Towards Sustainable 5G Networks

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Vision & Design Principles for New Horizons

VTC2015-Fall
BOSTON
Innovation Meets Tradition

5G Vision

Visual Interpretation of 5G

Meghalaya: **The Residence of Clouds**

- The Motive:
  - North-East India & 2000 m high
  - Possibly the wettest place on Earth with 12 m average annual rainfall
- The Challenge:
  - Wild & Unpredictable Rivers with continuous Rainfalls
  - Myriad of Water Channels impossible to cross
- The Solution:
  - A Sustainable Living Architecture
  - Bridges made of Tree Roots that can survive any rain

5G: **The Residence of Possibilities**

- The Motive:
  - Future Wireless & Mobile Networks
  - Possibly the widest set of use cases & applications in history mobile communications (predicted today & not known today)
- The Challenge:
  - Diverse & Dynamic Service Requirements
  - Future-proof System that can cope with such Diversity
- The Solution:
  - A Sustainable 5G System
  - Enabling Technologies: Service-Oriented Radio, NFV/SDN,…

✓Service-oriented

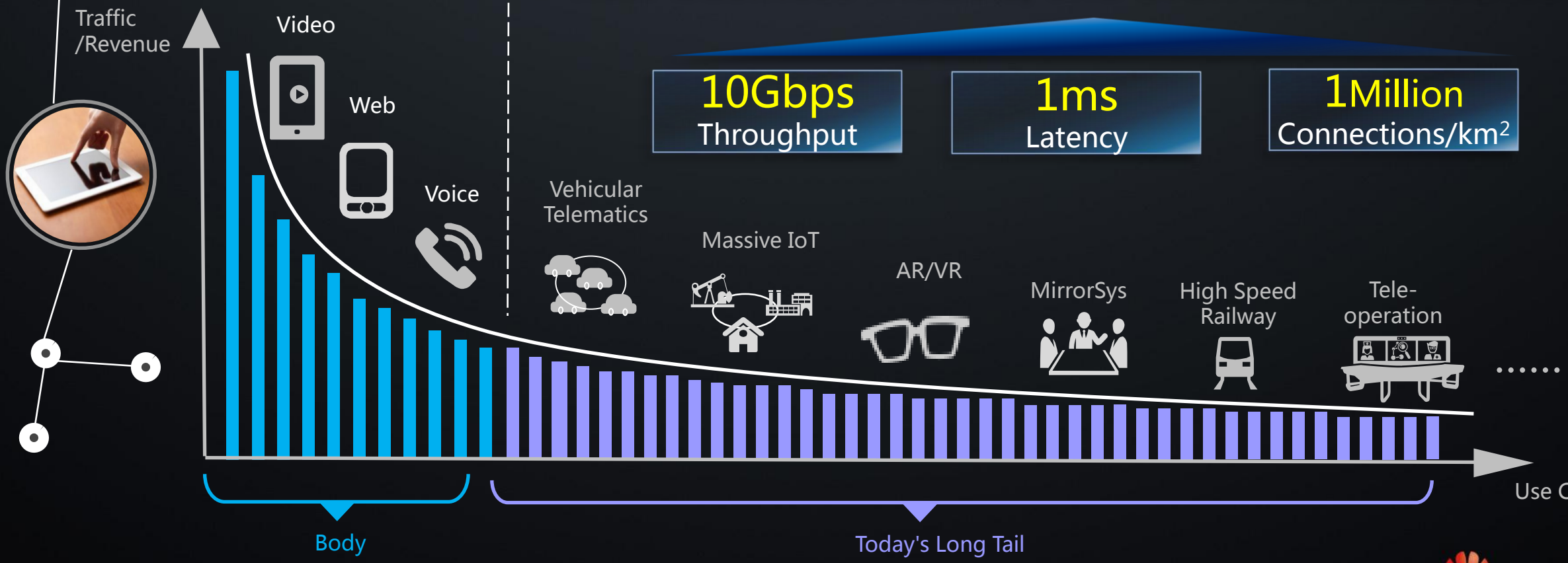
✓Flexible

✓Scalable

✓Efficient

Today's Long Tail, Tomorrow's New Field:
New Horizons

5G will enable **new applications**, **new business models**, and **even new industries**



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5G Will Carry Many Industries & Benefit Stakeholders

Enhance Mobile Internet

Empower Internet of Things

Consumers

- Ubiquitous consistent experience
- New services

Vertical Industries

- Easy access to the common infrastructure of 5G
- Real-time, on-demand service

Operators

- Easy deployment and maintenance
- Network flexibility for multiple industries

5G Design Principles

What to expect from 5G?

=

Service-oriented Flexible Configuration:

10Gbps

1ms

10^6 Links/km^2

99.999%

10 years

Challenge:
Low latency & High reliability

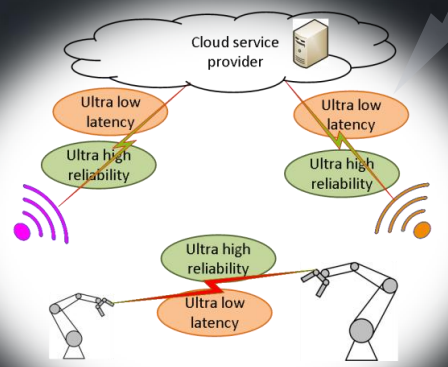
Challenge 2:
Low latency & Highly loaded cells

≠

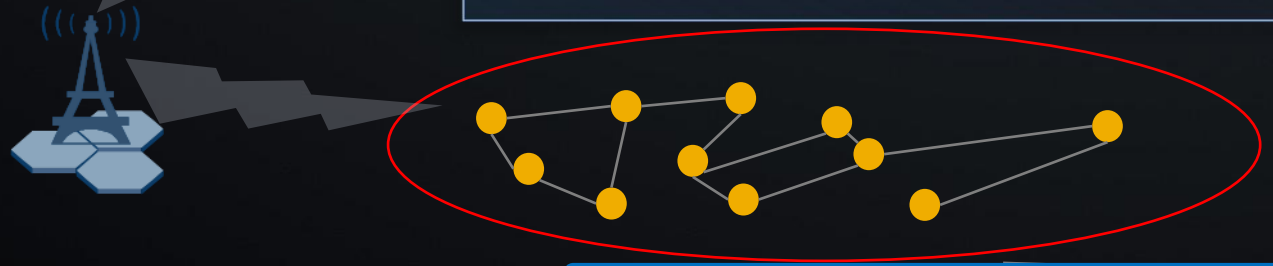
10Gbps + 1ms + 10^6 Links/km^2 + 99.999% + 10 years

5G Use Cases & Requirements

NGMN, METIS, 5G-PPP



- Broadband Access in dense areas (Pervasive video)
- Broadband access everywhere (50+ Mbps everywhere)
- Higher user mobility (High-speed Train)
- Massive Internet of Things (Sensor networks)
- Extreme real-time communications (Tactile internet)
- Lifeline communications (Natural disaster)
- Ultra-reliable communications (E-health services)
- Broadcast like services



Diverse set of requirements

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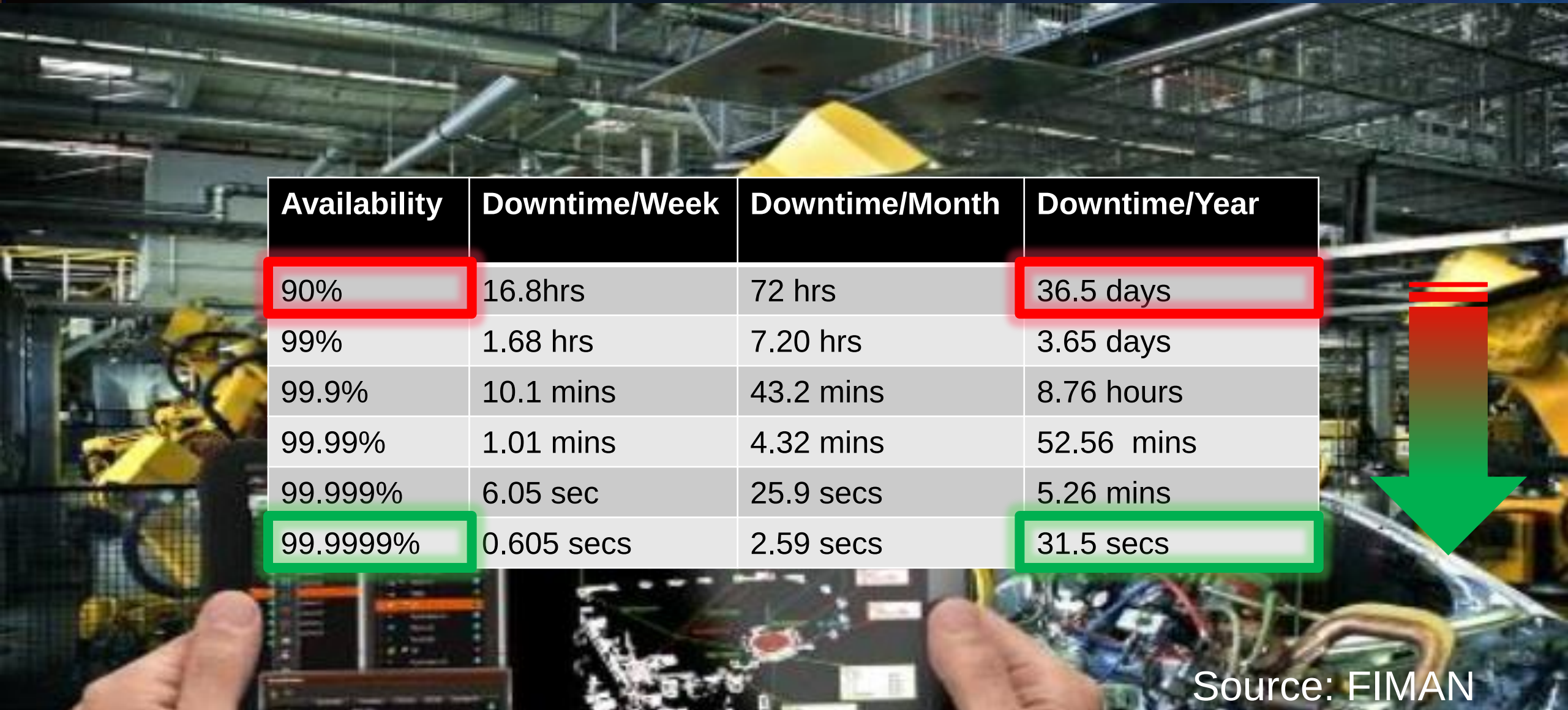
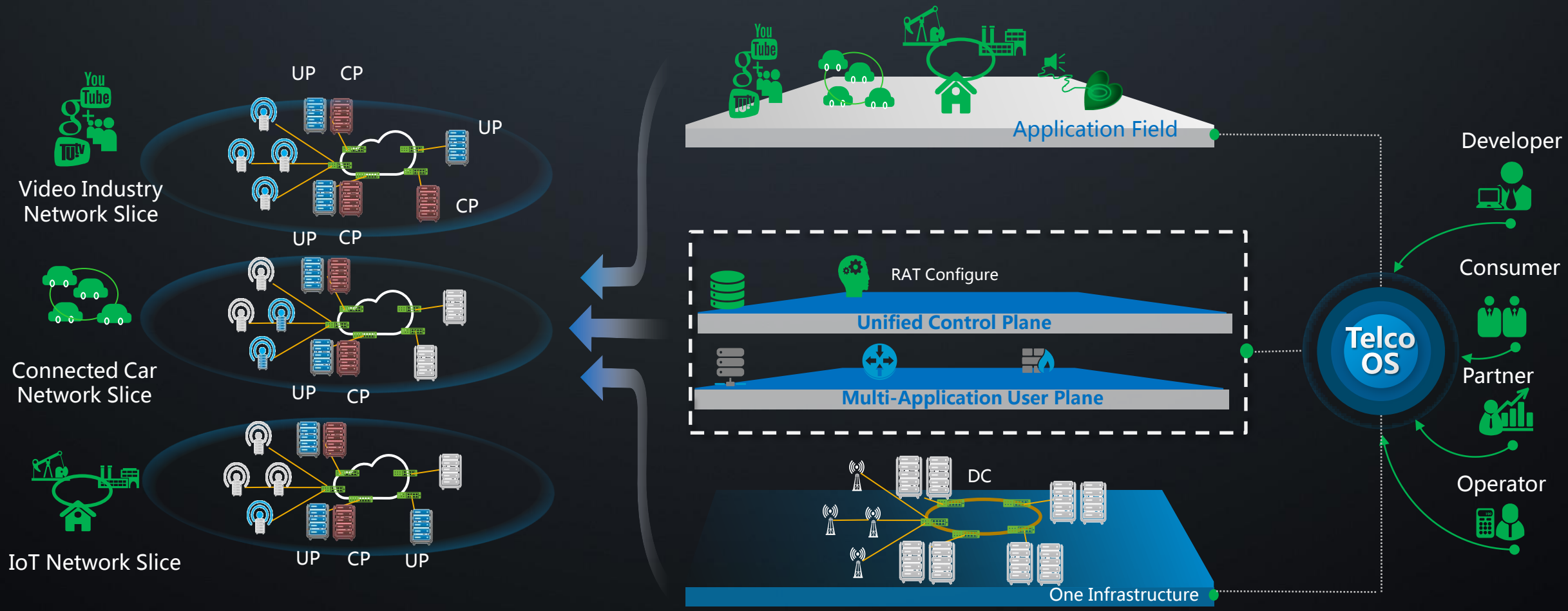
Example: Ultra-Availability for 5G



Availability	Downtime/Week	Downtime/Month	Downtime/Year
90%	16.8hrs	72 hrs	36.5 days
99%	1.68 hrs	7.20 hrs	3.65 days
99.9%	10.1 mins	43.2 mins	8.76 hours
99.99%	1.01 mins	4.32 mins	52.56 mins
99.999%	6.05 sec	25.9 secs	5.26 mins
99.9999%	0.605 secs	2.59 secs	31.5 secs

Source: FIMAN

A New Architecture & Operation



Industry defined network slicing

Service-oriented cloud-formation

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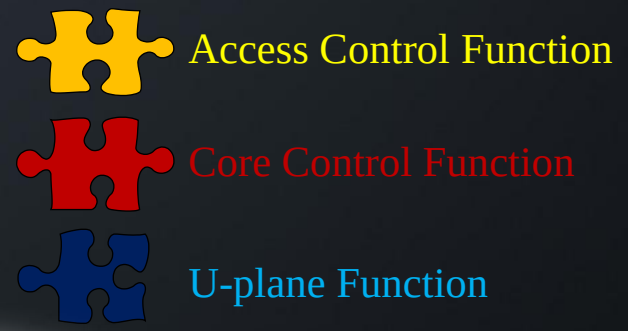
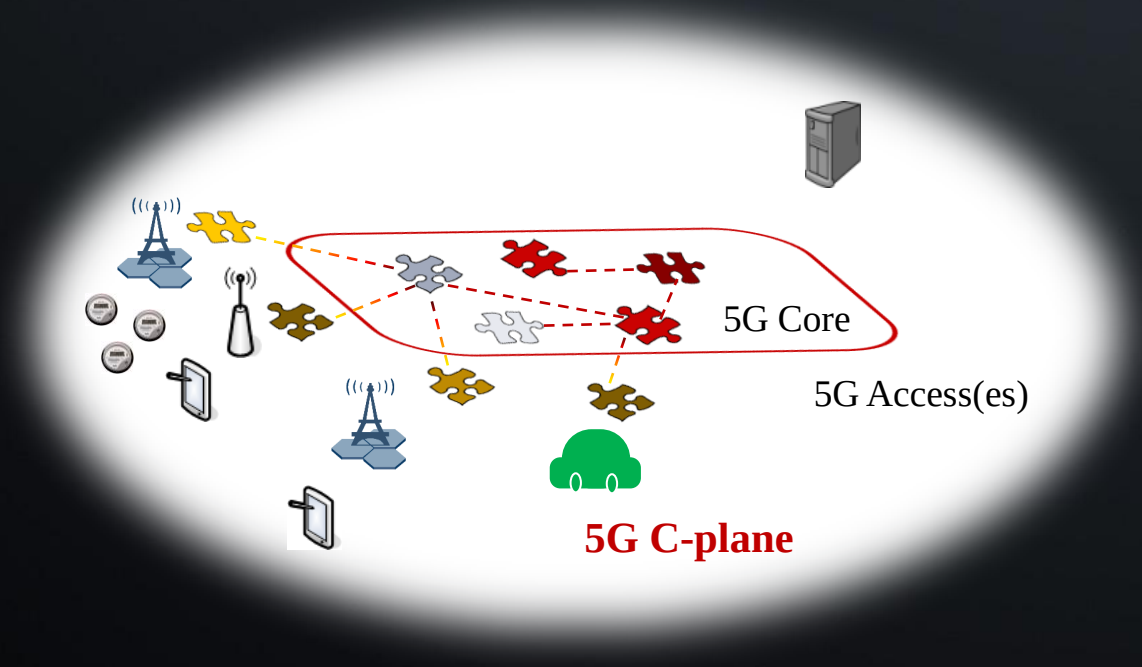
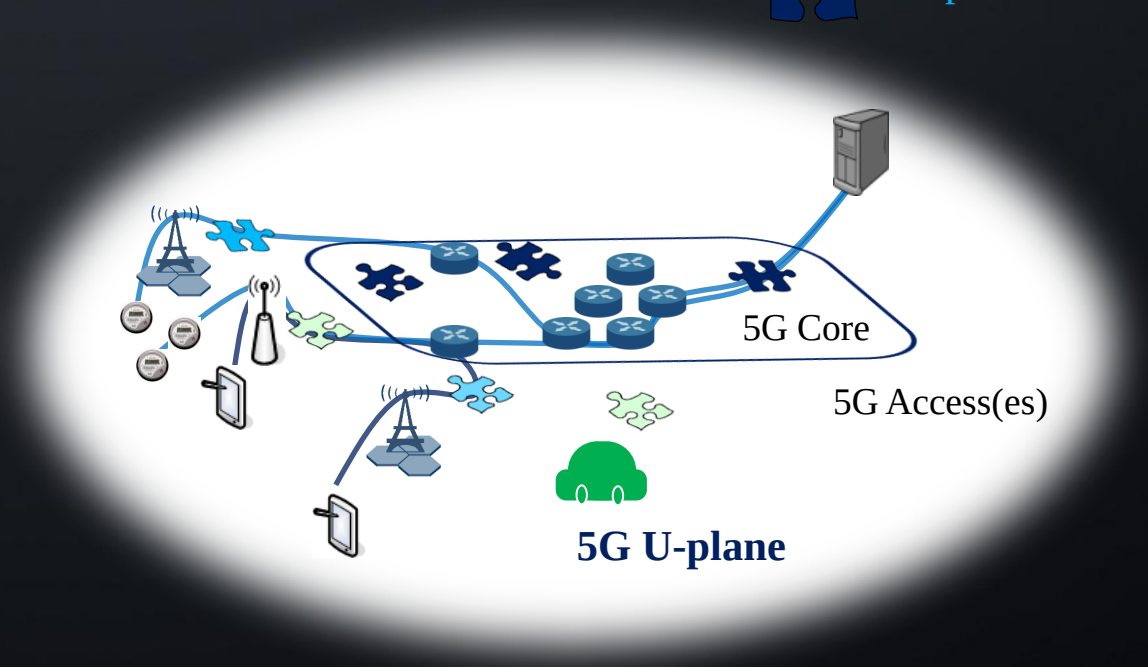
Tech Enabler: SDN/NFV Solutions

- 5G Services as a software on a programmable infrastructure
- Enabled by a set of technologies
  - ✓ Network Function Virtualization (NFV), Software Defined Networking (SDN)
  - ✓ Network Slicing







R. Trivisonno, et. al, Requirements and Design Principles for Next Generation Networks, HUAWEI ERC, IPWC 2015
"The Path to 5G: Continuing the pre-standard Debate" Bonn, June 15-17, 2015

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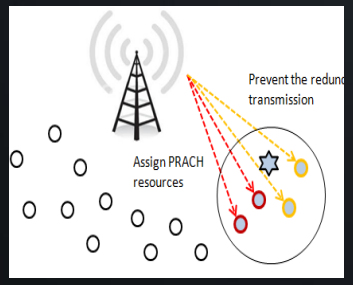
Tech Enabler: Service-oriented Radio

- Support for diverse service requirements
- Enables End-to-End Slicing of RAN

Service Requirements



MBB

MTC (ultra reliability)

MTC (large coverage)

V2V

MBB: Mobile Broadband

MTC: Machine-type Communications

V2V: Vehicle-to-Vehicle

Variable
Bandwidth
TTI time
Subcarrier Spacing
Waveform

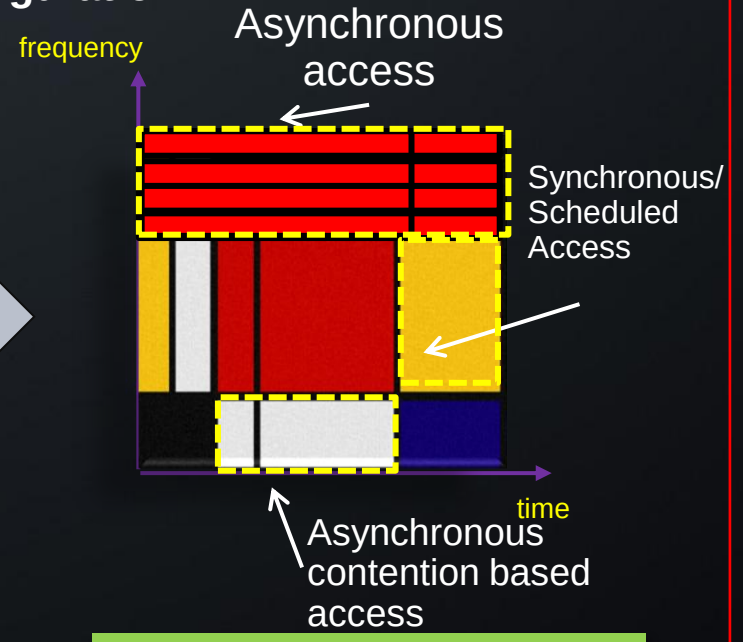
Dynamic Frame Structure

Periodic – non periodic
Scheduling

Flexible Resource Scheduling

TTI: Transmission Time Interval

Radio Configuration



Flexible Air Interface supports different radio configurations

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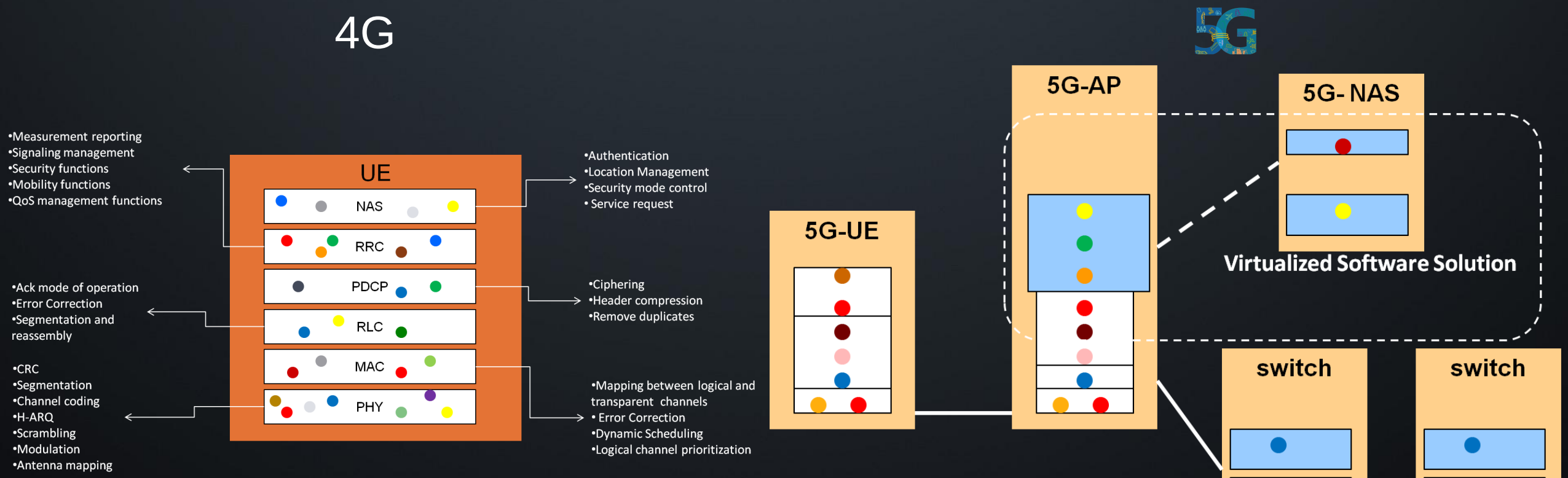
Service-oriented Flexible Configuration

4G

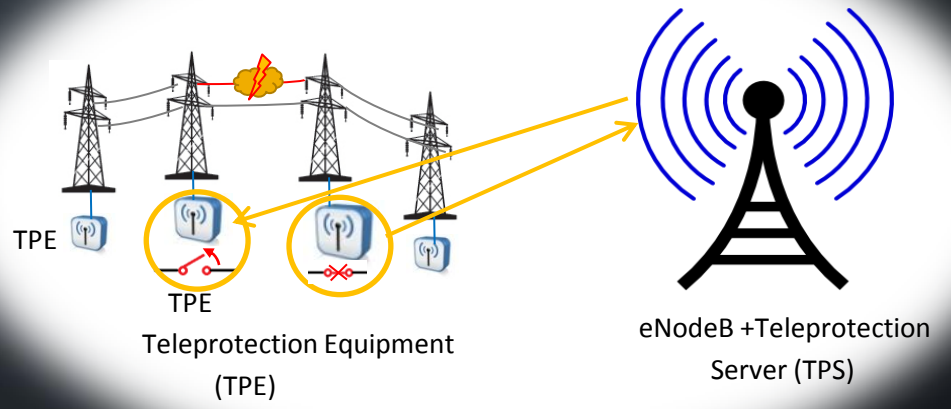


Main enablers

Service-oriented Air Interface	Fundamental functional elements tailor cut per use case	SDN/NFV

Example: Selecting only the needed "fundamental functionalities"

- **Use Case: Smart Grid**
- **Two types of traffic**
  - Periodic measurements / monitoring
  - Emergency event-triggered traffic (alarms, power outage)
- **What do we really need?**



We do not need indicatively the following functionality:

- Location updates
- Handover
- Header compression
- Fragmentation and reassembly
- Error correction

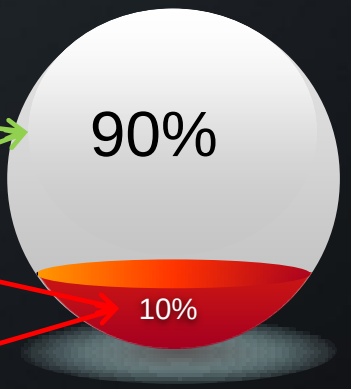
We may even want to modify/add:

- The logical/transport/physical channels
- Redefine the frame structure (priority to uplink)
- Provide scalable solutions for RACH
- Introduce new signaling states to meet delay/reliability requirements

Example: User-plane Simplification

- User-plane delay percentages
- Identifying Needed Existing Functions

	Function	Overall L2,L2+ contribution to delay
5G L2+	ROHC	20.01%
	De-ciphering	59.16%
	Header processing	7.83%
	Reassembly	8.60%
	Re-ordering	0.40%
	Header processing	1%
5G-PHY	De-mux	0.84%
	Header processing	2.16%

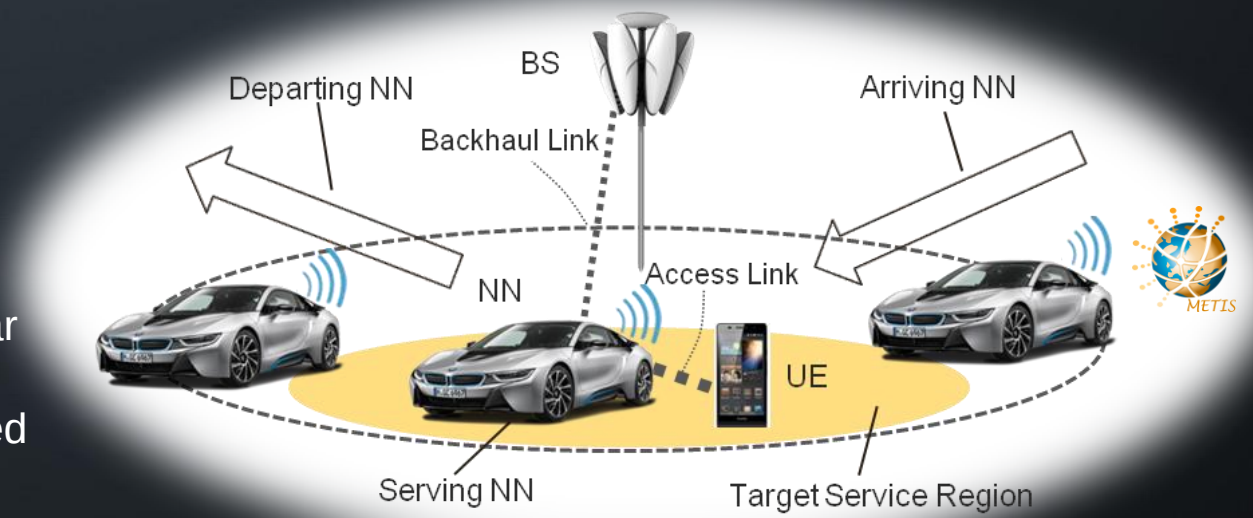


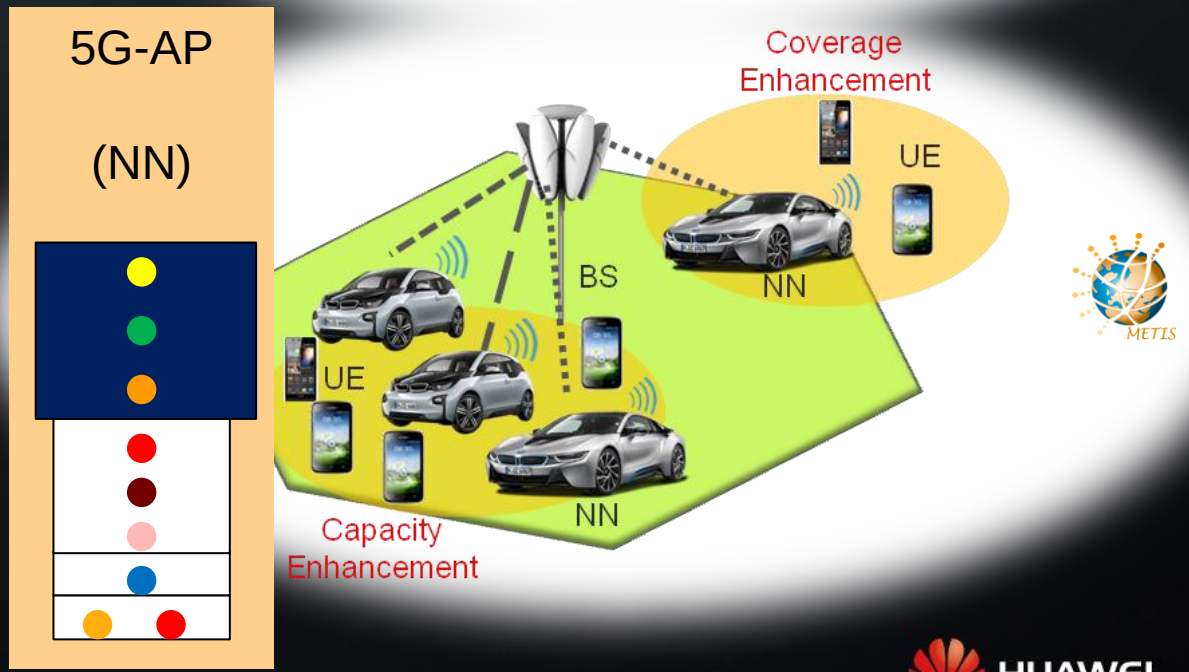
Source: David Szczesny et al., "Performance Analysis of LTE Protocol Processing on an ARM based Mobile Platform, SoC 2009

Example: Nomadic Node Integration

- Enabling Dynamic Network Topology
- Adding New Functions

- Nomadic Nodes (NNs) – Definition
  - Low power movable nodes (e.g., mounted on cars → Car Sharing Fleet)
  - Stationary or low-speed during the operation (e.g., parked cars)
  - Densely populated with inherent uncertainty w.r.t. their temporal and/or spatial availability (“movable” network)
  - Improved backhaul antennas (compared to mobile terminals)
- Key Advantages of Nomadic Nodes
  - Demand-driven coverage & Capacity improvement
  - OPEX-savings for Operator → No site leasing & No site search
  - Energy optimization & Load balancing





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Take Aways

- Sustainable 5G Networks with New Horizons
  - Future-proof
  - New Industries
  - New Business Models
  - Today´s Verticals → Tomorrow´s Integrals
- Introduce solutions tailor cut to specific use cases
  - Service-oriented Radio
  - Identify existing / add new “fundamental functions” per use case
  - Use SDN/NFV to simplify different deployments for different use cases
- Visit Meghalaya

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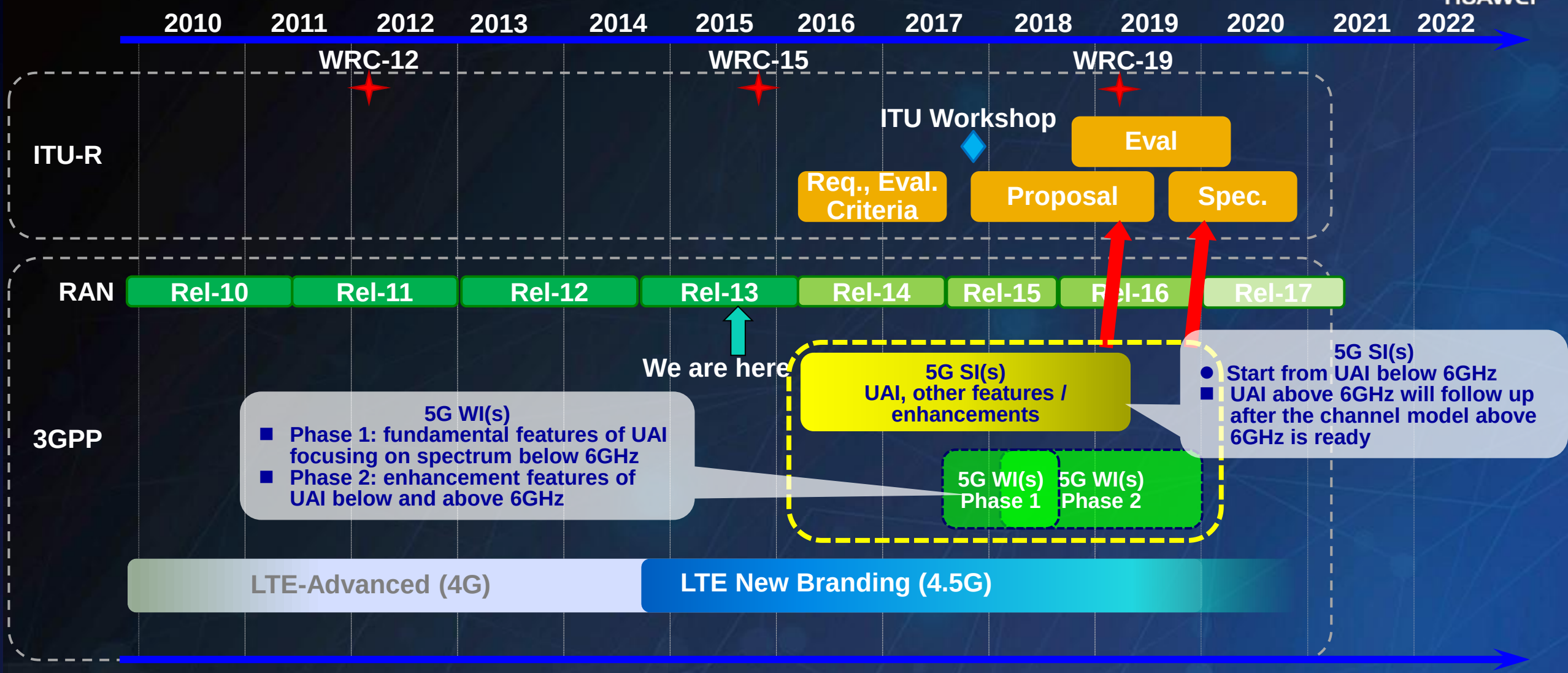
5G Timeline (Release 14 and onwards)



Notes:

* Proposal submission to ITU no later than June 2019
* Spec submission to ITU no later than February 2020

UAI: Unified Air Interface