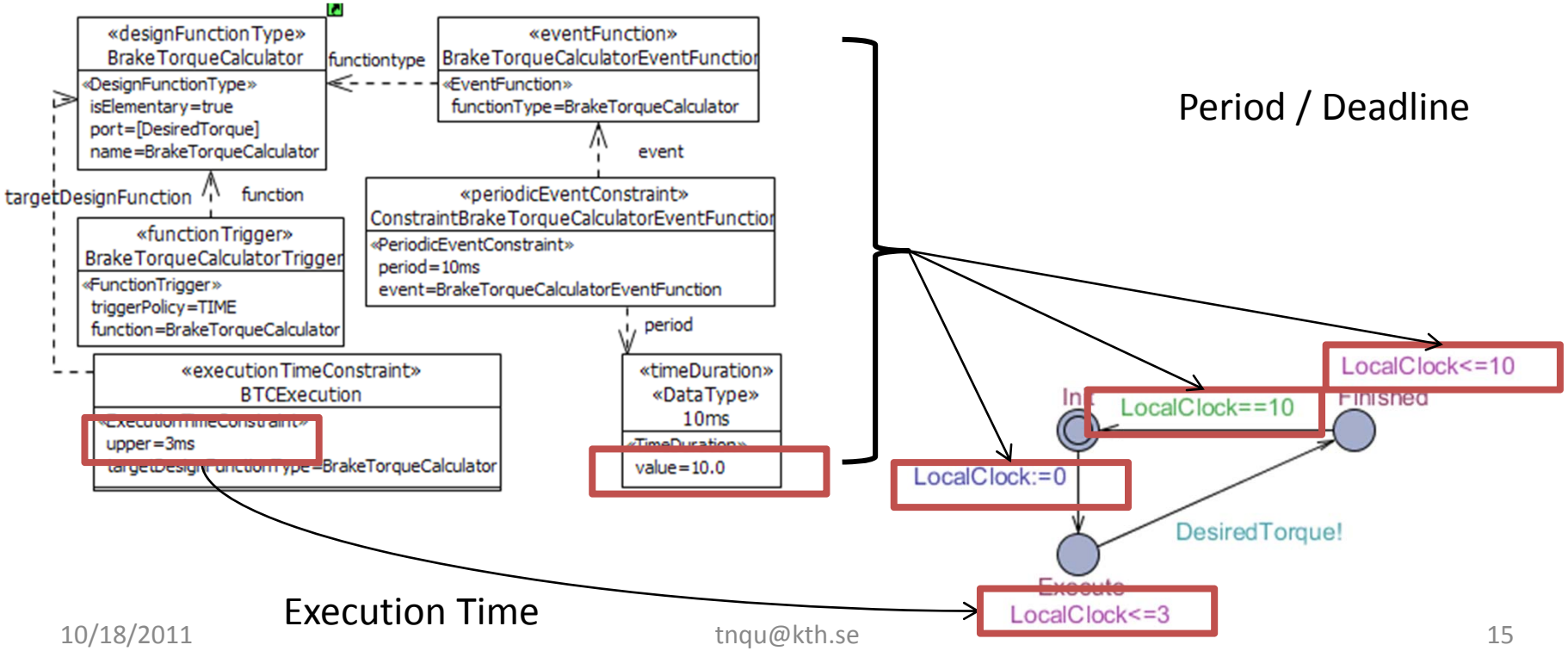


  - Aperiodic

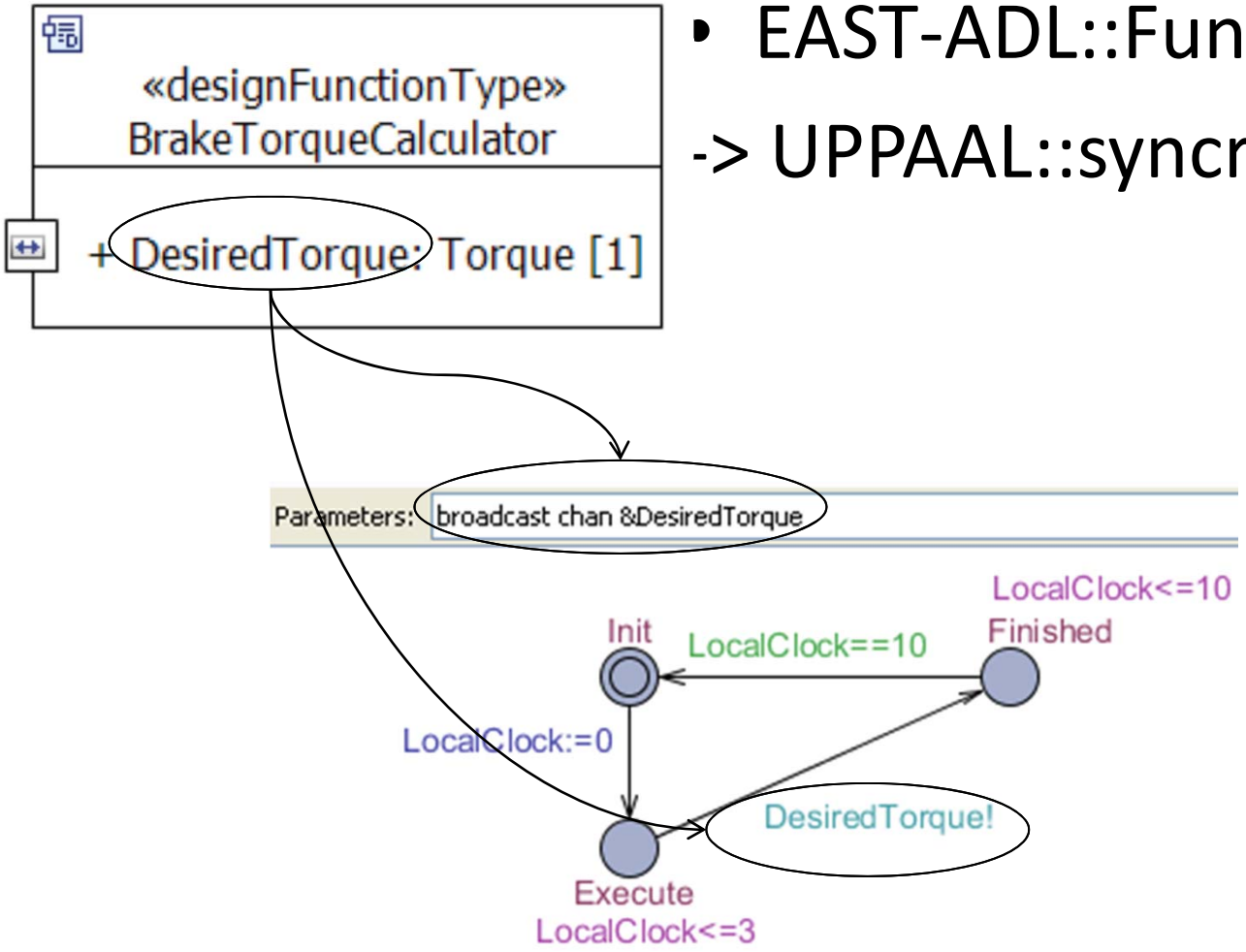


Transformation Scheme - III

- EAST-ADL::Timing
  - Period and execution time
- UPPAAL::Conditions & State Invariants



Transformation Scheme - IV

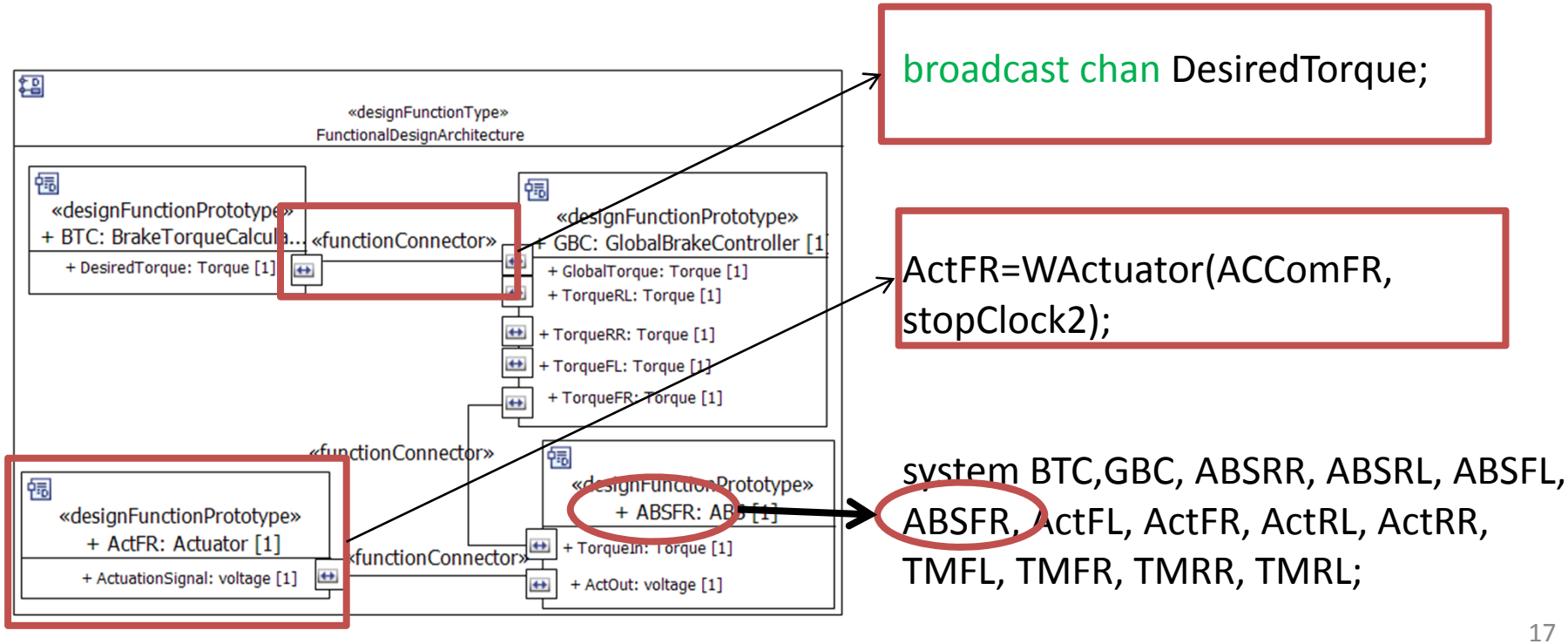


- EAST-ADL::FunctionPort

-> UPPAAL::syncrhonization event

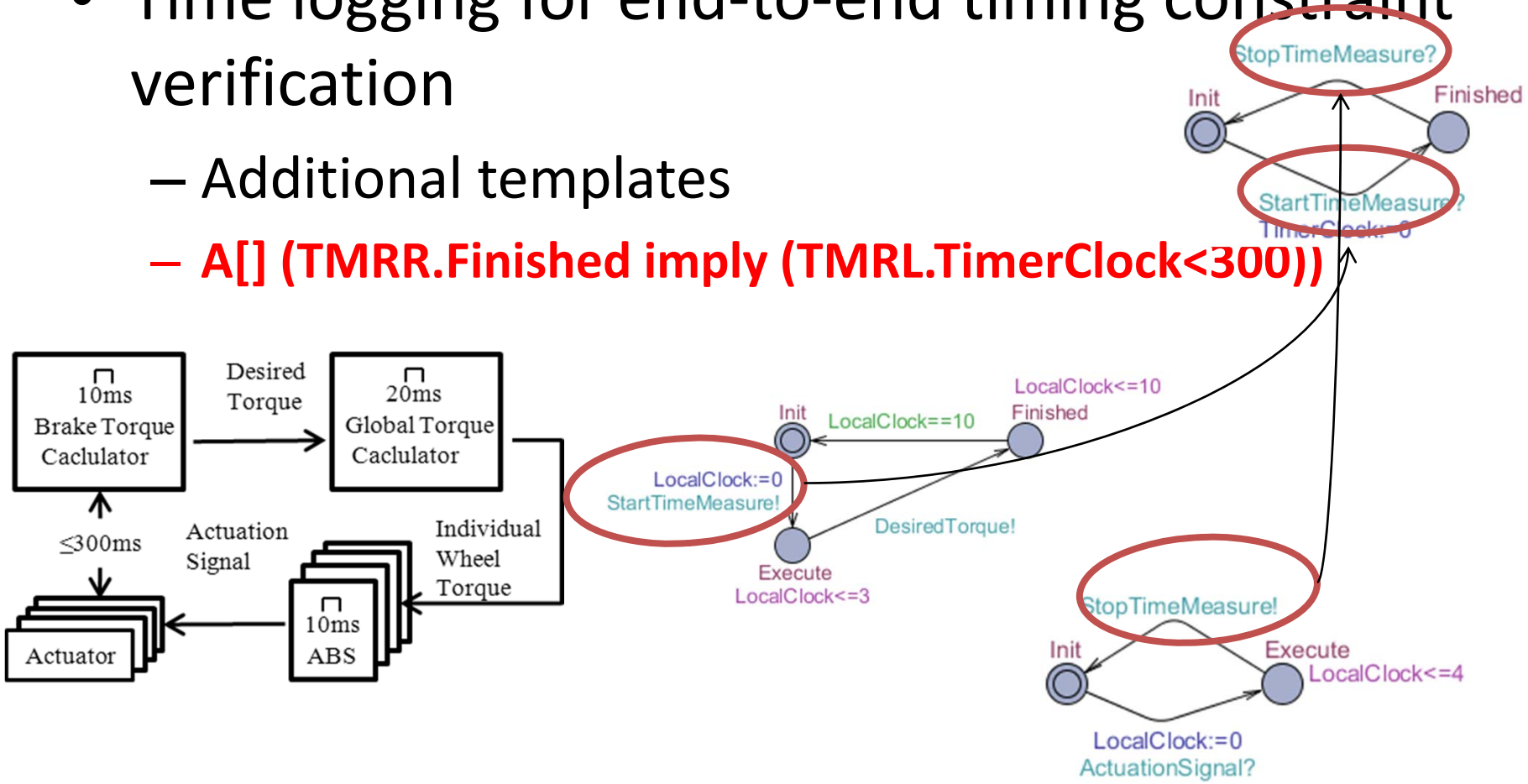
Transformation Scheme - V

- EAST-ADL::System (FDA) -> UPPAAL::system
- FunctionPrototype->UPPAAL::Process
- FunctionConnector -> UPPAAL::Channel



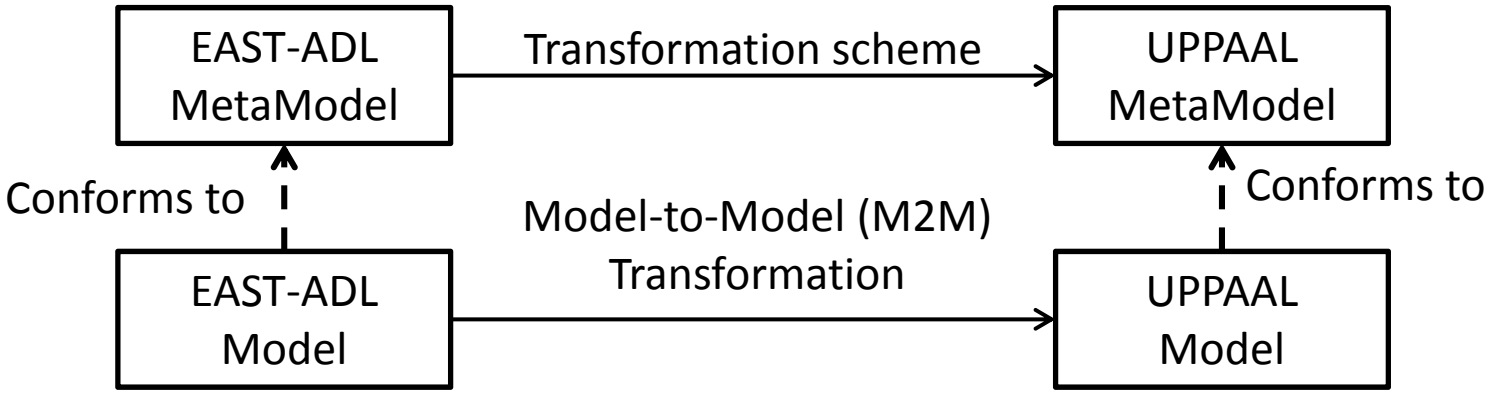
Transformation Scheme - VI

- Time logging for end-to-end timing constraint verification
  - Additional templates
  - **A[] (TMRR.Finished imply (TMRL.TimerClock<300))**



Transformation Prototype

- MDWorkBench and MQL
- Partially automatic
  - EAST-ADL EMF meta-model to UPPAAL EMF meta-model.
  - EMF to UPPAAL XML (manual)



BBW case verification

- Deadlock free
  - Only for sender-receiver interface
  - Client-server type for future enhancement
- Specification consistency
  - Execution time w.r.t period
  - End-to-end timing constraint w.r.t. local timing constraints
    - *Reaction time ≤ 300ms*

Summary

- One EAST-ADL and UPPAAL integration effort for verifying consistency of timing constraint specifications.
- Automated transformation possible but with challenges
  - Distributed information
  - Task allocation to hardware.
  - Multiple response times and event chains.

Future Work

- Supporting the upcoming EAST-ADL extension for native behavior specifications and the verification.
- Consistency checking between constraints specified at two different abstraction levels in EAST-ADL.
- Bi-directional transformation utilizing requirements to generate queries and V&V package for analysis results.

Questions