Fachhochschule Dortmund
University of Applied Sciences and Arts
IDiAL Institute for the Digital Transformation of Application and Living Domains

Bridging the Gap between SUMO & Kuksa: Using A Traffic Simulator for Testing Cloud-based Connected Vehicle Services

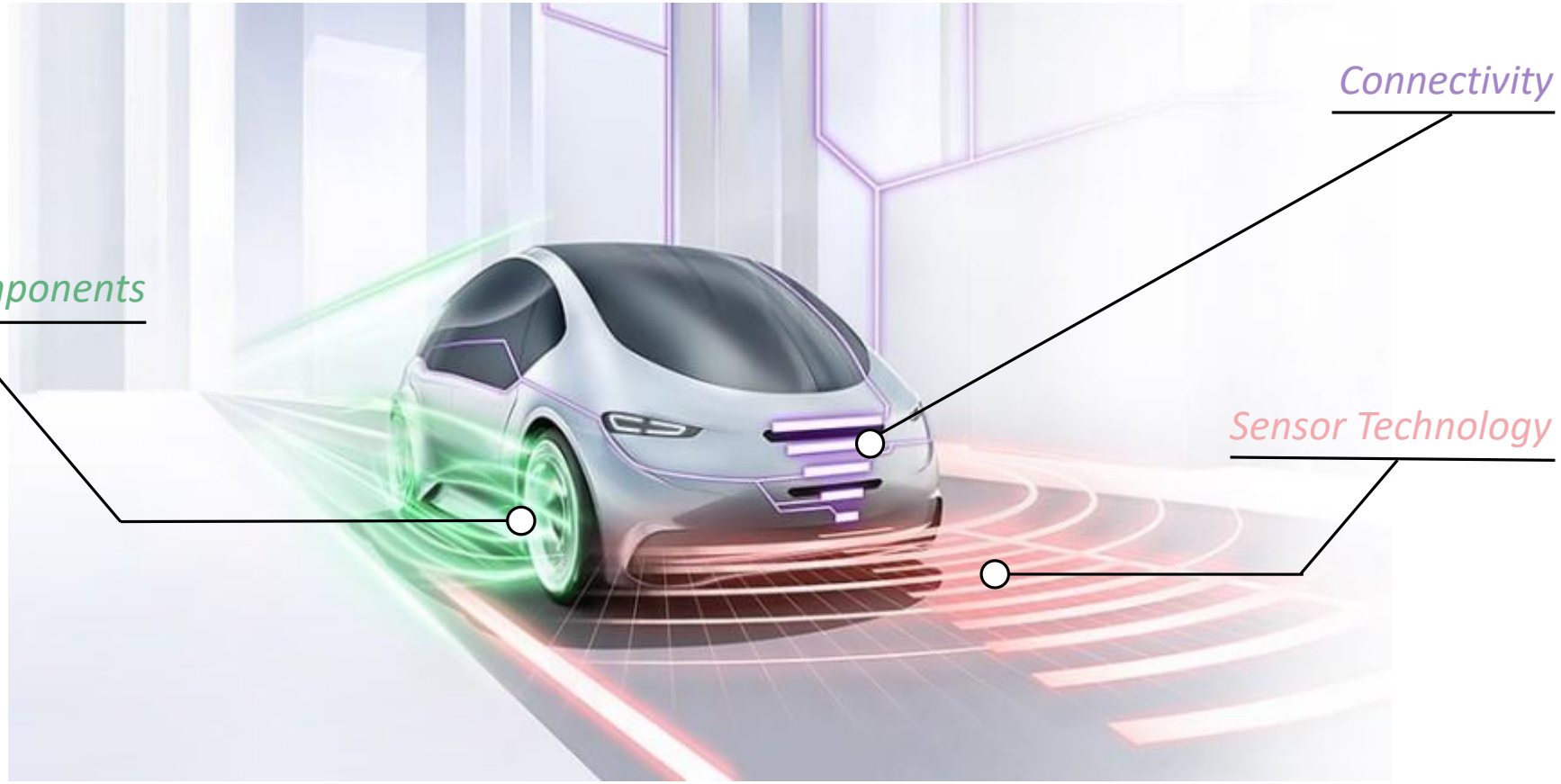
SUMO User Conference 2019

Philipp Heisig[1], Sven Erik Jeroschewski[2], Johannes Kristan[2], Robert Höttger[1], Ahmad Banijamali[3], and Sabine Sachweh[1]

[1] Dortmund University of Applied Sciences and Arts
[2] Bosch Software Innovations
[3] University of Oulu

MOTIVATION

Connected Vehicles

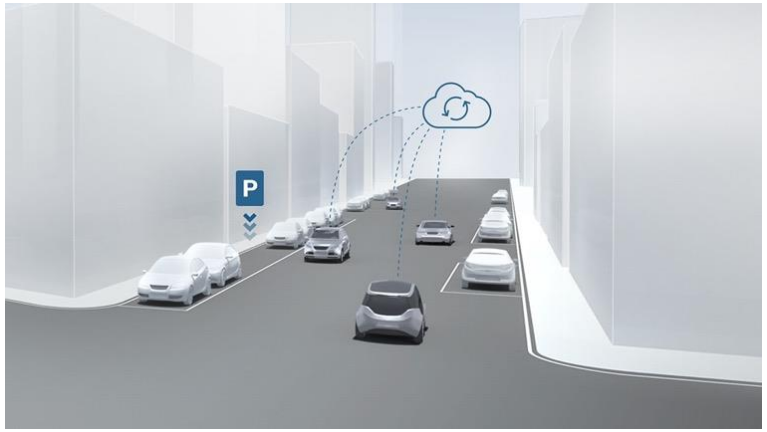


Source: https://www.bosch.com/explore-and-experience/iaa-2017/

Connected Vehicle Services

- Connected vehicles are expected to be the next frontier in automotive revolution
  - Extraction, storage, processing, analysis, and usage of vehicle data within the IoT
  - Integration of further data sources, e.g. Smart City or Smart Home
- Innovative and data-driven mobility services
- High degree of data-monetization and value creation based on disruptive business models
- Various application domains benefit from connectivity
  - Road safety
  - Smart, efficient, and green transportation
  - Location-dependent services

Cloud-based wrong-way driver warning



Community-based parking

Source: https://www.bosch-mobility-solutions.com/

KUKSA

Connected Vehicle Testbed

- Scalable and reliable connected vehicle services required
  - Increasing number of connected vehicles on the road
  - Connected vehicles operate in a safety-critical and time-sensitive environment
- How to test the service functionality and ensure a suitable software architecture?
- Focus on implementation rather than setting up a test environment

Does my service scale with a large amount of vehicles?

Is my service reliable also under changing circumstances?

Do my service work as expected within different scenarios?

KUKSA

Traffic Simulators for Testing Connected Vehicle Services

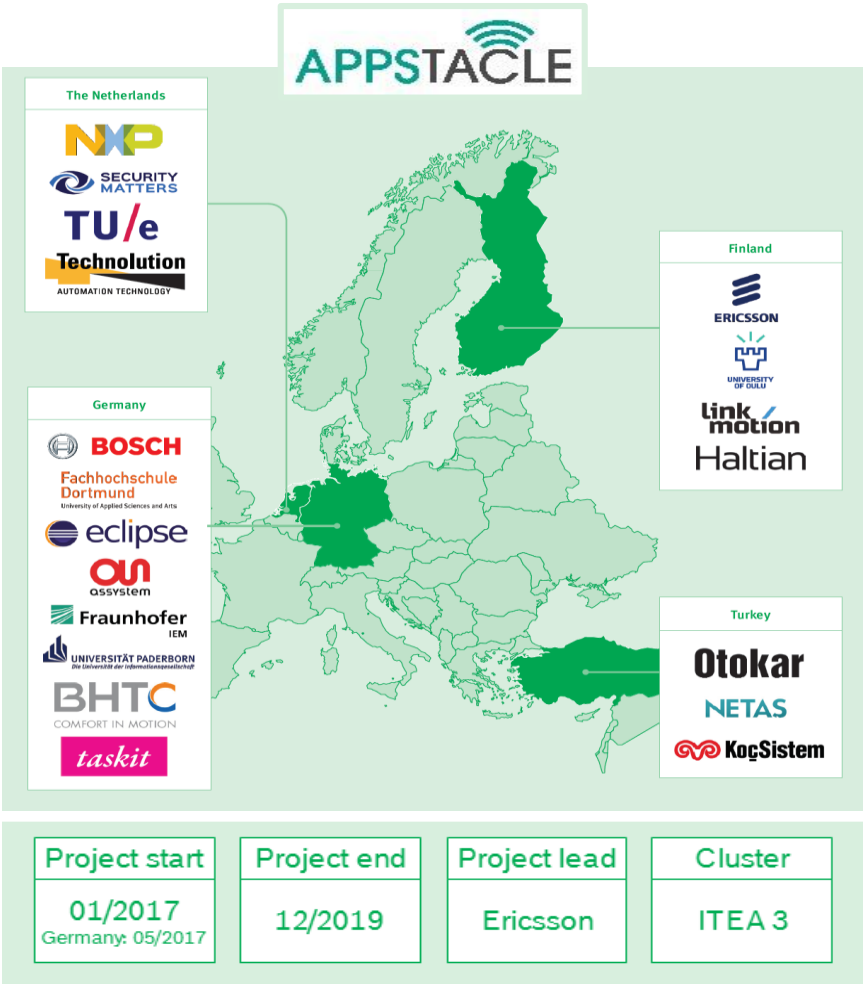
- Testbed for evaluating the functionality of the according software components
  - Setting up a large number of hardware and vehicle nodes is not practical due to economical and operational constraints
  - Context-specific automotive data from real-word scenarios that goes beyond few rudimental or fake data-sets
- Using an appropriate traffic simulator for …
  - …proof-of-concept regarding the software architecture design
  - …an evaluation of service functionality
- Simulation on microscopic level to provide vehicle-specific data
- Various reasons for using Eclipse SUMO
  - Designed for microscopic simulations
  - Supports large road networks and the modeling of intermodal traffic systems
  - Well established in the research community
  - Fosters real-world scenarios from areas such as Luxembourg, Bologna, Cologne, or Monaco
  - Provides a lot of modeling tools and APIs

ECLIPSE KUKSA

KUKSA

APPSTACLE

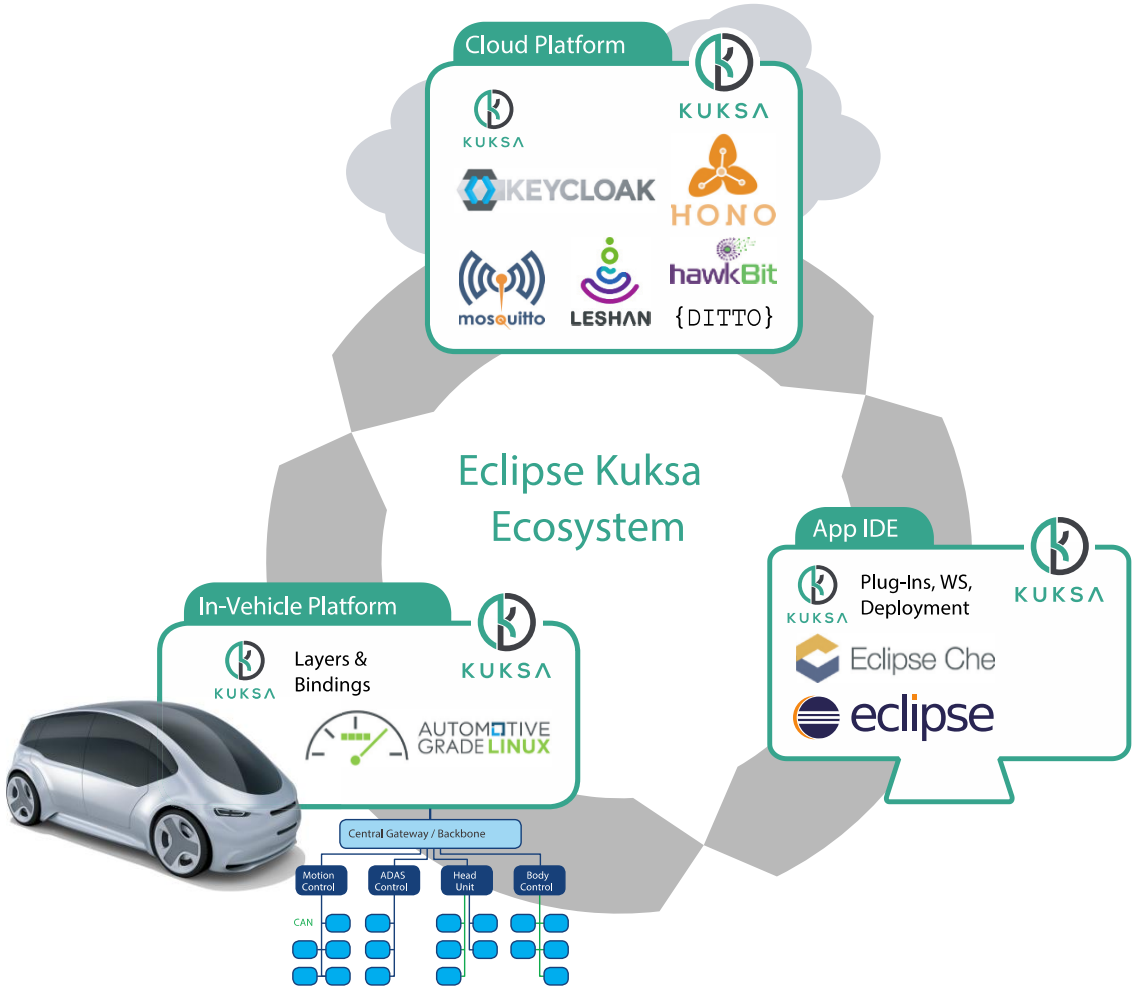
- **APPSTACLE**: open standard Application Platform for carS and TrAnsportation vehicles
  - Pave the way for connected driving
- Development of an Open Source Connected Vehicle Ecosystem
  - Open source automotive IoT Cloud Platform
    - Architectural considerations for the cloud platform
    - Establishment of standardized interfaces to the vehicle
  - Service enablers for car-to-cloud connectivity
    - Network infrastructure considerations
    - Next generation mobile networks
  - Open source in-vehicle platform
    - Safe and secure gateway to the cloud
    - In-vehicle data access mechanism and application platform
- **Eclipse Kuksa**: Open Source project that host the developed connected vehicle technology stack



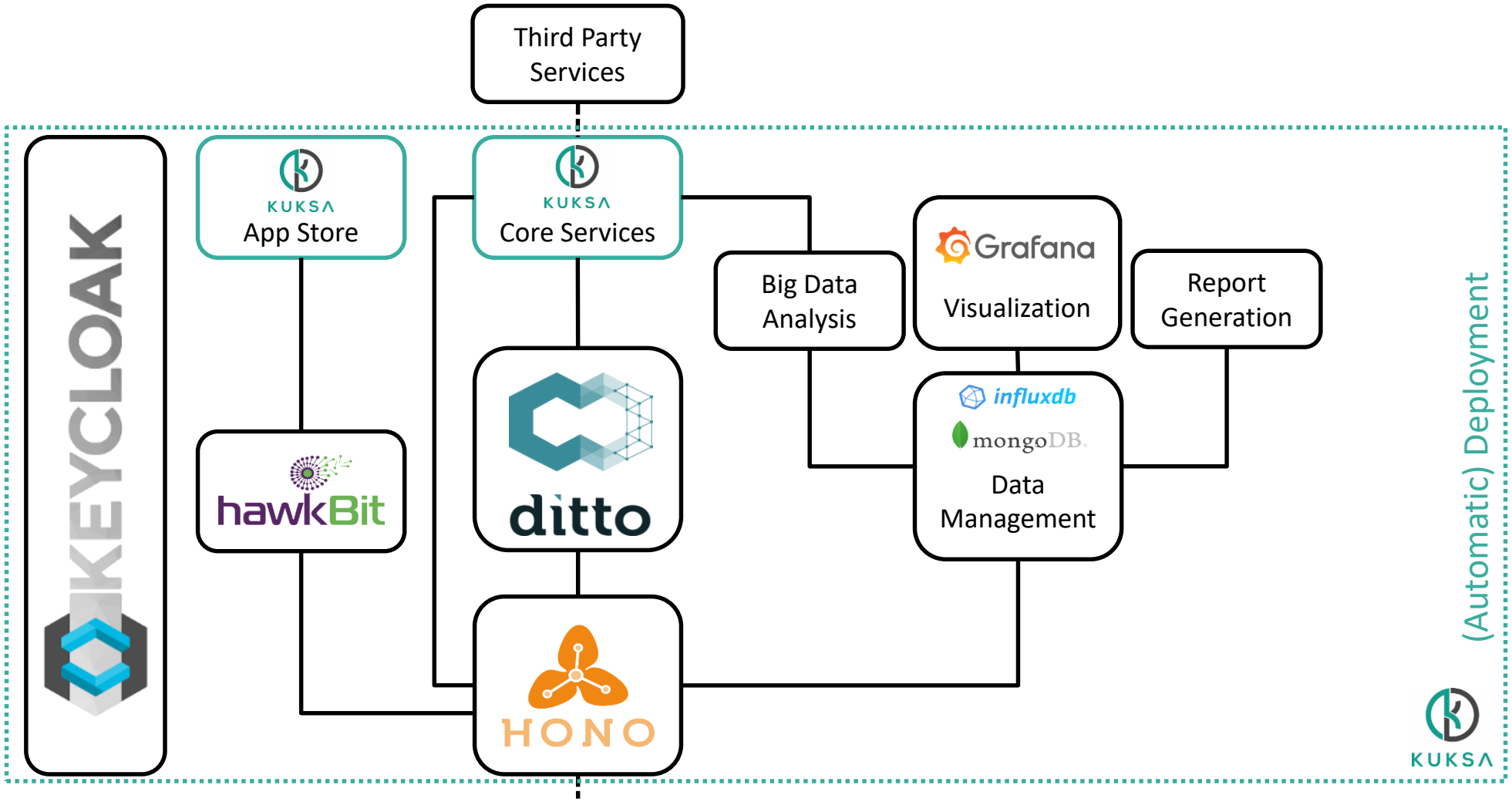
Eclipse Kuksa

*Create a **cross-vendor** connected vehicle platform that relies on*
open standards** and uses **open source software
*to leverage the potential of a **large developer community**!*

Eclipse Kuksa

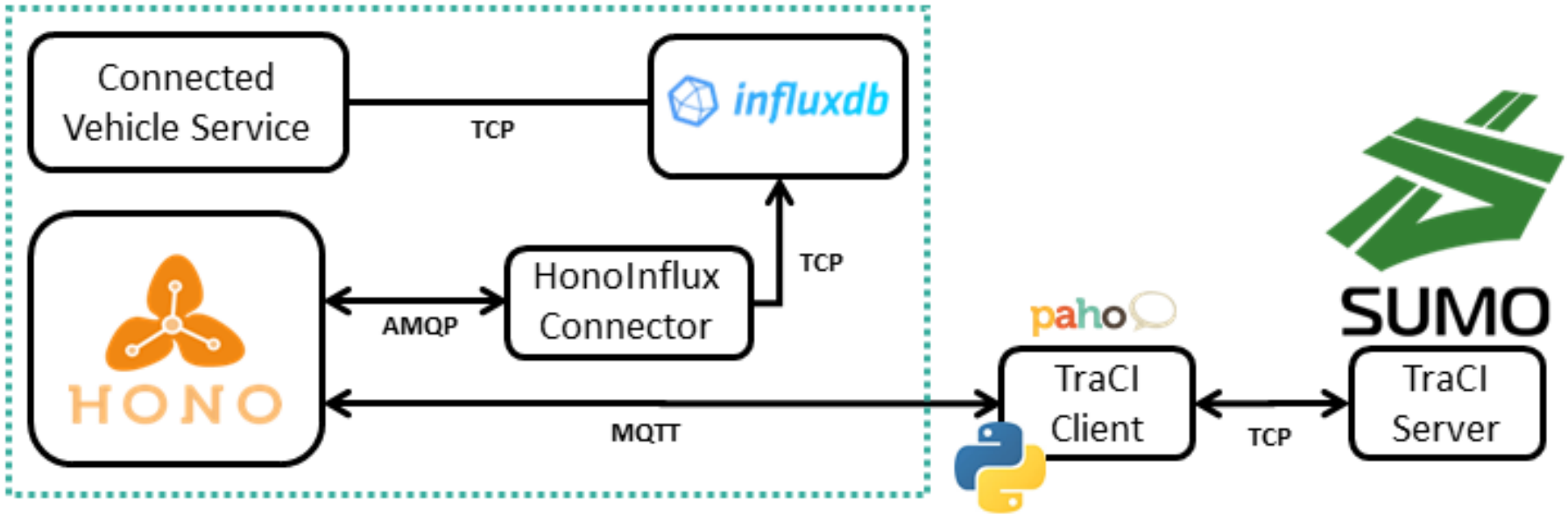


Eclipse Kuksa



CONNECTING SUMO WITH KUKSA

Connecting Eclipse SUMO with Eclipse Kuksa



KUKSA

Connecting SUMO with Eclipse Kuksa

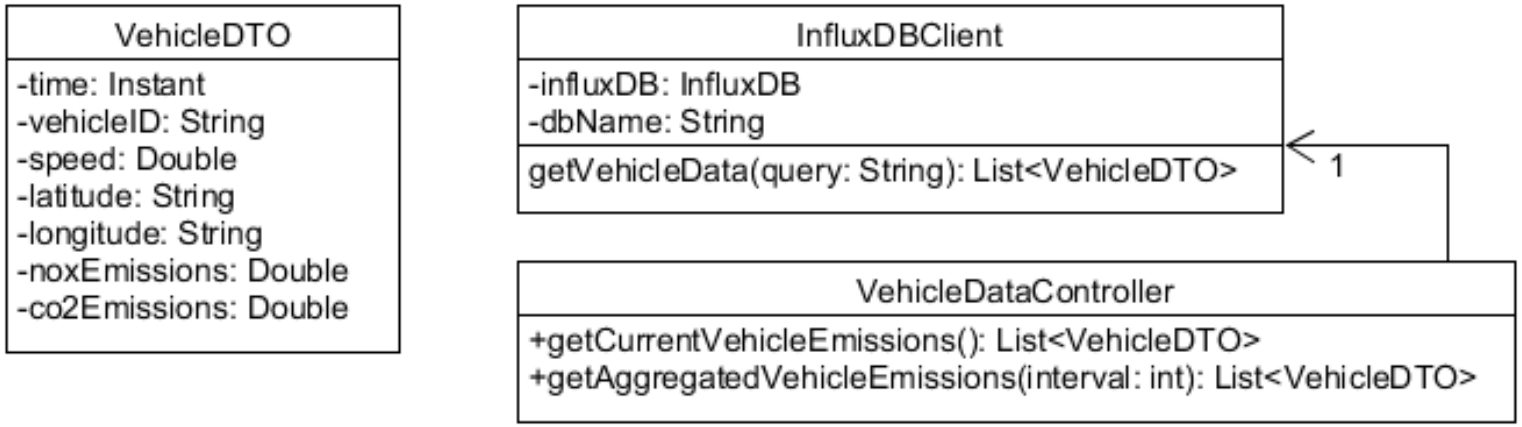
```
def connect_to_message_gateway():
     client.reinitialise(client_id="python_client",clean_session=True, userdata=None)
     client.username_pw_set(username, password)
     client.on_connect = on_connect
     client.connect(host, port, 60)
     client.loop_start()

def run():
     step = 0
     while traci.simulation.getMinExpectedNumber() > 0:
     traci.simulationStep()
     for vehicleID in traci.vehicle.getIDList():
          co2emission = traci.vehicle.getCO2Emission(vehicleID)
          noxemission = traci.vehicle.getNOxEmission(vehicleID)
          x, y = traci.vehicle.getPosition(vehicleID)
          longitude, latitude = traci.simulation.convertGeo(x, y)
          json_data = json.dumps({'Vehicle_ID': vehicleID, 'Latitude': latitude, 'Longitude': longitude,
                                  'CO2_Emission': co2emission, 'NOx_Emission': noxemission})
          client.publish(topic_to_publish,json_data,0,False)
     step += 1
traci.close()
sys.stdout.flush()
```

TESTING CONNECTED VEHICLE SERVICES

Integration of SUMO into the Kuksa application development process

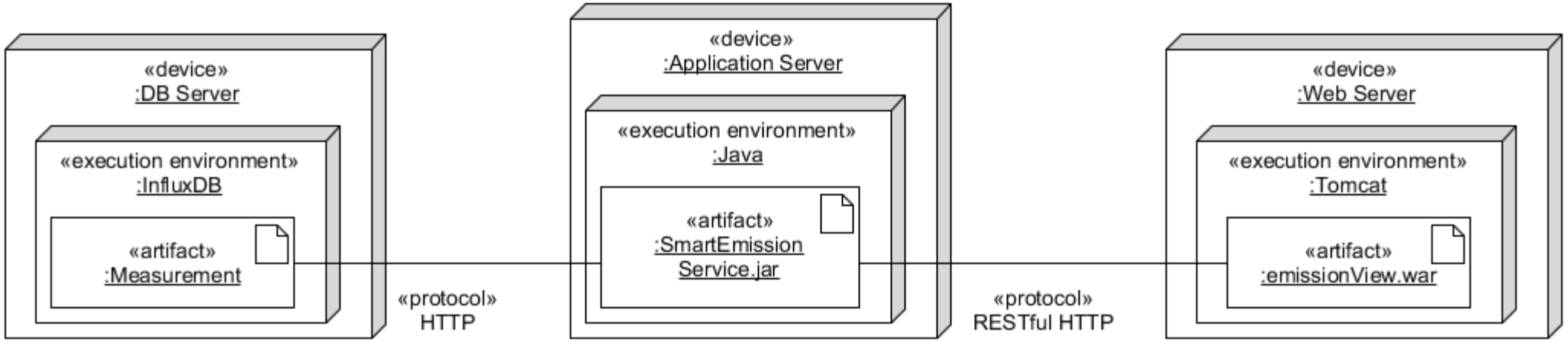
1. Service implementation
   - Example service: *Air Quality Monitor*
   - Visualizes the air pollution for certain areas on a real-world heatmap
   - Java-based Spring application
   - InfluxDB as underlying database



Integration of SUMO into the Kuksa application development process

2. Setting up the test environment

- Eclipse SUMO 1.1.0 (Windows 10 with Intel Core i7-5600U CPU at 2.60GHz and 16GB RAM)
- Python 3.6.4
- Scenarios: Monaco and TAPASCologne
- Eclipse Kuksa Cloud within Azure Kubernetes Service (Eclipse Hono 0.8)
- Air Quaility Monitor runs on Ubuntu 16.04 VM

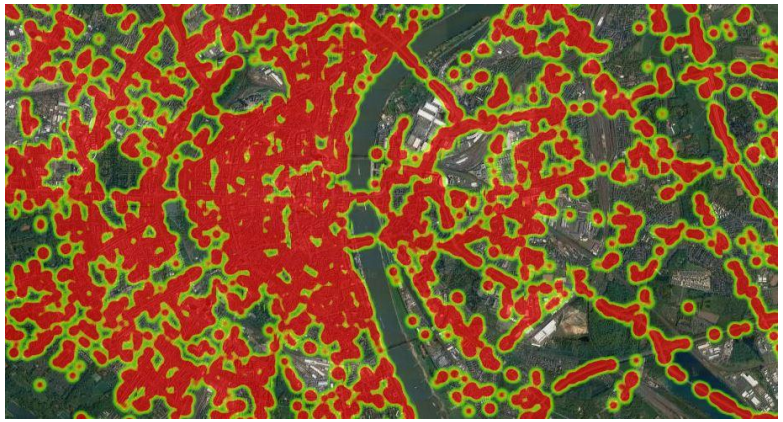


Integration of SUMO into the Kuksa application development process

3. Testing and enhancing the service

- Developer gets early feedback in the development process

- Different problems occured with initial design of the *Air Quaility Monitor* service:
  - Database schema
    - Initial not designed for querying large data sets in an efficient and flexible way
    - Improved the response time of the service
  - Presentation
    - Map gets unclear and overcrowded with larger amounts of vehicles
    - Changed the weighting of points dynamically
  - API usage
    - Heatmap was not updated correctly
    - Changing vehicle data from running simulation ease debugging



SUMMARY AND OUTLOOK

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Future Work

- Implementation and evaluation with different simulation scenarios and more sophisticated connected vehicle services
  - Consideration of Command & Control
  - Integration of other data sources, e.g. from the smart city
- Supporting real-time to test safety-critical services regarding responsiveness and reaction time
  - Record data and use time-stamps
  - What about Command & Control?
- Considering changing connectivity for end-to-end scenarios between vehicles and cloud backend
  - VSimRTI
- Investigation how to integrate with existing test processes, pipelines, and frameworks

KUKSA

Cooperation Possibilities

- Eclipse Kuksa Open Source project
  - Contribute with own ideas and development
  - Use and try the software
  - Be part of the development community from the beginning
- APPSTACLE Advisory board
  - Advice and proof of current development
  - Getting up to date results
  - Be part and shape the open source results
  - Cooperation based on open source solutions
- More information needed? https://www.eclipse.org/kuksa/