

**DENSO**  
Crafting the Core

**AMAA**  
**2018**

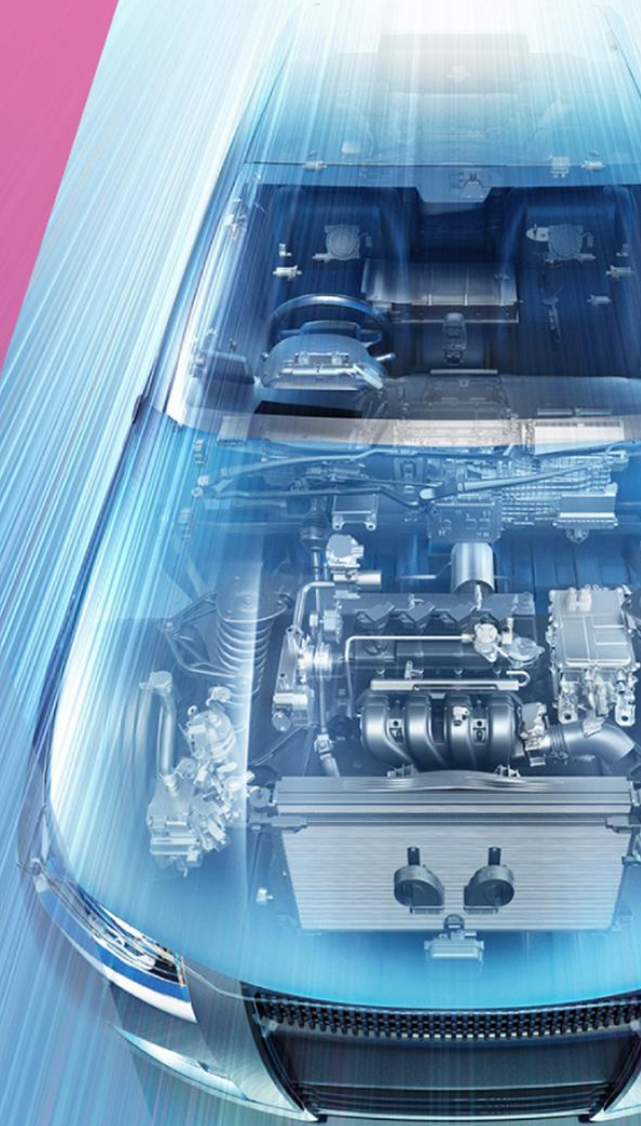
# **Adaptation Layer Based Hybrid Communication Architecture**

*Practical Approach in ADAS&ME*

Prachi Mittal

Co-authors: Tim Leinmüller, Emily Bourne

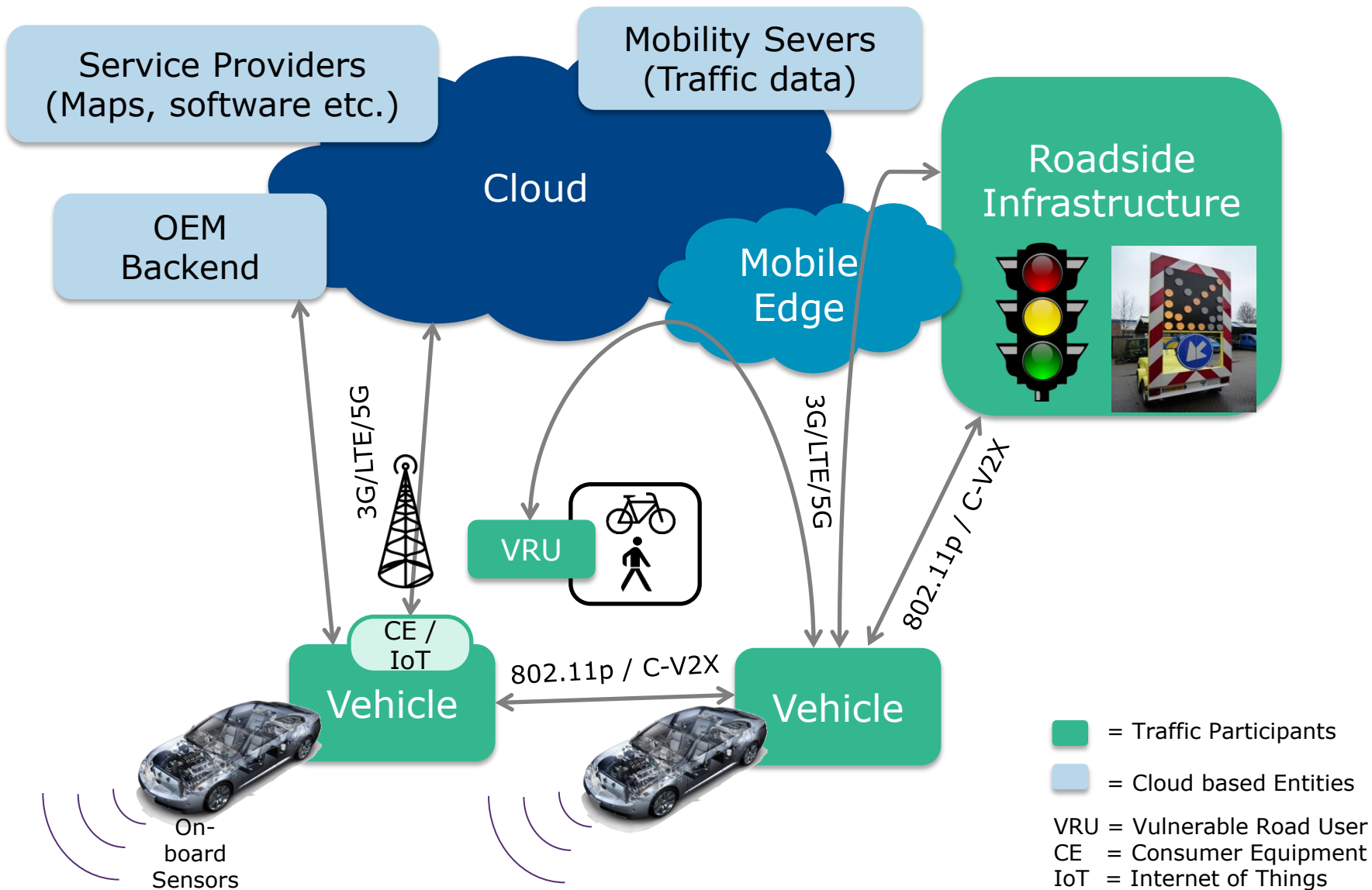
Denso Automotive Deutschland GmbH  
[p.mittal@denso-auto.de](mailto:p.mittal@denso-auto.de)



# 1.

## Communication in Automotive

# Multi-technology Communication in Automotive



Multiple technologies independently

- + Isolation of failures
- Less efficient

Multiple technologies in parallel

- + Redundancy
- + Better combined
- + penetration
- + Higher efficiency
- Complexity



Hybrid Communication

# Functions of Hybrid Communication

## Data Management

- Match latencies
- Manage different levels of trust
- Optimally combine information

## Media Management

- Address service / app requirements
- Coordinate usage of multiple media

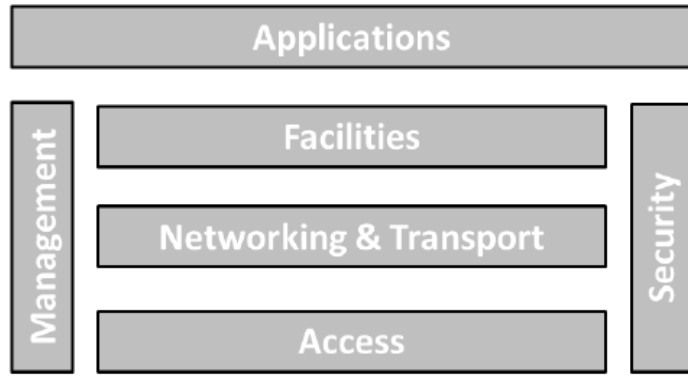
## Failure Management

- Realize failover (possibly with reduced / altered capabilities)

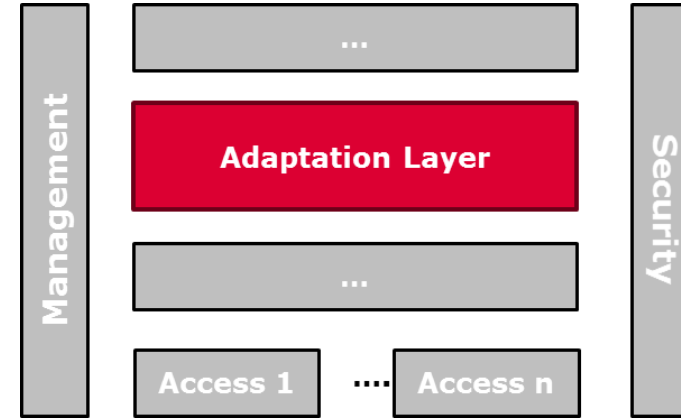
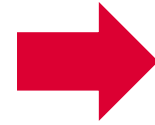
How to realize these functions?

➤ The 'Adaptation layer' approach

# Adaptation Layer based Architecture

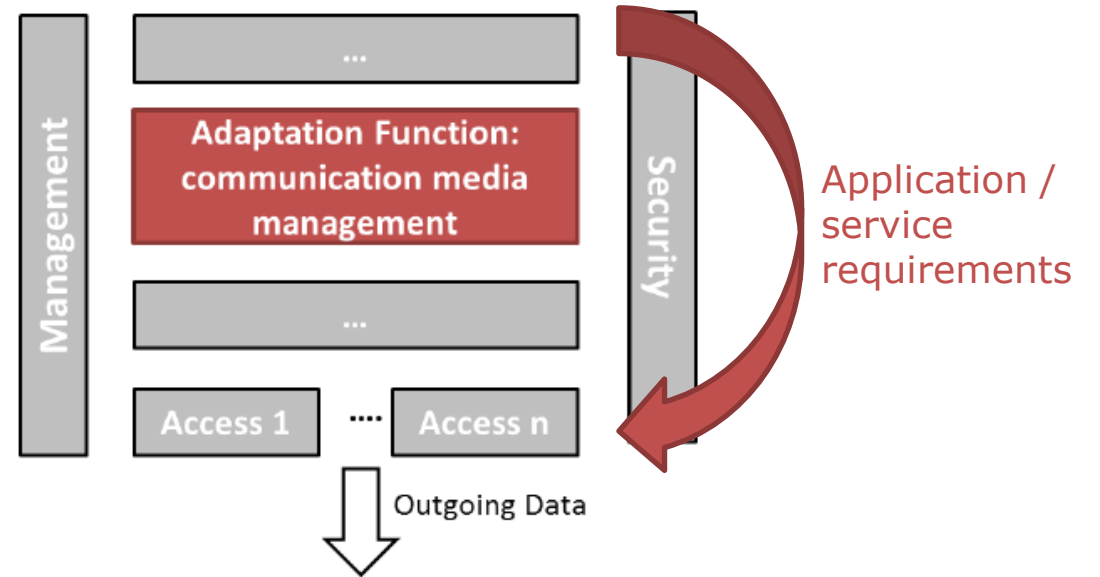
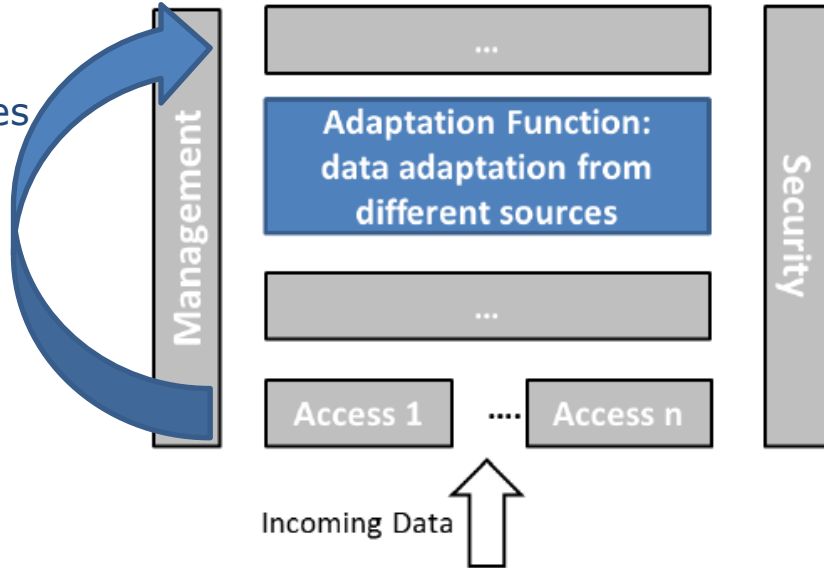


ETSI ITS Architecture

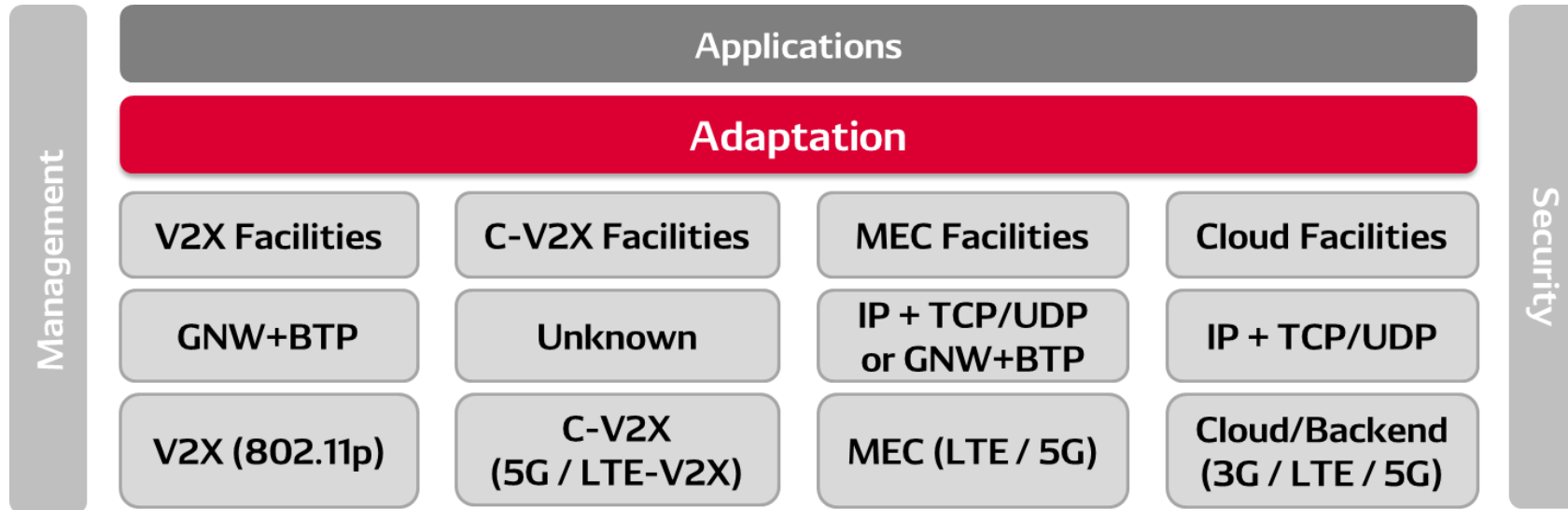


Adaptation Layer Based Architecture

Static capabilities of radio technologies, dynamic radio status (reach, congestion, ...)



# An Example of Multi-Technology Architecture



# 2.

## Communication in ADAS&ME

# ADAS&ME General Concept

## ADAS&ME develops ADAS...

... that incorporates driver state, environmental context and...

... adaptive HMI...

... to automatically hand over different levels of automation and thus...

... ensure safer and more efficient road usage...

... for all vehicle types (car, truck, bus, motorcycle)

## Administrative Information

Started: 01/09/2016

Duration: 42 Months

[www.adasandme.com](http://www.adasandme.com)



 This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 688900

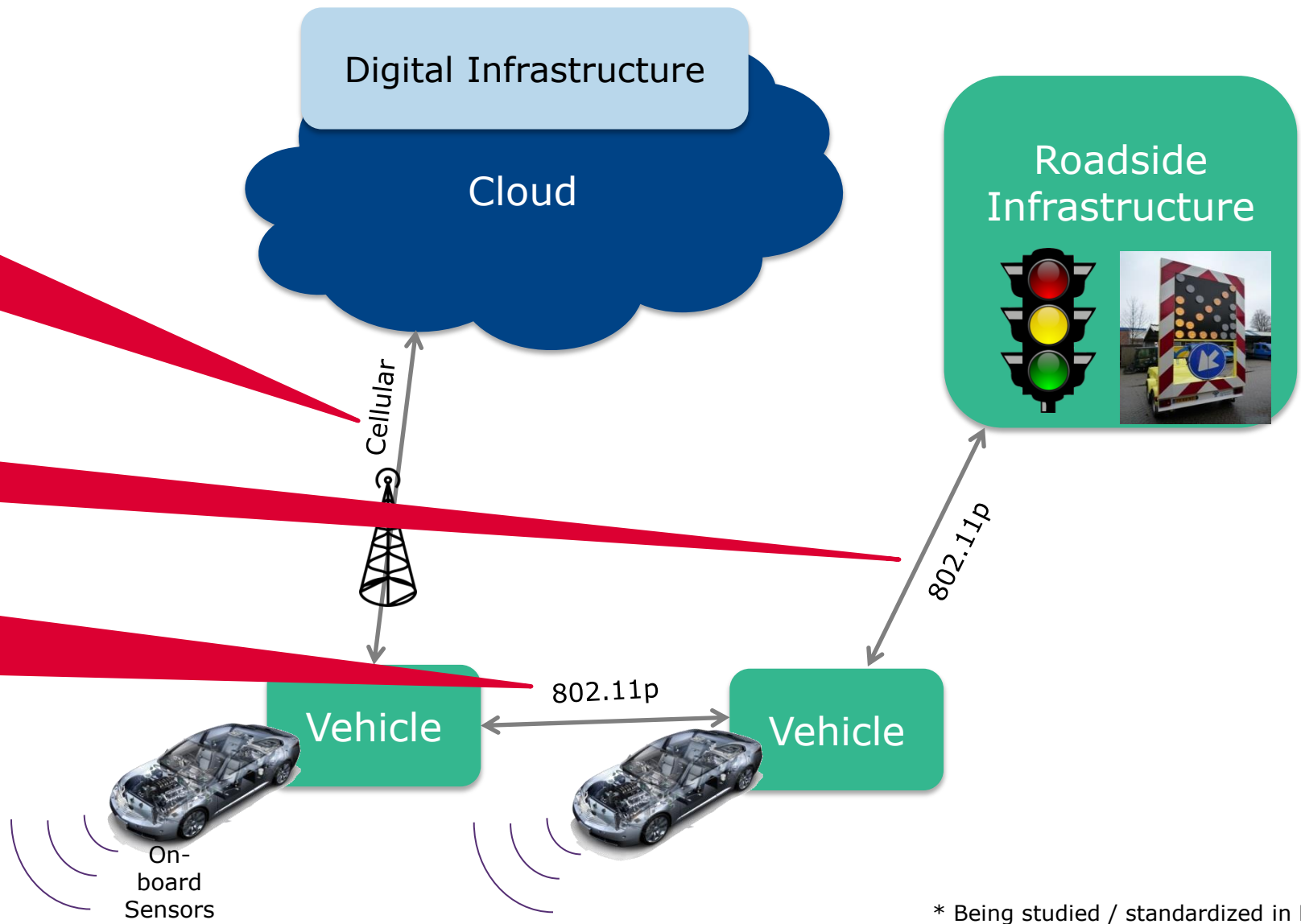


# ADAS&ME Communication Concept

Driving Task Intensity  
Map updates/ changes  
Weather Information  
Traffic Information

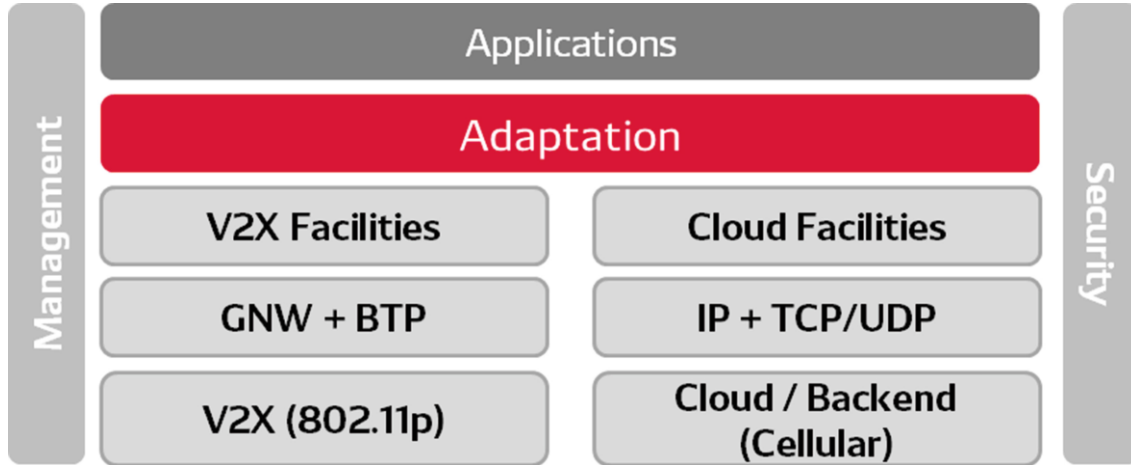
Decentralized Environment Notification  
Message e.g. roadworks

Cooperative Awareness Message  
Collective Perception Message\*  
Coordinated Manoeuvre message\*



\* Being studied / standardized in ETSI

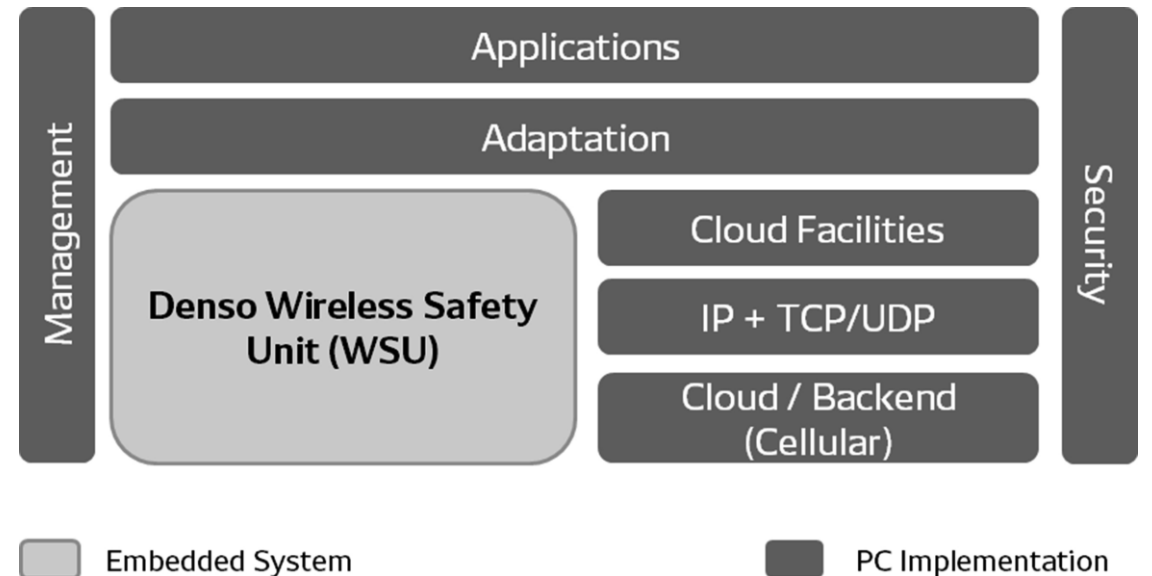
# Adaptation Layer Based Architecture in ADAS&ME



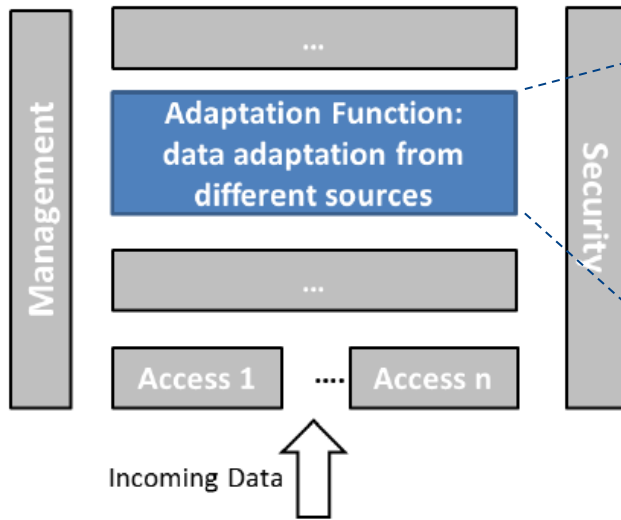
- Considers only 2 communication technologies – IEEE 802.11p (based ITS G5) and Cellular
- Only a subset of the example shown before was used

## Implementation features

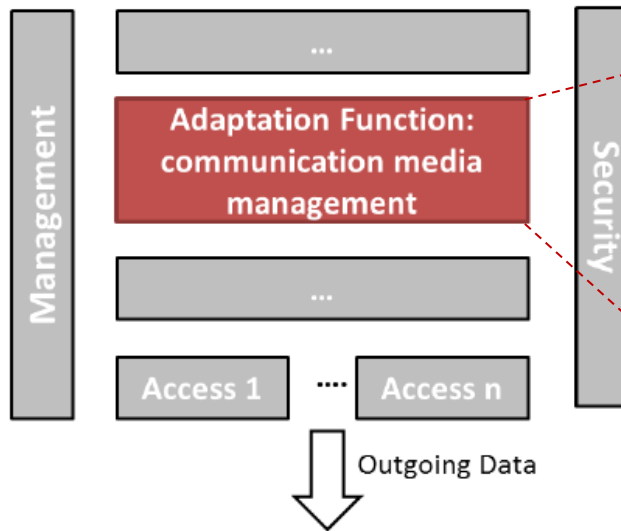
- Denso WSU + PC (RaspberryPi)
- Reuse of hardware → Modular architecture
- Simulated cellular connectivity → Ease of in-house testing



# Adaptation Functions in ADAS&ME



- **Adapting V2X data to a common data format** (used by other systems in the vehicle)
- **Adapting cloud data to a common data format**
- For data sets common between V2X and cellular (e.g. roadworks information), **matching the overlapping information** before adapting it into a common data format



- **Choosing a communication medium over the other** due to capabilities (e.g. choosing 802.11p for sending out V2V / V2I messages and cellular communication for digital infrastructure messages)
- **Adapting object data received from the sensor data fusion system** into a data format suitable for sending out in collective perception messages

# 3.

## Summary & Outlook

# Summary and Outlook

- Using multiple communication technologies / **Hybrid communication is essential** for (fully) automated vehicles
- Hybrid communication functions can be implemented using **Adaptation layer based architecture**
- **Practical implementation confirms the benefits** of such architecture, e.g. modular structure → re-use of existing hardware
  
- **Future work**
  - Extend the work with additional communication technologies
  - Add top-down dynamic communication resource management
  - Integrate this system in a simulation environment

***DENSO***

Crafting the Core