On Board Unit Simulator (by Martin Keesen)

Business case

The On Board Unit allows insurance company to apply bonus system for car users who obey traffic rules and who adapt their driving behavior to the actual traffic conditions.
Car user has to contribute in installation and communication costs. These are too high to be covered by insurance company.
This means the car user shall have other benefits from applying an OBU.

Goal

Implement demo to show possible applications.
User interface must be vivid and completely under control of ASD-model.

Requirements simulator

1. Model shall provide option to control a simulation run
   Start / pause / reset
2. Model shall provide option to alter speed of vehicles
   0 to 100 in steps of 10 km/h
3. Model shall provide option to alter traffic sign
   Speed limit 70 or 90 km/h, road blocked, sign off
4. Model shall indicate end of test run
   Vehicles move a given trajectory which is limited to the screen
5. Application shall display trace of ASD-debug info
6. Application shall provide option to filter trace
   Block info of a specific component
7. Application shall provide option to clear trace info
8. Application shall allow a minimum set of scenarios

Scenarios

Speed limit

RSU sets speed limit on Road Sign
OBU receives speed limit from RSU
OBU compares own car speed with received speed limit
OBU displays speed advice
Violation is logged

Speed difference

Truck drives with lower speed than Car
Car receives speed data from Truck
OBU displays speed advice

Tailgating

Distance between Car and Truck below given threshold
Violation is logged

Collision

Truck drives with lower speed than Car.
Car crashes into Truck.
Car stops
OBU sends alarm to Road Authority

Occupancy

Car and Truck drive at same speed
OBU sends occupancy data to RSU based on distance between vehicles

Components

On Board Unit

Unit in Car providing feedback to driver (Info, Alarms and Violations) and logging of violations

Car

Vehicle equipped with the OBU

Truck

Vehicle in front of Car

Road Sign

Indication of speed limit

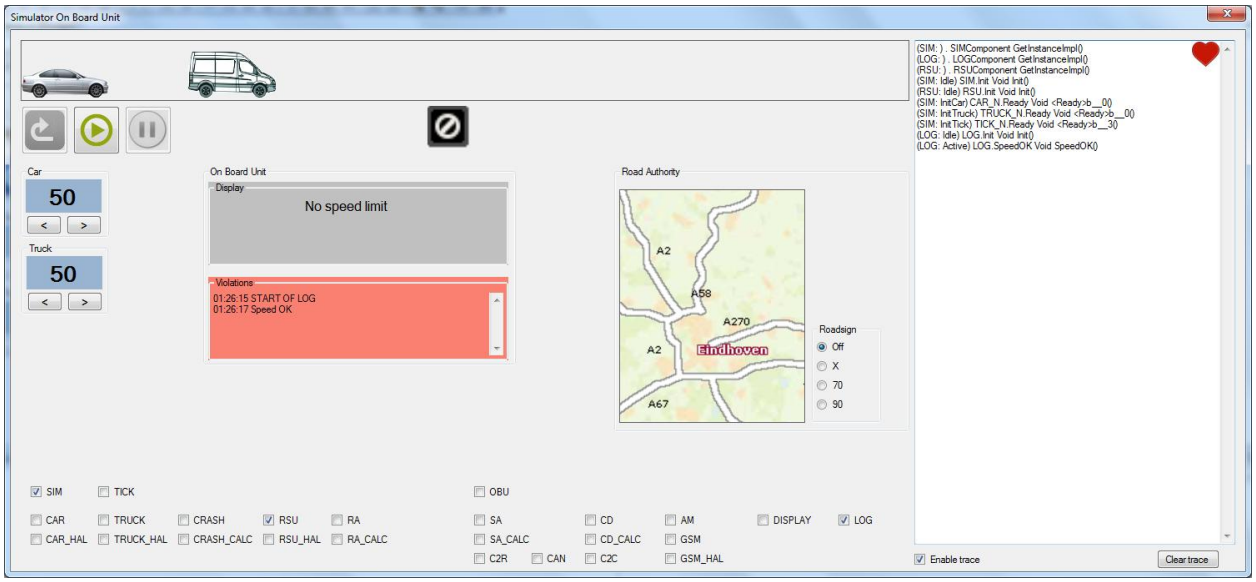
Road Side Unit

Unit communicates with Car

Road Authority

Controls road sign, monitors traffic condition

User interface



Design

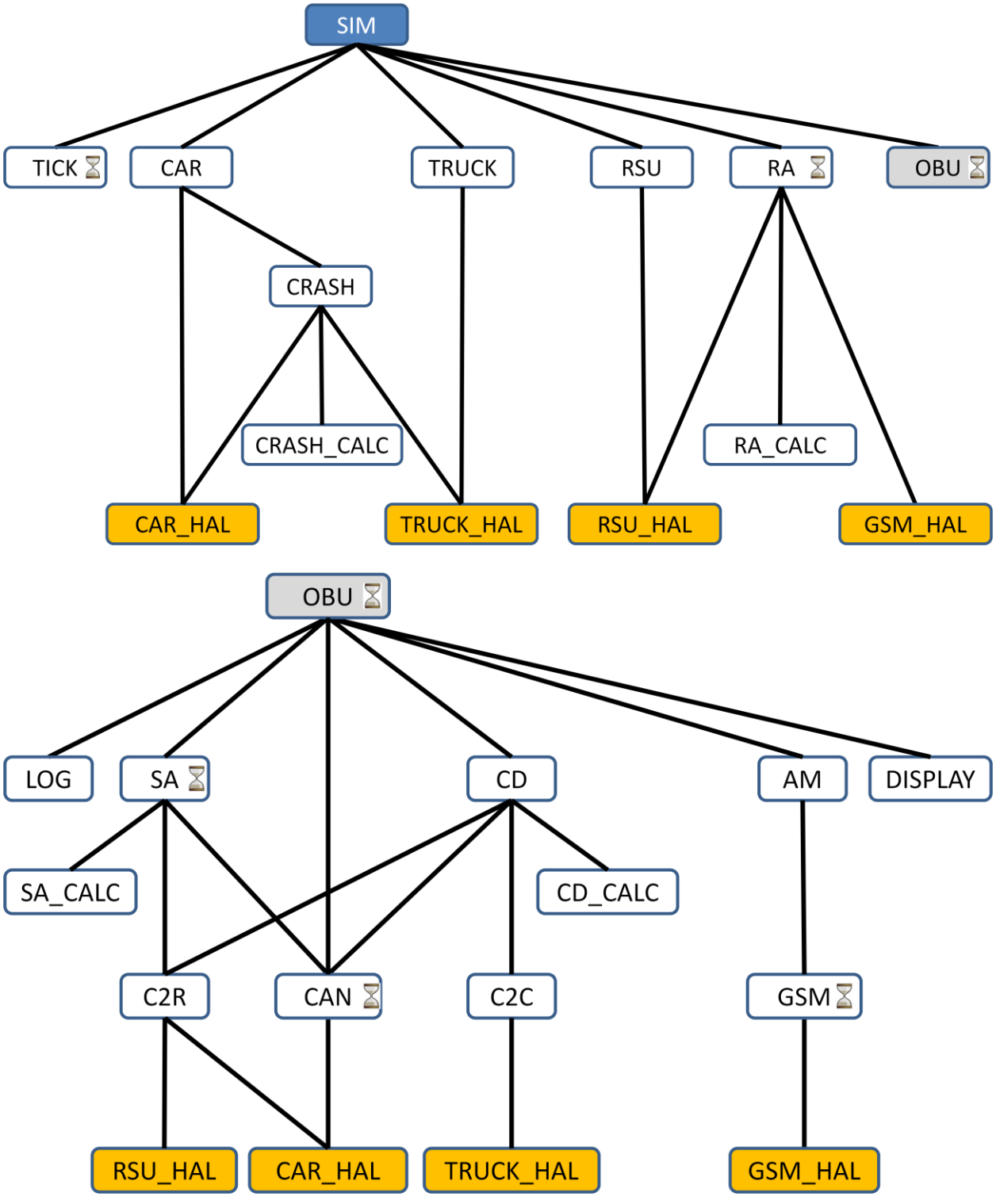
Components

- SIM
  Control simulation run
- TICK
  Heartbeat generation
- CAR
  Control position and speed of car
- TRUCK
  Control position and speed of truck
- CRASH
  Detection of crash of car and truck
- RSU
  State of road sign
- RA
- OBU
  Polls SA and CD, redirect violations to LOG, redirect text to be displayed to DISPLAY
- DISPLAY
  Priority of display of messages, output to several lines
- SA
  Speed advice based on speed limit information received from C2R
  Speed advice based on speed difference between car (CAN) and truck (C2C)
- CD
  Detection of tailgating
  Send occupancy data to Road Authority
- AM
  Alarm Manager
  Inform Road Authority on crash
- LOG
  Logging of violations
- C2C
  Car to Car communication
- C2R
  Car to Road Side Unit communication
- CAN
  Car internal bus
- GSM
  Send SMS

Foreign components

- CAR_HAL
  Speed and position of car
- TRUCK_HAL
  Speed and position of truck
- RSU_HAL
  Status road sign
- CRASH_CALC
  Calculation of distance between car and truck
- SA_CALC
  Calculation of speed violation
  Calculation of speed difference between car and truck
- CD_CALC
  Calculation of distance between car and truck
- GSM_HAL
  Send SMS
- RA_CALC
  Calculation of severity of collision

ASD-Model


SIM
TICK
CAR
TRUCK
RSU
RA
OBU
CRASH
CRASH_CALC
RA_CALC
CAR_HAL
TRUCK_HAL
RSU_HAL
GSM_HAL
OBU
LOG
SA
CD
AM
DISPLAY
SA_CALC
CD_CALC
C2R
CAN
C2C
GSM
RSU_HAL
CAR_HAL
TRUCK_HAL
GSM_HAL
X
ASD component
Y
Initializing component
Z
Foreign component
Timer included

Development issues

Several design problems passed by:

Calculations

All calculations are performed by foreign components.
A lot of time was spend trying to achieve calculations within the design models.
Attempts to do the calculations within the design models did not satisfy.

Simulation environment

The simulated environment (car, truck, road sign) is connected via hardware abstractions of the components. These hardware abstraction layers are all singleton foreign components.
Development time was lost on using referenced data by more than one component which verifies and compiles correct but fails in the actual deployment phase.

Notifications to multiple components

Implementation of broadcasting messages to multiple components was abandoned after several attempts to implement it. Instead separate notification channels are implemented.

Model verification

Verification of all models affected by a change in one of the models is very error prone. The chances you forget to verify one of the affected models is high. This can easily lead to the situation were a second change resulted in unexpected verification results due to not starting from the “all verified” situation.

Verification time

The design model of the OBU increased dramatically while implementing all interactions with other components. In fact it became unworkable. A complete design change was needed to fix this.
The change was from a design based on notifications to one with requests performed in a round-robin fashion with valued responses.

Validation

During validation a lot of unwanted behavior popped up when two scenarios were mixed.
This lead to many changes in almost all components.

Validation

Validation is performed using AutoIt to ensure repeatability.

Scenario “Speed limit”

Set speed RSU to 70 km/h
Set speed car to 80 km/h
Set speed truck to 80 km/h
Start simulation
As soon as car passes road sign:
- OBU displays info “Speed limit 70 km/h”
- OBU displays warning “Speed violation”
When speed car is reduced to 70 km/h or less:
- OBU removes warning
- OBU logs “Speed OK”
When speed car remains higher than 70 km/h:
- OBU displays “Speed violation recorded”
- OBU logs violation as “Speeding”

Scenario “Speed difference”

Set speed car to 80 km/h
Set speed truck to 60 km/h
OBU displays “Slow car ahead”

Scenario “Tailgating”

Set speed car to 60 km/h
Set speed truck to 50 km/h
When car close behind truck OBU displays warning “KEEP DISTANCE”
When speed car is reduced to 40 km/h or less:
- OBU removes warning
When speed car remains higher than 40 km/h:
- OBU displays “Tailgating violation recorded”
- OBU logs violation as “Tailgating”

Scenario “Occupancy”

Set speed car to 50 km/h
Set speed truck to 40 km/h
When car at certain distance from truck OBU displays warning “Dense traffic”
Set speed truck to 50 km/h
When car passes roadsign map shows dense traffic by coloring road yellow

Scenario “Collision”

Set speed car to 50 km/h
Set speed truck to 0 km/h
Start simulation
Car crashes into Truck before roadsign
OBU logs “Crash”
Road Authority receives alarm message with VIN and severity class 2 (medium crash).

Restart simulation
Set speed car to 100 km/h
Set speed truck lower than 40 km/h
Start simulation
Car crashes into Truck before roadsign
OBU logs “Crash”
Road Authority receives alarm message with VIN and severity class 1 (severe crash).
When Road Authority acknowledges the OBU displays info

Restart simulation
Set speed car to 50 km/h
Set speed truck to 40 km/h
Car crashes into Truck after roadsign
OBU logs “Crash”
Road Authority receives alarm message with VIN and severity class 3 (minor crash)
Accident is shown on map.

Known issues

Tracing

When all tracing is enabled the program will crash after a while. Reason: too many threads are started simultaneously to communicate the trace info. Note that all traces are handled by a separate thread.