Test-Driven Modelling of Embedded Systems

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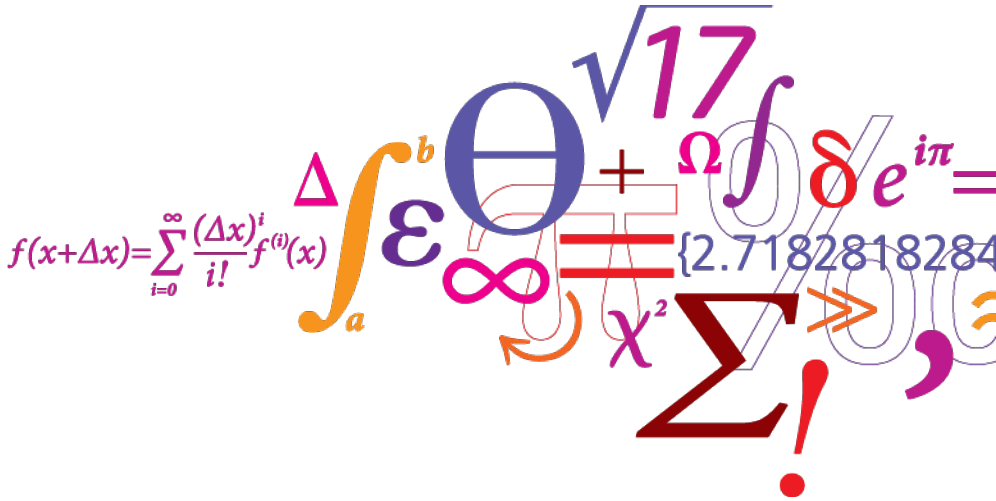


DTU Compute
Department of Applied Mathematics and Computer Science

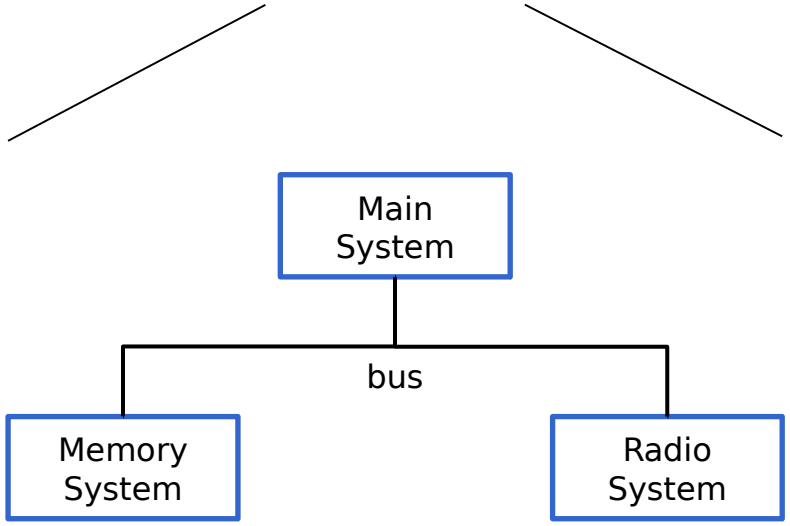
ReSound

GN ReSound – Smart Hearing Systems

3RD GENERATION
2.4 GHZ WIRELESS
smartRange
by ReSound

Control and Releif apps also for Andriod

Case study



Methodology

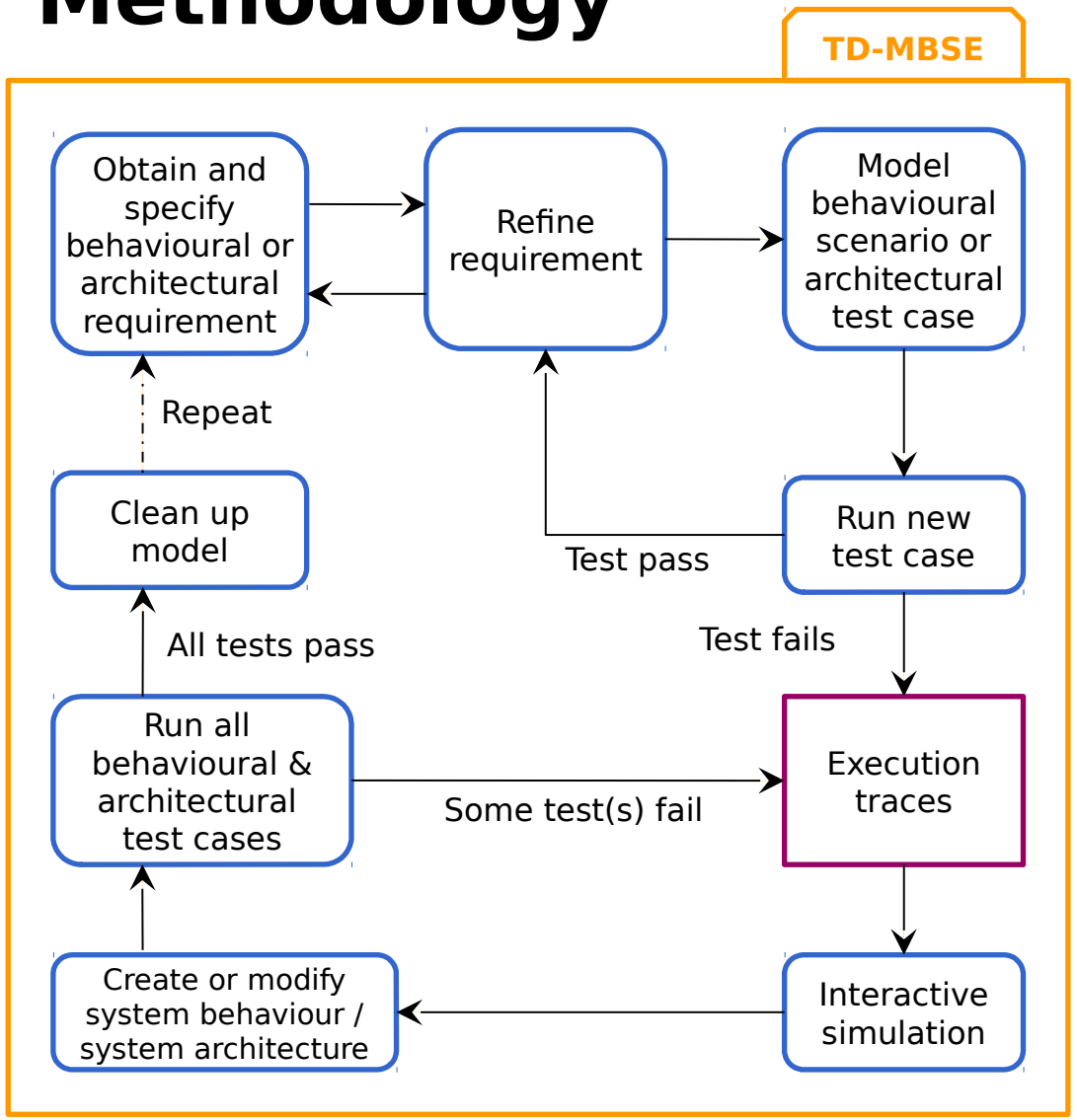


Figure 1: Test-Driven Model-Based Systems Engineering

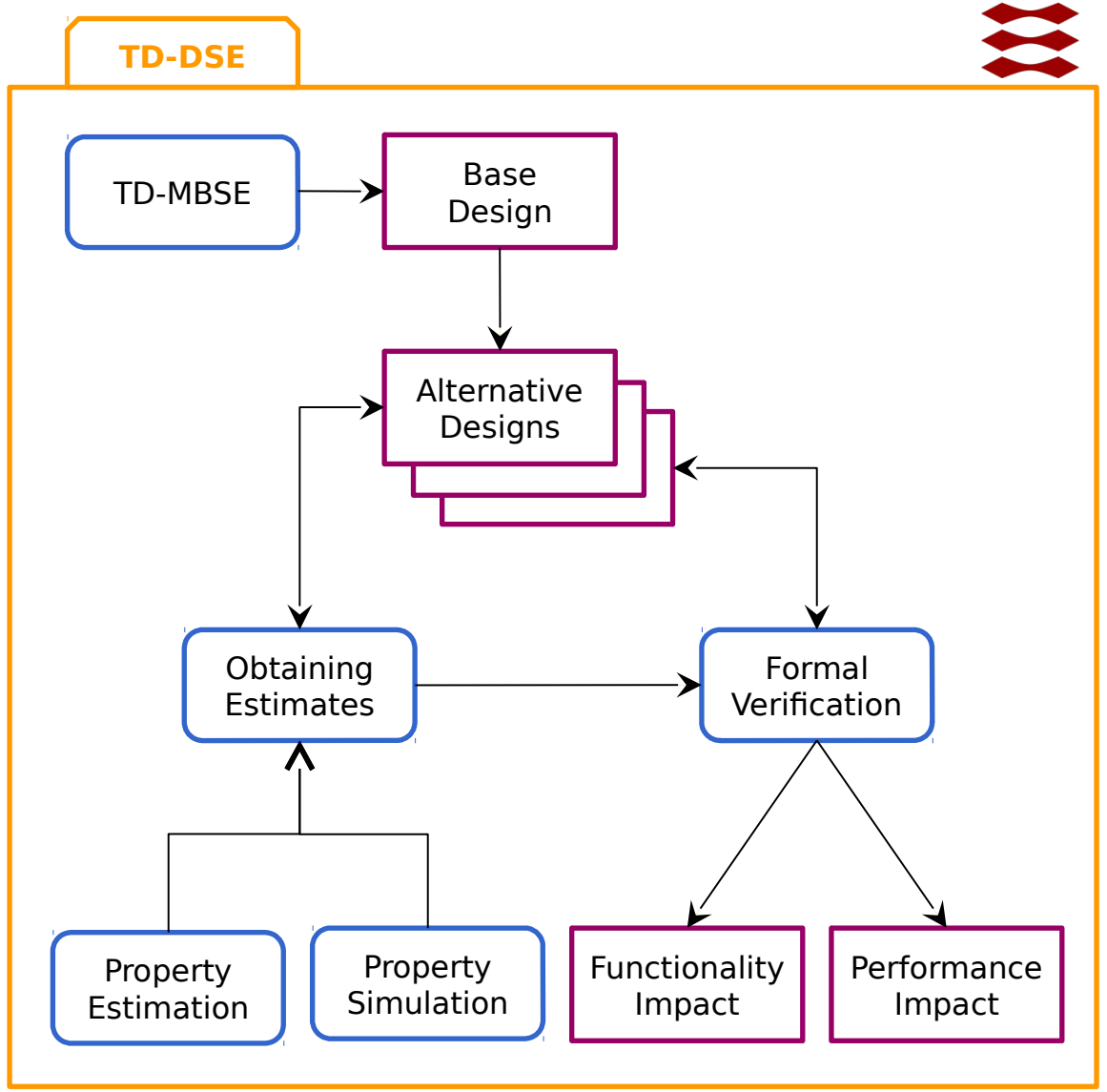


Figure 2: Test-Driven Design Space Exploration

Practical modelling and verification

- Collecting system knowledge in SysML.
- TD-MBSE with UPPAL (figure 3).
- Formal model checking queries, e.g.:
  - A[] not deadlock
  - Streaming.Receive --> Streaming.Done
  - etc.

  - Base design: “Efficient” solution.
  - Alternative: “Fast” solution.

  - E[<=100;2] (max:Streaming.delay)
  - simulate 1[<=200]{Streaming.curr}
  - Using UPPAAL plot composer + Matlab

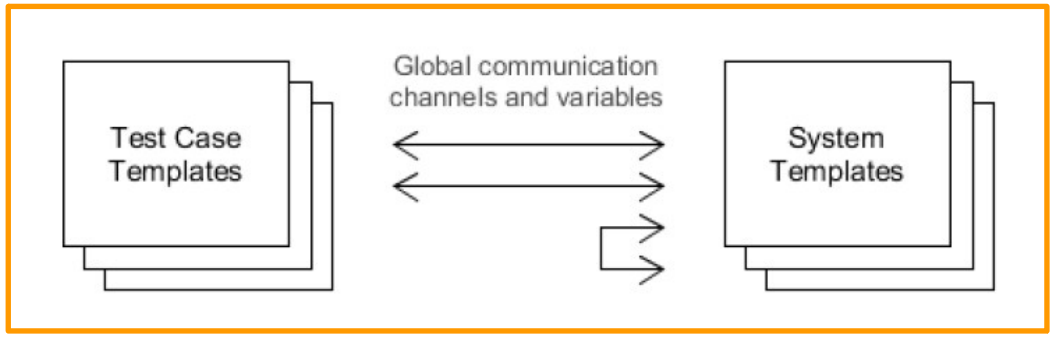


Figure 3: Test case scenario modelling

Related work

- Test-Driven Development (TDD) [e.g. Cordemans et al.]
  - Used heavily in the software industry to increase code quality.
  - Not directly applicable to embedded systems that include hardware.

- Model-based test-driven development [Mou et al.]
  - Method proposed but not tested or verified (no experimental data reported).
  - Has limited scope and is probably not feasible for embedded systems.

- Test-driven software modelling [Zhang]
  - Method based on simulations of message sequence charts.
  - Experimental data demonstrates increased productivity and quality on large projects.

- Test-driven UML modelling of software systems [Hayashi et al.]
  - Test-first methodology include both unit and scenario testing.
  - A tool to facilitate the method is provided – with somewhat poor usability.

Problem and solutions

- Previous work
  - Special tools required.
  - Too cumbersome to use.
  - Only unit or scenario testing.
  - Cannot find unintended emergent errors.
  - Cannot guarantee design.
  - Limited scope.
  - No widespread acceptance.

- Utilizing existing tools as is.
- Easy to use – modelling becomes a simple mechanical process.
- Formal and statistical verification.
- Captures unintended behaviour.
- This work is limited to modelling of architecture and behaviour of embedded systems.
- Method easy to adopt.

Discussion

- Traces generated by UPPAAL made modelling easy.

- Problem with memory exhaustion.
  - Very long traces for low level modelling.
  - State explosions for large models.
  - No simple long term solution.
  - Formal model checking may have to be abandoned.

- Only behaviour and architectural parameters considered in this work.
  - Architecture: Number of interfaces, coupling, etc. may also benefit from TDA.
  - User interfaces and even stakeholders, use cases, requirements, etc. may also benefit.

Industrial future

- Smart Products:
  - SoS : System of (independent) Systems.
  - CPS : Cyber Physical (sub) Systems.
  - BDS : Big-Data Systems.
  - Millions/Billions of users.
  - Connected via (multiple) clouds.

- No tools available to analyse complete system.

- Proposal:
  - Model and analyse single-user scenarios with UPPAAL.
  - Model and simulate system with thousands of users using SimJava, SystemC, VDM or equivalent language.
  - Vary parameters to obtain simulation results for subsequent estimation/extrapolation of realistic usage.

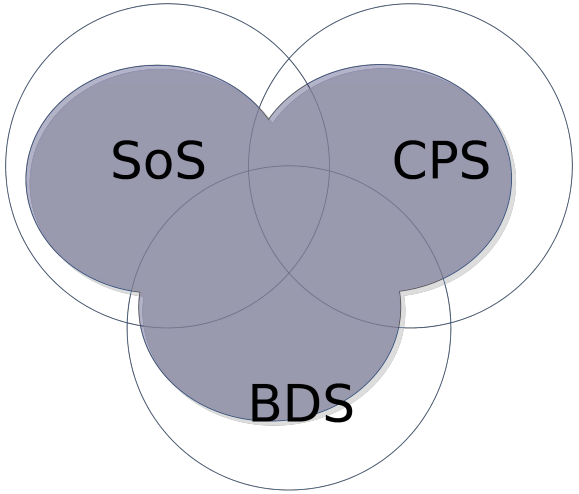


Figure 1: Characteristics of smart products

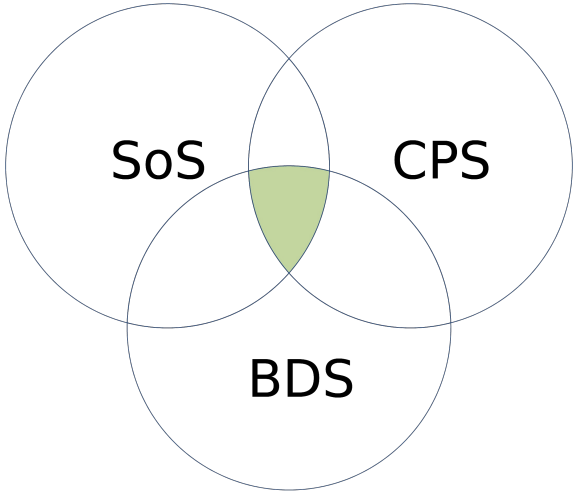


Figure 2: Available techniques

Summary

- TD-MBSE and TD-DSE proposed to handle increasing complexity.
- Includes test-driven modelling of behaviour and architecture.
- Methodology tested on an actual industrial case with success.

- Future research to overcome memory exhaustion problems.
- Future research to expand the methodology to include other aspects of modelling.
- Methodology for future industrial cases proposed.

Thank you for listening!

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