Software Plattform Embedded Systems 2020

Multi-aspect Virtual Integration approach for Real-Time and Safety Properties

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OFFIS

Motivation

- Volvo brake test

https://www.youtube.com/watch?v=aNi17YLnZpg

Motivation

- Embedded systems design => complex
- Proof obligations:
  - Compatibility of specification
  - Correct Real-Time behavior
  - Ensure safety
- Satisfaction Check (Specification ⇔ Implementation)
- **V**irtual **I**ntegration **T**est (Specification ⇔ Specification)
  - Real-Time (Refinement only, previous work)
  - Safety (this work)
  - Real-Time + Safety (this work)

Agenda

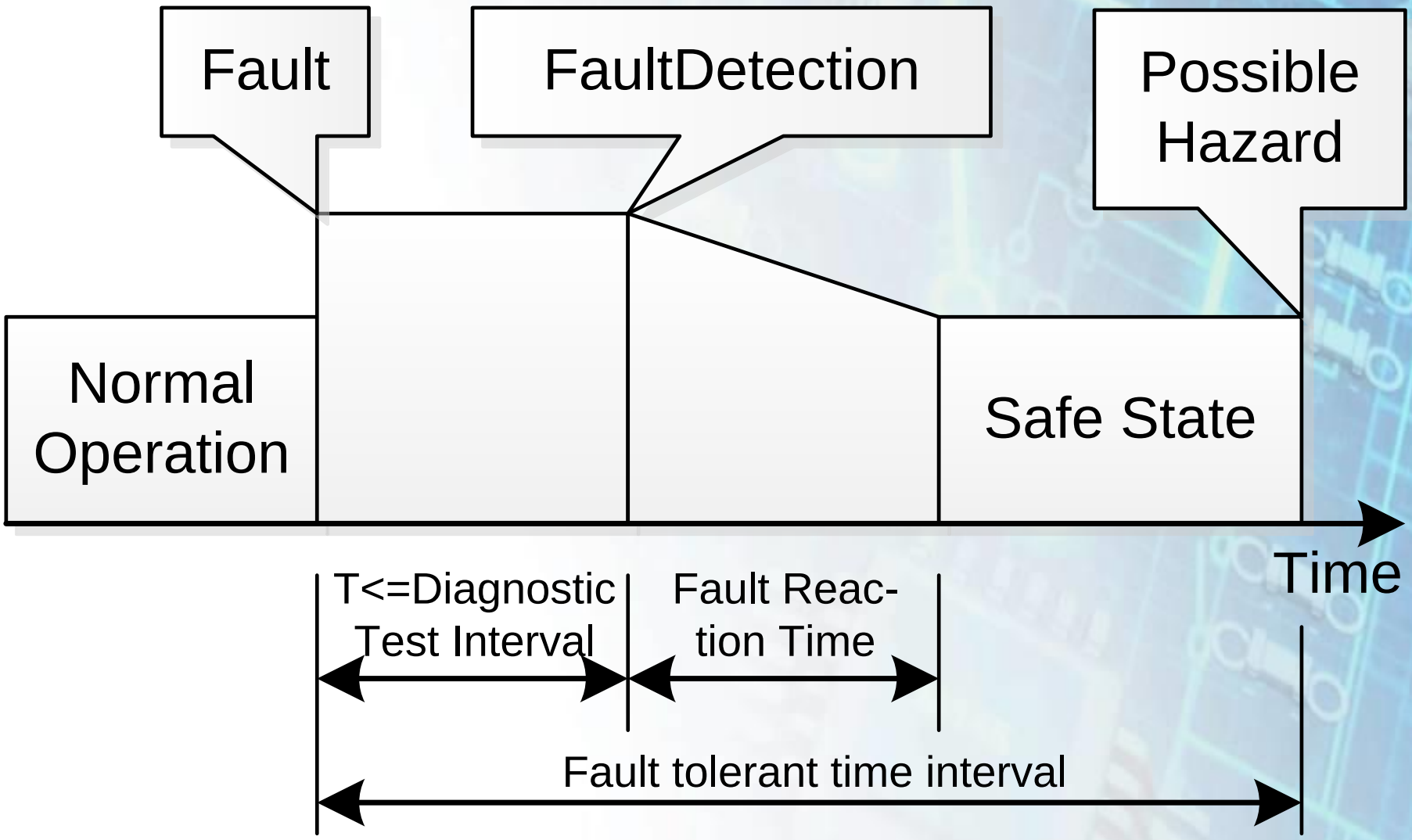
- Motivation
- Fundamentals
  - Contracts
  - Fault Tolerance Time Intervals
  - Virtual Integration Test (VIT)
- VIT for Safety & Real-Time
- Case Study + Results
- Conclusion + Outlook

Contracts

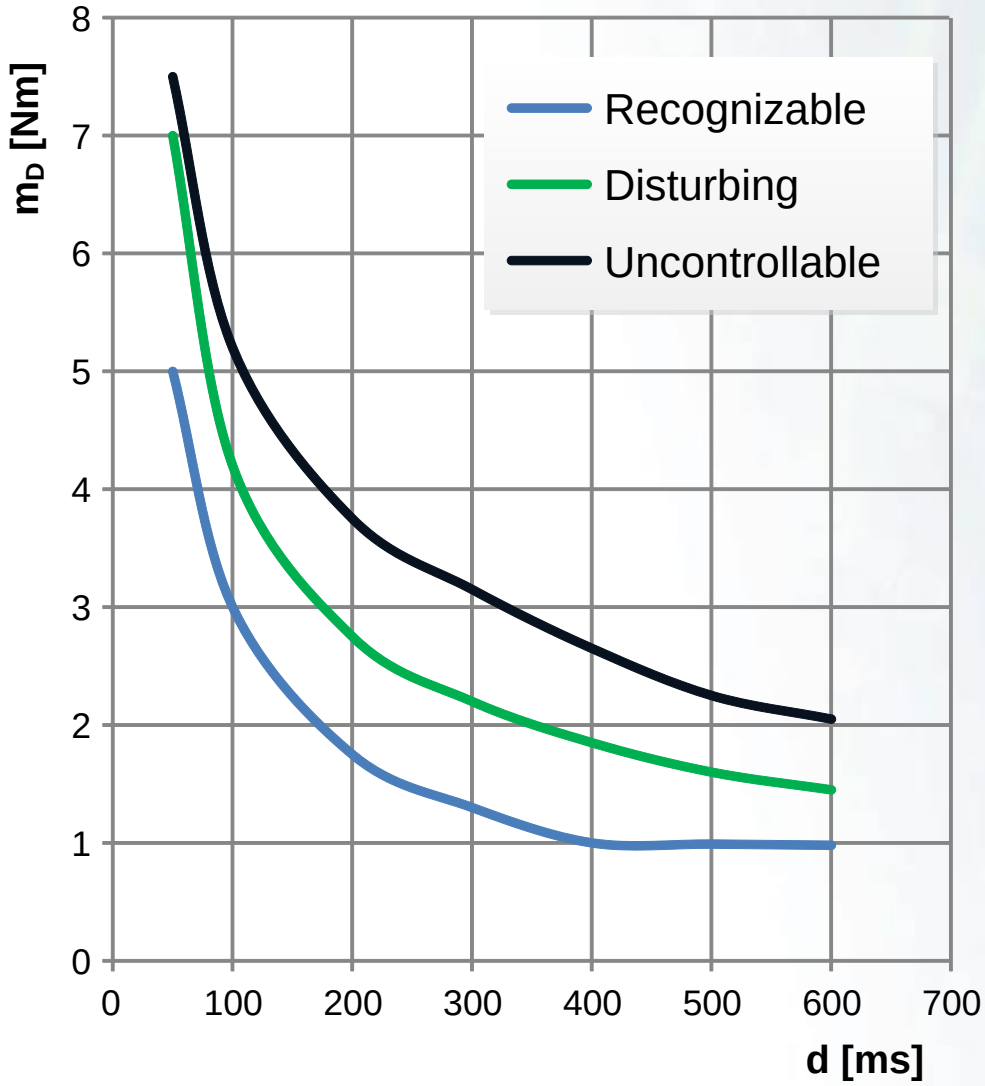
- (Strong) assumptions A_S specify how context of a component should behave
- If assumptions are fulfilled, component will behave as guaranteed (G).
- Extended by so called *weak* assumptions A_w
  → Describe a set of possible environments in which component guarantees different behavior

$$C = (A_s, G) \text{ with } G = (A_{w1} \Rightarrow G_1) \wedge \ \ldots \wedge (A_{wn} \Rightarrow G_n)$$

ISO 26262: Fault Tolerant Time Interval



Derived from e.g. Controllability Analysis



Virtual Integration Test

- Integrate components into a more abstract environment at an early stage in the design flow
- Let $A \subseteq A_i$ for all sub-contracts C_i then the VIT condition is defined as follows

$$i)\ A \wedge G'_1 \wedge \ldots \wedge G'_n \Rightarrow A'_1 \wedge \ldots \wedge A'_n$$

$$ii)\ A \wedge G'_1 \wedge \ldots \wedge G'_n \Rightarrow G$$

Passive observer automata with bad states

Trigger automata

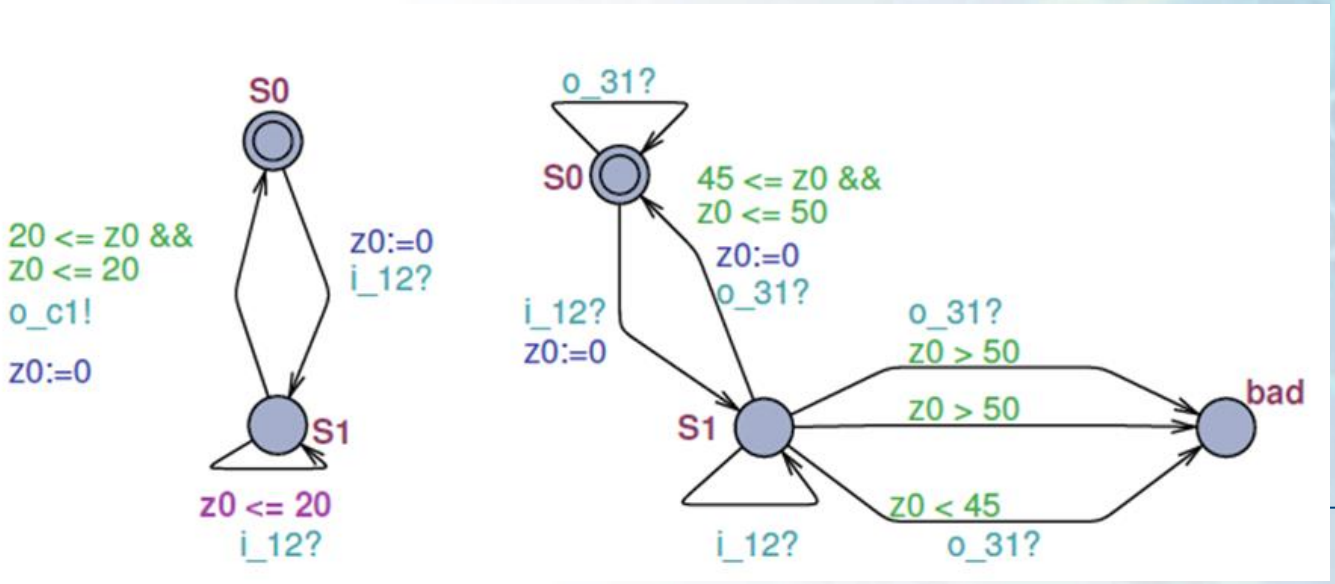
- Assumptions get weaker, guarantees stronger
- Contracts „fit“ together
- Derive timed automata and do reachability check of bad states of observer automata

From RSL to TA

- Specification of assumptions and guarantees via *Requirement Specification Language (RSL)*

> ***Whenever*** *event* ***occurs,*** *event* ***[does not] occur[s] [during*** *interval****]***.

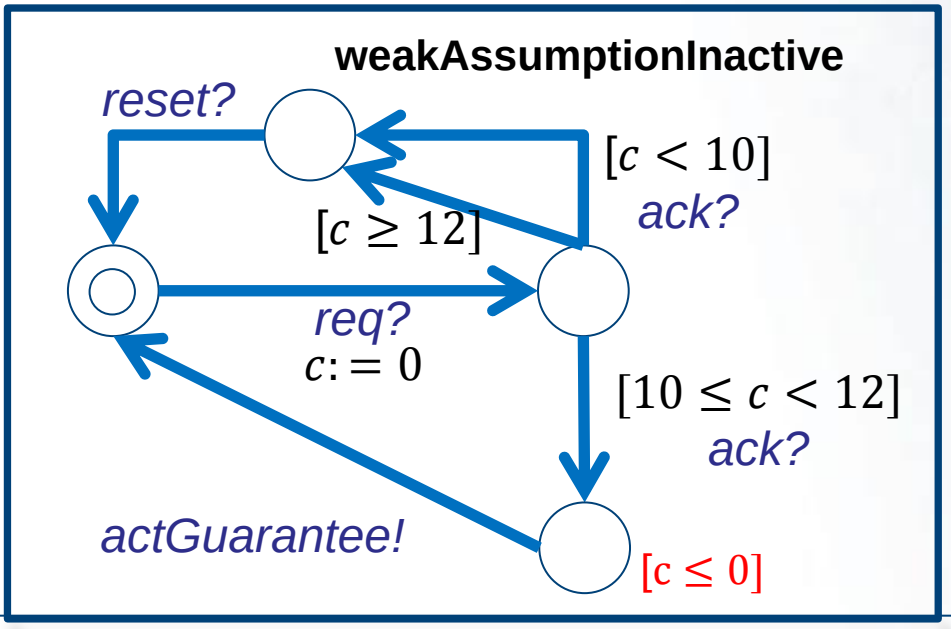
- Transform text pattern to automata

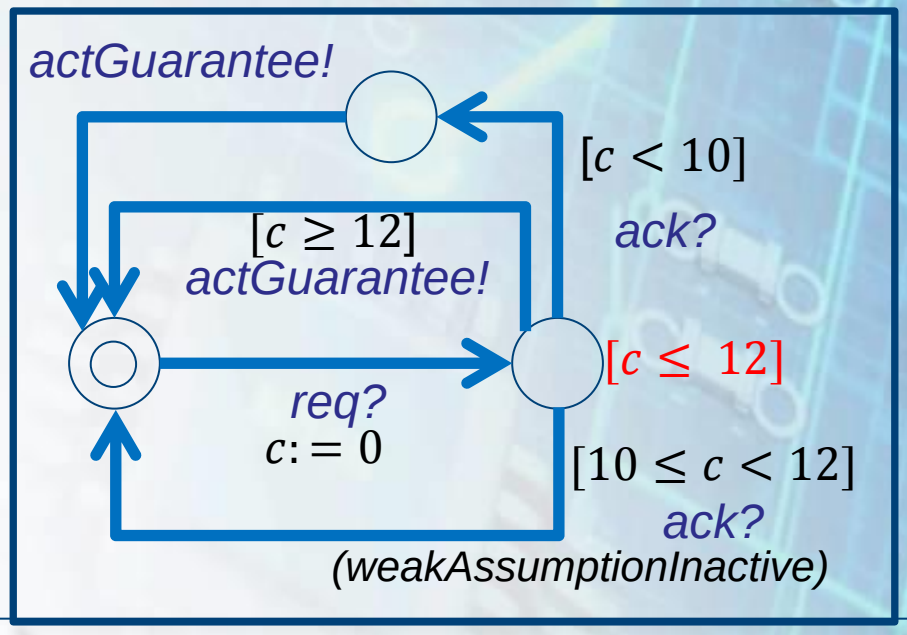


Extension with Weak Assumptions

Contract_AllOK
A_w: whenever req occurs, ack occurs during [10ms,12ms[.
G: whenver wd_activation occurs, faultDetected=false occurs during [10ms,15ms].

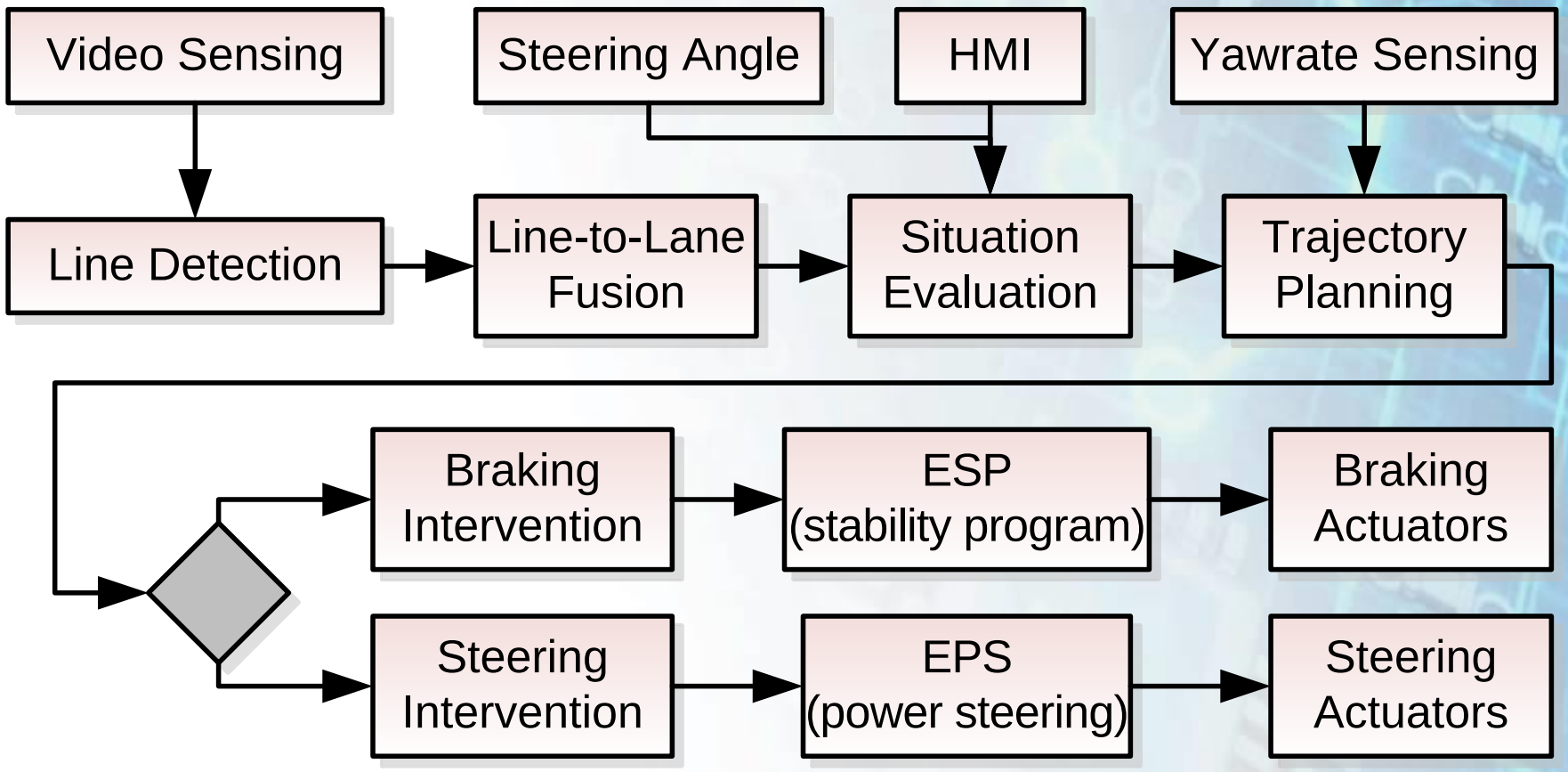
Contract_FaultDetection
A_s: wd_activation occurs each 15ms.
A_w: whenever req occurs, ack does not occur during [10ms,12ms[.
G: whenever wd_activation occurs, faultDetected=true occurs during [10ms,15ms].





Bosch Lane Keeping Support

- Functional structure



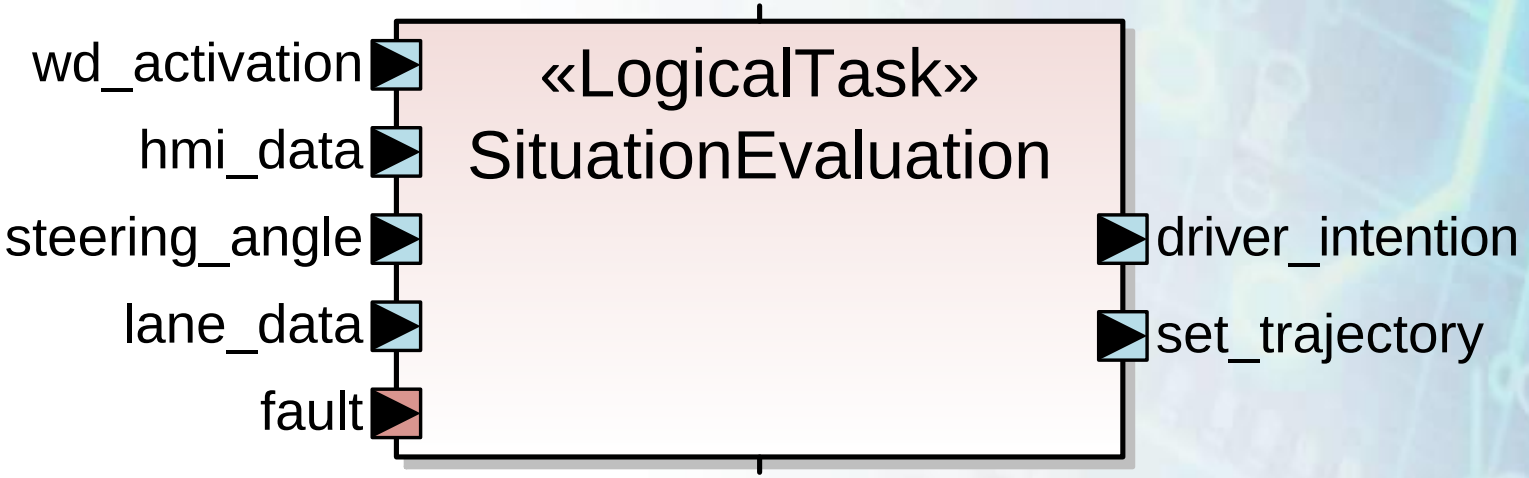
Contract_SE_RT

A_s: hmi_data && steering_angle occurs each 20ms;
wd_activation occurs each 15ms;

A_w: fault=false.

G: whenever hmi_data && steering_angle occurs, driver_intention && set_trajectory occurs during [10ms,20ms].

«Satisfy»



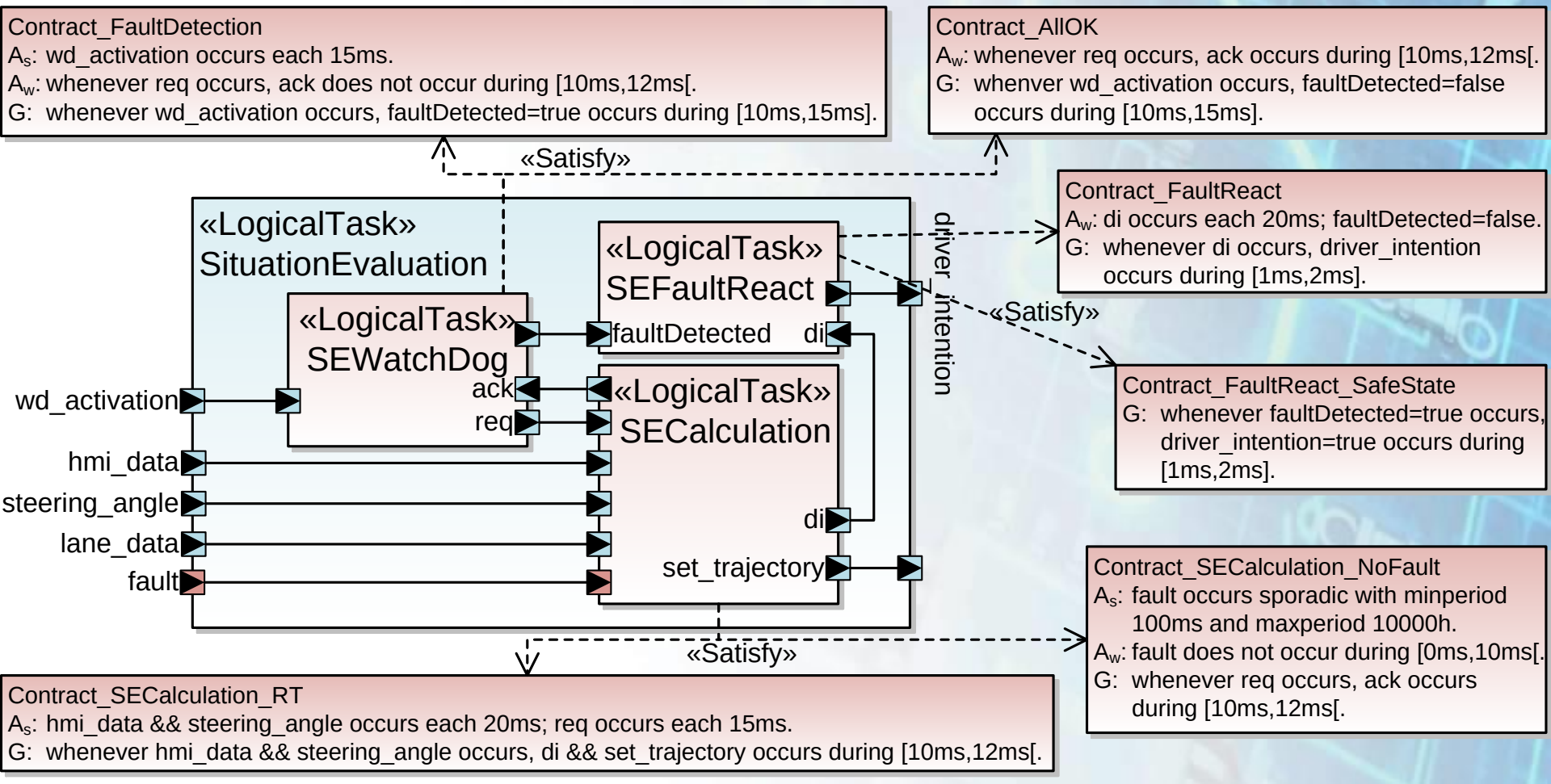
«Satisfy»

Contract_FTTI

A_s: fault occurs sporadic with minperiod 100ms and maxperiod 10000h.

G: whenever fault occurs, driver_intention=true occurs during [0ms,40ms].

Decomposed Situation Evaluation



Conclusion & Outlook

- Contract based design
- Real-Time + FTTI on specification level
- VIT for Safety and Real-Time properties
- Industrial Lane Keeping Support case study for evaluation

Outlook:

- Satisfaction for FTTI: Schedulability analysis
- Transient faults
- Other fault types + recognition