5G and Automotive
The Perfect Storm?

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5G - Transformer

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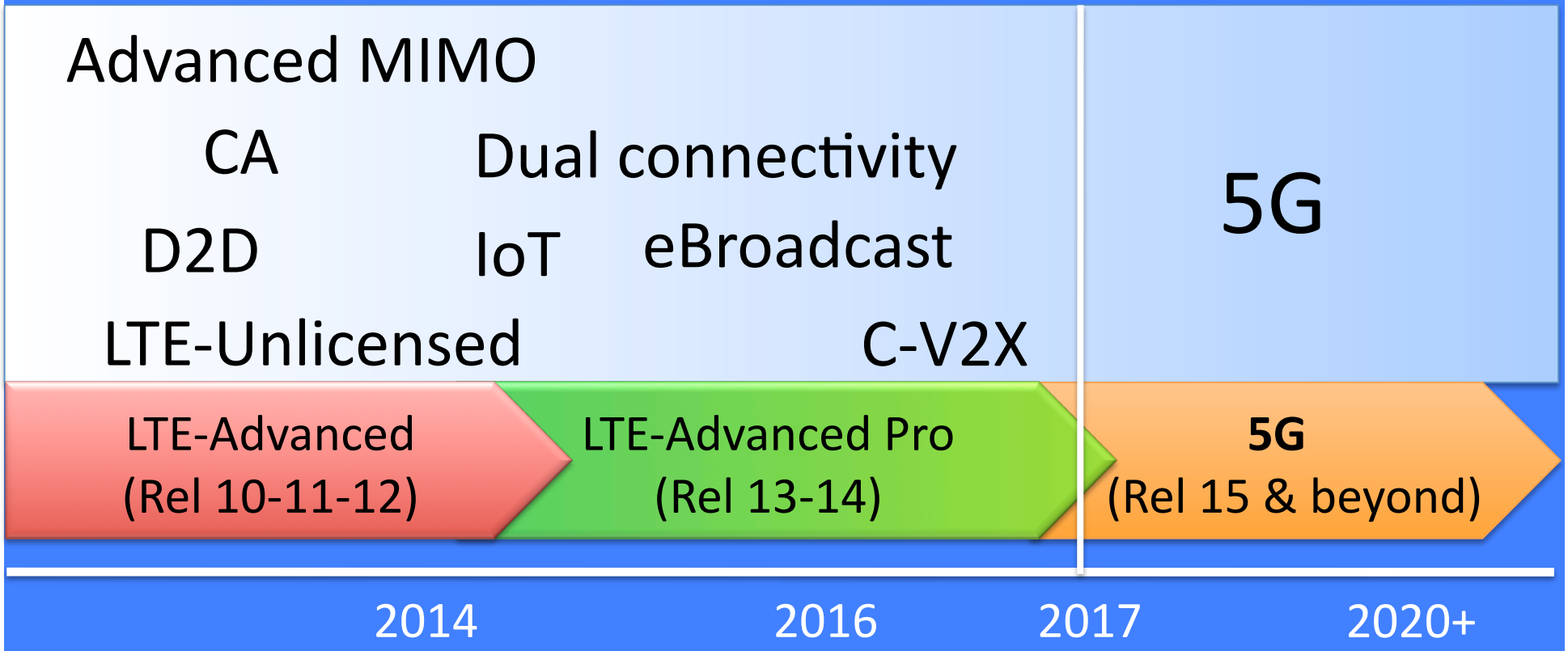
EVOLUTION



- 3GPP TR 36.nnn Rel. 14 – LTE V2X
- 3GPP TS 22.261 V15.1.0 (2017-06) Rel. 15 - Service requirements for the 5G system (eV2X)

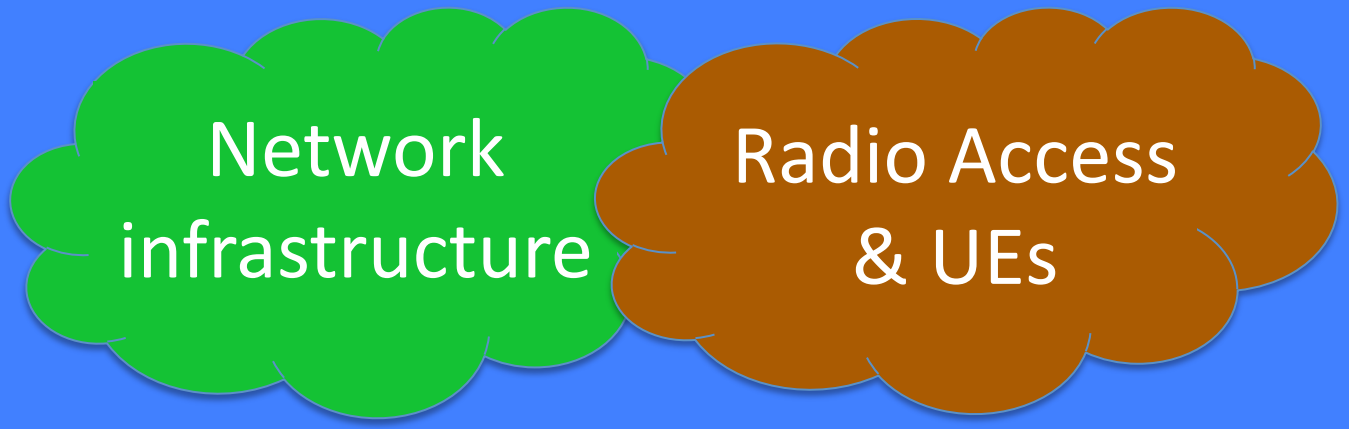
eV2X Services (Rel. 15)

- Platooning: vehicles dynamically forming a group travelling together
- Advanced Driving: sharing driving intentions, sensor data and videos with RSUs, other vehicles, pedestrians and V2X servers for safety, traffic efficiency, semi- or fully-automated driving
- Remote Driving: a remote driver or a V2X application operate a vehicle (disabled passengers, vehicles in dangerous environments, public transportation)

Use case	Data rate	Latency	Area traffic capacity	Availability/ Reliability/ Resilience	Connection density
Automotive	**0.5/10 Mbps 25/50 Mbps**	**1 ms- 10 ms**	0-500 km/h	**99.9999%**	**4000 veh/ km²**

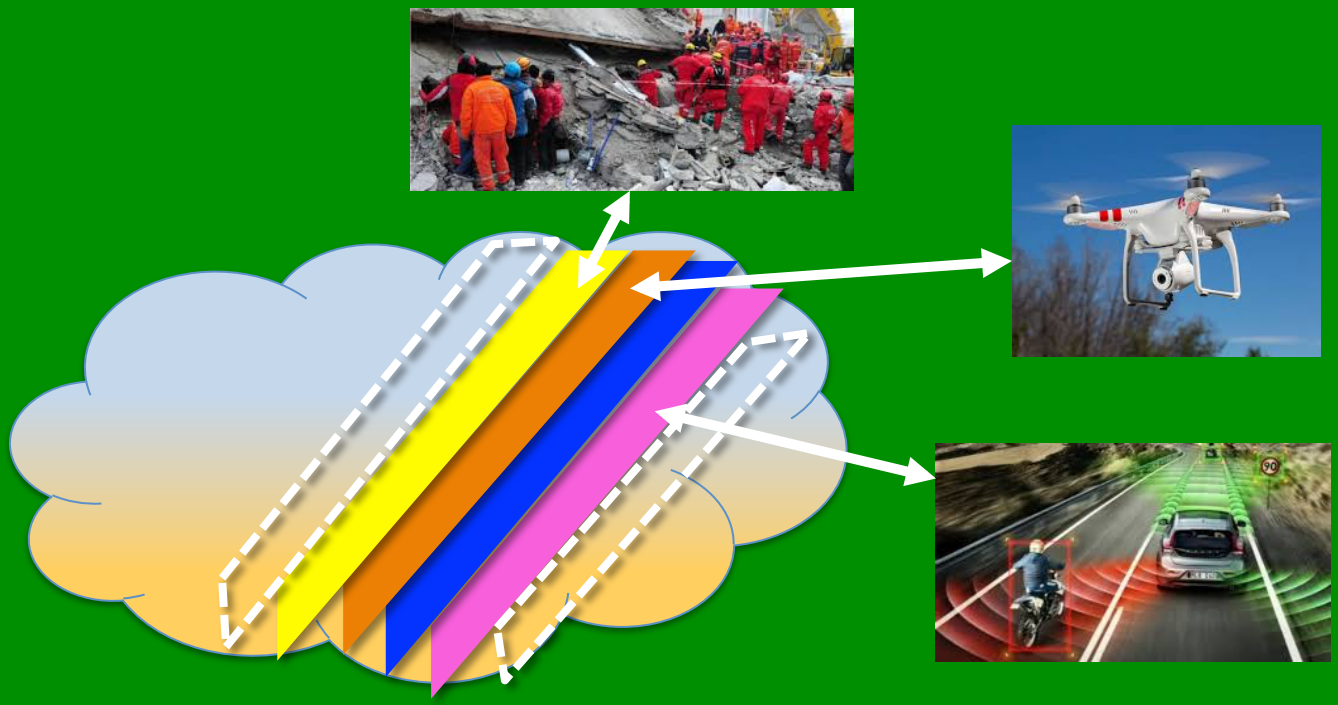
KEY 5G INNOVATIONS FOR THE AUTOMOTIVE DOMAIN

- Network slicing
- Multi-access Edge Computing (MEC)



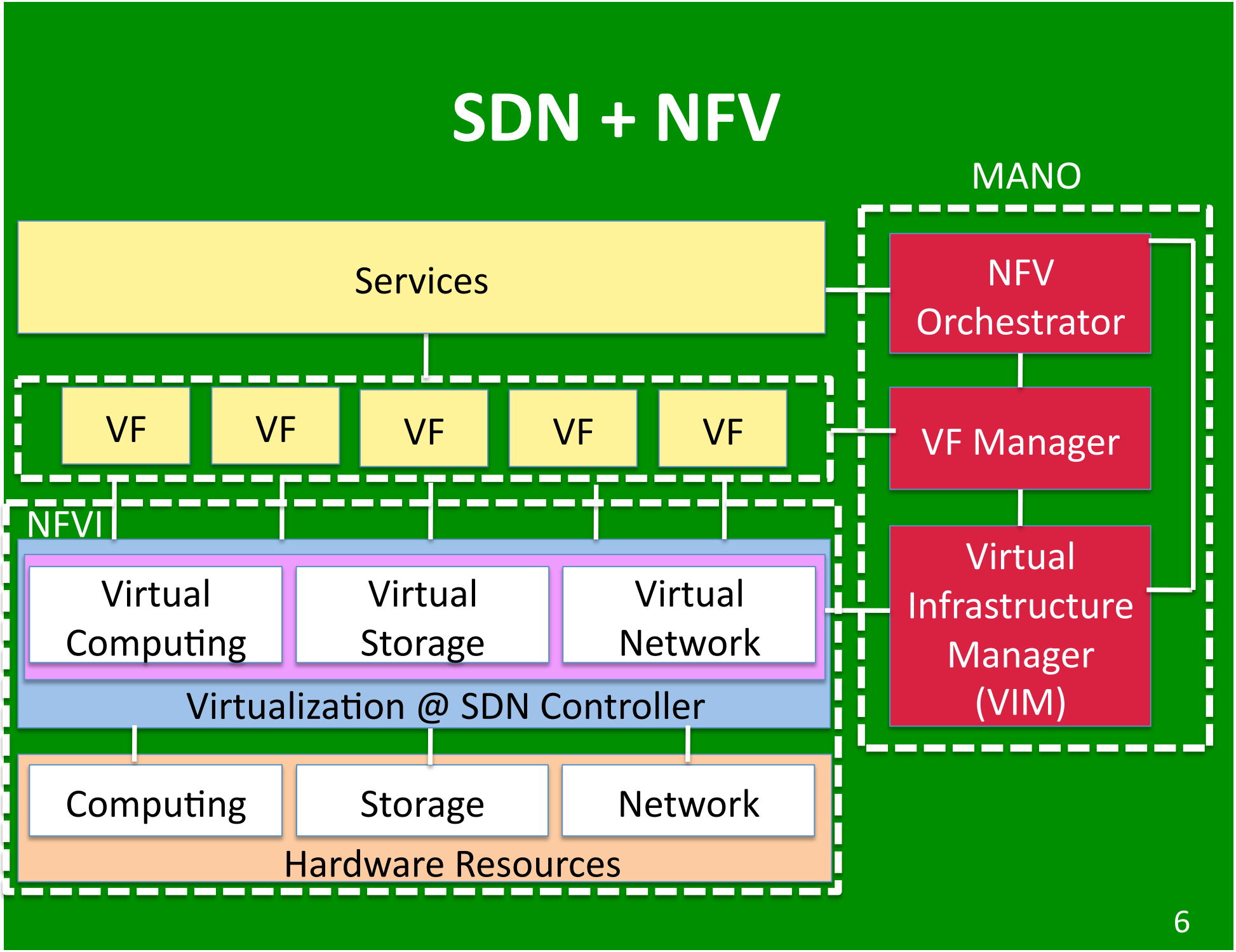
- eV2X communications
- mmWave communications

NETWORK SLICING



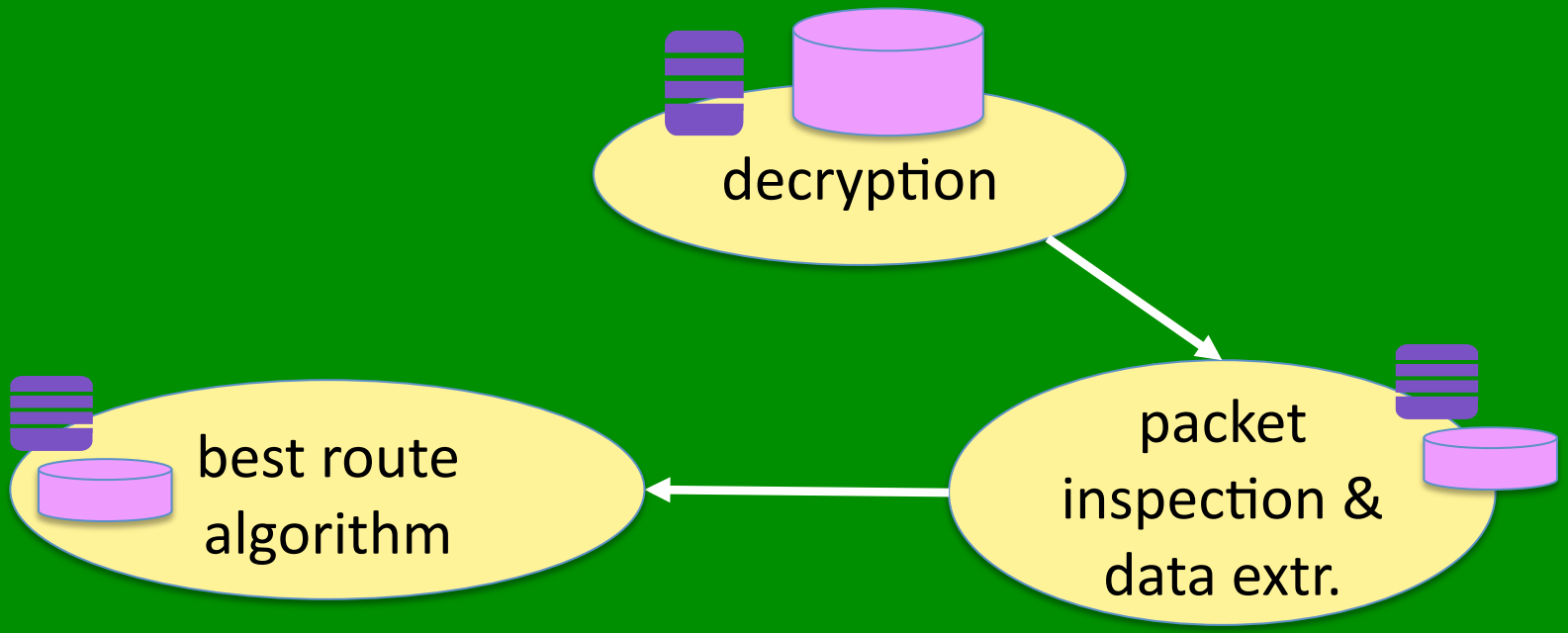
- Network slice: partitioning of virtual resources and functions to satisfy verticals' requirements
- Enabling technologies: SDN & NFV

SDN + NFV


MANO
Services
NFV Orchestrator
VF
VF
VF
VF
VF
VF Manager
NFVI
Virtual Computing
Virtual Storage
Virtual Network
Virtual Infrastructure Manager (VIM)
Virtualization @ SDN Controller
Computing
Storage
Network
Hardware Resources

VEHICULAR SERVICES

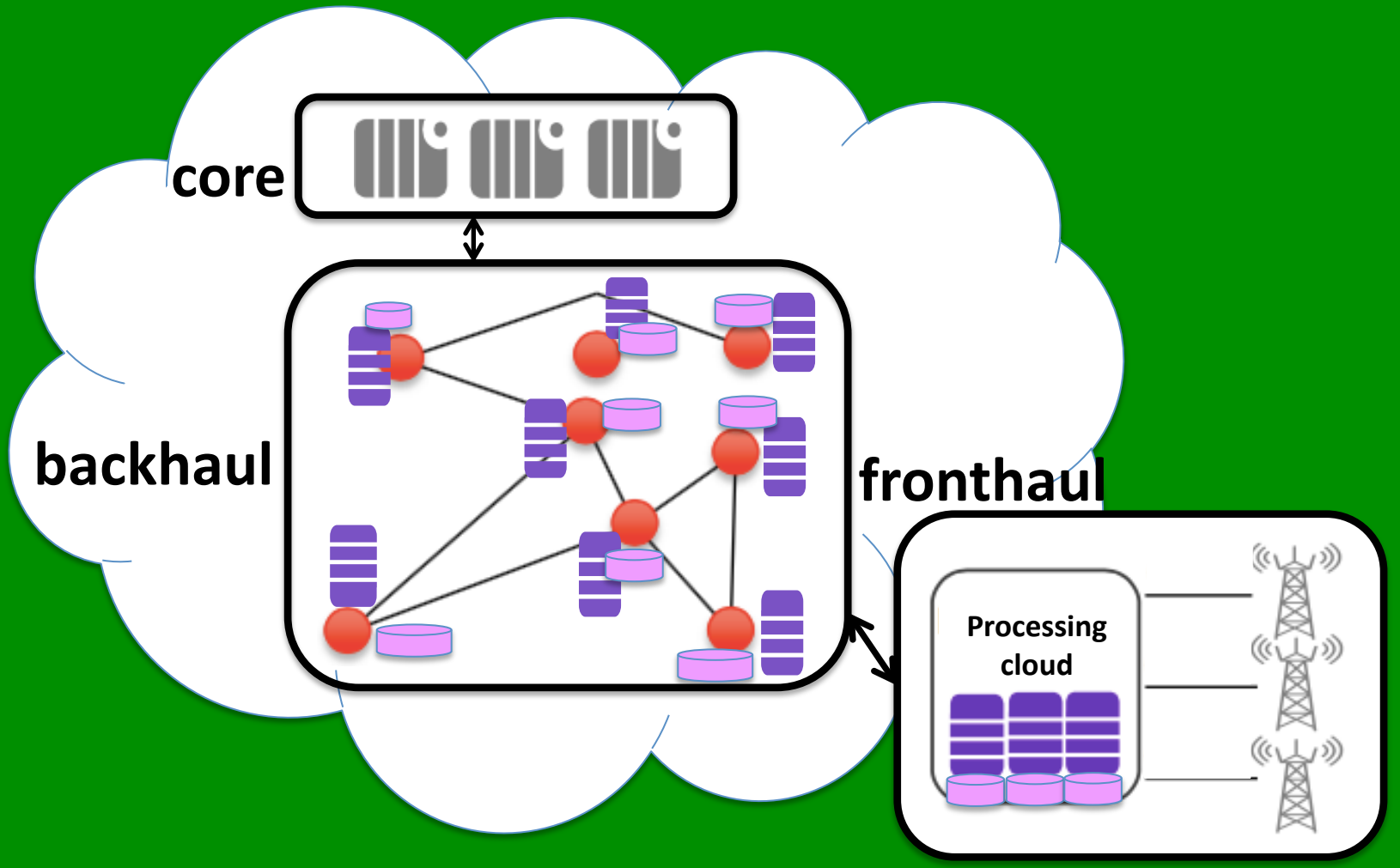
Navigation service



computational resources

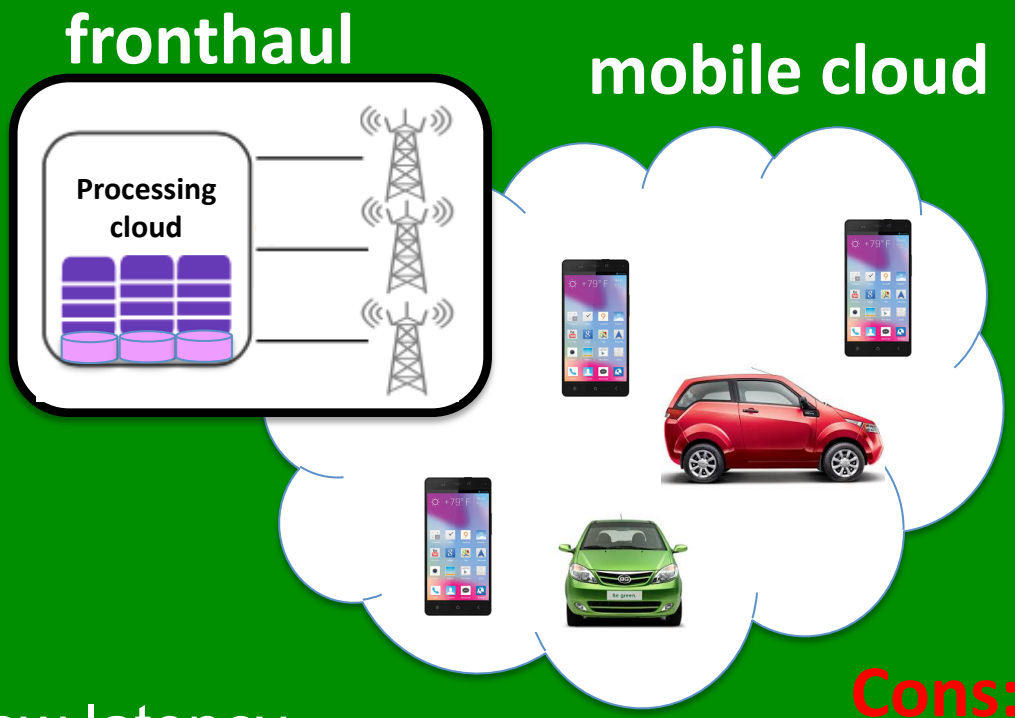
storage resources

MEC – MULTIACCESS EDGE COMPUTING (aka Mobile Edge Computing)



MEC: Distributed server deployment at network edge

EXTREME MEC



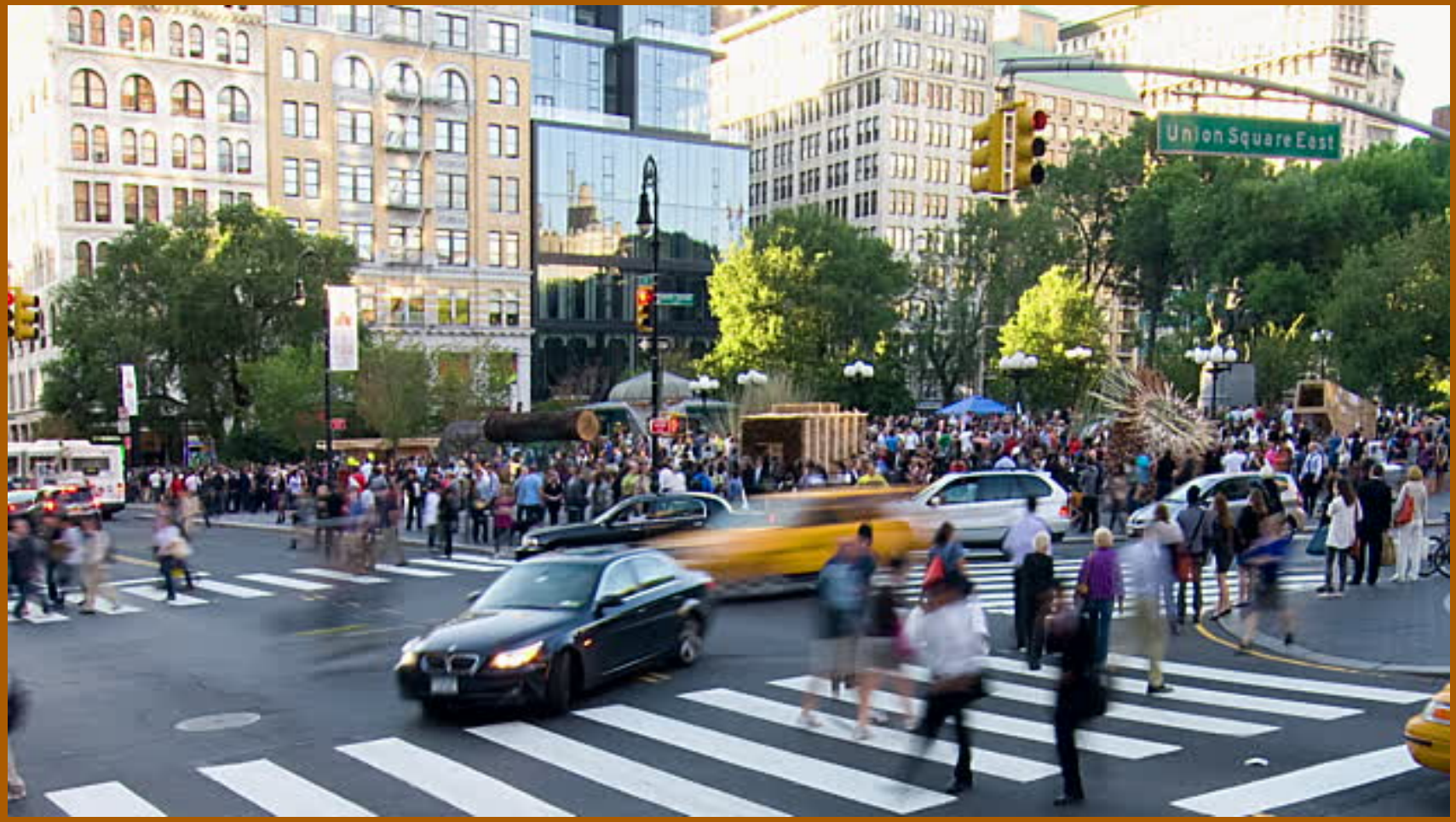
Pros:

1. Ultra-low latency
2. Lower bandwidth consumption
3. Lower energy consumption
4. Better privacy
5. Higher resilience

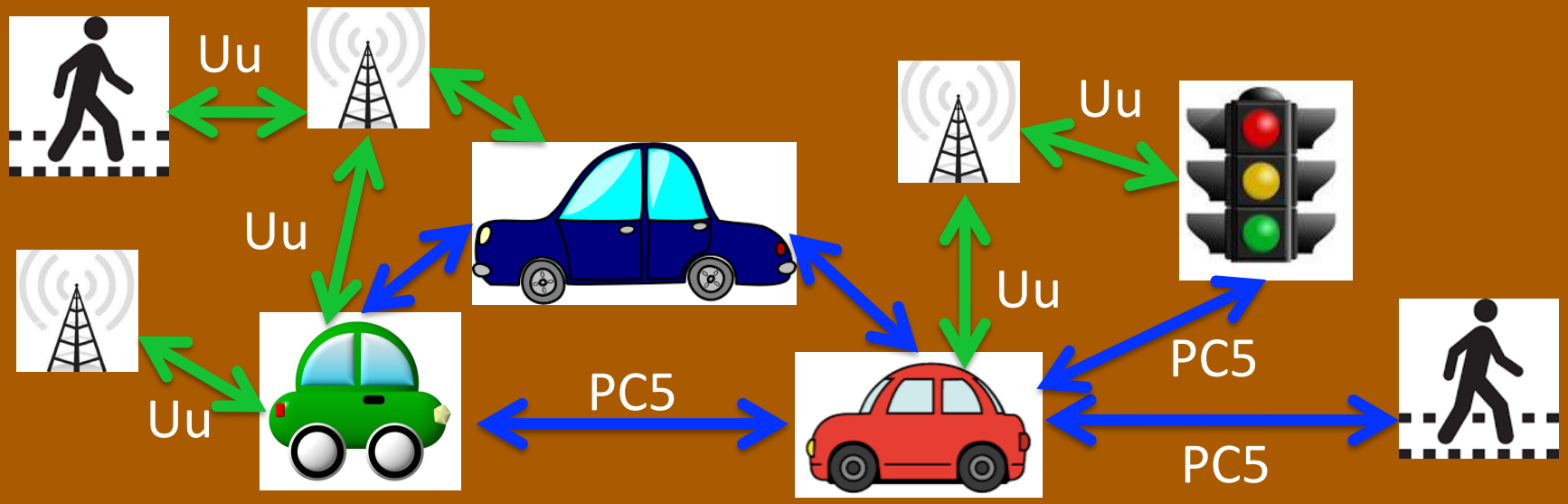
Cons:

1. Lower availability
2. Consistency issues
3. Service migration
4. Higher complexity

CELLULAR V2X (C-V2X) [Rel. 14]



C-V2X



- V2V, V2I, V2P communications through side link (PC5)
- PC5 uses LTE radio interface but in the 10 MHz unlicensed band at 5.9 GHz
- Resource pool allocated by BS if under coverage, or a-priori allocated if out of coverage
- Random access (not fully specified yet)

C-V2X vs. DSRC/ITS-G5

Pros:

- High PHY layer performance (in 5G: new radio waveforms) C-V2X: 500 m vs. DSRC: 225 m
- More efficient channel access: reduced packet losses due to random selection
- No need for multihop
- In 5G: cooperative sharing of operators' frequencies for safety
- Interaction with any user equipment (e.g., pedestrians)

Cons:

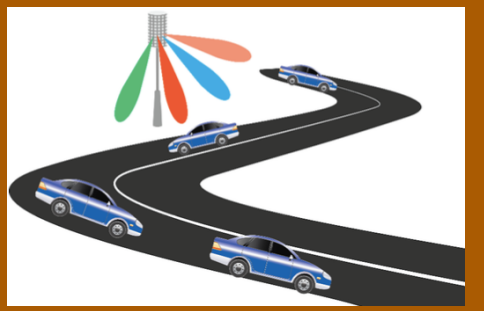
- Cost
- Broadcasting
- Synchronization
- Unclear out-of-coverage performance

Possible scenario

Different radio technologies will be integrated, addressing a variety of use cases and requirements

No registration required → Security threats

mmWAVE FOR CARS



- WHY
  - Connected cars will need Gbps data rate due to the expanding number of sensors
  - Cannot achieve Gpbs in 10 MHz channels @ 5.9 GHz
  - mmWave possible in low cost consumer devices
- HOW
  - Use carriers at 28-30 GHz or 76-78 GHz
  - Directional beamforming to compensate high path loss
  - Narrow beams reduce interference
  - mmWave already used for radars

THANK YOU