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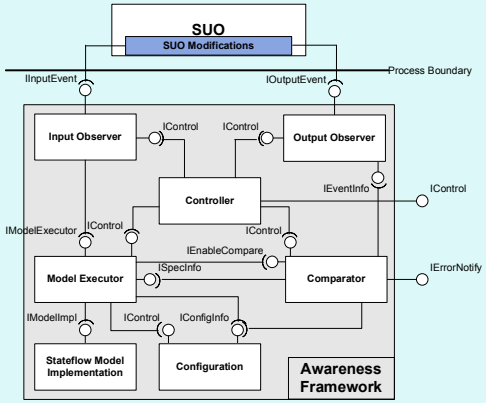
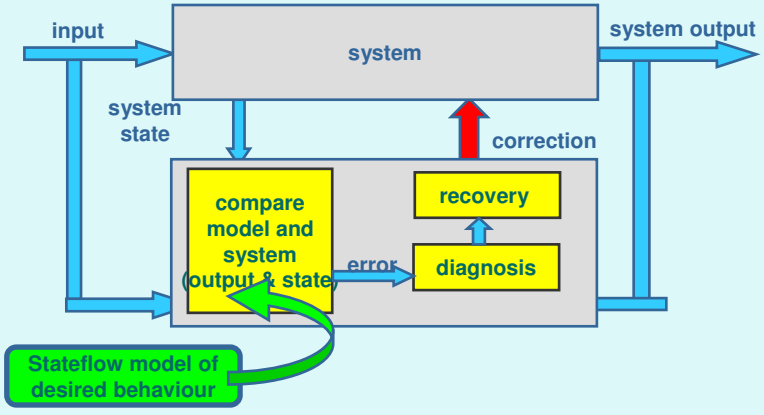
Model-Based Run-Time Error Detection

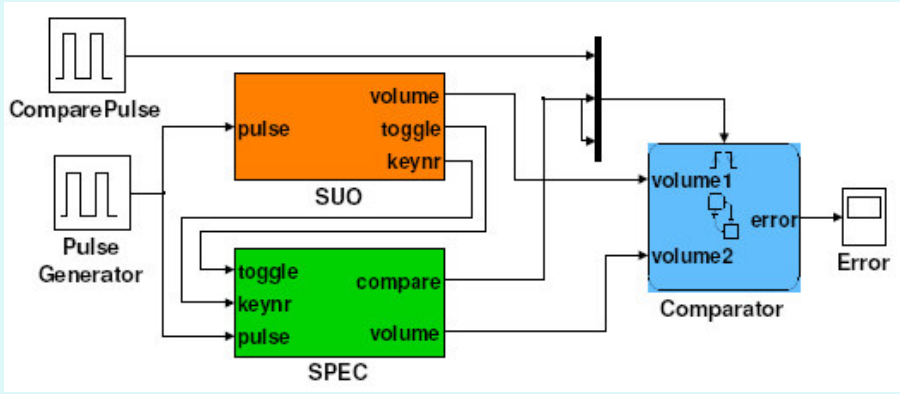
Jozef Hooman & Teun Hendriks

Embedded Systems Institute

Eindhoven, The Netherlands







Models@run.time, 2 October 2007

TRADER
System Reliability

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Previously known as Philips Semiconductors

NXP founded by Philips

Carrying Industrial Partner

Period: Sept. 2004 - Aug. 2009
20 fte/yr, 7 PhDs,
1 Postdoc, 10 Partners

TRADER

imec

TU Delft
Delft University of Technology

TU/e technische universiteit eindhoven

DESIGN TECHNOLOGY INSTITUTE

Universiteit Leiden

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Embedded Systems INSTITUTE

TASS software professionals

NXP founded by Philips
Research

PHILIPS
Consumer Electronics

Goal

Develop methods and tools to optimize reliability of high-volume products

Issues

- Minimize product failures.
- Maintain high-level of user-perceived reliability

Case studies from TV domain

Reliability threats in TV domain

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Increasing complexity

- **Functions/content increases rapidly**
  - *Play music (mp3, ..), view photos, search teletext, Electronic Programming Guide, child lock, sleep timer, Picture-in-Picture, TV ratings, emergency alerts, many image processing options and user settings, …*
- **External information sources multiply**
  - *Connected planet strategy, downloadable applications*

➔ **Increase of SW (1KB in 1980 – 64MB in 2007)**
Increase of third party content (EPG, codec's)

Decreasing time-to-market

- **Fixed shipping gates to occupy reserved shelf space**

Business impact

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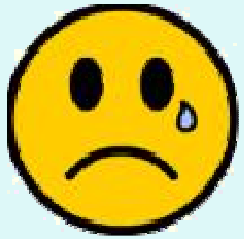
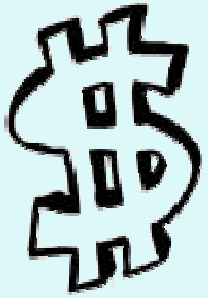
- **Not satisfying the high reliability expectations**
  - **Many returned products**
  - **Damages brand image**
  - **Reduces market share**





Challenge:

- **Prevent product faults causing customer complaints given constraints:**
  - **Low costs**
  - **Short time to market**

Approach: run-time awareness

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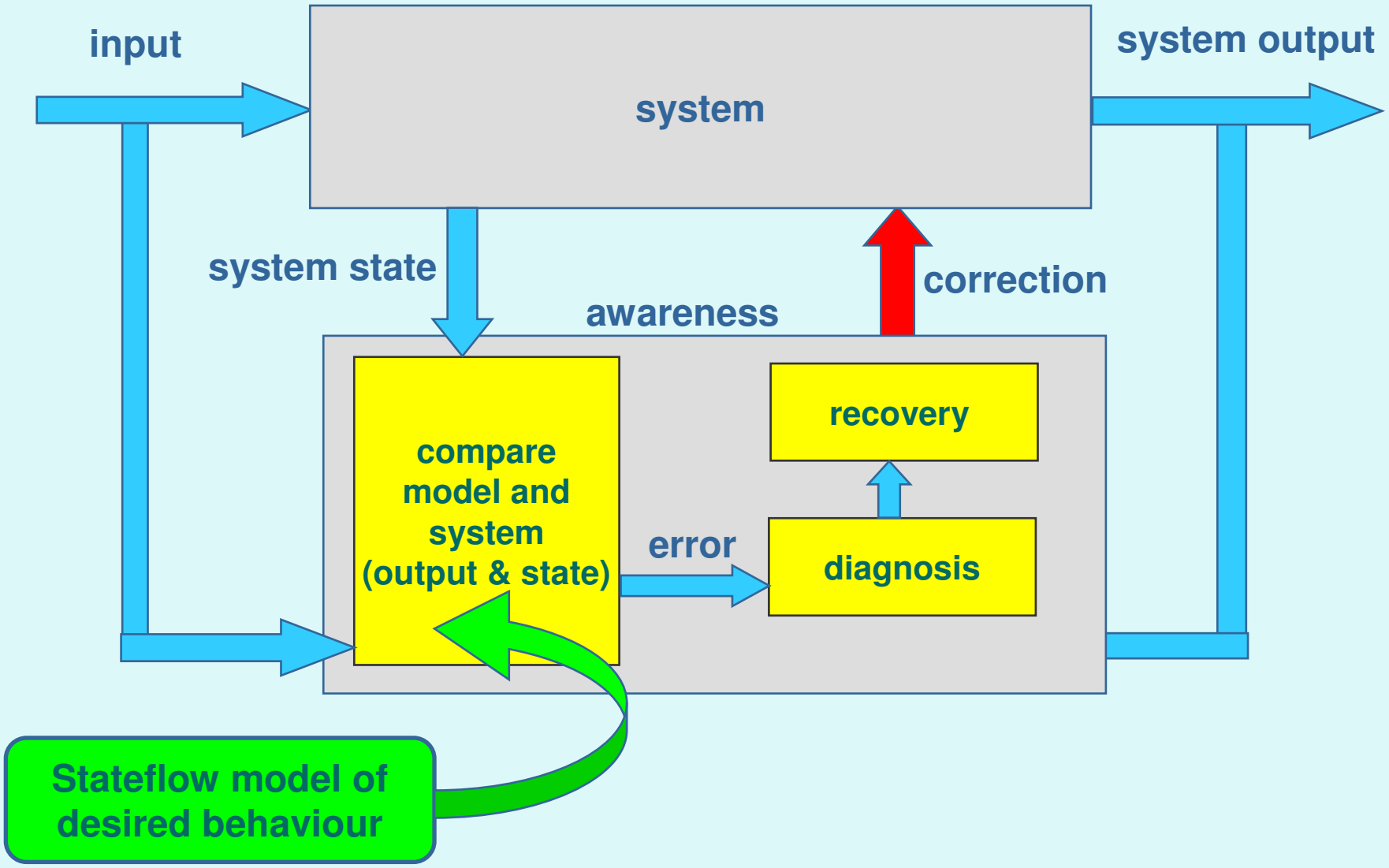
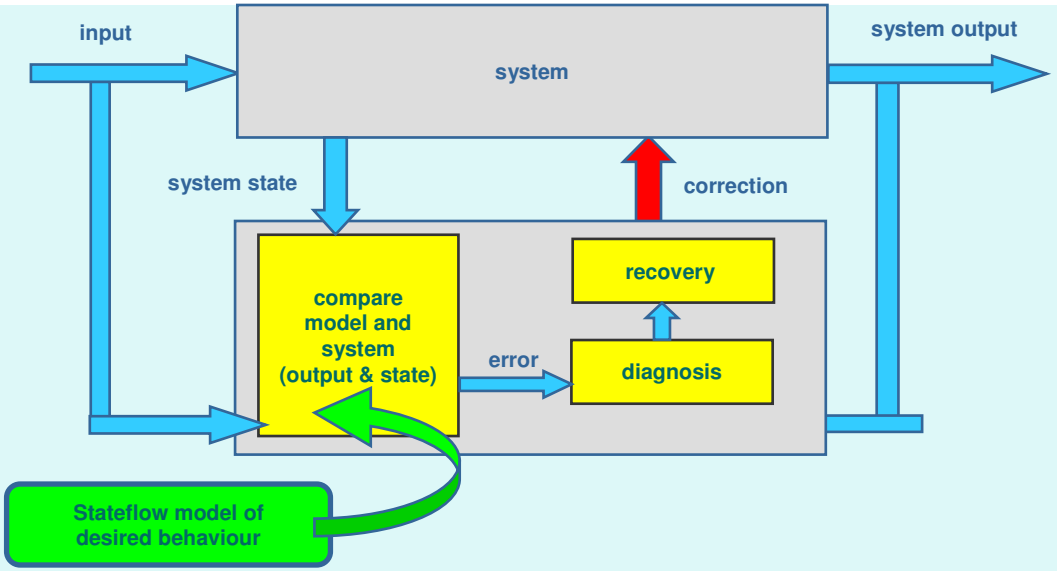


Research Questions (1)



Modeling

- Which part of the system to model?
- What are most suitable models, at which level of abstraction?
- Which models can be implemented most efficiently?
- How to obtain suitable models?
- How to increase confidence in the model?

Model desired behaviour

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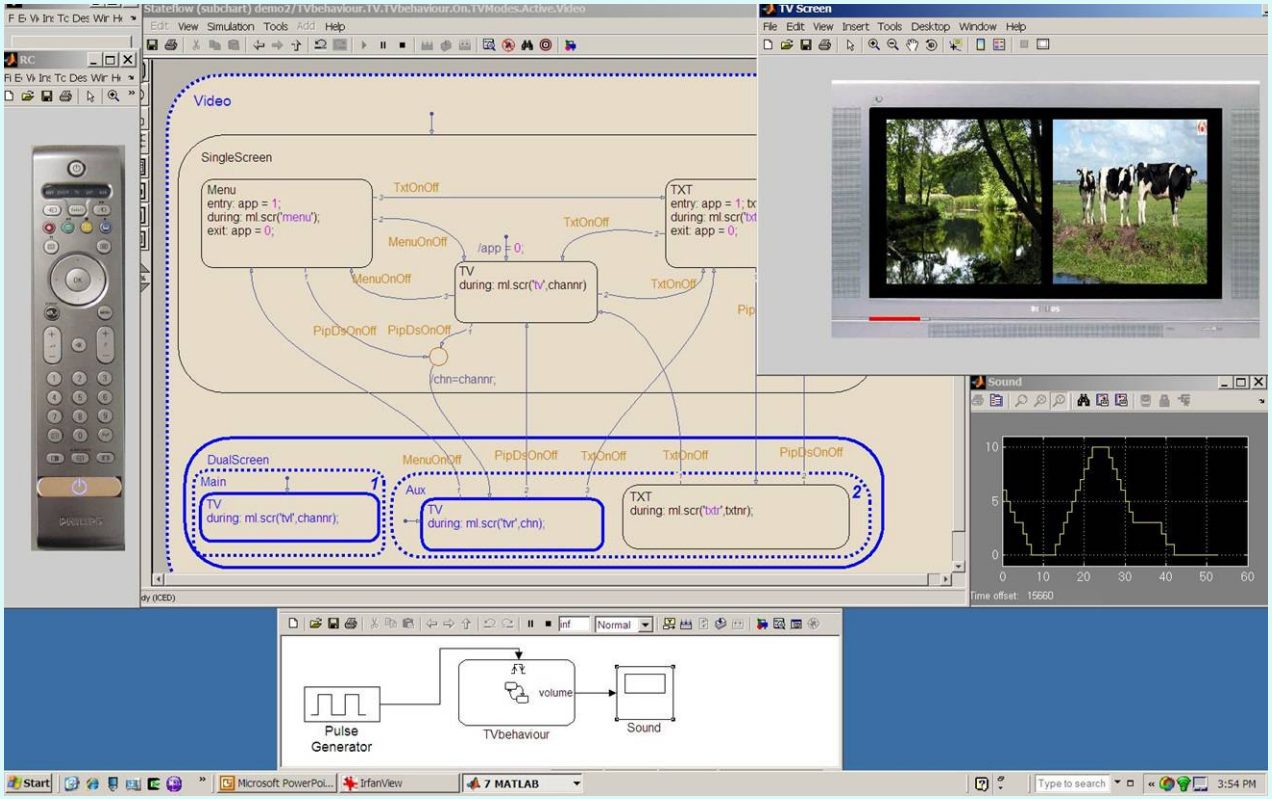
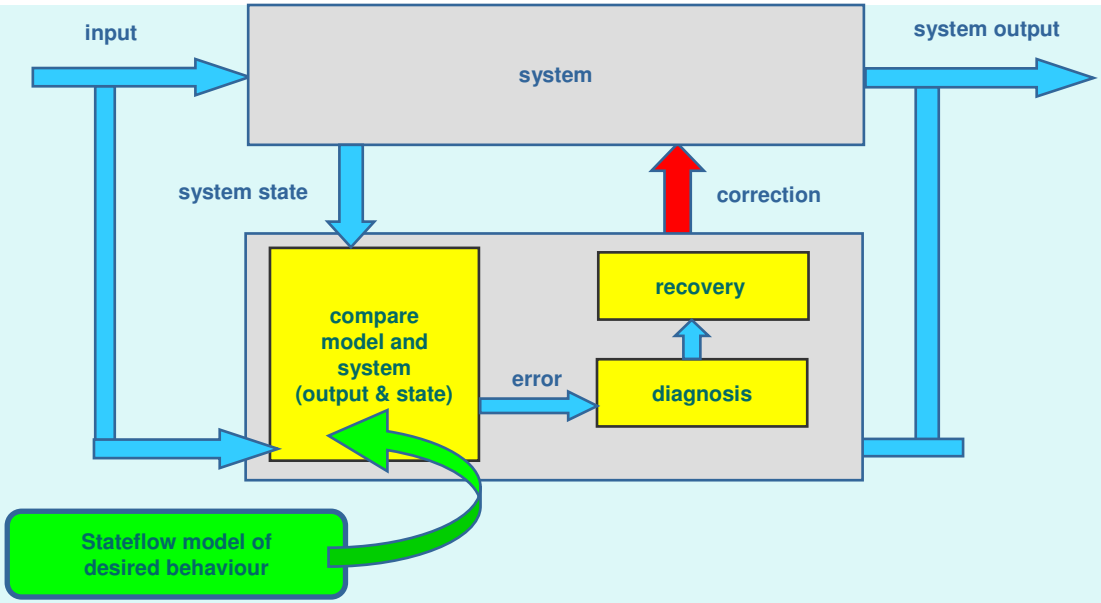
First model desired user-perceived behaviour
(in Matlab/Simulink/Stateflow)

➔ More difficult than expected;
not explicit in current requirements documents



Research Questions (2)



Models at run-time

- How to preserve model semantics in implementation?
- How to avoid false errors?
- When to compare system observations with model?
- When to report an error, how much tolerance is allowed?

Awareness Experiments

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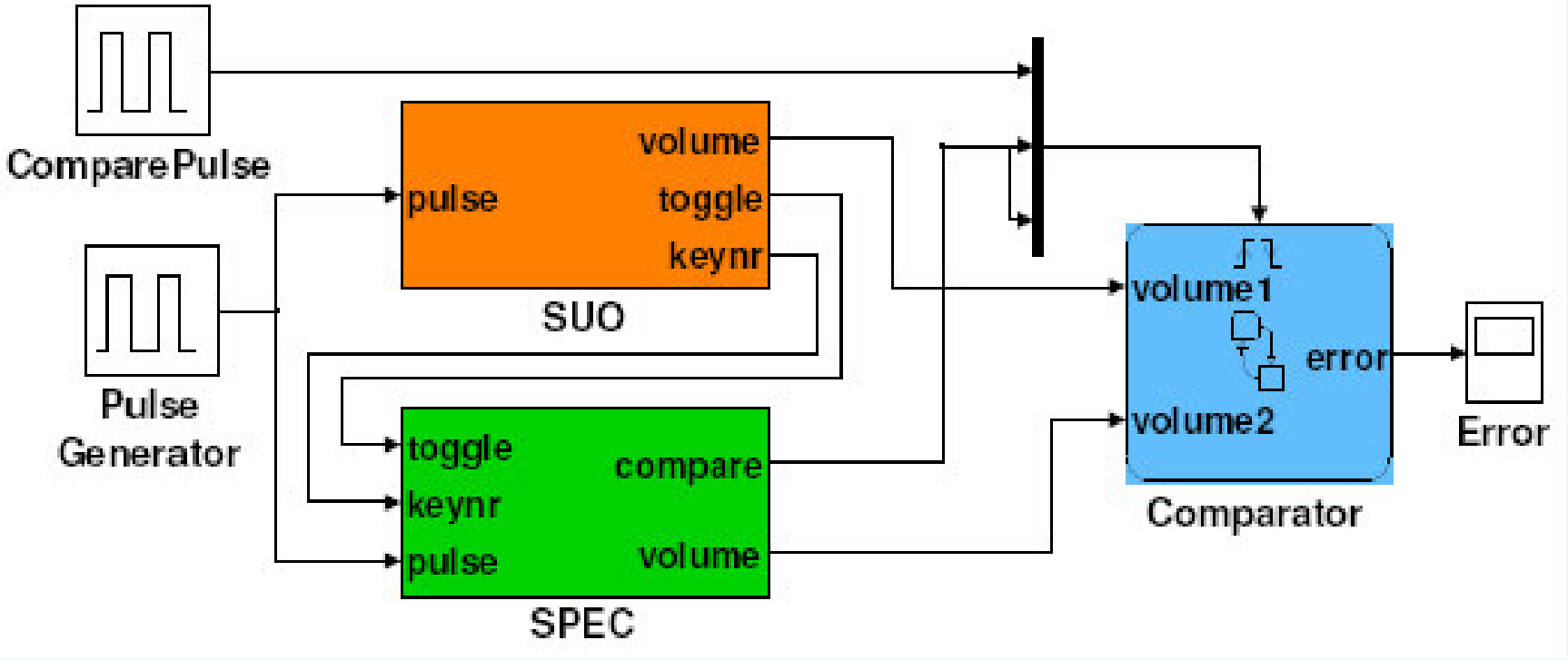
Experiment with awareness concept:

- **Simulation using Simulink/Stateflow**
  compare model of System Under Observation (SUO) and SPEC, try different error detection strategies
- **Linux-based awareness framework**
  in which SUO and SPEC can be inserted easily
- **Open source media player MPlayer [current work]**
  model desired behaviour and insert system and spec in Linux-based framework
- **Add awareness to part of TV system [future work]**

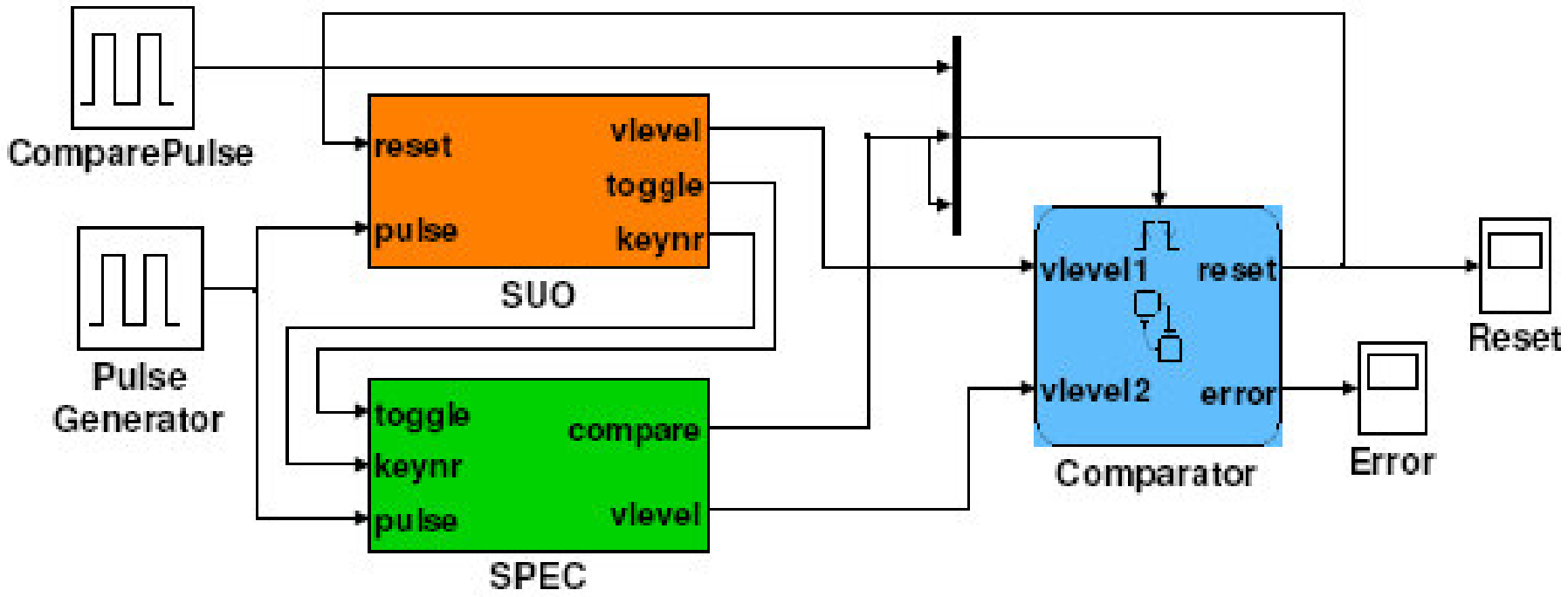
Simulating Awareness



Comparison can be

- Time-triggered (compare pulse)
- Event-triggered (compare signal from model)

Simulating Awareness



Observe internal variable to detect error earlier and allow recovery before user observes failure

Design of Framework in Linux

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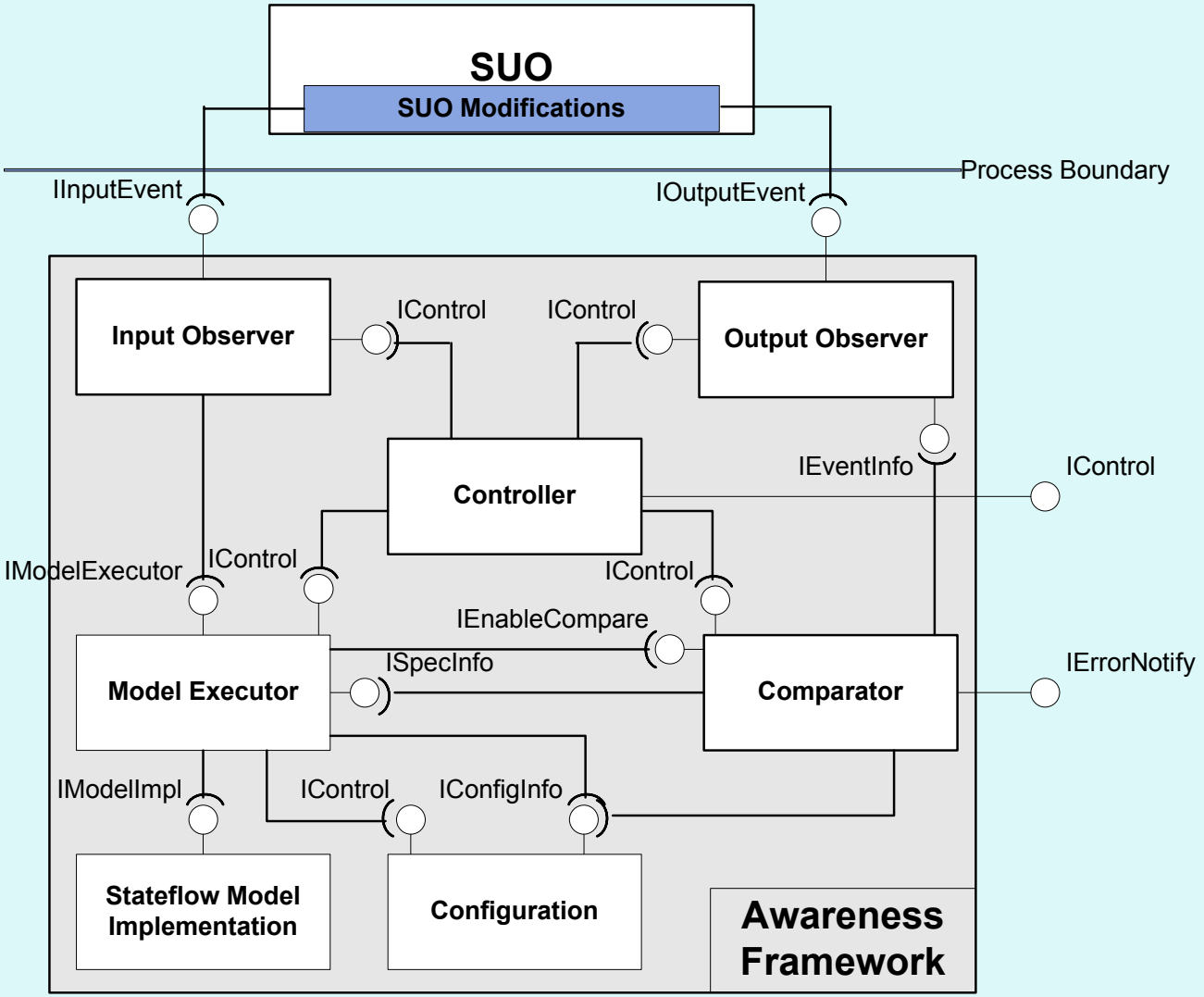

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Application: MPlayer

Process Boundary

IInputEvent

IOutputEvent

Input Observer

Output Observer

Controller

Model Executor

Comparator

Configuration

Awareness Framework

IControl

IEventInfo

IModelExecutor

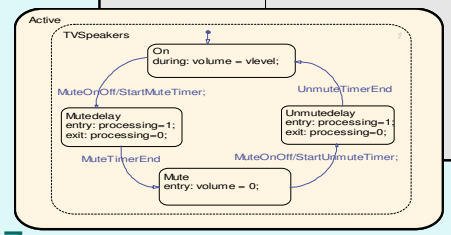
IEnableCompare

ISpecInfo

IErrorNotify

IModelImpl

IConfigInfo



Concluding Remarks

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- **Stateflow suitable modeling language**
  - **Allows various forms of model validation**
  - **Various options for code generation**
- **Linux-based framework suitable for experiments**
- **Comparison strategy needs further study**
  - **When to compare to avoid false errors**
  - **In Linux framework we allow the specification of**
    - **Maximal allowed deviation on values**
    - **Maximal number of allowed consecutive erroneous deviations**
  - **Uncertainty about system behaviour, such as worst-case & best-case execution times, are included in model**

    Avoid comparison when systen behaviour is uncertain

Thank you for your attention!

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