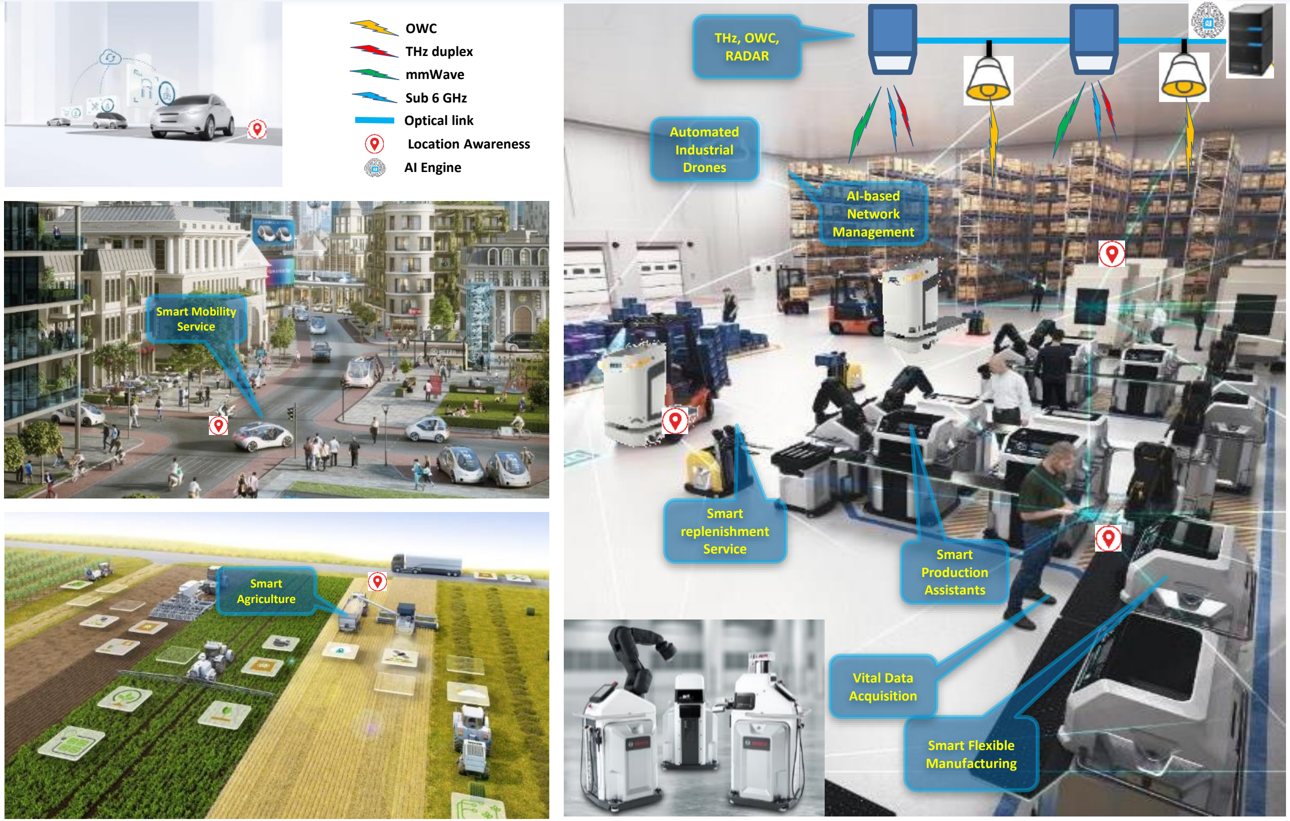
6G BRAINS(Bring Reinforcement-learning Into Radio Light Network for Massive Connections):

6G Measurable Proof of Concept Performance KPIs

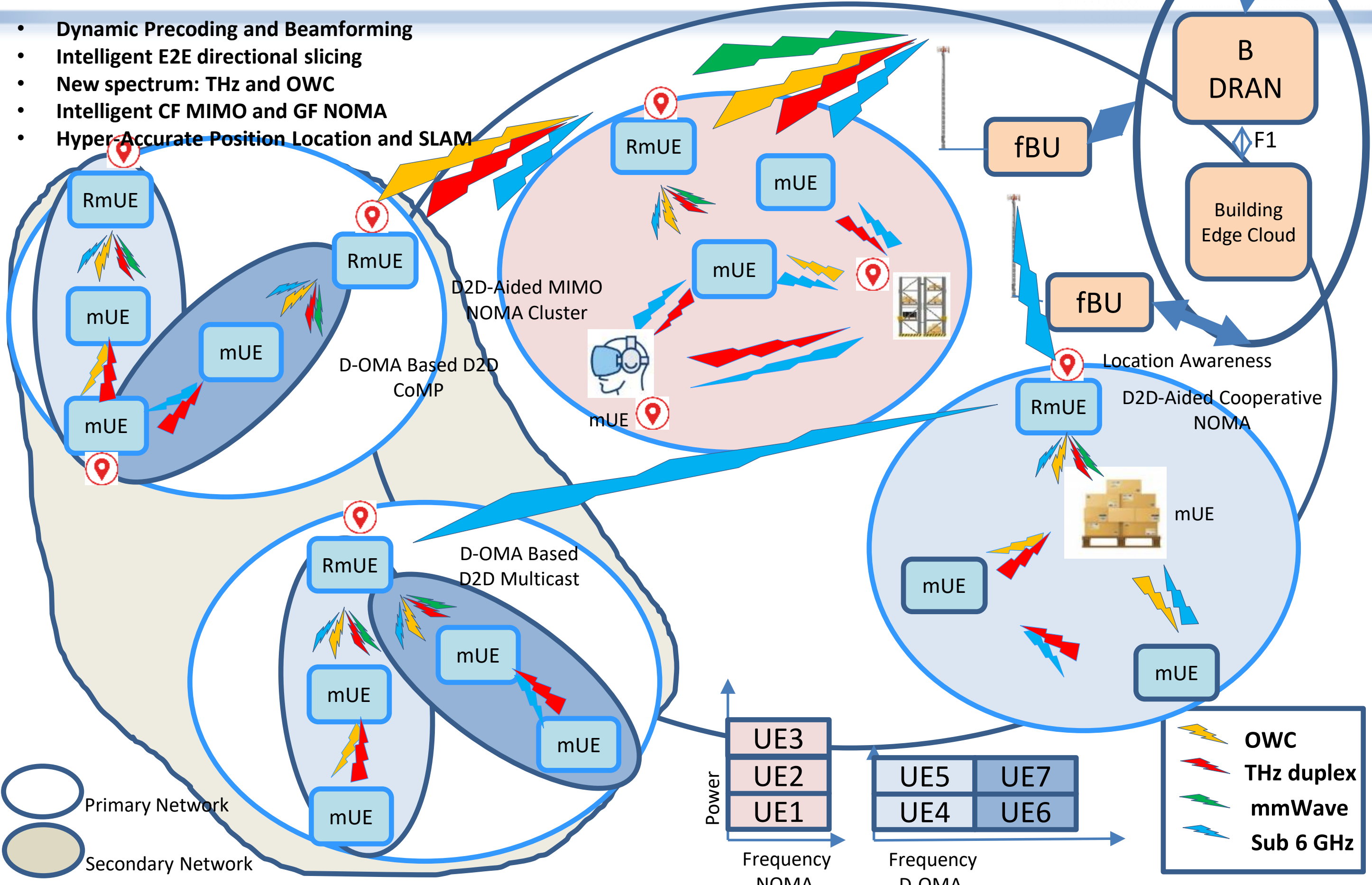
Dr. Wei Li Viavi Solutions

6G BRAINS: Vision



Challenge and Enabling Technologies

- **Dynamic Precoding and Beamforming**
- **Intelligent E2E directional slicing**
- **New spectrum: THz and OWC**
- **Intelligent CF MIMO and GF NOMA**
- **Hyper-Accurate Position Location and SLAM**



(KPI and measurement part)

- Primary test cases
  - Offloading of the PLC Control Function to the Edge
  - Advanced Network Slicing
  - Smart Transportation Vehicles: Localization and Video Processing Offloading

- Secondary test cases
  - Maintenance Video Guides in Factories and Warehouses
  - Animal Tracking in Indoor Farming Scenarios
  - Airports Service and Baggage Handling Robots

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	A	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE
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2		Month	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
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9	Task 2.1: Definition and Analysis o	BOSCH						D2.1																		D2.4				
10	Task 2.2: 6G-BRAINS Network Req	UWS								D2,2																				
11	Task 2.3: Multi-agent Deep Reinfor	THALES									D2.3																			
12	Task 2.4: Measurable Proof of Con	VIAVI								D2.2																				

(KPI and measurement part)

	Offloading of the PLC Control Function to the Edge	Smart Transportation Vehicles		Maintenance Video Guides	Advanced Network Slicing	Animal Tracking in Indoor Farming Scenarios	Airports Service and Baggage Handling Robots
		Localization	Video Processing Offloading				
Round trip time (sensor to controller to actuator)	< 10 ms (250 µs - 10 ms)	50 ms	50 ms	>50ms	5-15ms	>50 ms to seconds	10 ms
Reliability (packet error rate within latency reqs.)	10^{-8}	10^{-6}	10^{-4}	10^{-2}	10^{-6}	10^{-5}	10^{-6}
Data rate	kbit/s-Mbit/s	kbit/s-Mbit/s	Mbit/s-Gbit/s	kbit/s-Mbit/s	kbit/s-Mbit/s; 10+Gbps at backbone	kbit/s	Mbit/s-Gbit/s
Packet size	up to 1500 Byte	20-50 Byte	1500 Byte	<300 Byte	<300 Byte	<80 Byte	>200 Byte
Covered distance (from an access point)	within the facility	within the facility	within the facility	<200 m	within the facility	100 m-1 km	<100 m
Movement speed of the user	< 1 m/s	<10 m/s	<10 m/s	<40 m/s	< 10 m/s	< 10 m/s	< 3 m/s
Time critical handover support	Yes	Yes	Yes	No	Yes	No	No
User equipment density	0.33-3 per m^2	0.001 per m^2	0.001 per m^2	0.1 per m^2	0.3 per m^2	10000 per plant	0.03-0.02 per m^2
Energy efficiency (user equipment battery lifetime)	n/a	n/a	n/a	n/a	< 8h	1 years	1 day
Location detection accuracy	<50 cm	1 cm	n/a	<1 cm	<5 cm	from 1 mm to <10 cm	< 1 cm
Service availability	99.999 %	99.999 %	99.999 %	99.9 %	99.999 %	99.9 %	99.9 %
Slice configuration / reconfiguration time	1 s	1 s	1 s	1 s	1 s	1 s	1 s

(KPI and measurement part)

❑ For raw data streaming driven test cases

Partner	Innovation aspects of 6G BRAINS (expected to be present in one of the use cases)	Short description of the aspect incl. its expected value/quality (i.e. requirement)
ULEIC	Industry E2E Reliability (low package loss) over D2D	In industrial scenarios, closed-loop control applications will require E2E reliability of up to $1\text{-}10^7$to maintain close synchronization at E2E, per-link reliability of around $1\text{-}10^9$
	E2E Latency	Latencies as low as 1 ms, and user plane latency around 0.1 ms
	Area traffic capacity	>1 Gb/s/m^2
VIAVI	Peak UE data rate (L3)	>1 Gbps/UE
	UE latency	1 ms
	UE density	>10^4 per base station
UBrunel	Traffic Analyser and Scheduler	Time required to change slice capacity or update schedule = one subframe slot interval e.g. 1ms for SCS = 15kHz. Slice or schedule changes occur maximum three times a day (i.e. once every new shift) for Flexible Factory IoT use case scenario and maximum once a week for Highly Flexible and Customised Factory IoT use case scenario. Detect packet size, inter-packet arrival time and jitter statistics. Eight 9s reliability
	Heterogeneous traffic generator	Time required to change slice capacity or update schedule = 1 slot interval e.g.1ms for SCS = 15kHz. Traffic changes occur maximum three times a day (i.e. once every new shift) for Flexible Factory IoT use case scenario and maximum once a week for Highly Flexible and Customised Factory IoT use case scenario. Eight 9s reliability
	Localization Precision	1 cm accuracy every 0.5 seconds.
	Localization Precision	1.0 m accuracy every 60 seconds.
ISEP	Localization reliability, visible light and RF	PD angle error (+/-3°)
	Localization coverage	99%
REL	RAN (PHY) Latency	< slot interval (e.g., 1 msec) per hop
	RAN (PHY) reliability	< 10exp(-6)
	RAN capacity/ UE	> 1Gbps

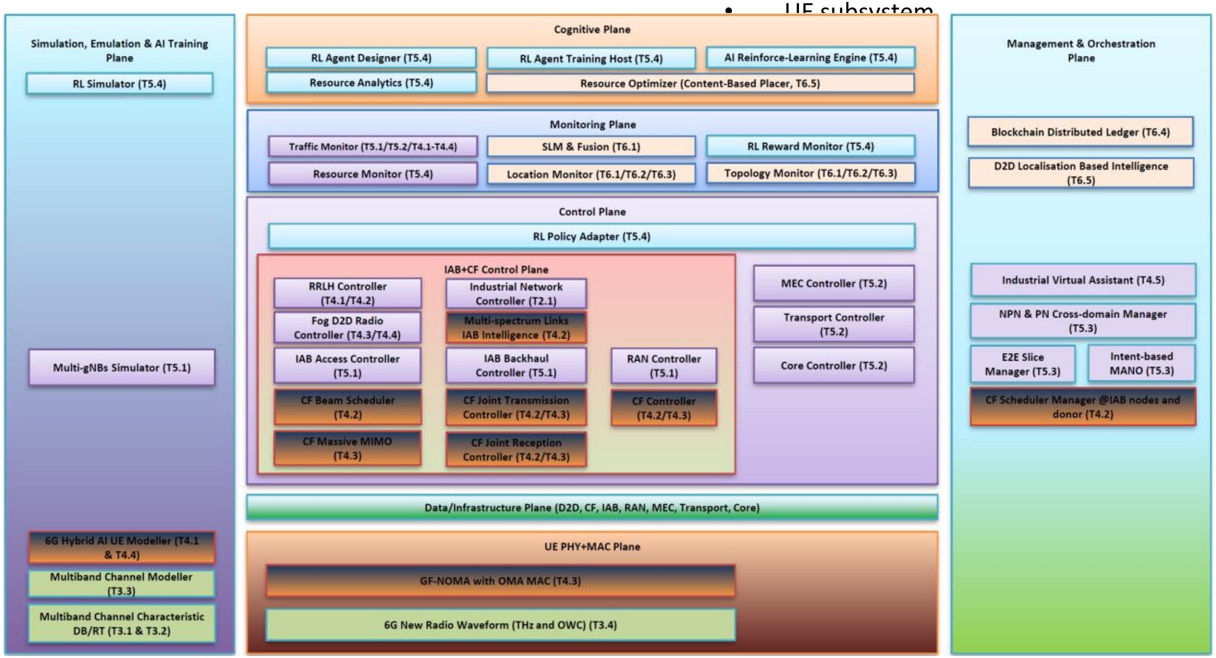
(KPI and measurement part)

❑ For raw data streaming driven test cases

Partner	Innovation aspects of 6G BRAINS (expected to be present in one of the use cases)	Short description of the aspect incl. its expected value/quality (i.e. requirement)
UWS	High-speed backbone network slicing capacity	10+ Gbps network slicing capacity at data plane switches
	Low delay to change/stop/start/create a backbone network slice	In the order of seconds in worst cases, and under 1 second in best cases
	High flexibility in backbone slice definition	Allowing flexible definition of network slices in terms of multi-tenancy, flows at various levels of granularity, industrial protocols, and so on.
ECOM	RAN network slicing capacity	RAN slicing with 2-4 ms latency and 200 Mbps DL and UL
	AI-based RAN slicing	Optimised radio resource allocation and scheduling for both inter-slice and intra-slice cases
	Directional RAN slicing	Coupled with beamforming informed by CSI
	RAN network slicing capacity	RAN slicing with 2-4 ms latency and 200 Mbps DL and UL
OLED	Light source & photoreceiver modulation bandwidth	The light source modulation bandwidth (BW) may limit the achievable data rate (e.g. white LED with 2 MHz BW = data rate < 50 Mbps). Infrared sources may be preferred (e.g. 200 MHz IR source with high SNR = 1Gbps+ data rate)
	Sigal to noise ratio of the received OWC signal	The data rate, bit error rate and coverage of any OWC system are closely related to the SNR of the received signal (uplink or downlink). An SNR target must thus be fixed depending on the QoS and service area needed for each use case.
BOSCH	Example: High data rate	Data rate up to 3 Gbps, pick data rate 5 Gbps
	Example: Self-optimized management of campus networks	Using feedback from and monitoring of UEs, network optimizes itself with the help AI
	Example: Low transmit jitter	To support deterministic communication, data transfer system identifies deterministic flows and guarantees low jitter in the range from 100 till 200 ns
FhG	Multi-band measurements in large scenarios	Integration of multi-band channel sounders in sub-6 Ghz, mm-waves, sub-THz, and VLC to analyze propagation in the different frequencies
	Multi-band propagation parameters	Influence of frequency and system aspects (antenna's directivity) on coverage, DS, and Ass

System overall logical architecture

- UE subsystem



User cases

Primary user cases:

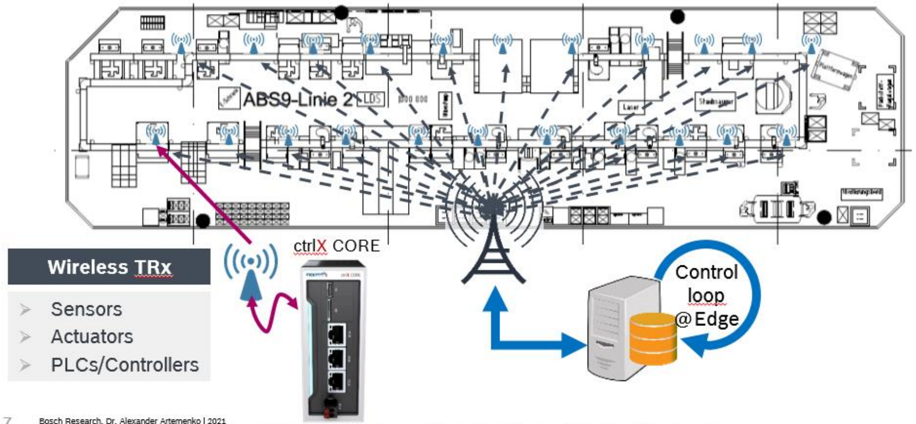
- Offloading of the PLC Control Function to the Edge
- Smart Transportation Vehicles: Localization and Video Processing Offloading
- Advanced Network Slicing

Secondary user cases:

- Maintenance Video Guides in Factories and Warehouses
- Animal Tracking in Indoor Farming Scenarios
- Airports Service and Baggage Handling Robots

Primary user case
-- Offloading of the PLC Control Function to the Edge

- Control from the Edge: Offloading the controller application of all machines in the production line to an edge device



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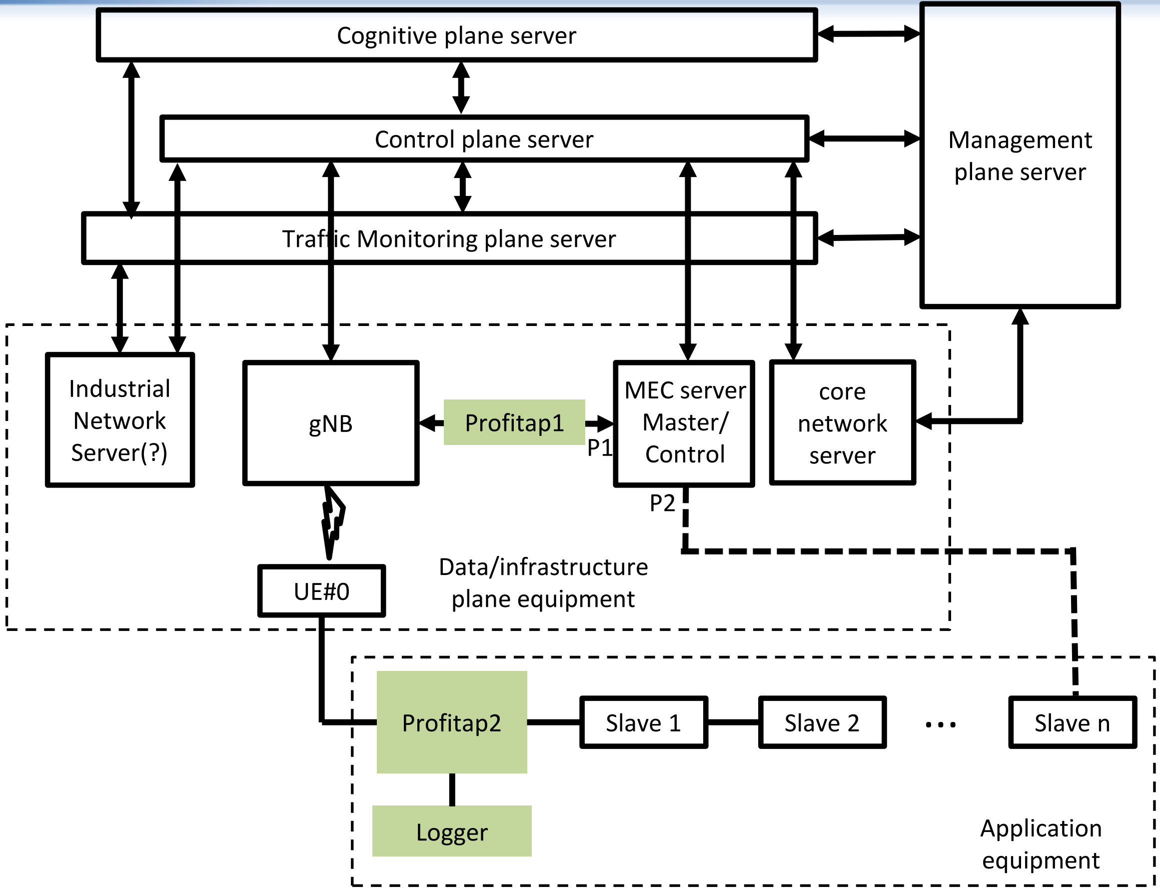
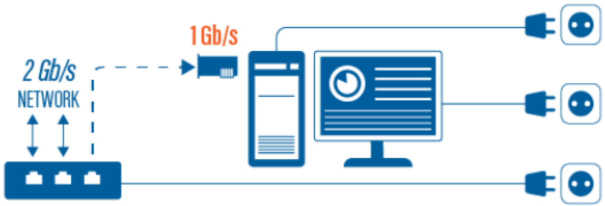
Primary user case

-- Offloading of the PLC Control Function to the Edge



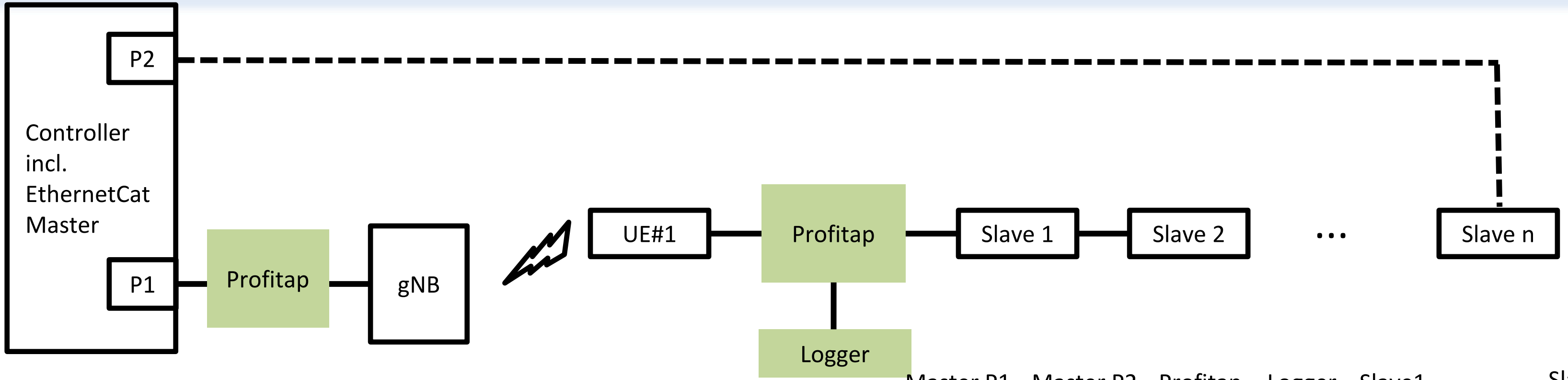
Profitap:

- High precision network packet capture device (8 ns)
- With dedicated hardware to monitor data packet



Primary user case(Phase 2)

-- Offloading of the PLC Control Function to the Edge

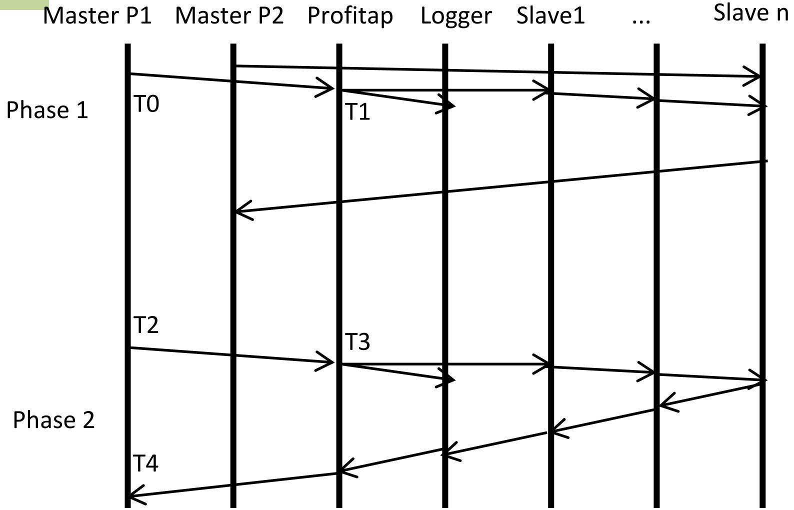


Main Tools:

- Profitap, Profitshark
- Time measurement tool, such as counters

Measurement precondition:

- Measurement environment: Normal wireless environment with reasonable interference from WiFi, Bluetooth, microwave band devices etc. Emulated metallic equipment.
- All the Profitshark equipment is synchronized to the same clock source.
- Number of slave devices is less than 500, such that RTT < 1ms (assume cycle time < 1ms)
- Better to have ability to emulate mobillity , LoS for reliability test

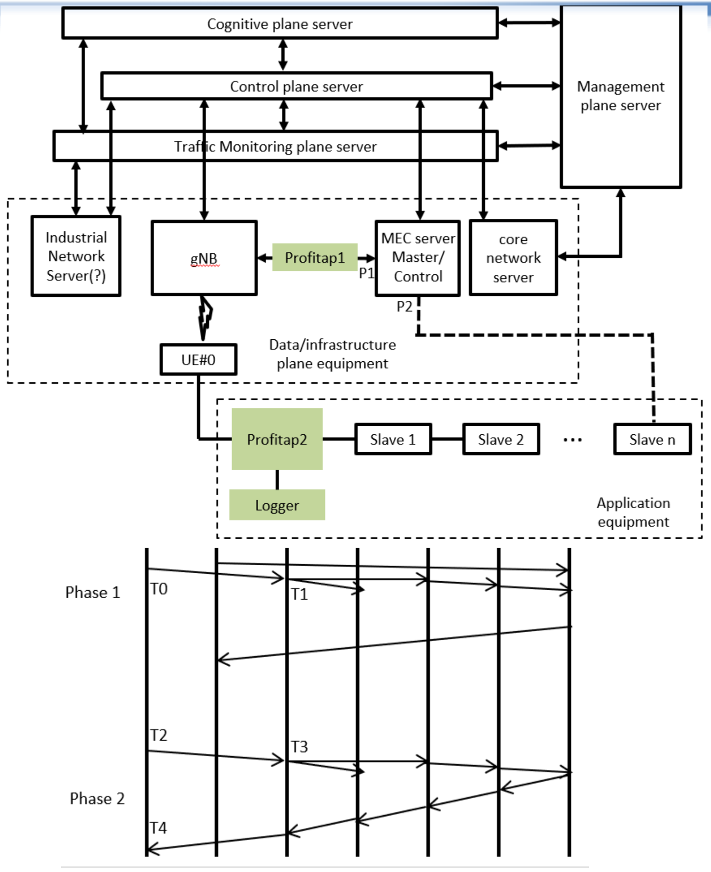


Primary user case(Phase 2)

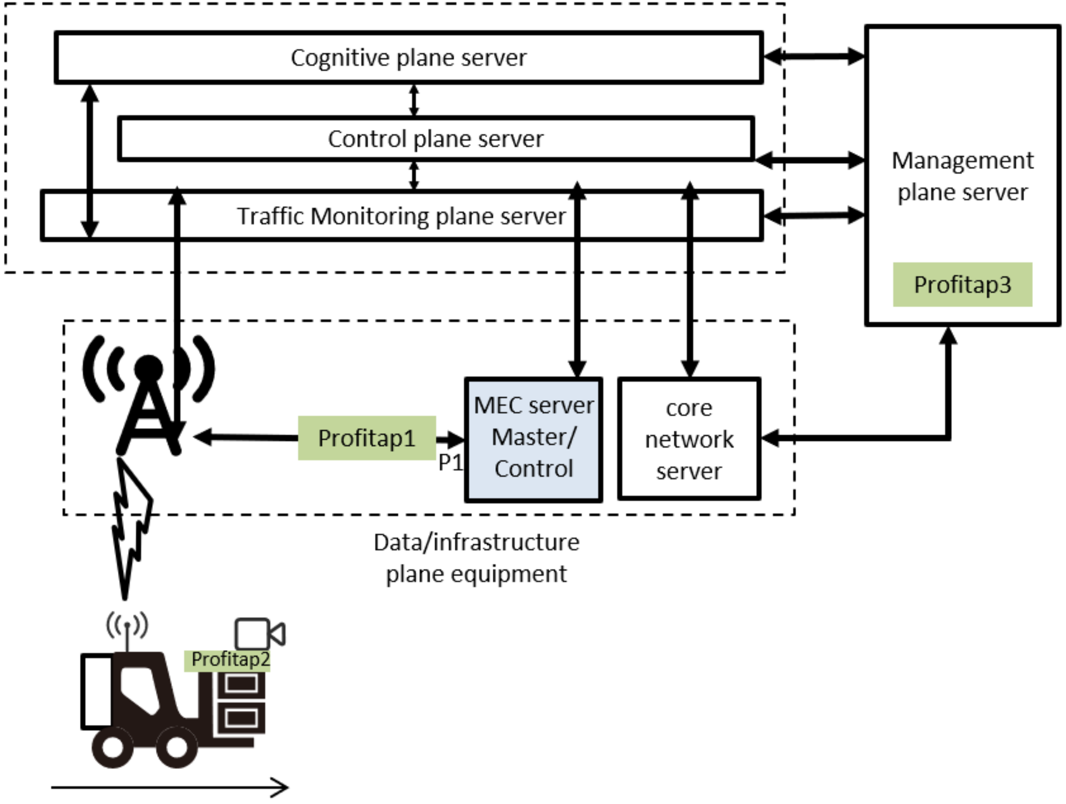
-- Offloading of the PLC Control Function to the Edge

Measurement steps:

1. Configure network slice for measurement from management server. e.g. bandwidth, QoS
2. Start slice creation procedure.
3. Configure Profitap1 and Profitap 2 into capture/monitoring mode
4. UE attach to the network
5. Send command from MEC to UE and forward data packet to slaves. Meanwhile, slaves generate feedback data packet to UE, then send back to MEC server.
6. Profitap1 and Profitap2 measure the timing, jitter, traffic data rate, analyze packet error rate.



Primary user case
-- Smart Transportation Vehicles: Localization and Video Processing Offloading

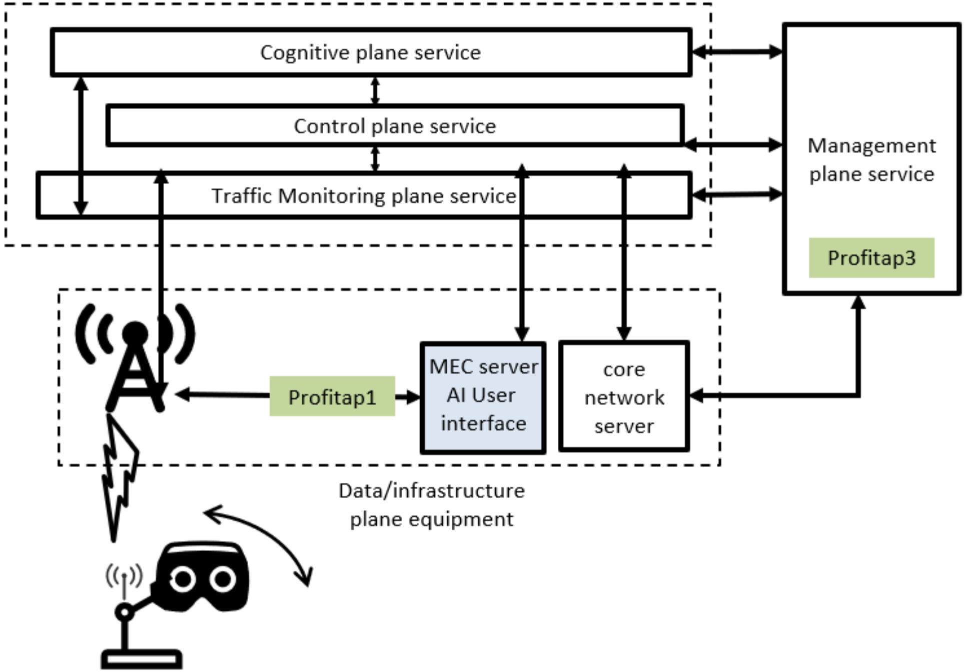


- Receive a request for a transport job
- A fleet planning agent assigns a new job to an available AGV and informs the communication and compute system about new participant along with requirements for communication and localization functions.
- The network optimization and QoS provisioning agent assigns/modifies a corresponding network slice to provide the required QoS for time of the operation.

Challenge

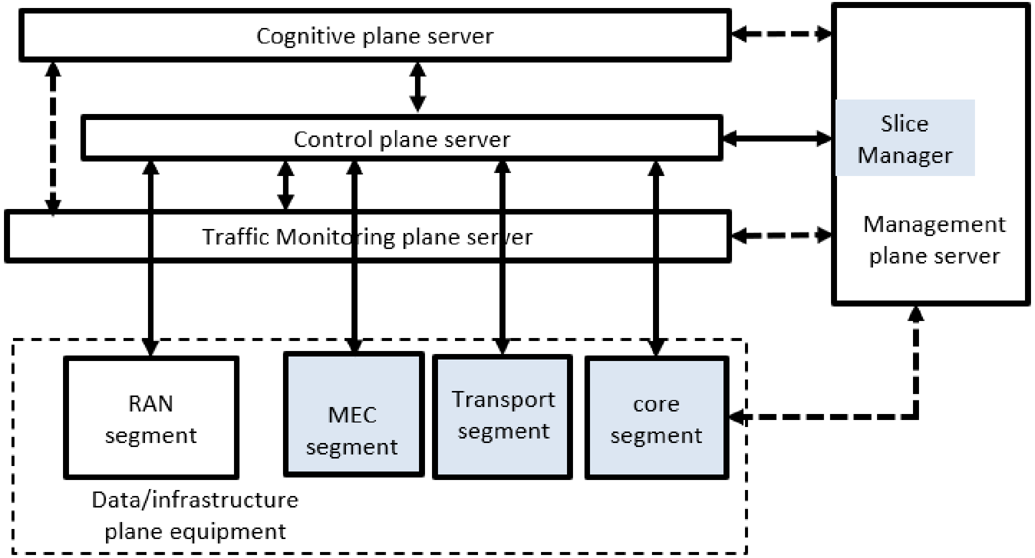
- Latency & Jitter
- Localization

Secondary user case
-- Maintenance Video Guides in Factories and Warehouses



- Initiate AR maintenance session by accessing app, specify type of equipment and fault symptoms to view and access from database, view video of equipment with pausing and/or rewinding if required using voice commands.
- Initiate AR maintenance session by accessing app, specify type of infrastructure and fault symptoms to view and access from database, view graphics of infrastructure correctly overlaid onto screen and use voice commands to change types of infrastructure.
- During maintenance session, enable access to an interface with virtualized software regarding maintenance systems, equipment control software or other relevant software systems.
- Upload record of maintenance procedure videos on database and voice key words for hash searches.
- Update any modifications/enhancements to gas, water, electricity, pneumatics infrastructure after completion of a maintenance job on graphics of infrastructure.

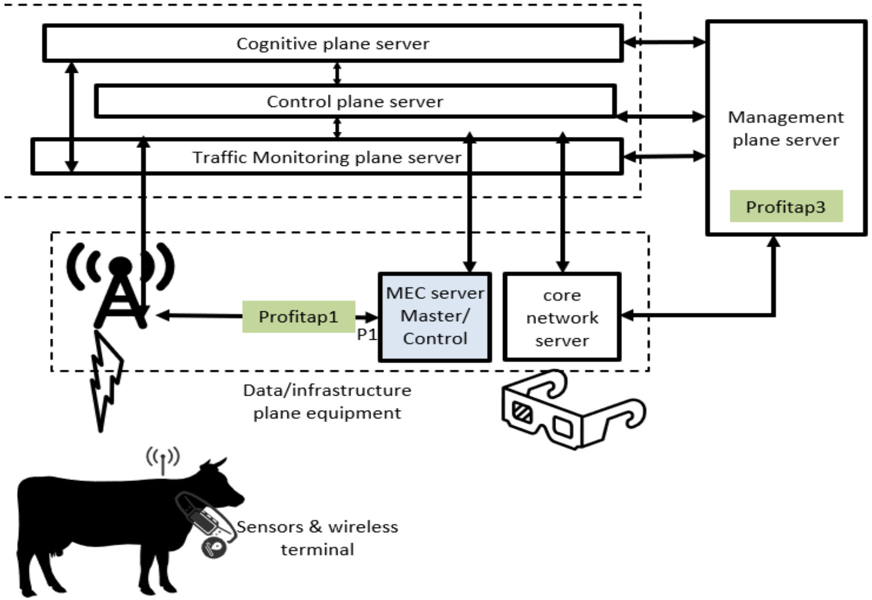
Secondary user case
-- Advanced Network Slicing



1. First trigger: Network slice service subscription by a vertical user through the voice-controlled user interface.
2. Network slice definition and creation/instantiation through intent-based management and control.
3. Network slice instances are up and running end to end.
4. Trigger: intra-slicing issue.
5. Response: intra-slicing AI control loop solution.
6. Trigger: inter-slicing issue.
7. Response: inter-slicing AI control loop solution.
8. Trigger: UE out of range.
9. Response: directional RAN slicing solution.
10. Trigger: backbone slicing issue.
11. Response: hybrid backbone slicing solution.

Secondary user case

-- Animal Tracking in Indoor Farming Scenarios



1) Start a network slice for animal tracking service.

2) UE attaches to the network.

3) Sensors collect animal information and send back the information to the network side. And optionally camera send back live dynamics video of the herd.

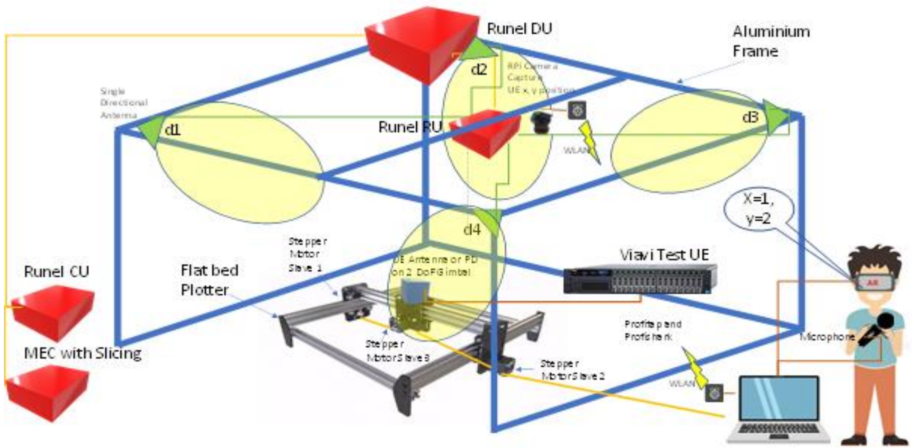
4) Network side construct AR video for each animal using received animal information and video

5) Farmers could inspect each animal via AR video.

6) Animal monitoring system notifying farmer of likely distress state of animal and identification of the distressed animal so that the farmer can find it with the help of augmented reality glasses.

7) Upload record of animal health on regulatory body database and voice key words for hash searches

Secondary user case
-- Airports Service and Baggage Handling Robots



1) Set up network to measure distance from UE to one RU and measure accuracy mean and variability.

2) Set up network to measure distance from UE to four RUs successively and measure accuracy mean and variability.

3) Send distance measurements to location database and server of Monitoring Plane Server, and calculate mean and variance position accuracy.

4) Use data from location server on Monitoring Plane Server to generate topology

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- This presentation reflects the author's view, only, and the Commission is not responsible for any use that may be made of the information provided.

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WEI.LI@VIAVISOLUTIONS.COM AND ALL@5G-PPP.EU
HTTPS://6G-BRAINS.EU/

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