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5G NetMobil

5G Solutions for Future Connected Mobility

presented by

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Gesellschaft für Informatik - Regionalgruppe Köln,13.02.2019

INTRODUCTION

(1) 5G NetMobil at a glance
(2) Consortium
(3) Motivation & Objectives
(4) Project Structure

5G NETMOBIL AT A GLANCE

5G NETMOBIL – 5G SOLUTIONS FOR FUTURE CONNECTED MOBILITY

SPONSOR	Federal Ministry of Education and Research
CALL	5G Tactile Internet within the german research program „IKT 2020 – Research for Innovation“
PARTNERS	Bosch (Coordinator), Technische Universität Dresden (Co-Coordinator), Acticom, BMW AG, CLAAS, Deutsche Telekom, dresden elektronik, Ericsson, Fraunhofer Heinrich-Hertz-Institut, Heusch Boesefeldt, Hochschule für Technik und Wirtschaft des Saarlandes, Logic Way, Nokia, Technische Universität Kaiserslautern, Vodafone, Volkswagen AG
BUDGET	14.9 Mio. € (8,5 Mio. € Funding)
DURATION	01.03.2017 – 29.02.2020

CONSORTIUM

OEMs & Suppliers

- VOLKSWAGEN AKTIENGESELLSCHAFT
- BMW GROUP
- MINI
- CLAAS
- BOSCH

Operators

- T · ·
- vodafone

Vendors

- ERICSSON
- NOKIA

SMEs

- acticom
- HEUSCH BOESEFELDT Brains for roads
- dresden elektronik
- LOGIC WAY Logic Way GmbH

Academic Organisations

- TECHNISCHE UNIVERSITÄT DRESDEN
- TECHNISCHE UNIVERSITÄT KAISERSLAUTERN
- Fraunhofer Heinrich Hertz Institute
- FGVT htw saar Forschungsgruppe Verkehrstelematik

TACTILE CONNECTED DRIVING: MOTIVATION

Tactile connected driving enables new driving strategies

Increased traffic safety → Accident free driving

Significant reduction in CO_2-emission

Improved traffic efficiency: better road utilization and reduced road congestion

Improved comfort of both drivers and passengers

Achieving this vision requires **reliable, secure and robust communications** that enable **real-time** control

OBJECTIVES

Development of a holistic **communication architecture** for **tactile connected driving** and highlighting the new capabilities enabled by the next mobile network generation for bringing automated driving forward and improving **traffic safety and efficiency**.

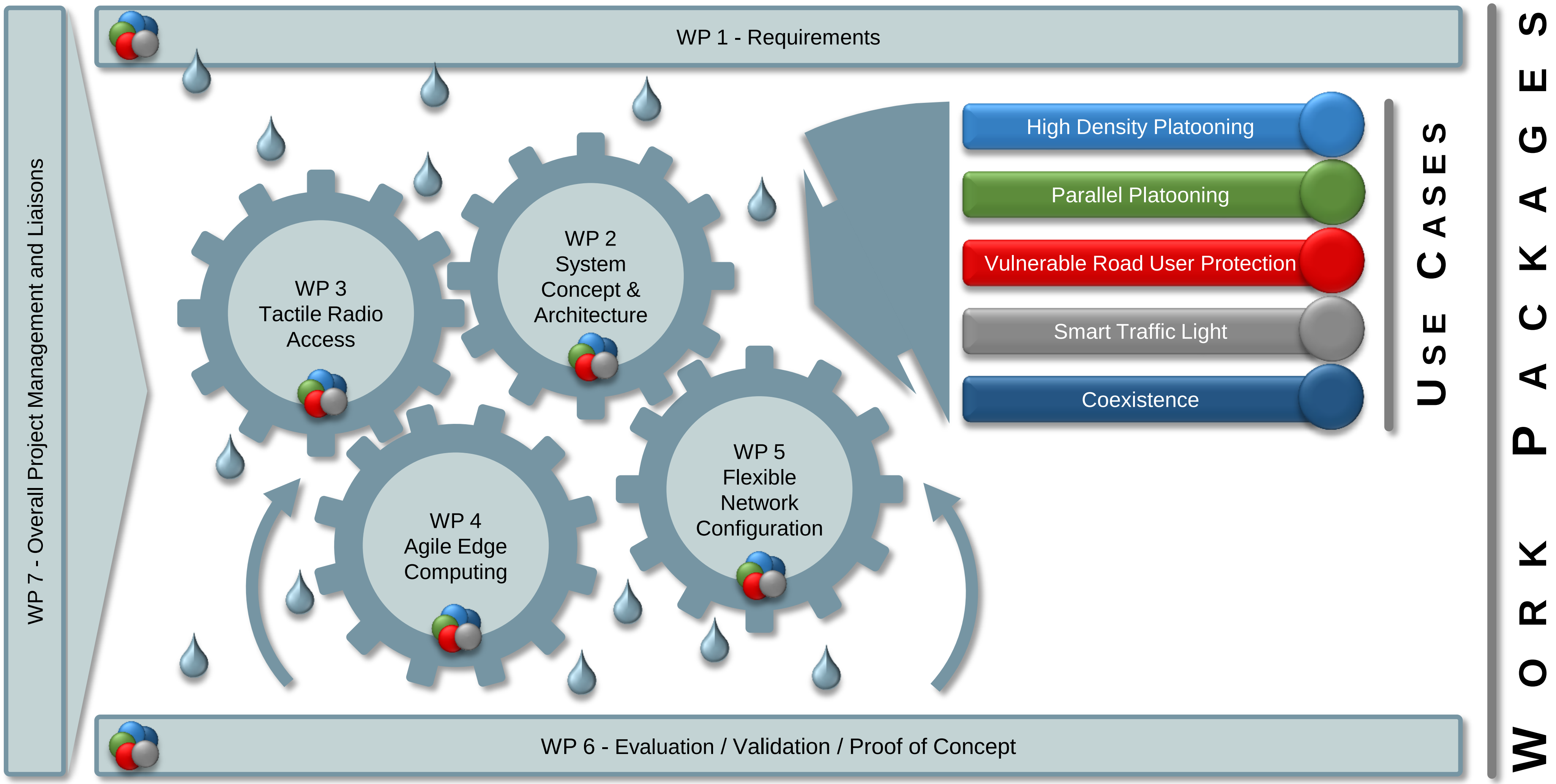
Development of technical solutions and concepts for fifth generation (5G) mobile radio networks fulfilling requirements of connected driving through...

- ultra-high reliability
- ultra-low latency

Validation of the developed solutions and concepts by means of...

- simulations
- system modeling
- demonstrations in realistic scenarios

PROJECT STRUCTURE



Mar '17
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Nov '19
Jan '20
WP1
Start 01.03.17
Finish 29.02.20
Definition of Use Cases 01.03.17 - 31.08.17
Value Chain and Market Players 01.12.17 - 30.04.18
Technical Specifications 01.04.17 - 30.11.17
Evaluation 01.03.19 - 29.02.20
Methology of Evaluation 01.07.17 - 30.11.17
D.1.1 30.11.17
D.1.2 30.04.18
D.1.3 29.02.20
WP2
Start 01.03.17
Finish 29.02.20
5G based overall Architecture 01.05.17 - 29.02.20
Model of Communication & Message Formats 01.07.17 - 30.06.19
Security Aspects 01.11.17 - 30.04.19
Spectrum and Operations 01.09.17 - 28.02.19
D.2.1a 30.11.17
D.2.1b 31.08.18
D.2.2 29.02.20
WP3
Start 01.03.17
Finish 29.02.20
D2D and cellulare Communication 01.07.17 - 31.10.19
Coordination of various Types of Communication 01.09.17 - 31.10.19
Concepts of Diversity 01.09.17 - 31.12.19
Coexistence- and QoS-Aspects 01.09.17 - 31.01.20
D.3.1 31.10.17
D.3.2 28.02.18
D.3.3a 31.08.18
D.3.3b 28.02.19
D.3.4 31.01.20
WP4
Start 01.03.17
Finish 29.02.20
Agile Mobile Edge Cloud 01.09.17 - 28.02.19
Mobility Management 01.12.17 - 31.01.20
Inter-Operator-Service 01.04.18 - 28.02.19
D.4.1a 28.02.18
D.4.1b 28.02.18
D.4.3 28.02.19
WP5
Start 01.03.17
Finish 29.02.20
SDN- and NFV-based Network-Management 01.07.17 - 30.06.19
E2E QoS and Automotive Network Slicing 01.09.17 - 31.08.19
Cognitive Automotive-Network-Management 01.09.17 - 31.01.20
D.5.1 28.02.18
D.5.2a 31.08.18
D.5.2b 28.02.19
D.5.3 31.01.20
WP6
Start 01.03.17
Finish 29.02.20
Establishing Testbeds, Integration 01.09.17 - 29.02.20
Establishing and Implematation of Simulating Platforms 01.11.17 - 28.02.19
Establishing of Lab-Enviroments, Implementation of Use Cases 01.06.18 - 29.02.20
Evaluation of Overall Systems 01.01.19 - 29.02.20
D.6.1a 28.02.19
D.6.1b 30.11.19

USE CASES

USE CASES

Technical requirements identified based on five use cases:

- High Density Platooning
- Parallel Platooning
- City Crossing Assistance for Vulnerable Road User Protection
- City Crossing by Smart Traffic Lights
- Coexistence of Automotive Safety-Related and Consumer Infotainment Services

Technological innovations will be validated in several proof of concepts.

HIGH DENSITY PLATOONING

PURPOSE

- Reduction of the inter-vehicle distances (below 10m) for optimized energy efficiency
- Keep platoon in safety while driving with small inter-vehicle distances

REQUIREMENTS OF USE CASE

- Low Latency (below 10 ms)
- Ultra-reliable communication

TECHNICAL CHALLENGE

- Hybrid communication of IEEE 802.11p and 5G
- Improvement of availability and reliability using radio diversity concepts
- Prediction of Quality-of-Service (QoS) in V2X communications

PARALLEL PLATOONING


PURPOSE

- Establish and control appropriate relative distances between vehicles to relieve strain on the machine operators
- Increase harvesting efficiency

REQUIREMENTS OF USE CASE

- Low Latency (below 50ms)
- High reliability for communication
- Standardized interfaces

TECHNICAL CHALLENGE

- Integrate different 5G V2V-communication technologies into agricultural machines' architectures
- QoS prediction in off-road usage
- Interoperability

CITY CROSSING ASSISTANCE FOR VULNERABLE ROAD USER (VRU) PROTECTION

PURPOSE

- Increased road safety for pedestrians and cyclists
- Support of automated driving: increase field of view beyond local sensors

REQUIREMENTS OF USE CASE

- Reliable VRU localization and prediction of movement patterns
- Low latency and high reliability communications

TECHNICAL CHALLENGE

- Integration of edge computing in 5G Network for local low latency information processing
- Local data broadcasting

CITY CROSSING BY SMART TRAFFIC LIGHTS

PURPOSE

- Inform road users about red light violations, approaching emergency vehicles, dangerous situations, etc.
- Efficient platoon routing through cities

REQUIREMENTS OF USE CASE

- Data rate of 10Mbit/s overall

TECHNICAL CHALLENGE

- Enable the different V2X applications in urban environments even with hundreds of cars within radio range of a traffic light
- Cope with different prioritizations of means of transportations (Car, Bus, Tram, etc.)

COEXISTENCE OF AUTOMOTIVE SAFETY-RELATED AND CONSUMER INFOTAINMENT SERVICES

PURPOSE

- Assure the coexistence of different service classes in the same network
- Assure that services do not suffer from an unexpected drop in the QoS

REQUIREMENTS OF USE CASE

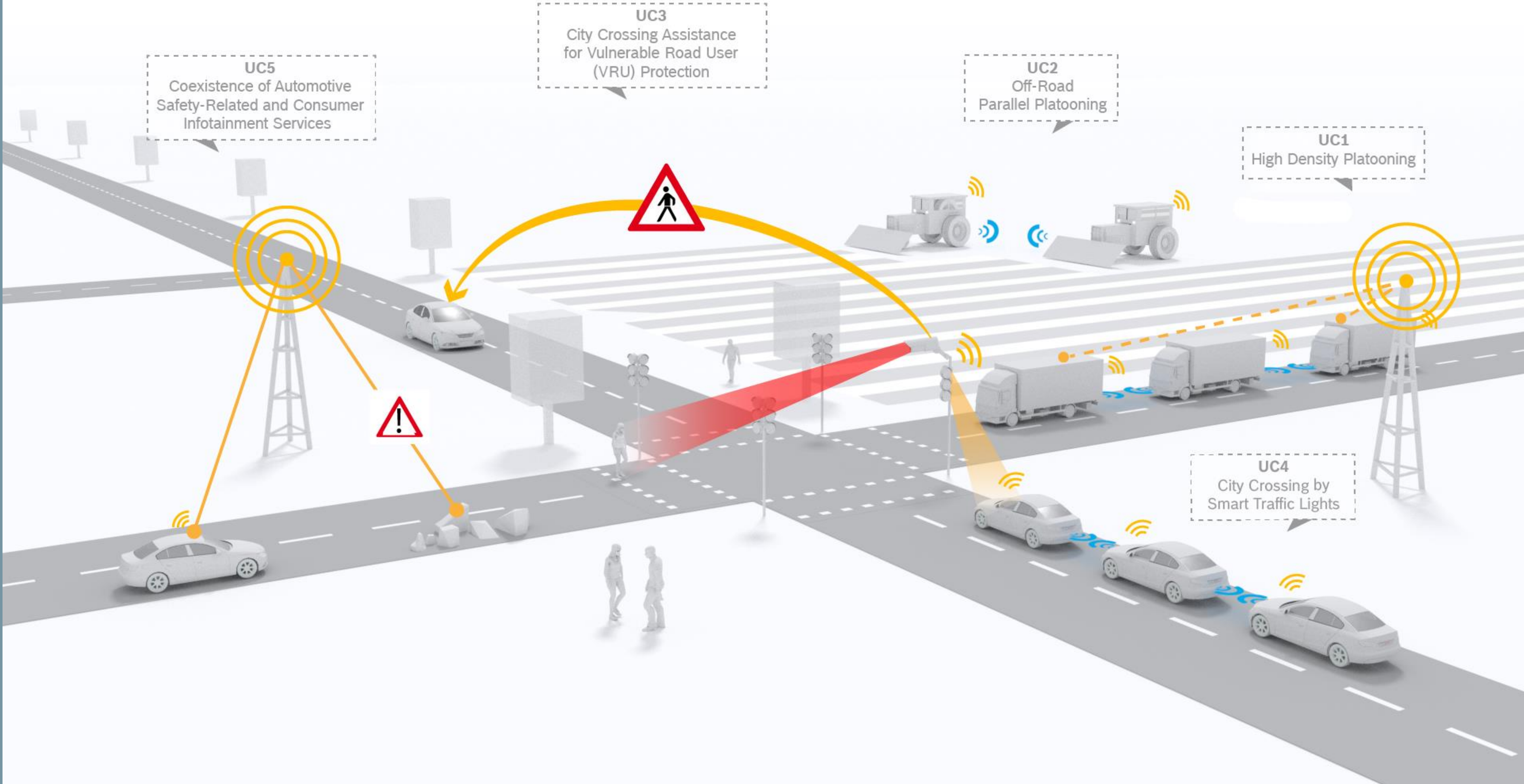
- High availability and reliability, and low latency for safety-related services
- Broadband service for infotainment applications with data rates of up to 14 Mbps per passenger and vehicle

TECHNICAL CHALLENGE

- Cope with a diverse mix of QoS requirements for simultaneously running applications
- Create an API for dynamic (and predictive) QoS negotiation and service adaptation

TECHNOLOGY COMPONENTS

OVERVIEW



UC3
City Crossing Assistance for Vulnerable Road User (VRU) Protection
UC5
Coexistence of Automotive Safety-Related and Consumer Infotainment Services
UC2
Off-Road Parallel Platooning
UC1
High Density Platooning
UC4
City Crossing by Smart Traffic Lights

TECHNOLOGY APPROACHES

Vertical project partners pursue different communication technology approaches

Cellular

4G/5G
Unicast | Multi-/Broadcast

BMW GROUP
BOSCH
VOLKSWAGEN AKTIENGESELLSCHAFT

Direct

4G/5G
Network-assisted Sidelink
Ad-hoc Sidelink

BMW GROUP
BOSCH
CLAAS
VOLKSWAGEN AKTIENGESELLSCHAFT

IEEE 802.11p

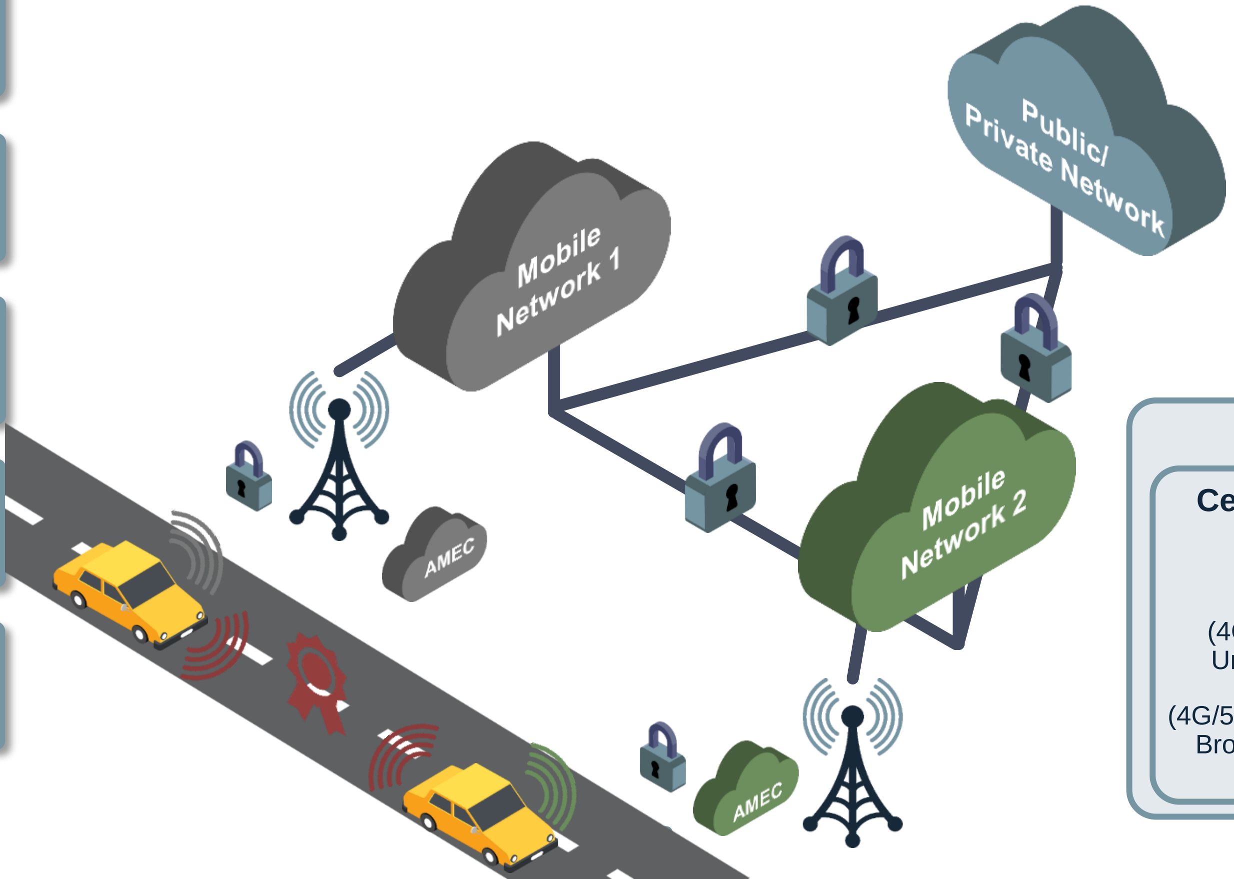
BOSCH
CLAAS
VOLKSWAGEN AKTIENGESELLSCHAFT

HOLISTIC ARCHITECTURE

Providing reliable, secure and robust communications that enable real-time control

- Radio Resource Management for Low Latency & High Reliability
- Hybrid V2X-Communication
- Network Slicing
- Agile Mobile Edge Cloud
- Predictive Quality of Service

- Multi-operator Networks
- Security
- New Communication Protocols and Message Formats



Communication Profiles

Cellular
- (4G/5G) Unicast
- (4G/5G) Multi-/ Broadcast

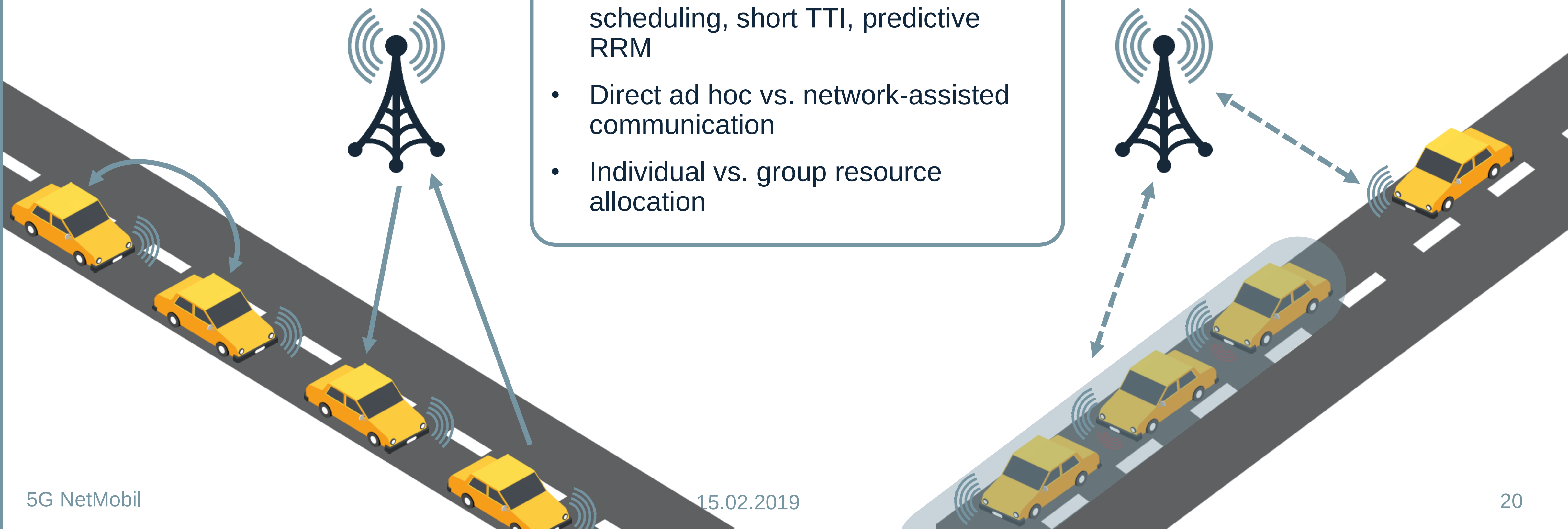
Direct
- **Assisted**: (4G/5G) Network-assisted Sidelink
- **Non-assisted**: (4G/5G) Ad-hoc Sidelink; IEEE 802.11p

RADIO RESSOURCE MANAGEMENT FOR LOW LATENCY HIGH RELIABILITY

New radio resource management approaches adapted to the special characteristic of automotive environments

Control (dashed arrow)
Data (solid arrow)

- Centralized vs. distributed scheduling, short TTI, predictive RRM
- Direct ad hoc vs. network-assisted communication
- Individual vs. group resource allocation



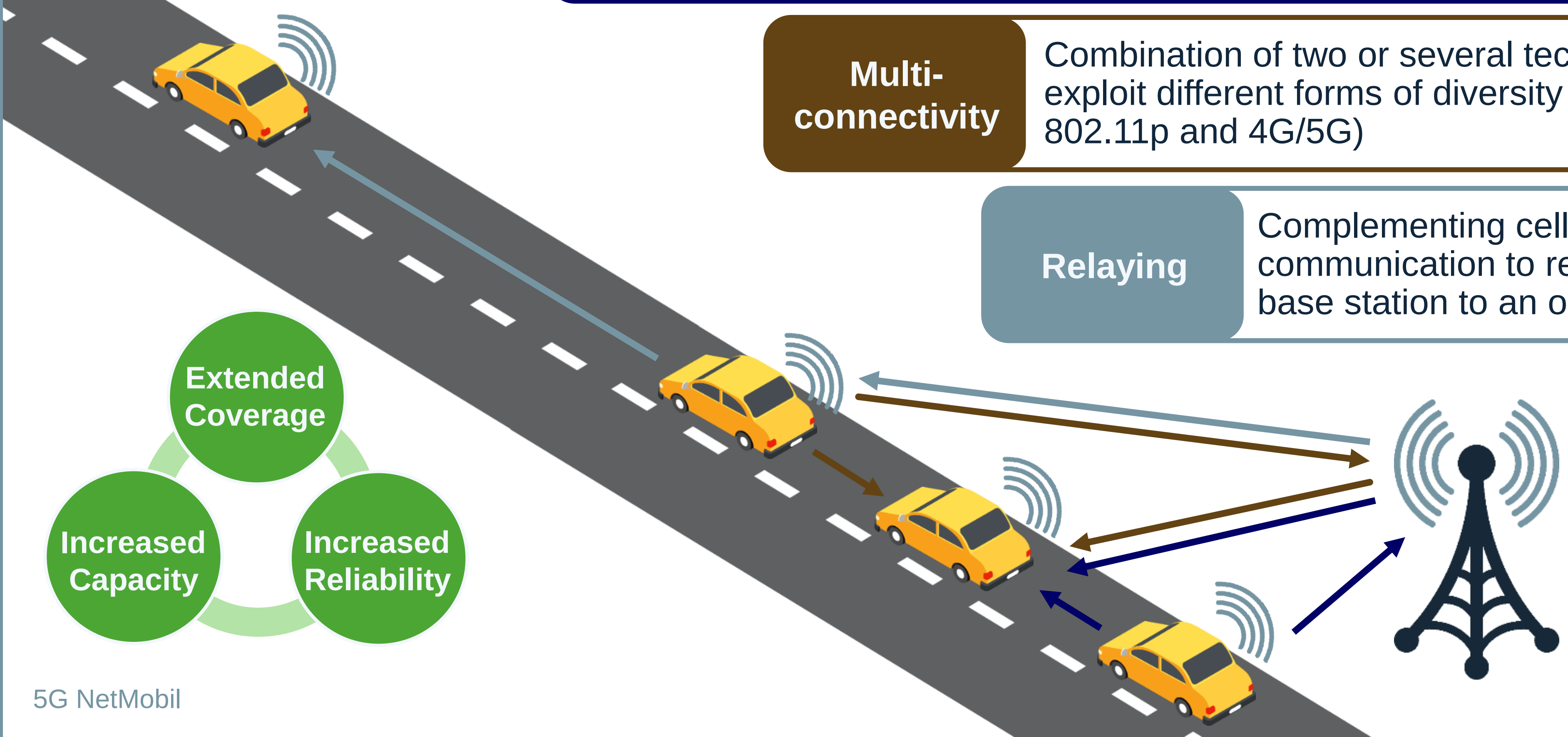
HYBRID V2X COMMUNICATION

Increase of reliability, coverage and capacity of network

Selection – Best appropriate technology to fulfill the specific service requirements (e.g. cellular link or sidelink)

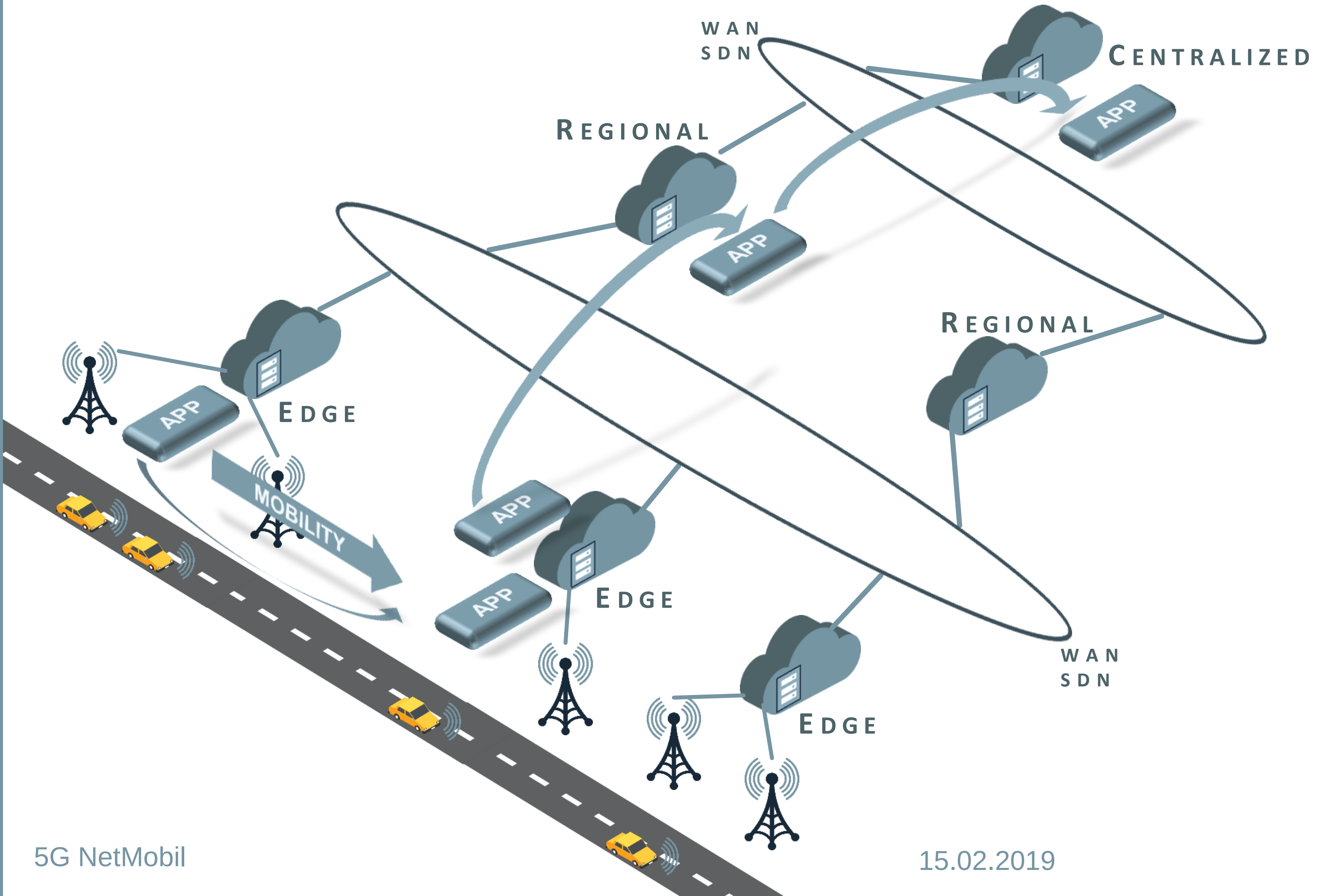
Multi-connectivity – Combination of two or several technologies to exploit different forms of diversity gains (e.g. 802.11p and 4G/5G)

Relaying – Complementing cellular links with sidelink communication to relay data from the base station to an out-of-coverage node



AGILE MOBILE EDGE CLOUD

Reducing E2E latency by bringing the application closer to the network edge



Optimized application placement

Service components are located where they are needed to meet the service requirements while ensuring an efficient use of resources

Cloud for URLLC services

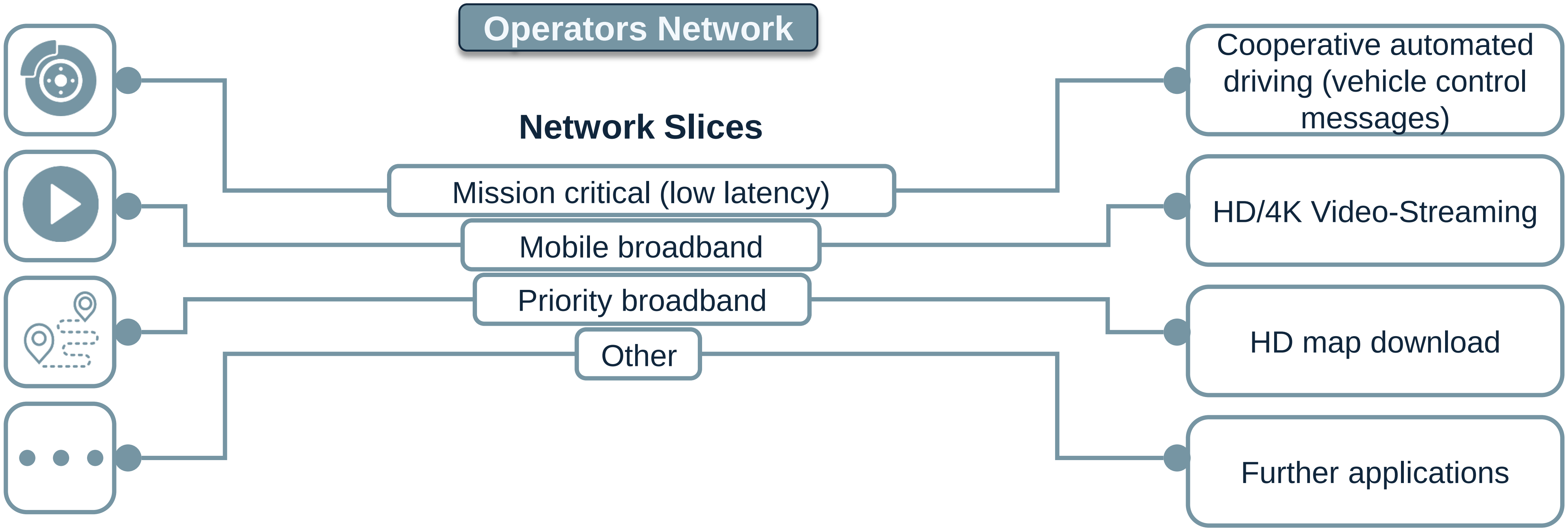
Leveraging the advantages of the cloud computing concept to provide resilience and scalability to critical V2X services

Inter-MEC application transfer for seamless mobility

Service continuity for vehicles across operator domains and country borders

NETWORK SLICING

Multiple virtual E2E networks created on top of a common shared physical infrastructure



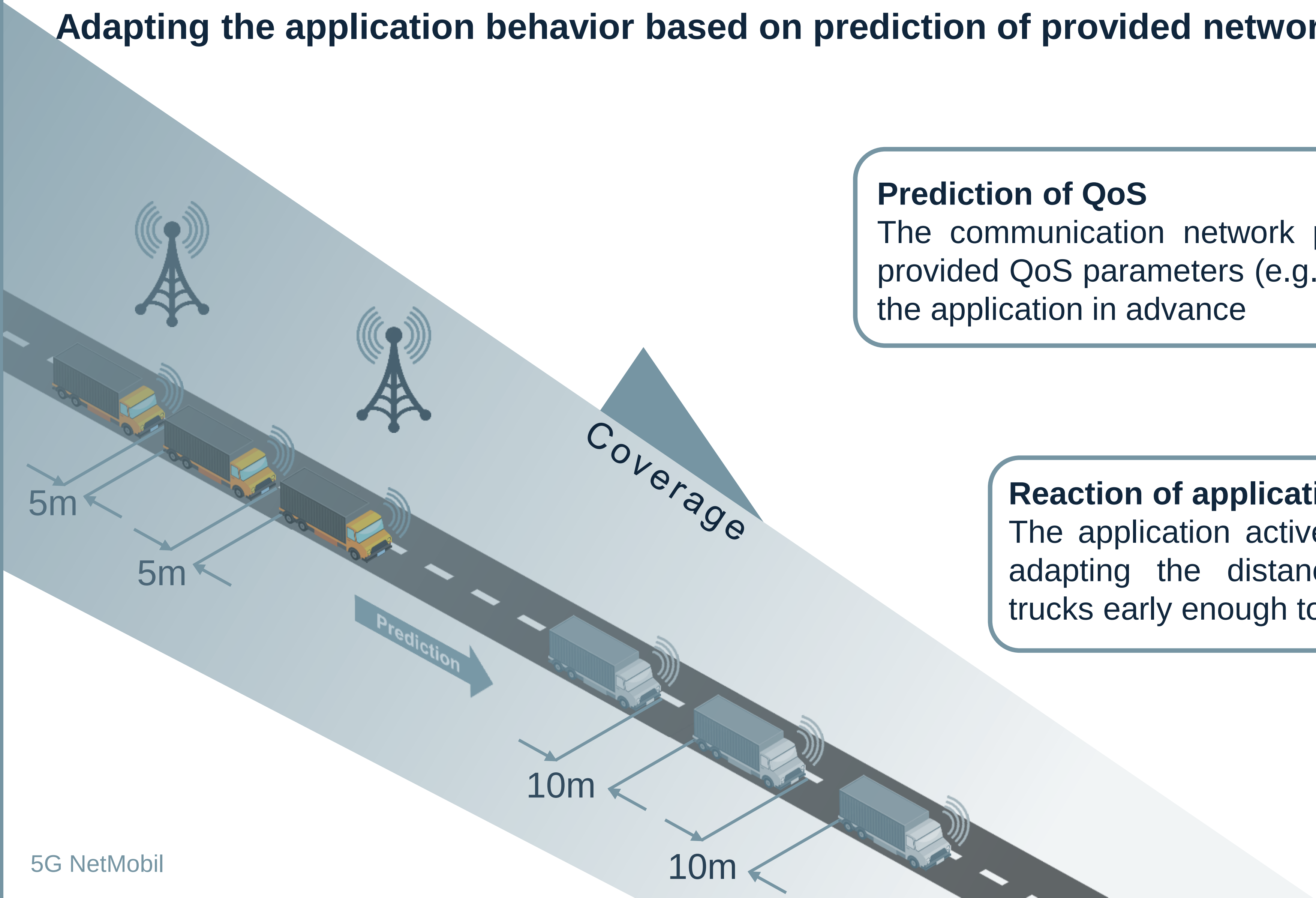
Slice isolation
Performance is not dependent on the load of other slices.

Different requirements
Slice configuration fits the application requirements.

Service priority
Resources of low priority slice can be granted to high priority slices.

AGILE QUALITY OF SERVICE ADAPTATION

Adapting the application behavior based on prediction of provided network performances



Prediction of QoS
The communication network predicts the changes of the provided QoS parameters (e.g. delay, reliability) and informs the application in advance

⇩

Reaction of application
The application actively reacts to the changes by adapting the distances between the individual trucks early enough to ensure Platoon efficiency

VALIDATION & PROOF OF CONCEPT

EVALUATION & VALIDATION / PROOF OF CONCEPT

Simulation

Large scale evaluations

Cyber-physical Co-Simulation of UC

Results

Models

Small scale evaluations

Prototypical implementation of

Results

Real-Word Scenarios

Selected sub-UC as real life evaluation

Implementation of all use cases

Results / Public demonstration

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