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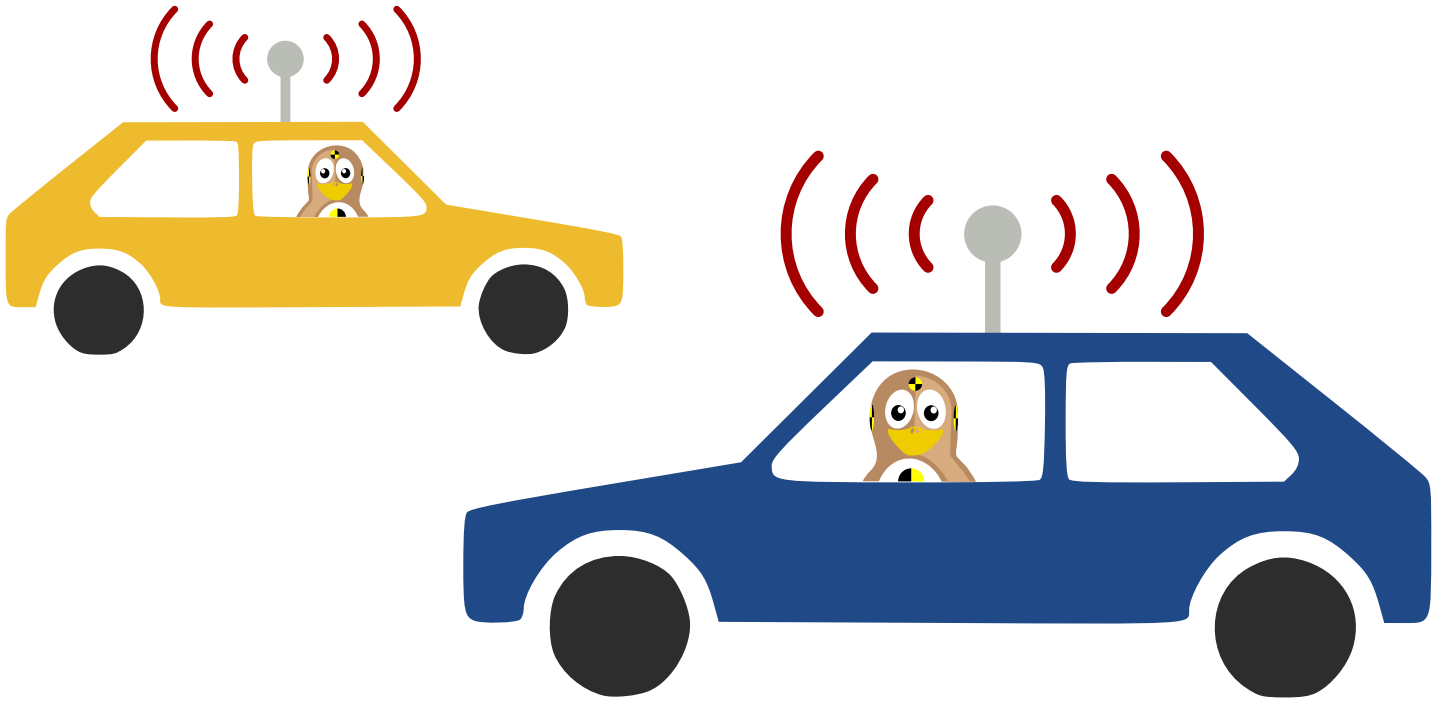


Observations on OMNeT++ Real-Time Behaviour

Christina Obermaier, Christian Facchi · 7. September 2017

Outline

1. Inter Vehicle Communication
2. HIL Testing with OMNeT++
3. Timing Observations
4. Conclusion
5. Further Work

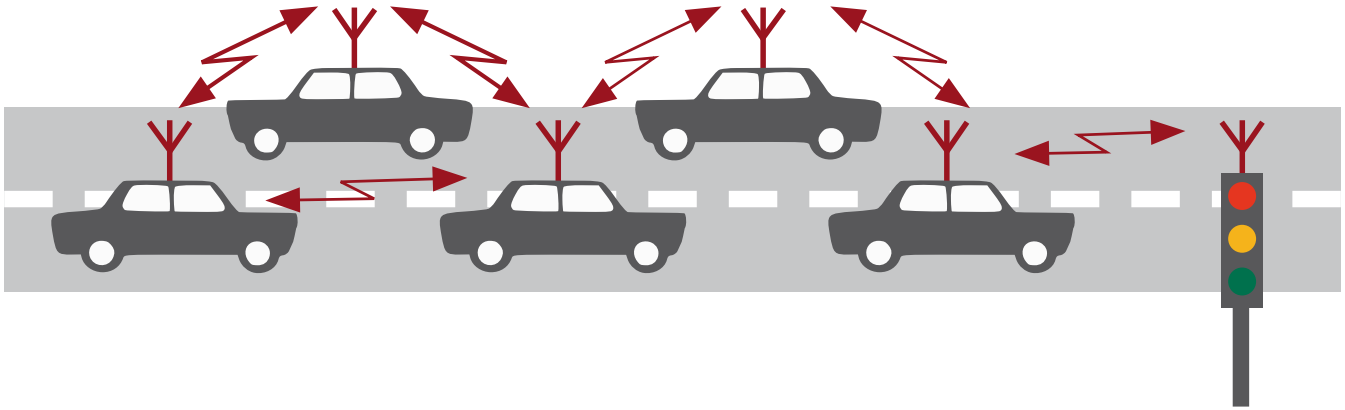
Inter Vehicle Communication

Inter Vehicle Communication

Overview

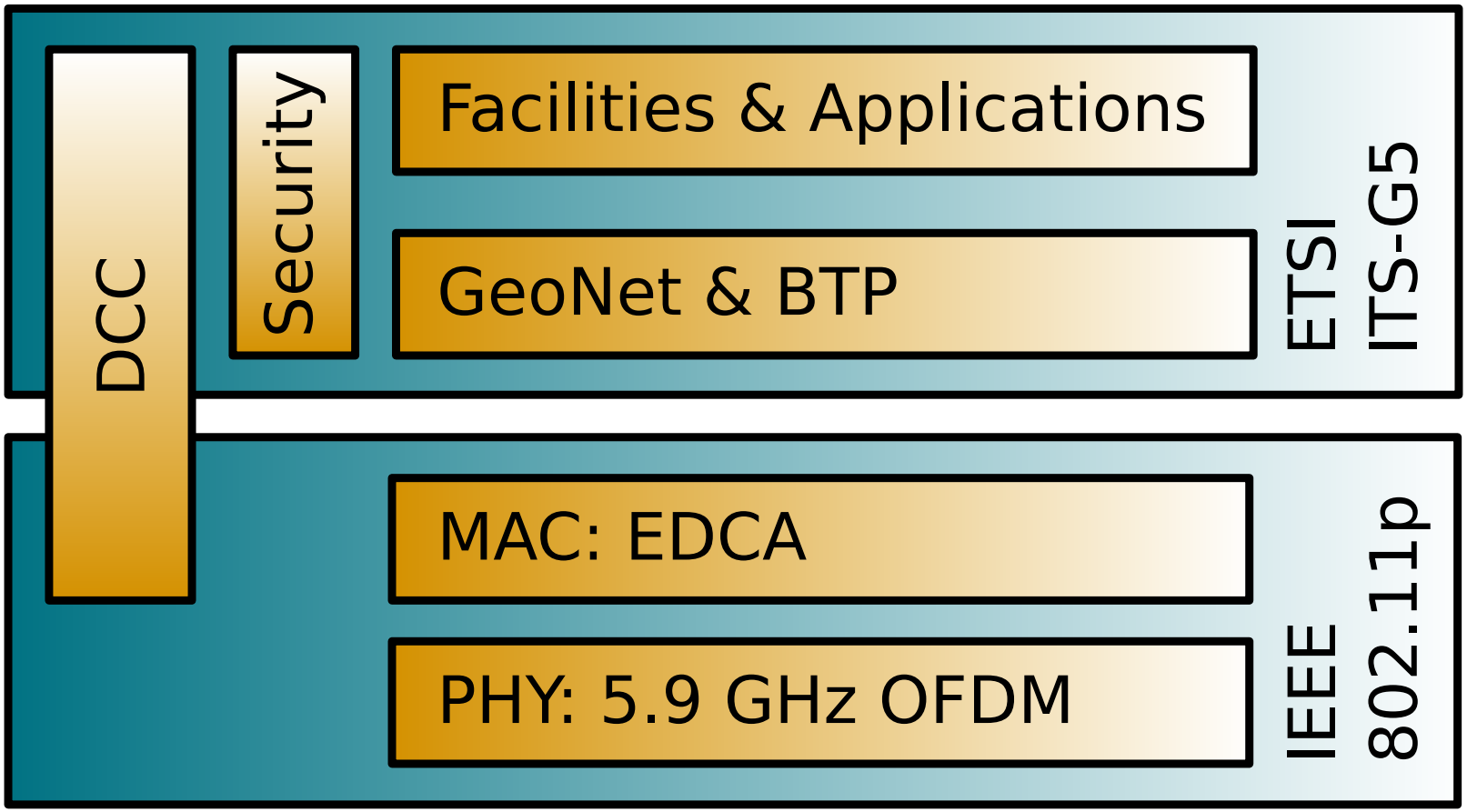
Features

- Communication between vehicles as well as road side units
- Acts like a 360 degree (bidirectional) sensor
- Enhances traffic flow and traffic safety



Inter Vehicle Communication

ETSI ITS-G5 Protocol Stack



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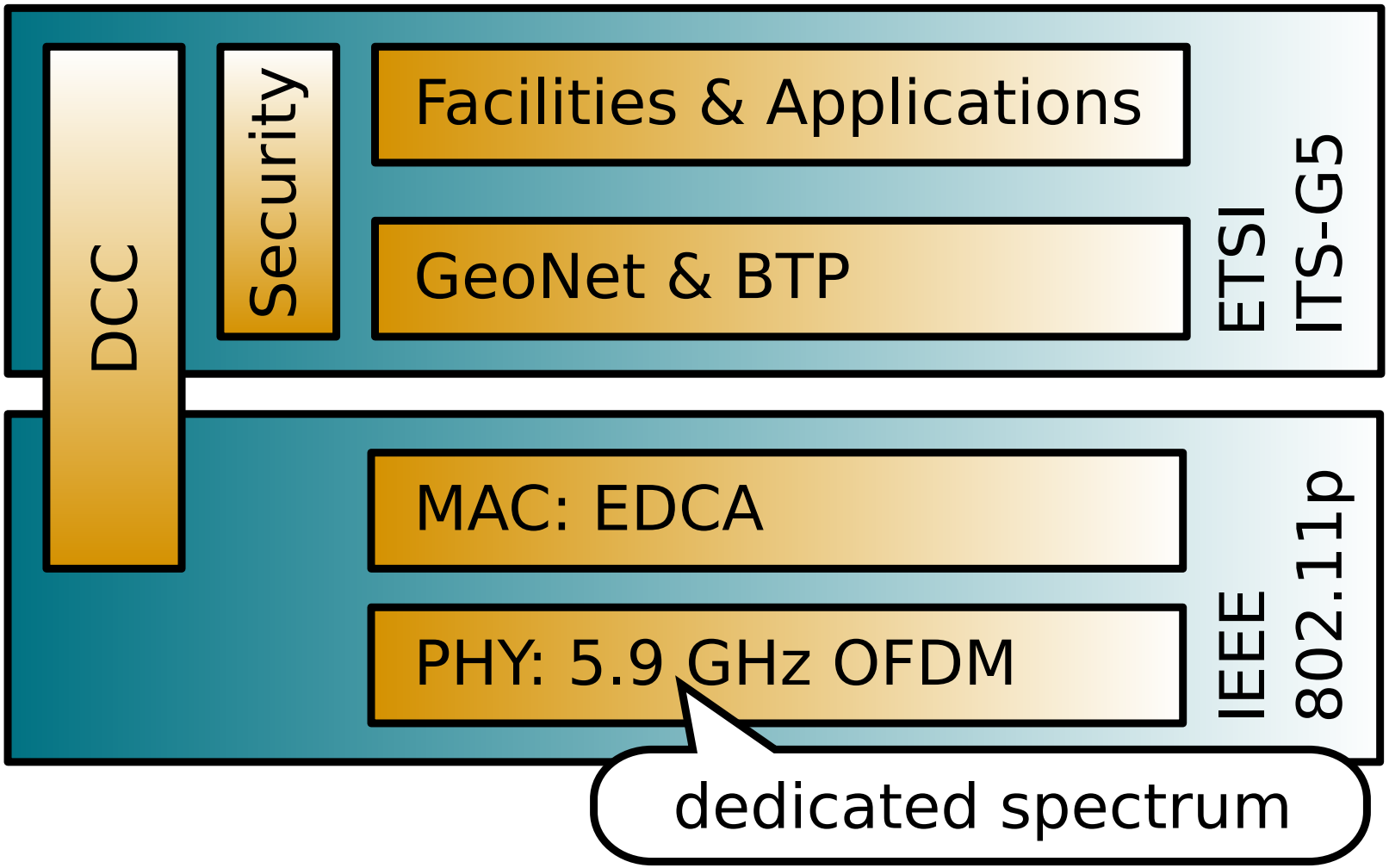

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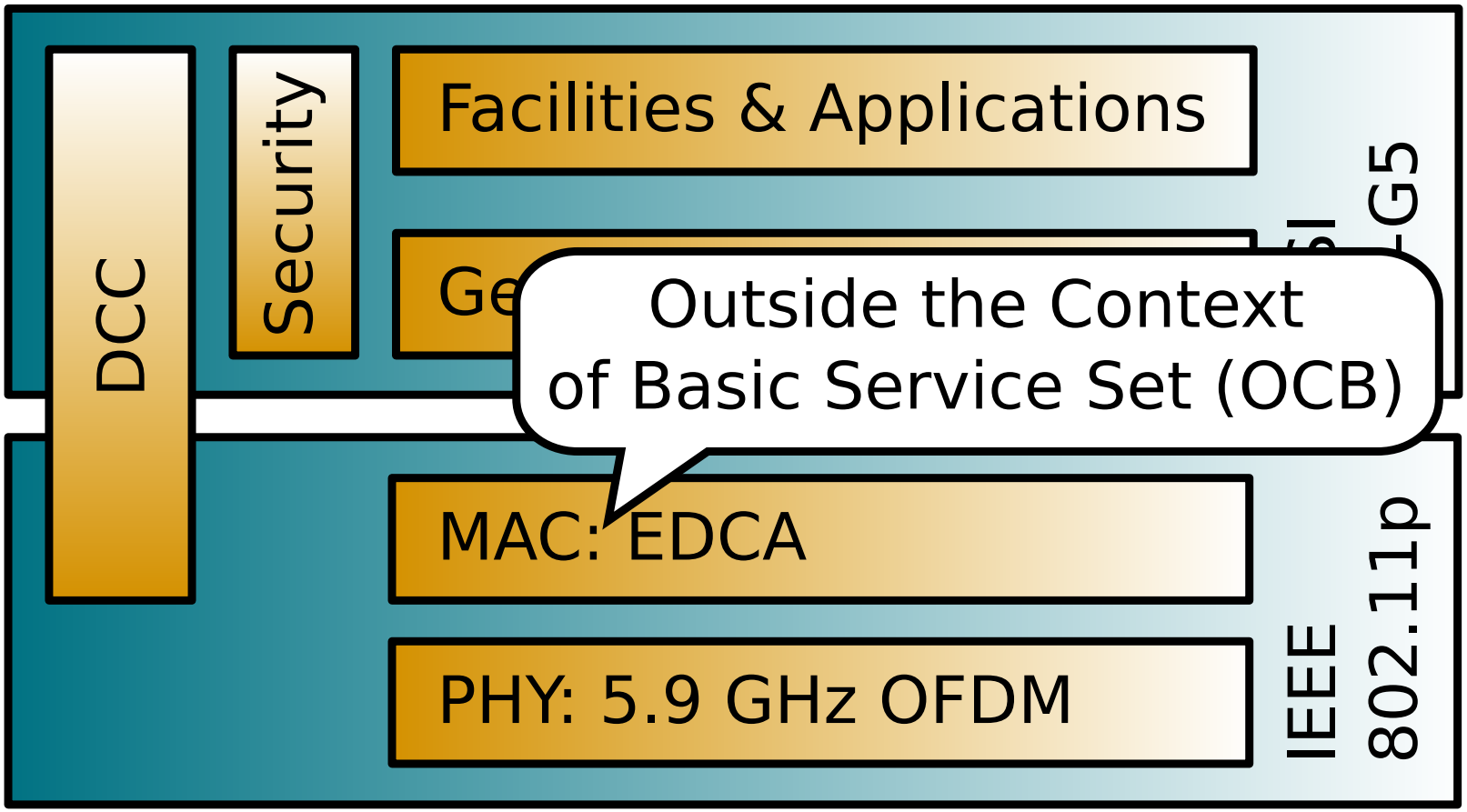

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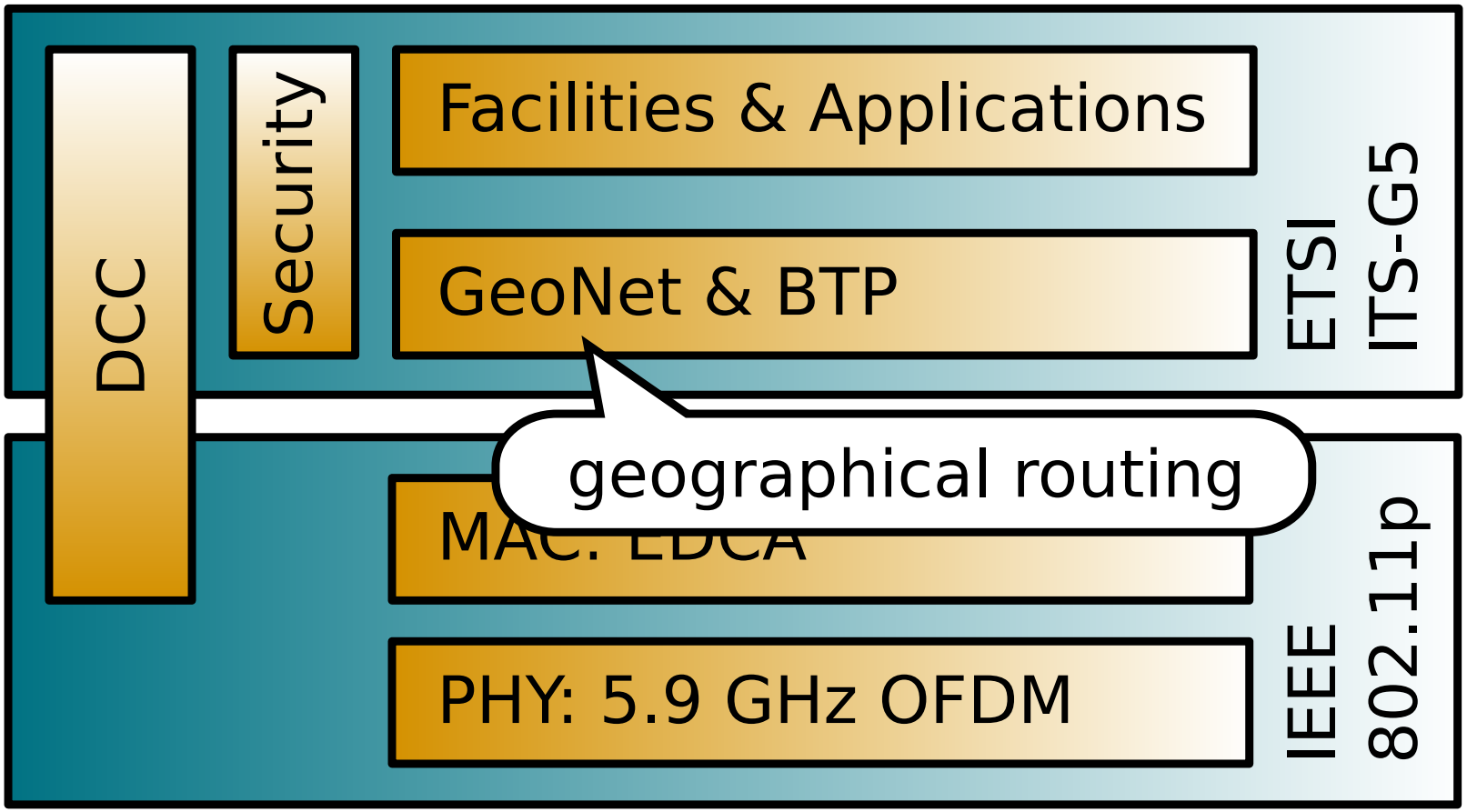

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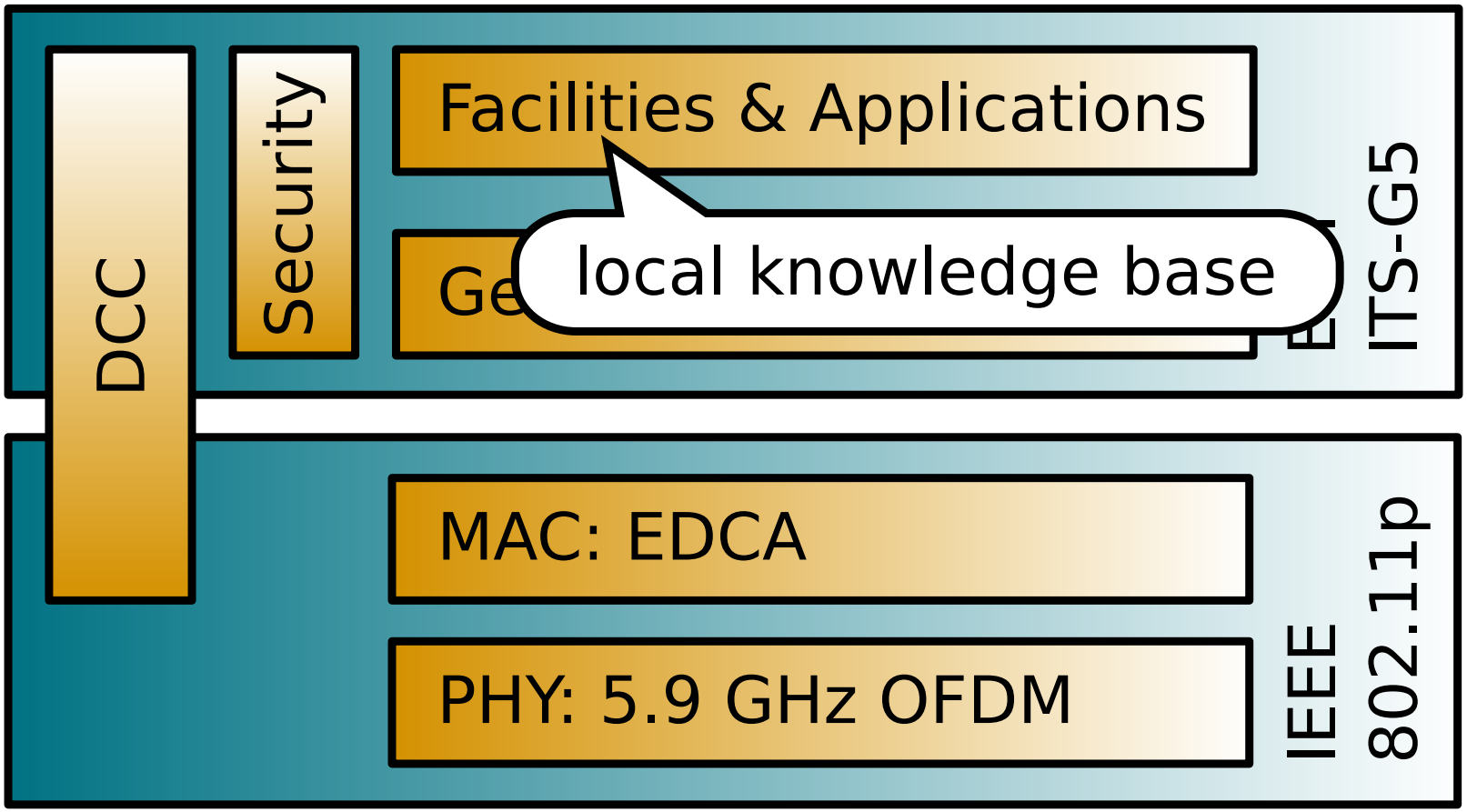

Inter Vehicle Communication

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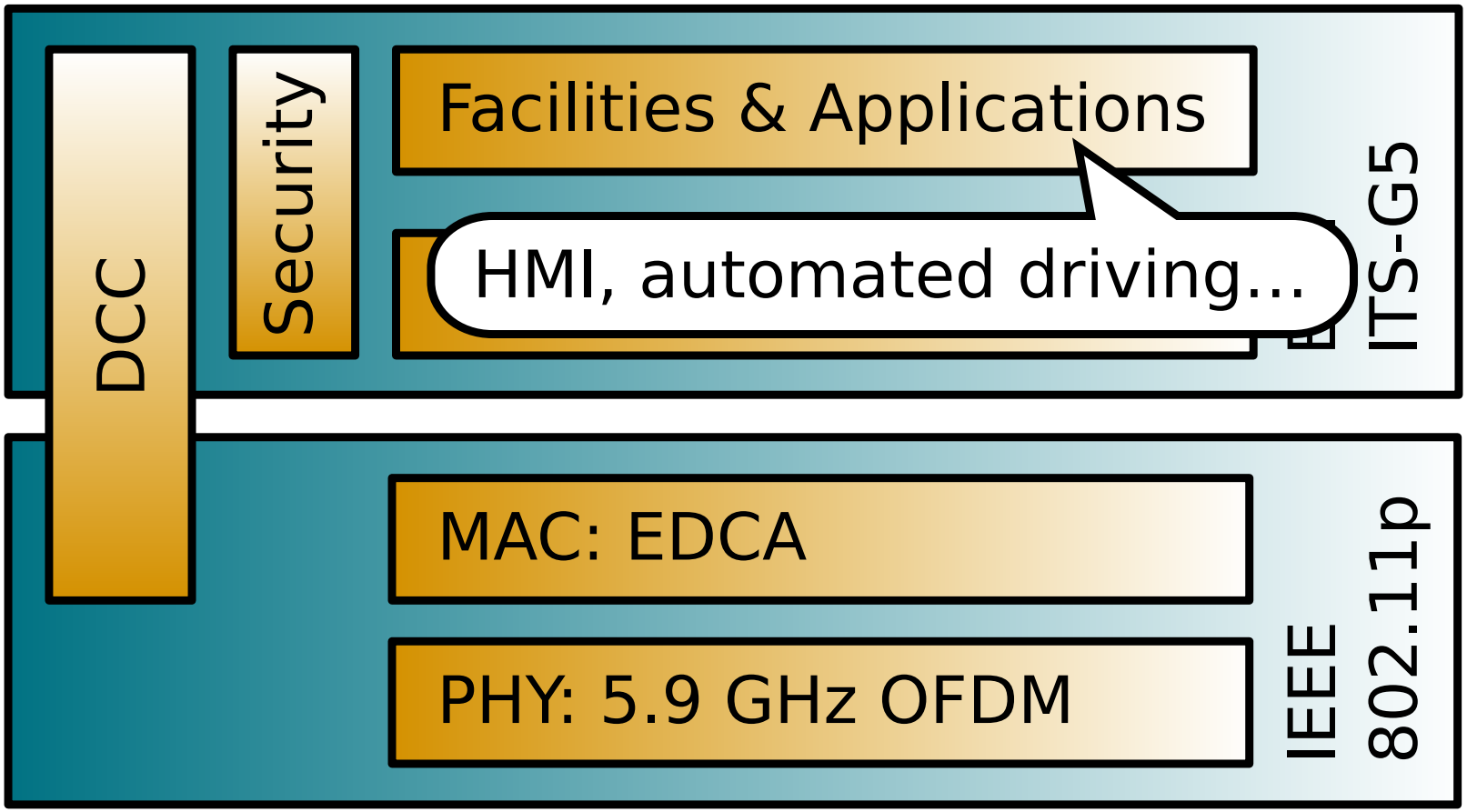

Inter Vehicle Communication

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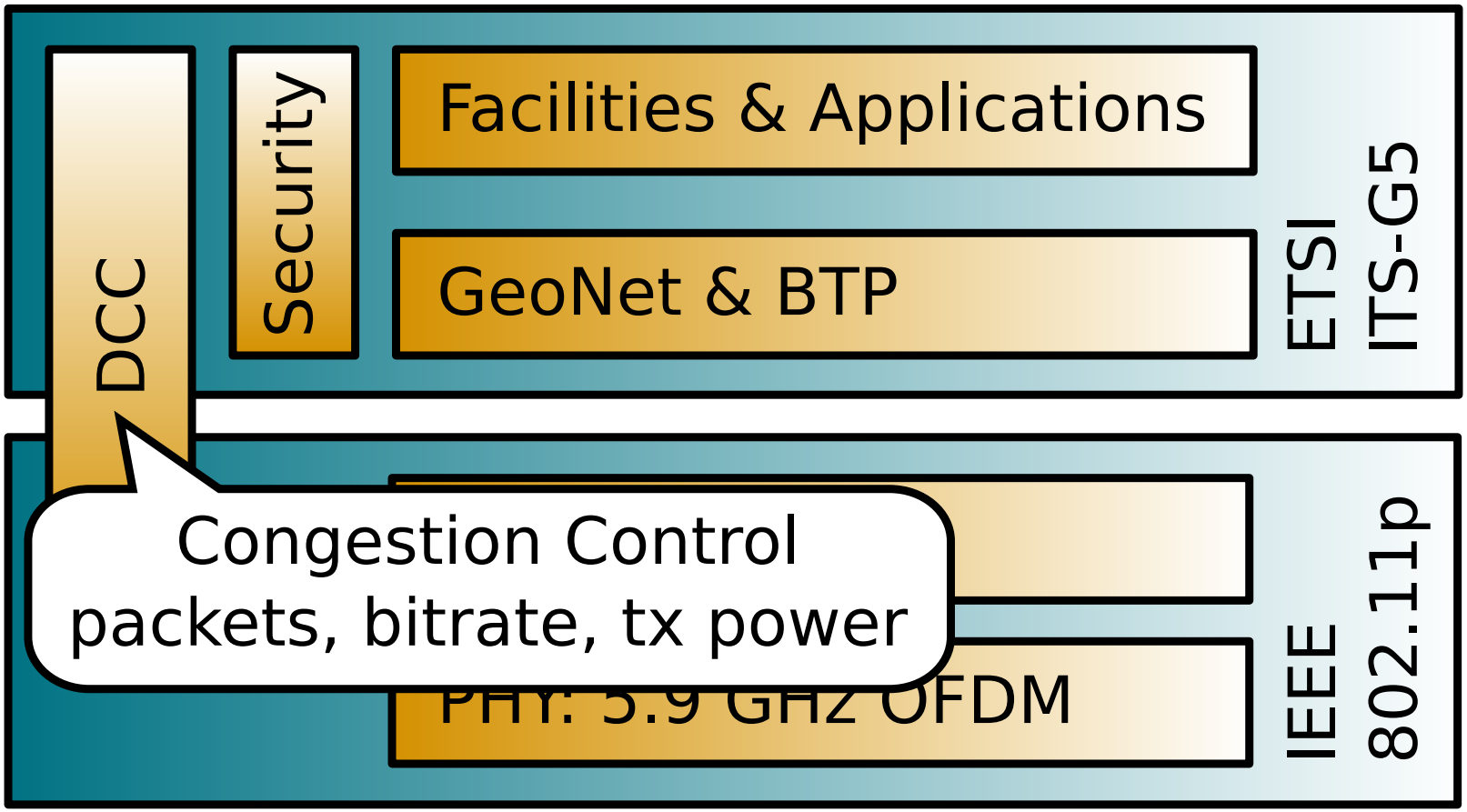

Inter Vehicle Communication

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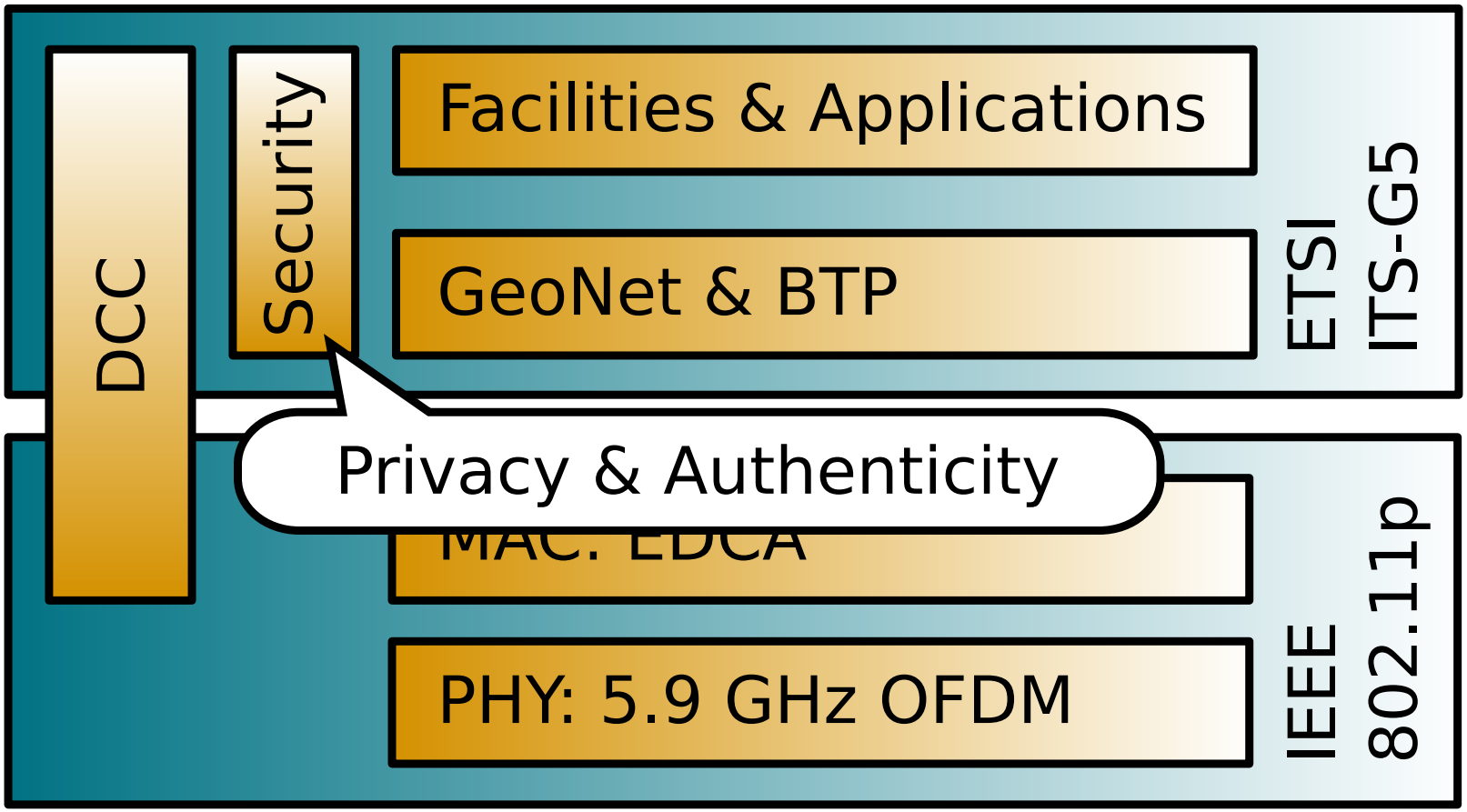
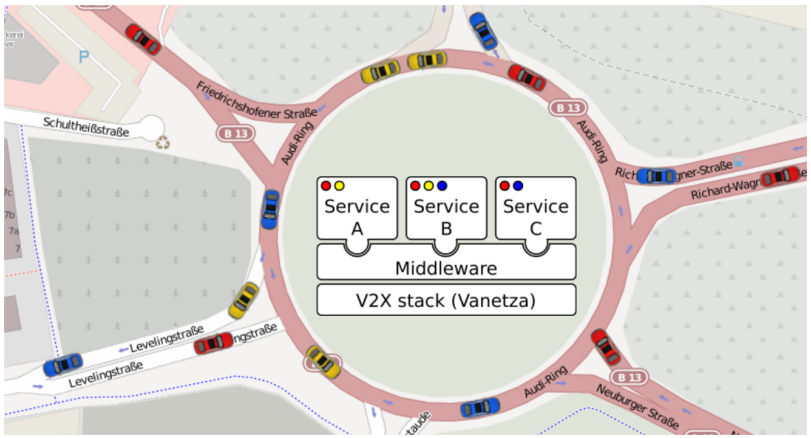


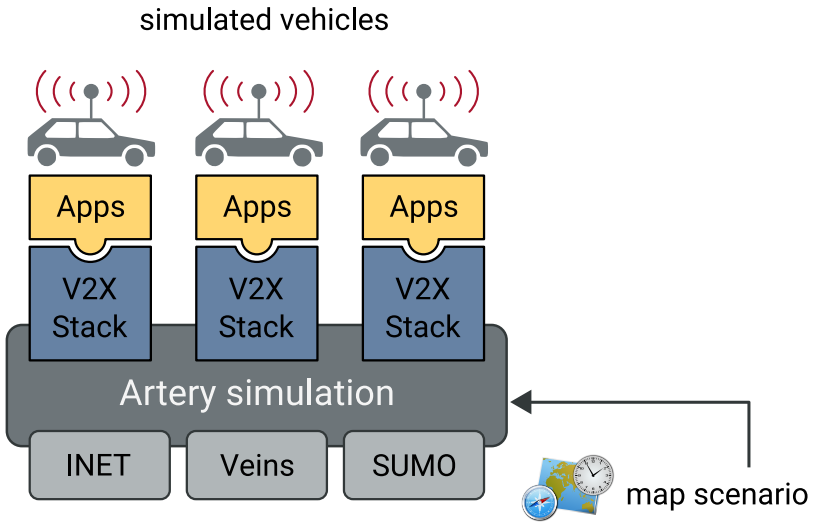
Simulation Tools

VANET simulation tools by THI Research Centre

Vanetza

- open-source ITS-G5 stack
- standard compliant packets
- integrated in Artery





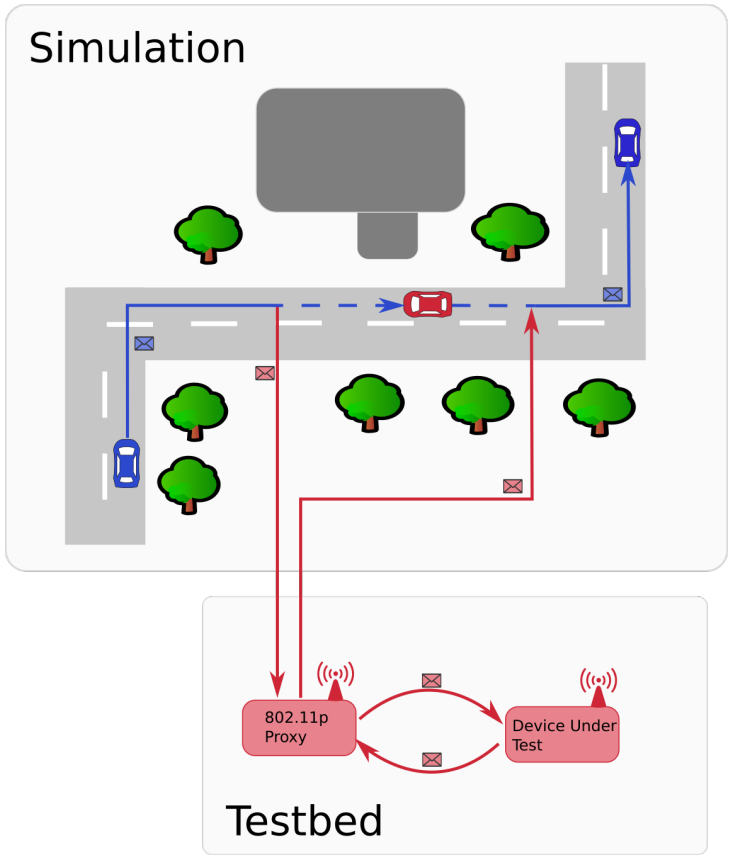
Artery

- variable application sets
- suitable for rapid prototyping
- soon: radar sensors

Available at https://github.com/riebl/{artery, vanetza}

HIL Testing with OMNeT++

HIL Concept
Overview



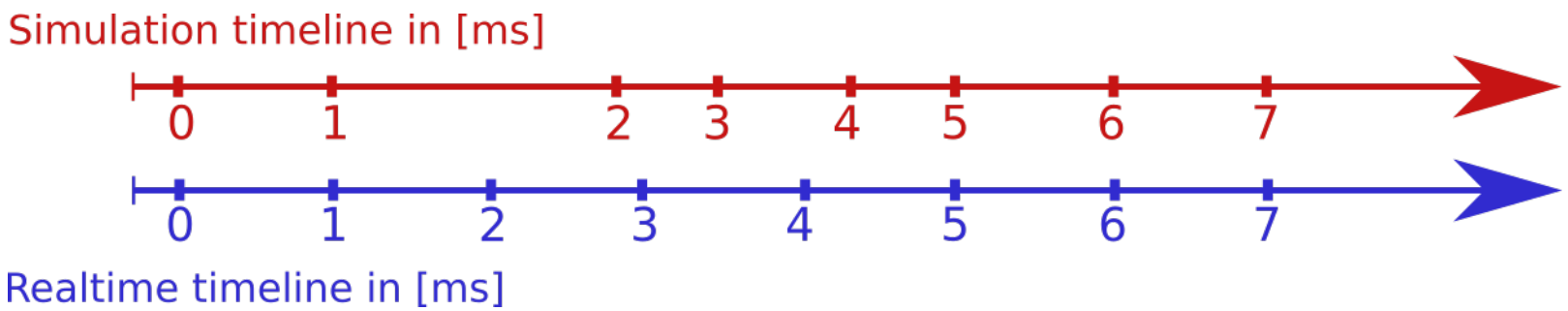
HIL Overview

- Simulated environment vehicles (blue)
- Physical twin vehicle with stripped down functionality (red)
- 802.11p proxy (USRP RIO)
- Message forwarding
- Simulated packets are sent over the air

HIL Concept
Possible Problems

Timing Problems

- OMNeT++ is running too fast
- OMNeT++ is running too slow
- Running too slow is not recognized



cEvent RealTimeScheduler::takeNextEvent* pseudocode

Result: next cEvent
currentRealTimeMiss = *simTime* - *wallClockTime*;
if (*currentRealTimeMiss* * -1) >*realTimeMissThreshold* **then**
    `// simulation unacceptable slow`
    stop simulation;
else
    eventDuration = *wallClockTime* - *eventStartTime*;
    log *currentRealTimeMiss* and *eventDuration* and *nextEventIdentifier*;
    while *SimTime* <*wallClockTime* **do**
        `// simulation faster than real time`
        wait;
    end
    set *nextEventIdentifier*;
    set *eventStartTime*;
    return *nextEvent*;
end

HIL Testing

Real Time Requirements

- Duplicate packet detection
- GPS timestamp
- Replay attack detection
- DENM validity
- Long range communication using MAC layer unicasts

Timing Observations

Real-Time Observations

Scenario Description

Hardware

Component	Laptop Computer	Simulation Cluster
CPU	Intel Core i5-6300U @ 2.40GHz	Intel Xeon E7-8867 v4 @ 2.40GHz
Cores	1 x 4	4 x 18
RAM	16GB	3TB
Hard Drive	256GB SSD	450GB SAS SSD RAID 1

Scenario

- Three vehicles on highway
- Five vehicles on highway

Real-Time Observations

Event List

ID	Event name	# Events ”3 vehicles”	# Events ”5 vehicles”
1	TraCI Connect	1	1
2	TraCI Step	322	370
3	GeoNet packet	3870	11298
4	GeoNet data frame	3870	11298
5	txStart-0	3	5
6	endIFS	661	1189
7	configureRadioMode	1322	2378
8	transmissionTimer	661	1189
9	remove non Interfering Transmission	661	1188
10	report CL	928	1650
11	middleware update	925	1645
12	txStart-1	658	1184
13	GeoNet radio frame	1274	4460
14	reception Timer	1274	4460
	Overall events	16430	42315

Real-Time Observation

Event Times

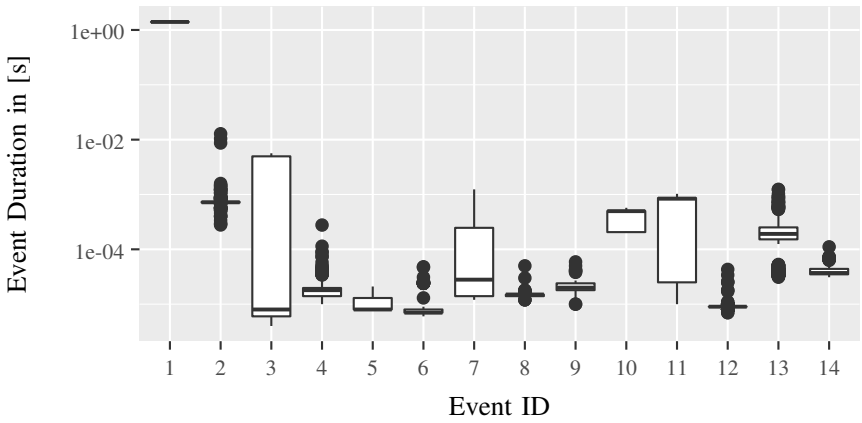


Figure: Event times cluster

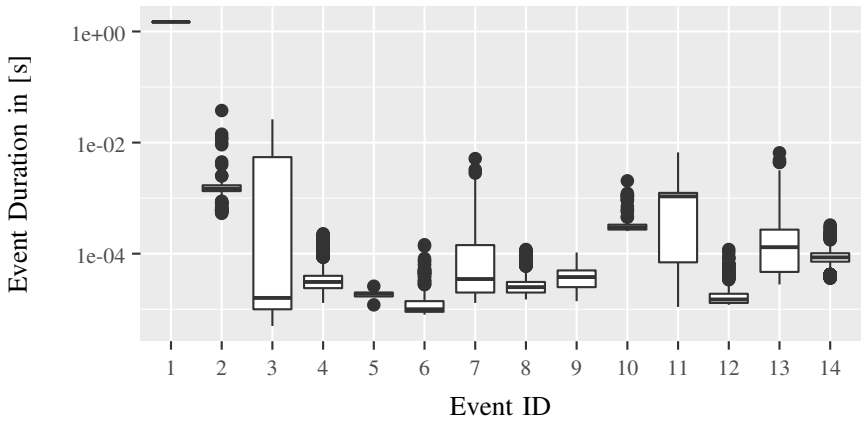
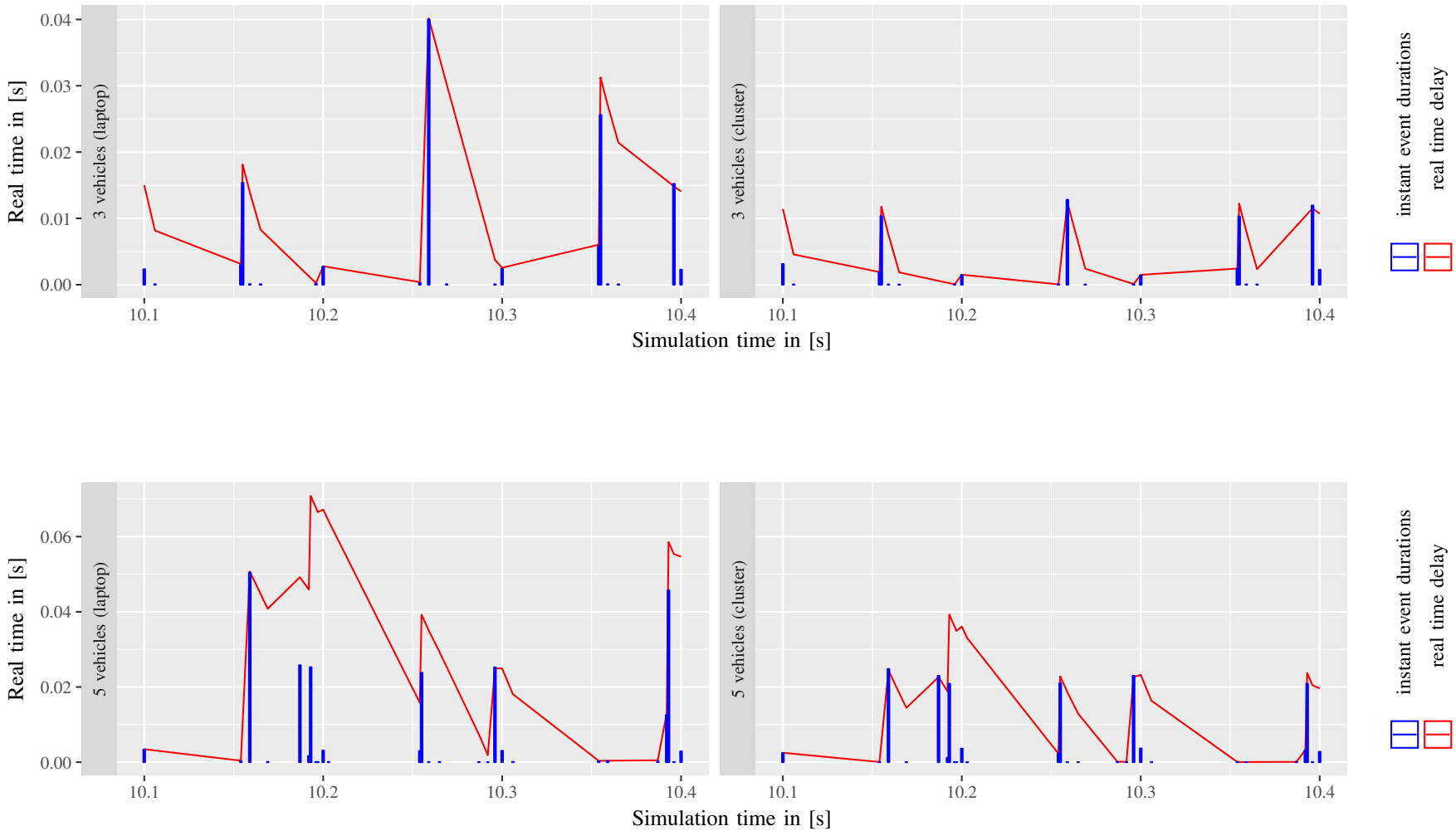


Figure: Event times laptop

Real-Time Observation

Real-Time Flow



Real-Time Observation

Simulation Run Overview

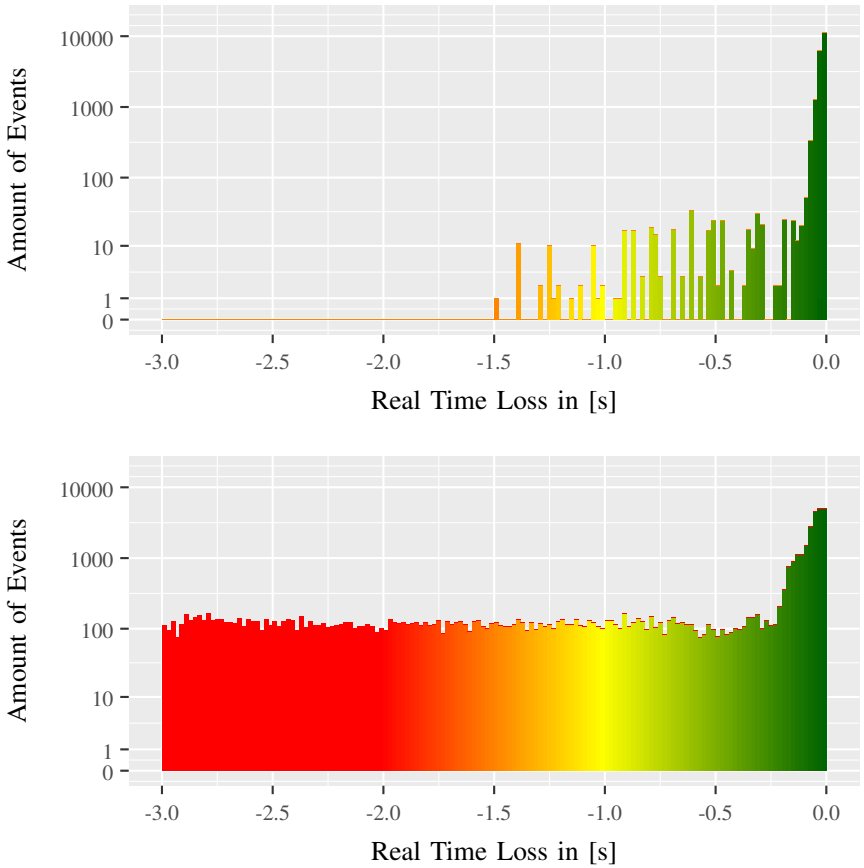


Figure: Laptop

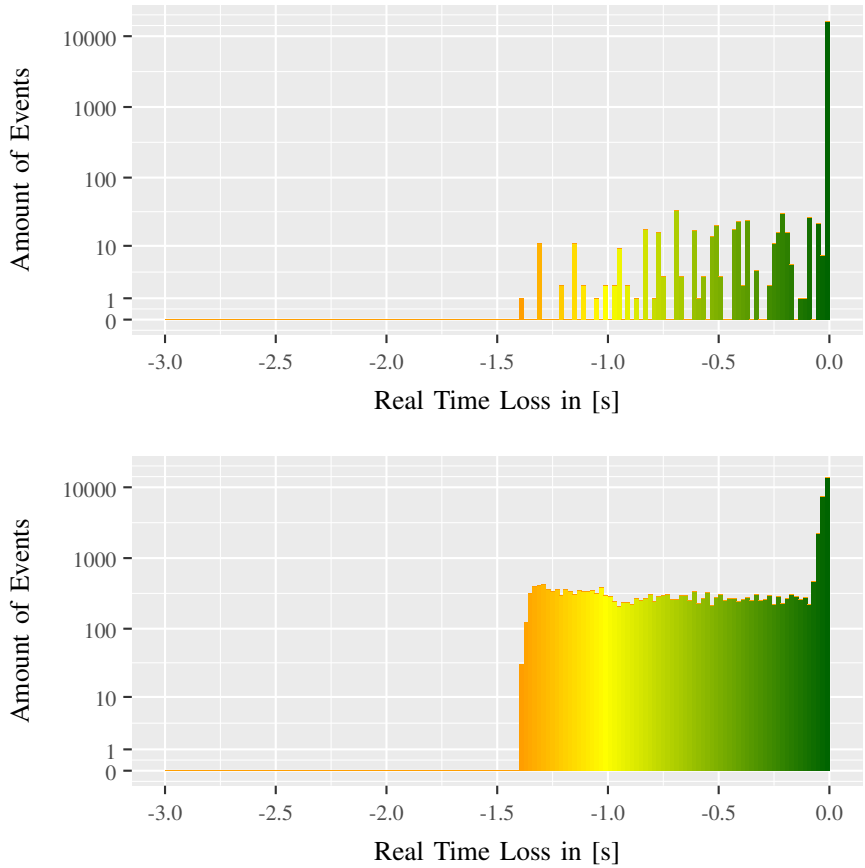


Figure: Cluster

Conclusion

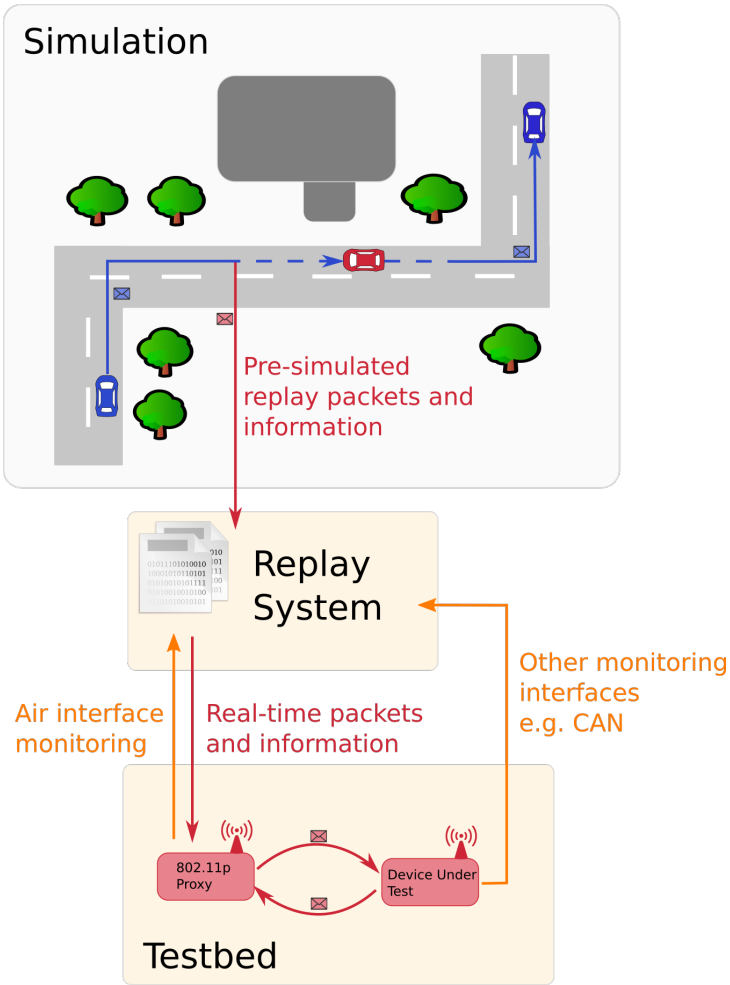
Conclusion

Which Parts can be Tested Properly?

- Duplicate packet detection
- GPS timestamp
- Replay attack detection
- DENM validity
- Long range communication using MAC layer unicasts

Further Work

Further Work



- Tweak simulation performance
- Add some parallelism
- Replay simulated test data

Thank You For Your Attention

Any Questions?