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Enabling an Intelligent Planet

Tech Talks: Evolving Wireless Connectivity in the Age of IoT & 5G

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1G	Mobile Telephony
2G	Mobile Telephony
3G	Mobile Data
4G	Mobile Broadband
5G	*Mobile Everything*

Analog ⟶ Digital

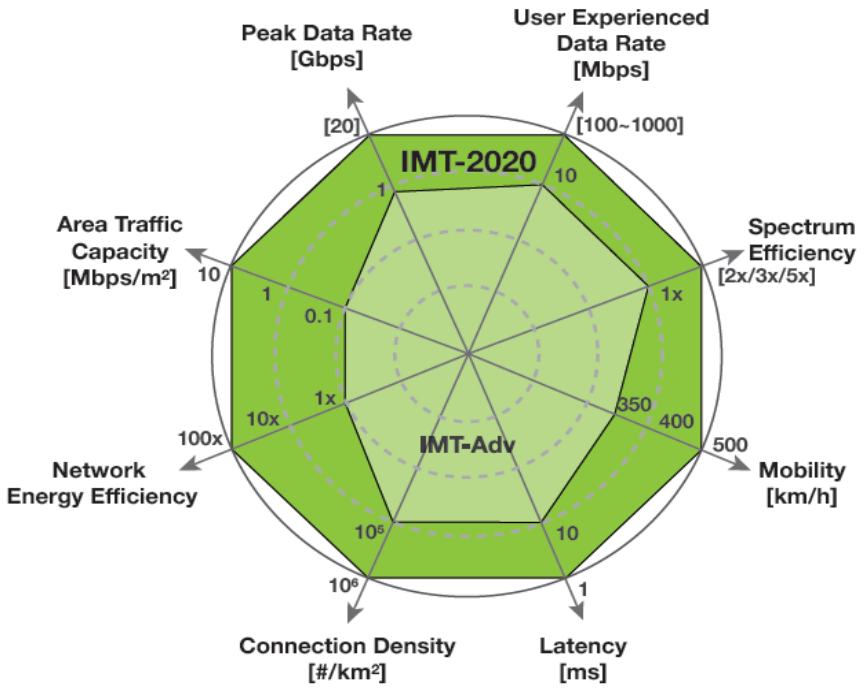
kbps ⟶ Mbps

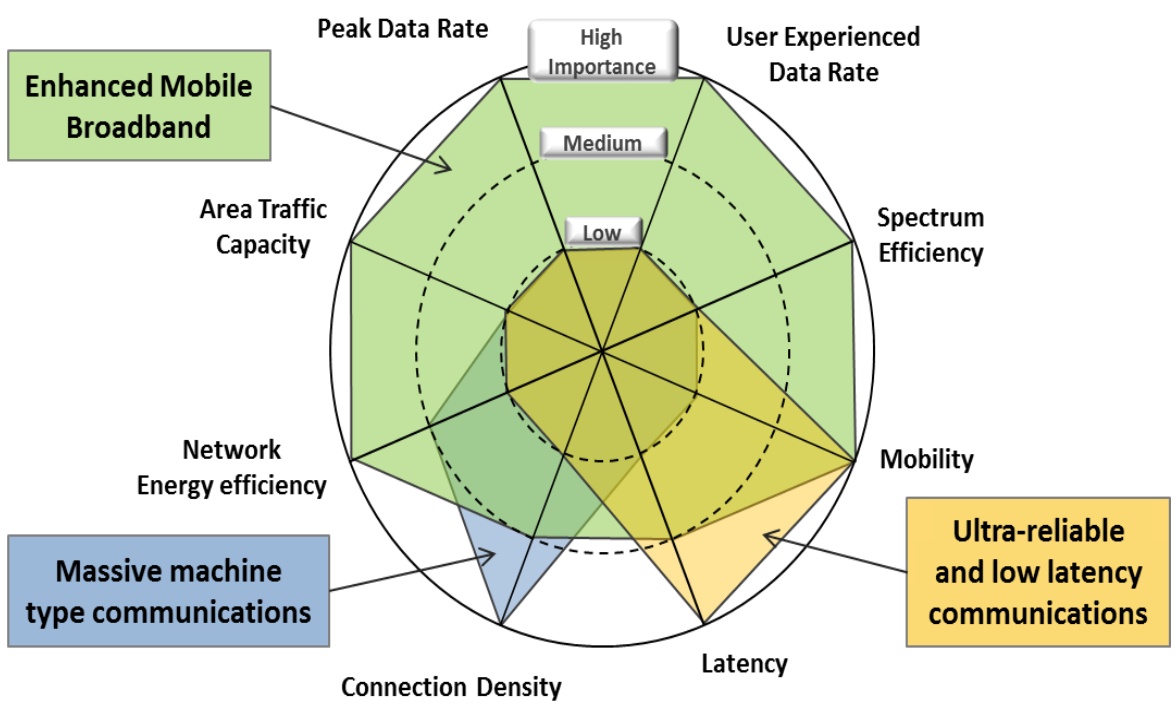
Mbps ⟶ Gbps

Data Differentiation

Vision on 5G
– A Brand New World with Various Terminals

Diverse 5G Requirements





Three different usage scenarios
→ very different modem requirements

1. Enhanced Mobile Broadband, eMBB: (e.g. smart phone)
2. Massive Machine Type Communications, mMTC: (e.g. sensors)
3. Ultra-Reliable and Low Latency Communications, URLLC: (e.g. for car)

Source: ITU-R WP5D/TEMP/548-E: IMT Vision – "Framework and overall objectives of the future development of IMT for 2020 and beyond," Feb. 2015.

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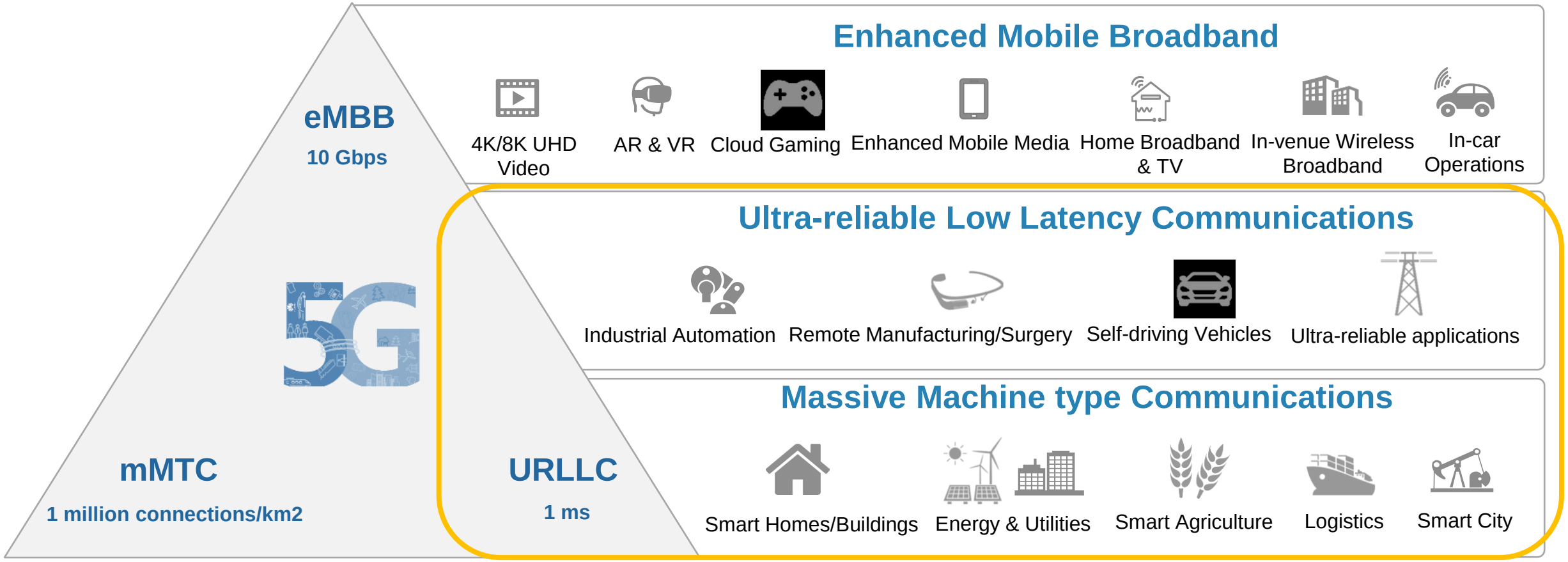
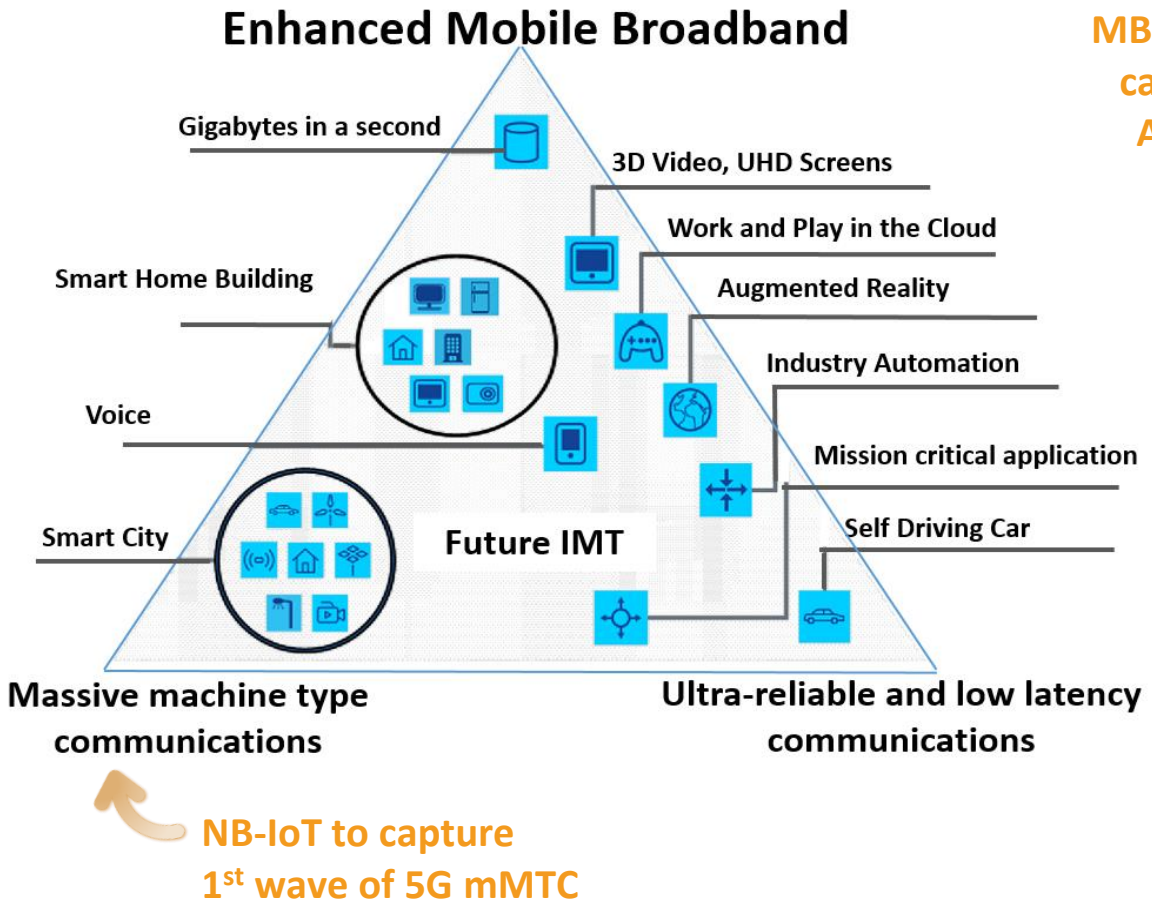
Key Usage Scenarios for 5G



Source: Recommendation ITU-R M.2083

5G @ 2020: Primary Focus on eMBB



NB-IoT to capture 1st wave of 5G mMTC

Evolution from existing 4G MBB business with more use cases (e.g. telemetric, VR, AR, home broadband…)

New business cases especially in IoT area (e.g. Industrial Automation, Mission critical, …)

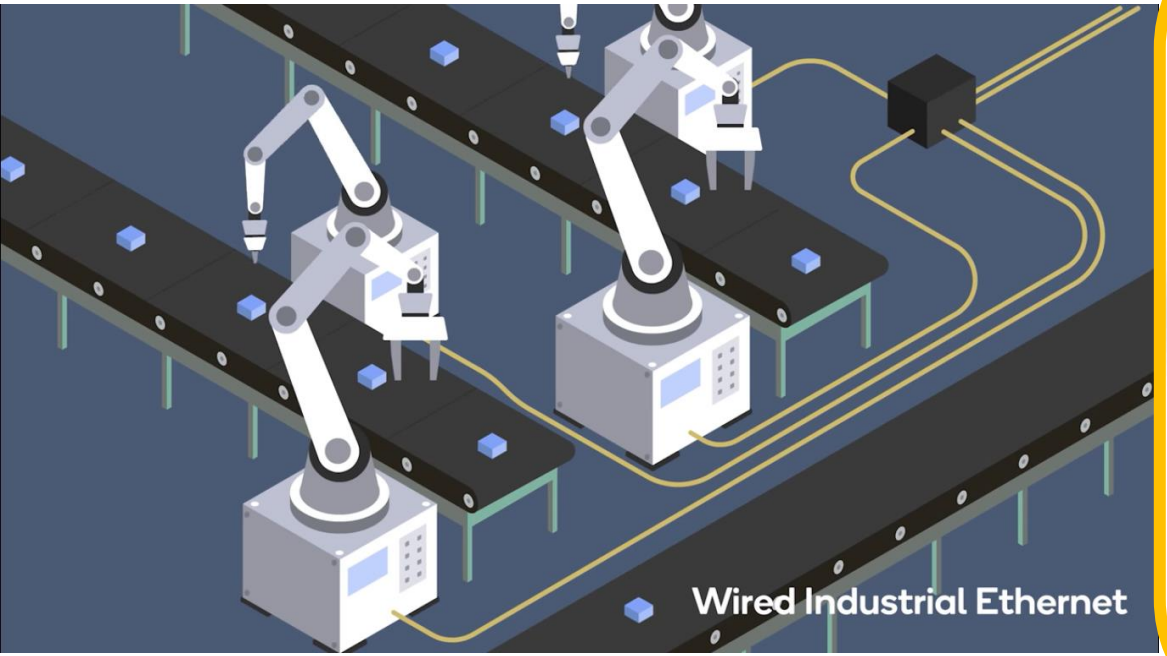
1st wave 5G = eMBB + partial URLLC capability

First generation 5G device optimized for eMBB, with lower latency capability

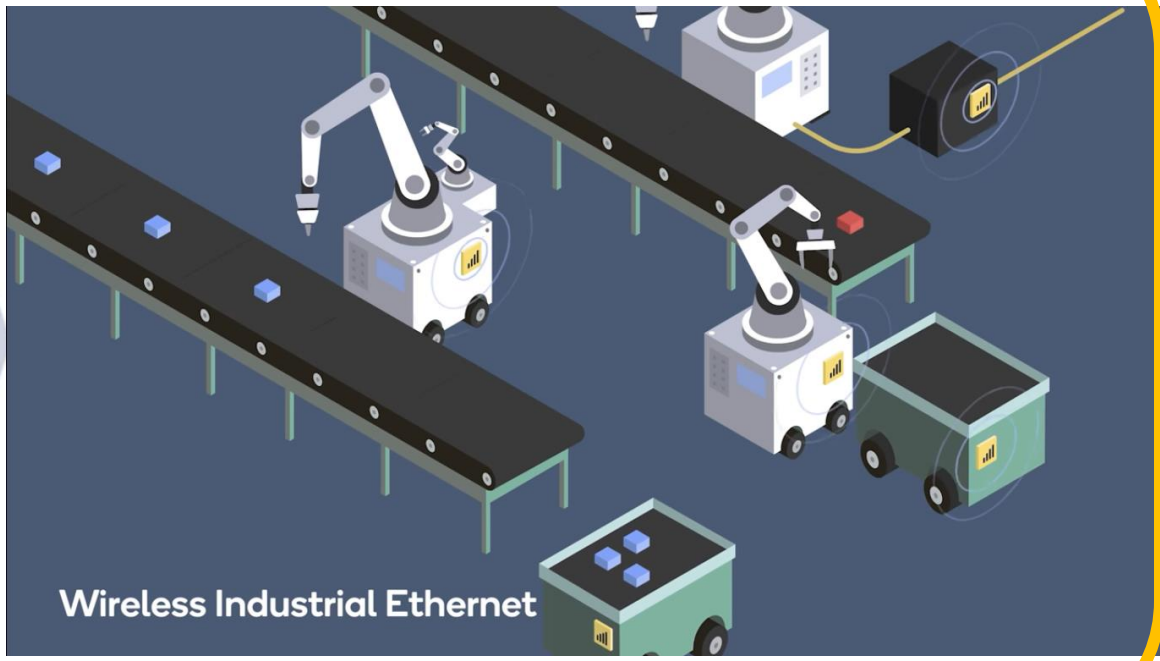
3GPP URLLC QoS and Use-Cases

	Use case	Reliability	Latency	Data packet size and traffic model	Description
3GPP Rel-15	**generic**	99.999 (BLER 10^{-5})	**1 ms**	32 bytes	
	Factory automation	99.9999 (BLER 10^{-6})	**1 ms**	32 bytes Periodic and deterministic, arrival interval 2 ms	Motion control
3GPP Rel-16	**Power distribution**	99.9999 (BLER 10^{-6})	**2-3 ms**	100 bytes FTP model 3, arrival interval **100 ms**	Power distribution grid fault and outage management
		99.999 (BLER 10^{-5})	**6-7 ms**	250 bytes Periodic and deterministic, arrival interval 0.833 ms	Differential protection
	Transport Industry	99.999 (BLER 10^{-5})	**3 ms**	UL: 2.5 Mpbs; Packet size 5220 bytes DL: 1Mbps; Packet size 2083 bytes	Remote driving
		99.999 (BLER 10^{-5})	**7 ms**	1.1 Mbps; Packet size 1370 bytes Arrival rate 100 packets/sec for periodic traffic	Intelligent transport system (ITS)

5G Wireless Connection for Industrial IoT



5G



PROFINET EtherNet/IP EtherCAT CANopen Modbus

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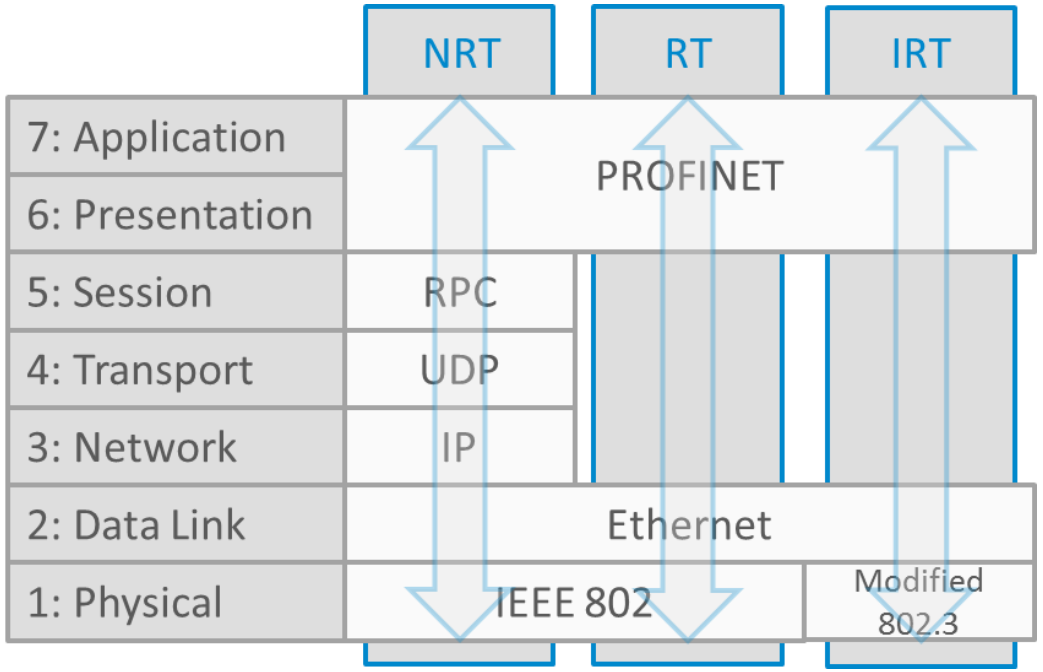
Protocol in Current Industry (Profinet)

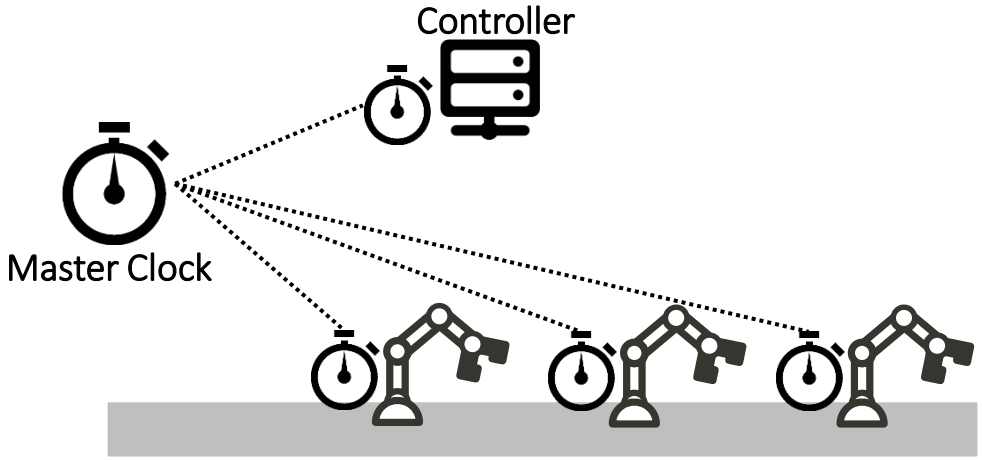
- Requirements of Profinet
  - Non-Real Time (NRT)
    - Using all OSI layers
    - Accessible from Internet via IP address
  - Real Time (RT)
    - Using modified frame structure to achieve low latency and low jitter
  - Isochronous Real Time (IRT)
    - Determinism and Time Synchronization
    - Transmission/reception behavior from CSMA/CD to Deterministic TDMA
- 5G network has supported Ethernet PDU session



Requirements for Time Synchronization

	Latency	Jitter	Minimun Cyclic Time	Time Sync.
NRT	100 ms			
RT	10 ms		1 ms	IEEE 1588 (optional)
IRT	1 ms	<1 µs	31.25 µs	IEEE 1588

Requirements for Profinet NRT/RT/IRT



5QI Value	Resource Type	Default Priority Level	Packet Delay Budget	Packet Error Rate
82	Delay Critical GBR	19	10 ms	10^{-4}
83		22	10 ms	10^{-4}
84		24	30 ms	10^{-5}
85		21	5 ms	10^{-5}

Standard 5QI values for URLLC (3GPP TS 23.501)

Analysis of IIoT Protocols

	Low Latency	Robust (Reliability) (99.9999%)	Time Sync	Mobility	Wireless Support	
PROFINET	X	X (Wireline and PI PROFINET mechanism)	X (IEEE 1588v2 and PI PROFINET Mechanism)		X (Only for NRT)	
IEEE TSN	X	X (Wireline and IEEE 802.1CB)	X (IEEE 802.1AS and IEEE 802.Qbv)			
3GPP Rel-15	(~ 1ms)			X	X	NRT/RT (w/o time sync)
3GPP Rel-16 (TSN support)	X	X	X (DL time sync)	X	X	NRT/RT
3GPP Rel-17 (further enhancement)	X	X	X (DL/UL time sync)	X	X	NRT/RT/IRT

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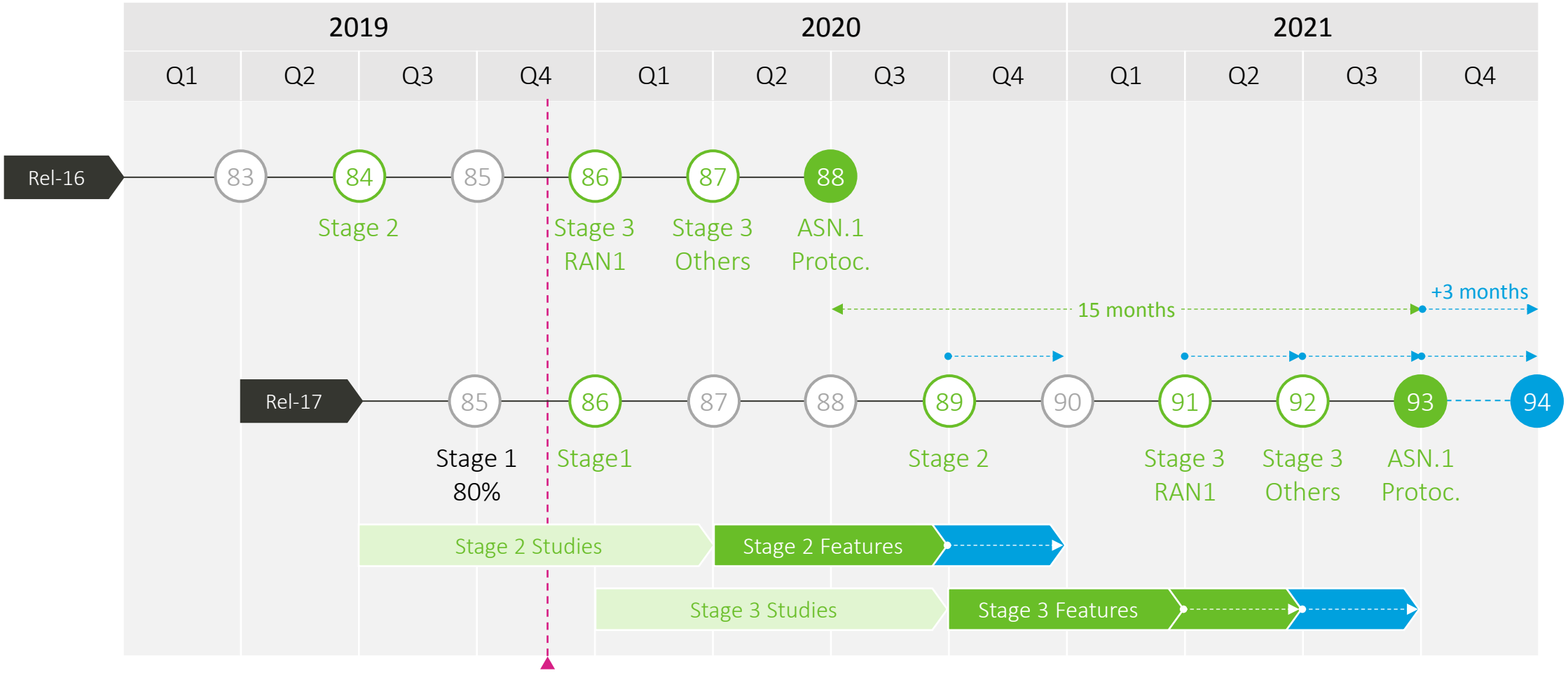
Release 17 timeline



Industrial IoT Requirements for 5G

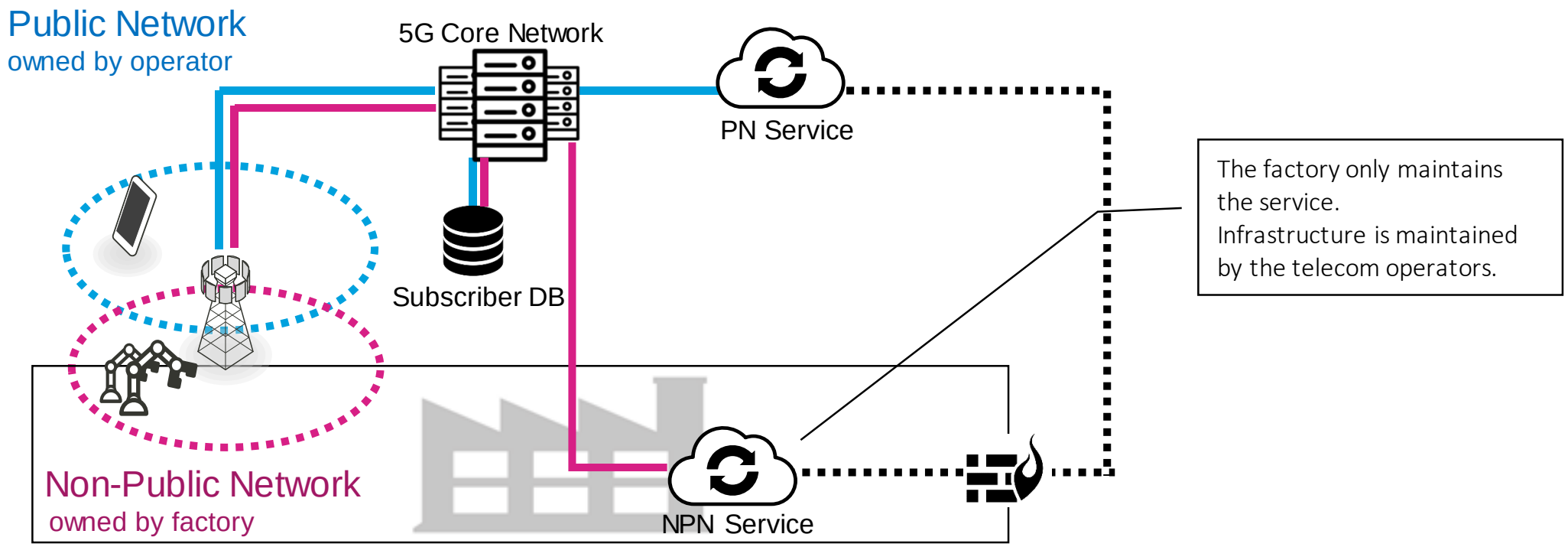
5G Radio

- Latency
- Bandwidth
- TSN
- QoS
- Positioning
- Spectrum flexibility

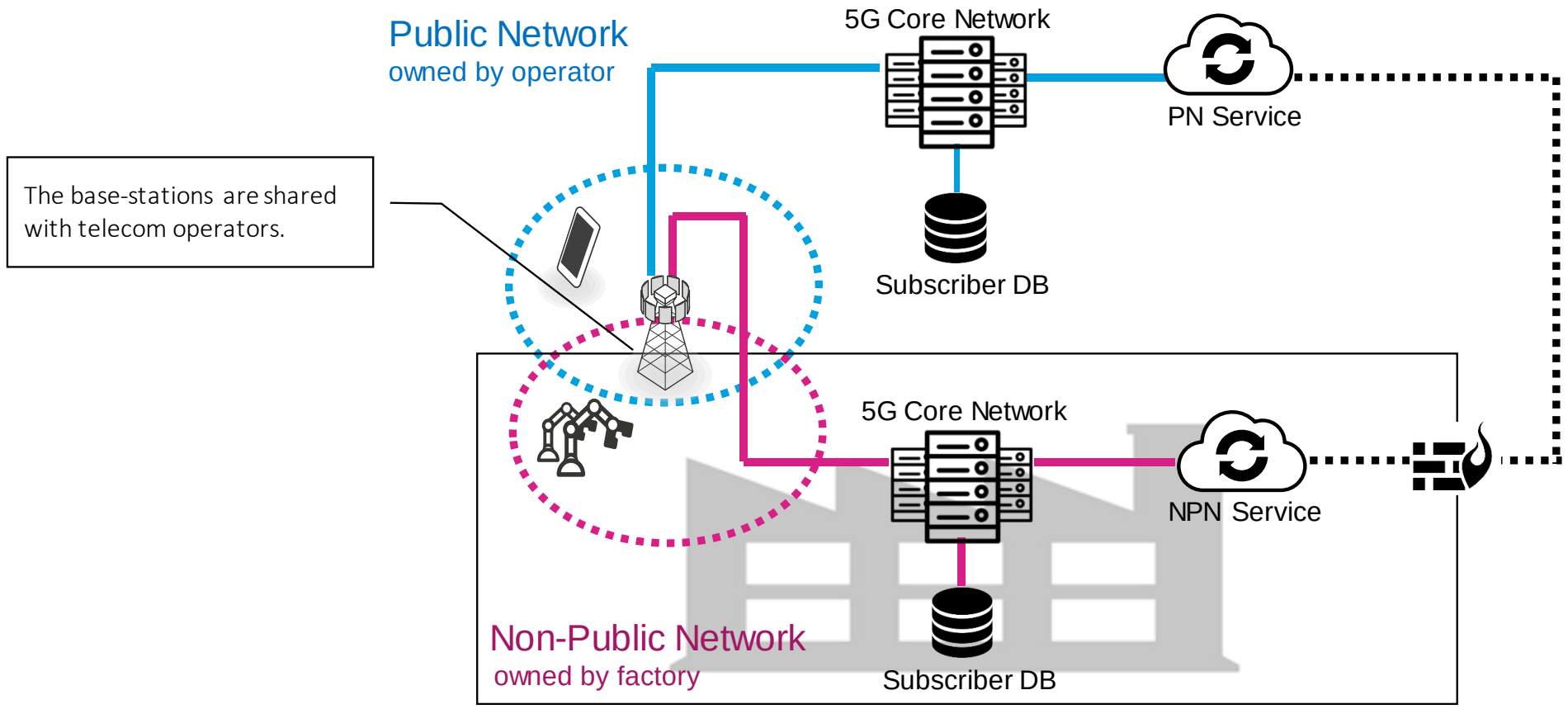
5G System

- Network slicing
- Authentication methods
- Security
- Edge deployment
- On-premises
- APIs

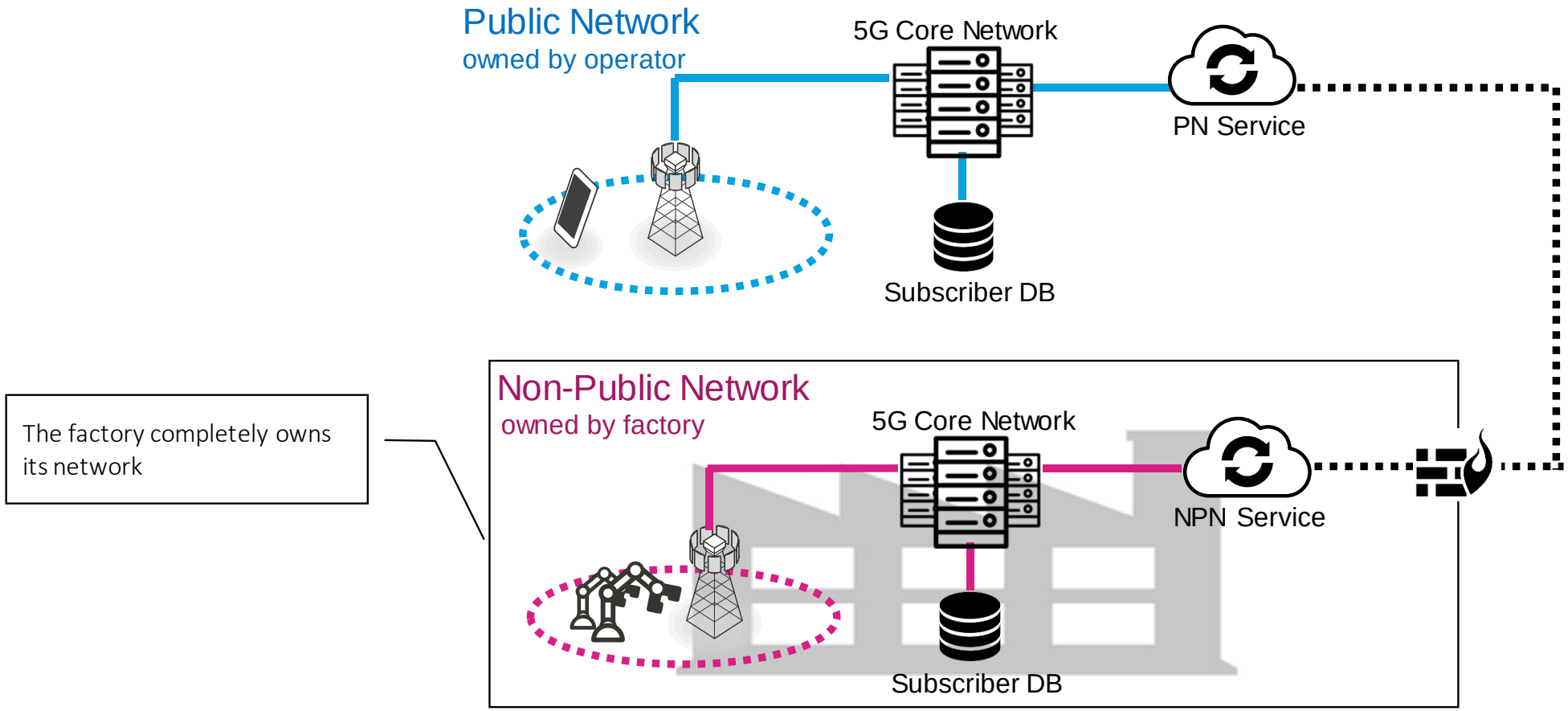
Deployment options:
Public Network integrated Non-Public Network (1/2)



Deployment options:
Public Network integrated Non-Public Network (2/2)



Deployment options:
Stand-alone Non-Public Network



Private 5G Wireless Edge for Industrial IoT

5G Private Network

WISE-PaaS/ DeviceOn

Private 5G Wireless Edge

- Ultra Reliable Low Latency with QoS
- TSN and Ethernet replacement
- Cellular grade security

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Advantech Industrial Wireless

AIW 5G Module

Embedded Boards

Embedded PCs

Embedded Computers

Wireless IoT Gateways

Vertical Focused Solutions

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Embedded IoT Wireless Connectivity Solutions

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AIWireless

Advantech Industrial Wireless


Transportation


AGV


Medical

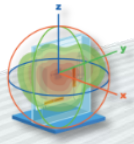

Smart Lighting

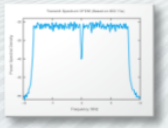

Bridge


Construction

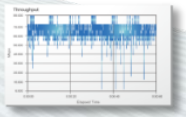

Aquaculture


Logistics


Optical Antenna Design

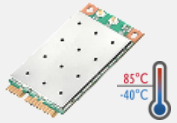

RF Certification

Software Integration


System Performance Tuning

Wireless Design-in Services

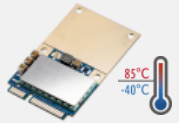
Wi FI | GPS | LTE | 5G | NB-IoT | LoRa



Industry-Grade WiFi-5 Module


Industry-Grade
GPS + G-sensor Module


Industry-Grade
Cellular Module


New M.2 3052
Sub-6G Module


Mini PCI-e Module


Wireless IoT Gateway &
Sensor Node


WiFi-5 Module


WiFi-6 Module


Industry-Grade
GPS Module


4G LTE Module


Sensor Node Module

Embedded Wireless Module

IoT Solution

Co-Creating the Future of the IoT World