Qualcomm

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April 2019

How will 5G transform Industrial IoT?

Qualcomm Technologies, Inc.

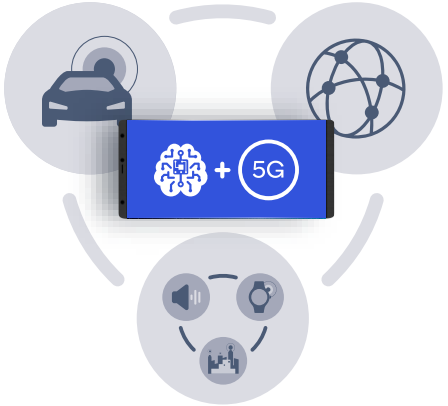
Leading mobile innovation for over 30 years

Digitized mobile communications

Analog
to digital

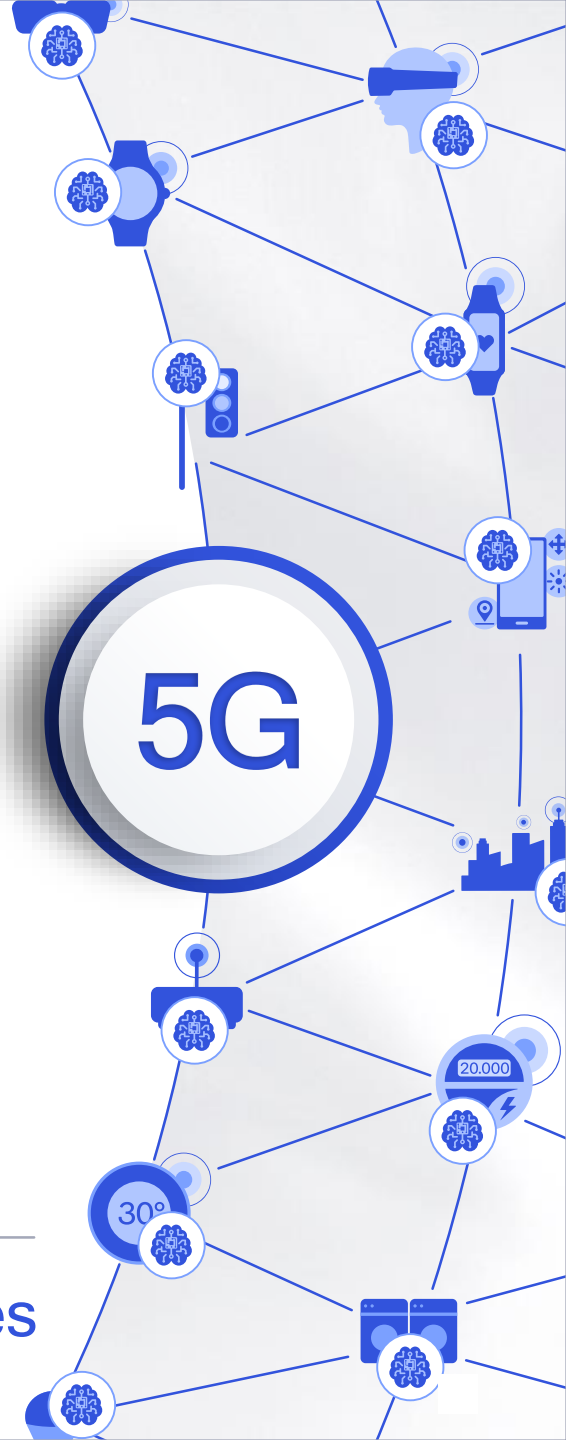
Redefined computing

Desktop to
smartphones



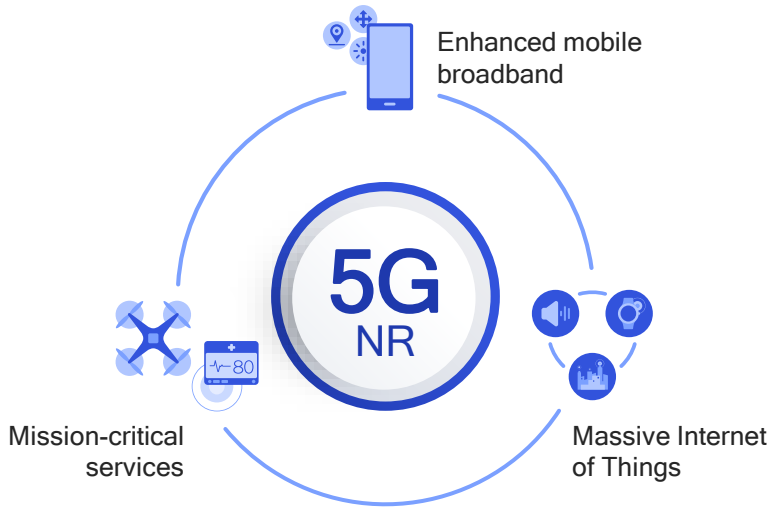
Transforming industries

Connecting virtually everything
at the wireless edge



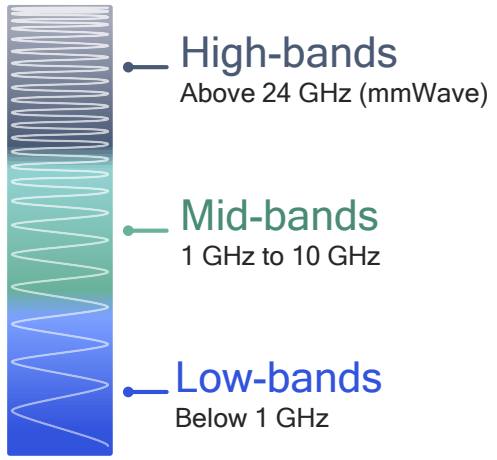
Transforming how the world connects, computes and communicates

5G NR Designing a unified, more capable 5G air interface



Diverse services

Scalability to address an extreme variation of requirements



Diverse spectrum

Getting the most out of a wide array of spectrum bands/types

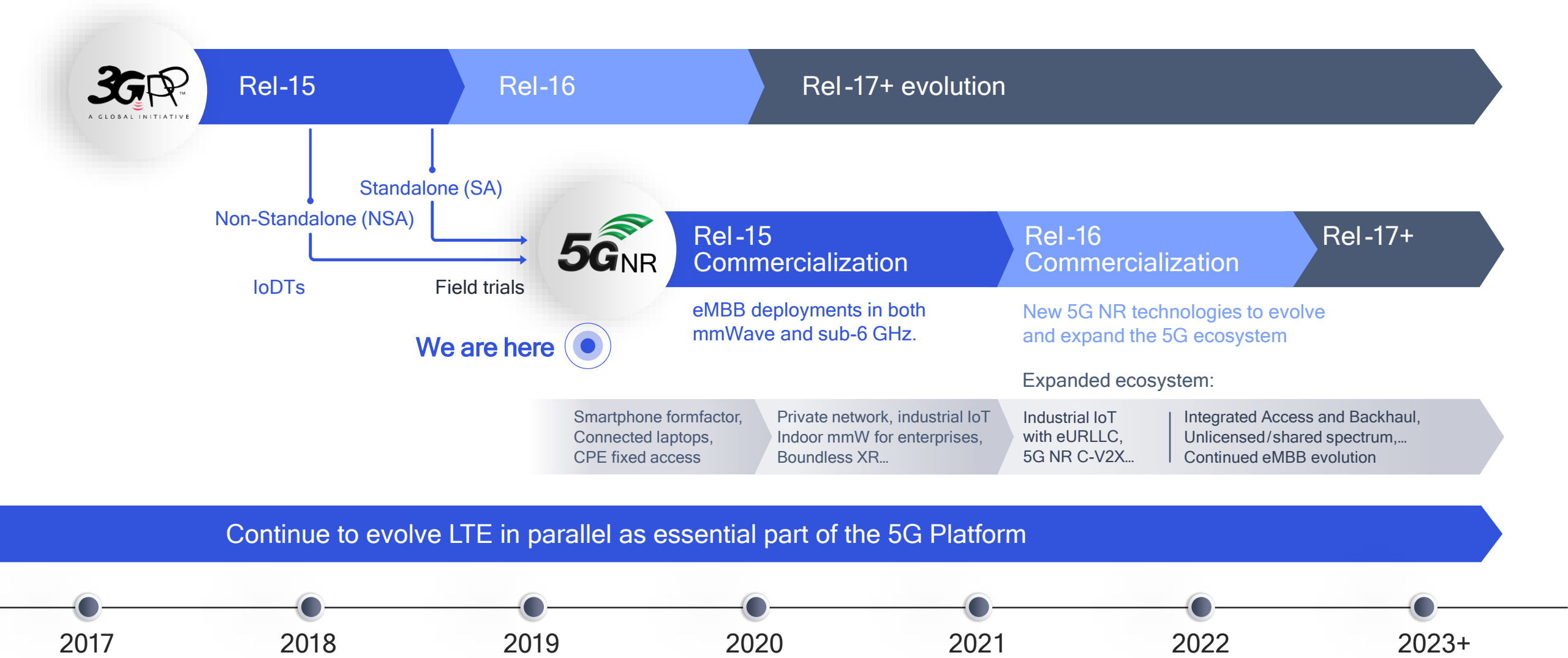
Diverse deployments

From macro to indoors, with support for diverse topologies such as private networks

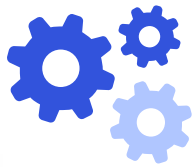
A unifying connectivity fabric for future innovation

A platform for existing, emerging, and unforeseen connected services

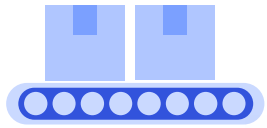
Driving the 5G roadmap and ecosystem expansion



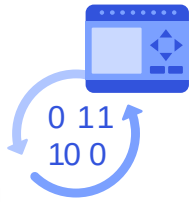
5G takes Industry 4.0 to the next level



Industry 1.0
Mechanization



Industry 2.0
Electrification



Industry 3.0
Digitalization

Industry 4.0 + 5G
Wireless Connectivity

Compute • Security • Connectivity

On-device processing and sensing

CV and AI for autonomous robots

Edge services and data privacy

Single futureproof 5G network

Scalable capacity and reliability

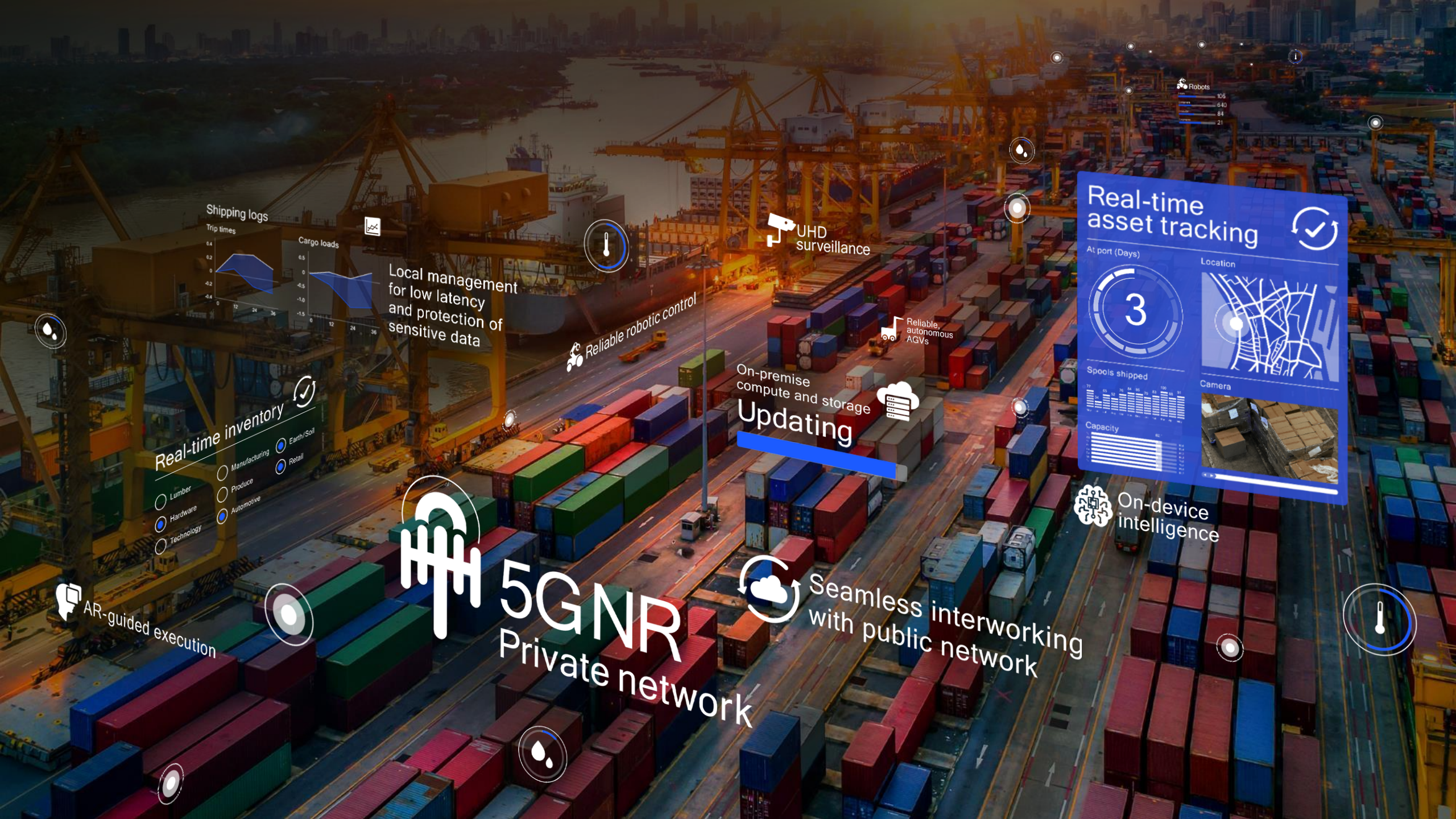
Flexibility with wireless Ethernet

>$5 Trillion[1]

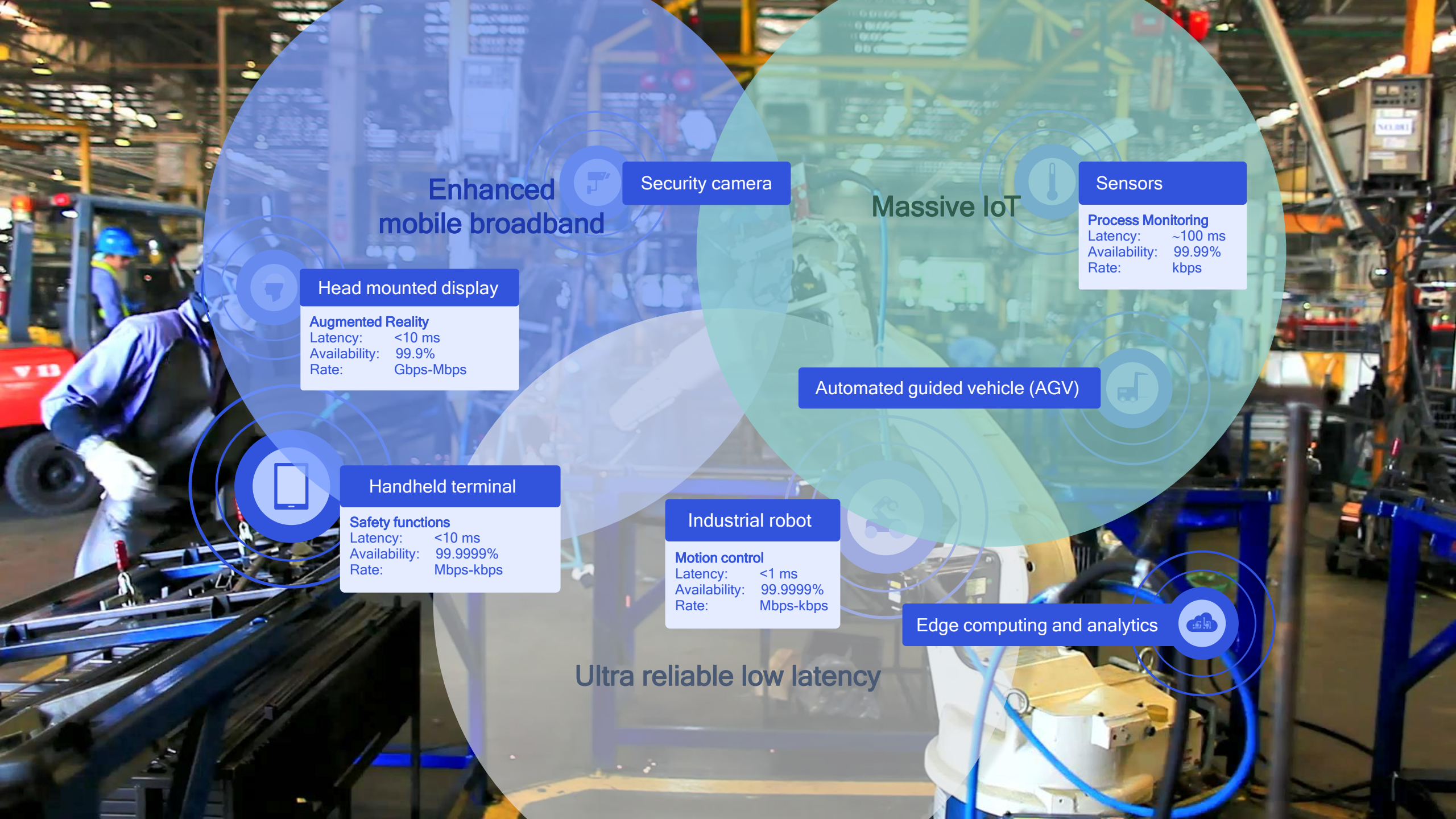
Global economic output in 2035 enabled by 5G in the following five categories

Manufacturing	Transport	Construction	Utilities	Mining
$3,364B	$659B	$742B	$273B	$249B

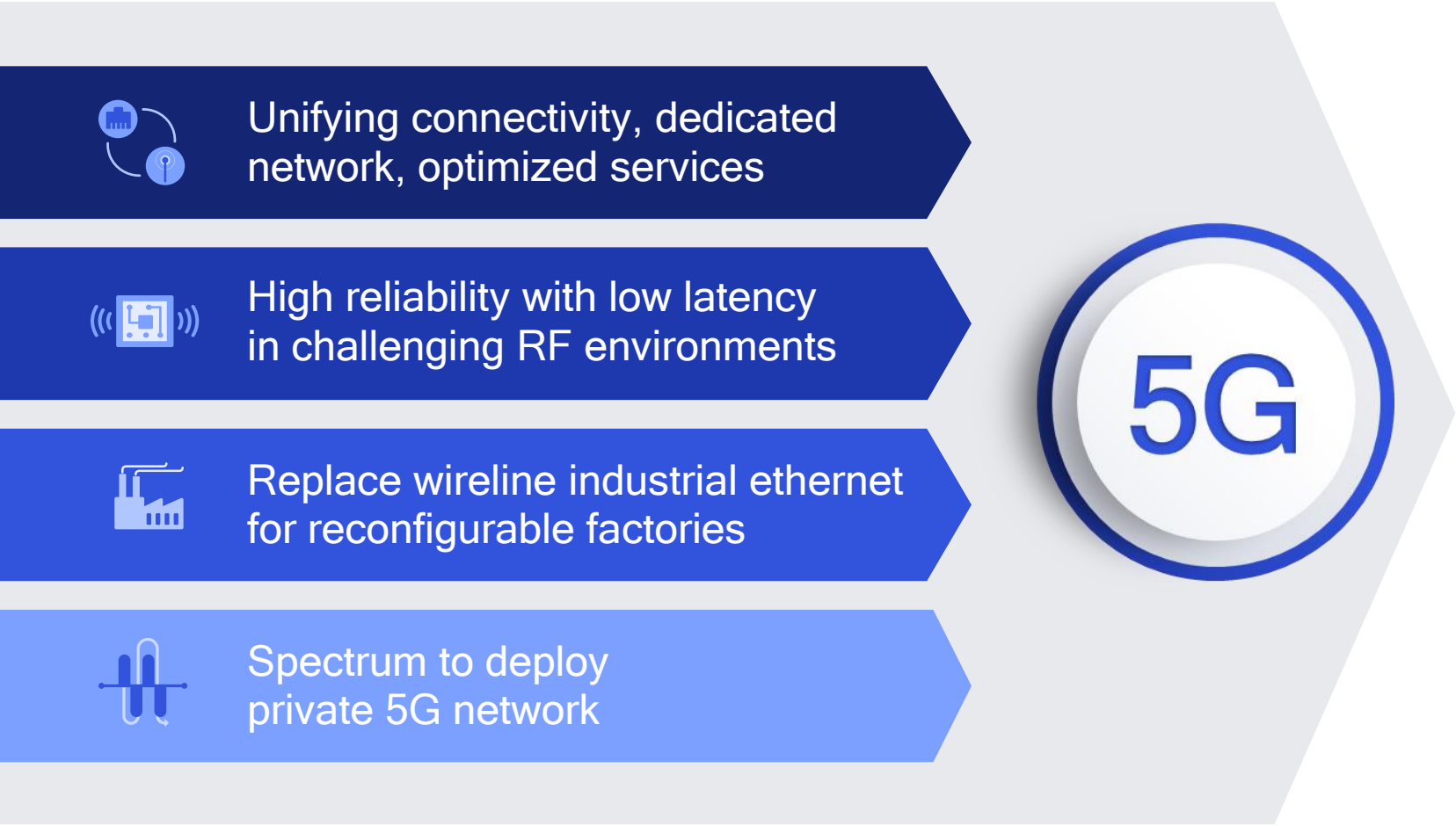
1. “The 5G economy: How 5G technology will contribute to the global economy” by IHS Economics / IHS Technology


Shipping logs
Trip times
Cargo loads
Local management for low latency and protection of sensitive data
Reliable robotic control
UHD surveillance
Reliable, autonomous AGVs
On-premise compute and storage
Updating
Real-time inventory
Lumber
Hardware
Technology
Manufacturing
Produce
Automotive
Earth/Soil
Retail
AR-guided execution
5G NR
Private network
Seamless interworking with public network
Real-time asset tracking
At port (Days)
3
Location
Spools shipped
Capacity
Camera
On-device intelligence
Robots


Turbine sensor
Drone inspection
Blade sensors
Vehicle tracking
Environmental sensors
Handheld computing


Enhanced mobile broadband
Security camera
Head mounted display
Augmented Reality
Latency: <10 ms
Availability: 99.9%
Rate: Gbps-Mbps
Massive IoT
Sensors
Process Monitoring
Latency: ~100 ms
Availability: 99.99%
Rate: kbps
Automated guided vehicle (AGV)
Handheld terminal
Safety functions
Latency: <10 ms
Availability: 99.9999%
Rate: Mbps-kbps
Industrial robot
Motion control
Latency: <1 ms
Availability: 99.9999%
Rate: Mbps-kbps
Edge computing and analytics
Ultra reliable low latency

Designing 5G to meet industrial IoT requirements



Private 5G network for all services

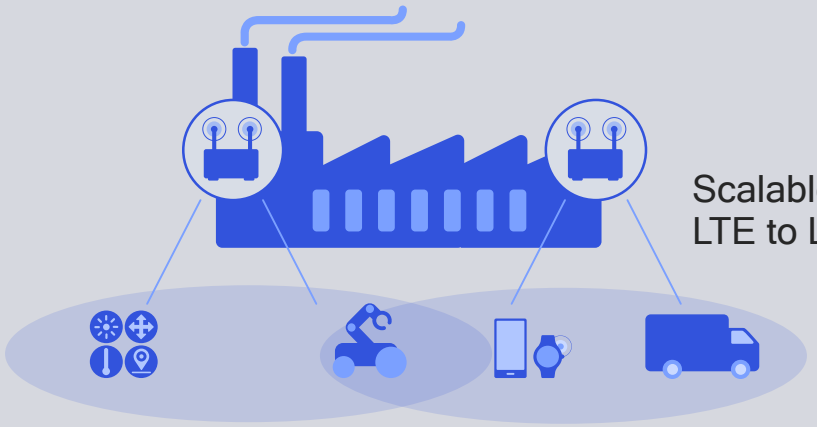
Ultra Reliable Low Latency Communication (URLLC)

Time Sensitive Networking (TSN)

Dedicated licensed or shared/unlicensed spectrum

Private 5G networks for Industrial IoT use cases

Optimizing LTE for the Industrial IoT today



Scalable from Gigabit LTE to LTE IoT

New opportunities with 5G NR capabilities

Ultra reliable low-latency

TSN[1] and Ethernet replacement

Enhanced MBB[2] for new uses like XR[3]

Expand to shared / unlicensed spectrum

1. Time Sensitive Networks (TSN); 2. Mobile Broadband (MBB); 3. Extended Reality (XR)–umbrella term for Augmented Reality (AR), Virtual Reality (VR), mixed reality (MR), etc.

Optimized

Tailored for industrial applications, e.g., QoS, latency

Dedicated

Local network, easy to deploy, independently managed

Secure

Cellular grade security and keeping sensitive data local

URLLC

Ultra Reliable Low Latency Communication

99.9999% reliability[1]

Spatial diversity is essential

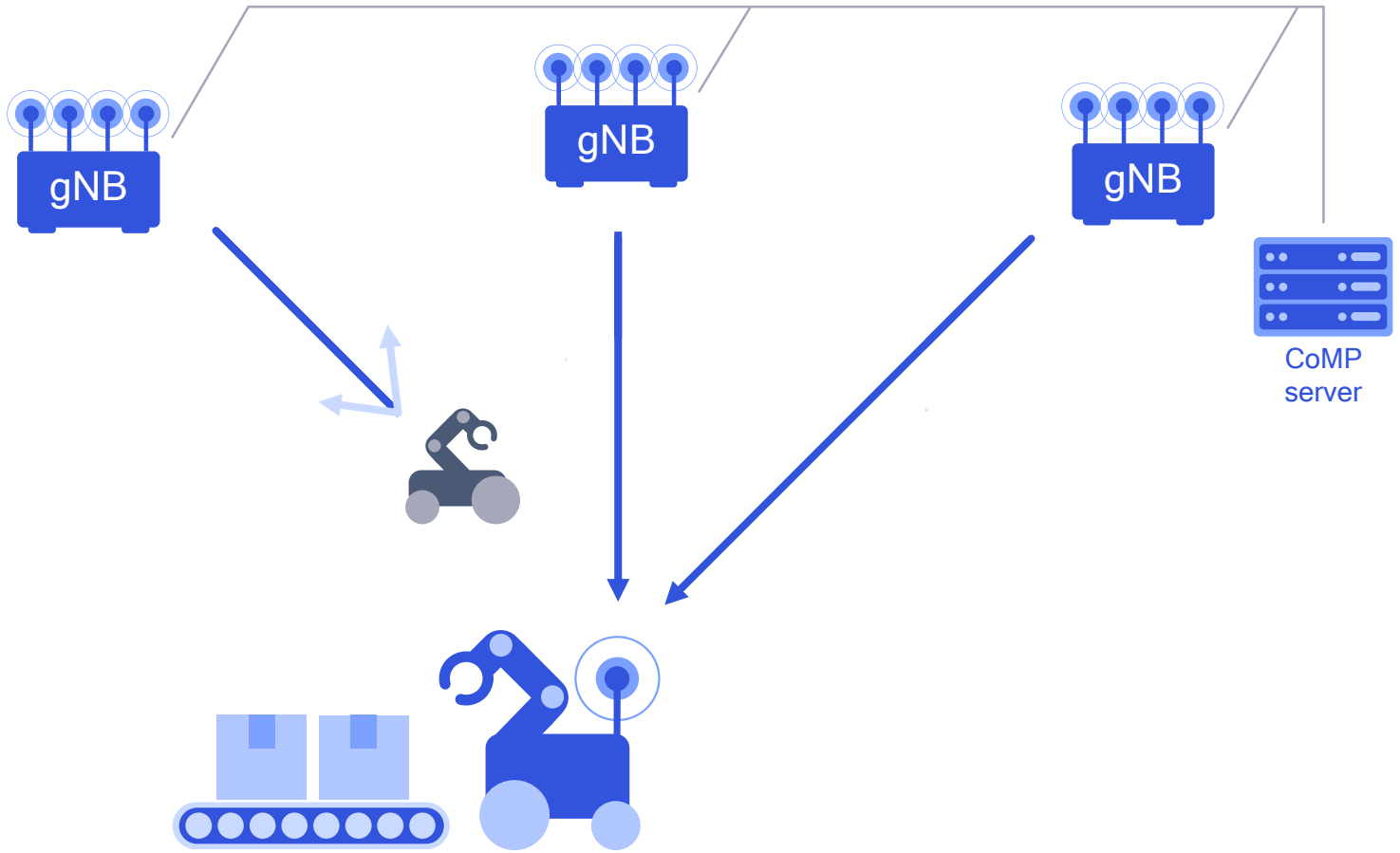
- Coordinated multi-point (CoMP) provides spatial diversity with high capacity
- CoMP enabled with dense deployment of small cells with high bandwidth backhaul

Other diversity limited

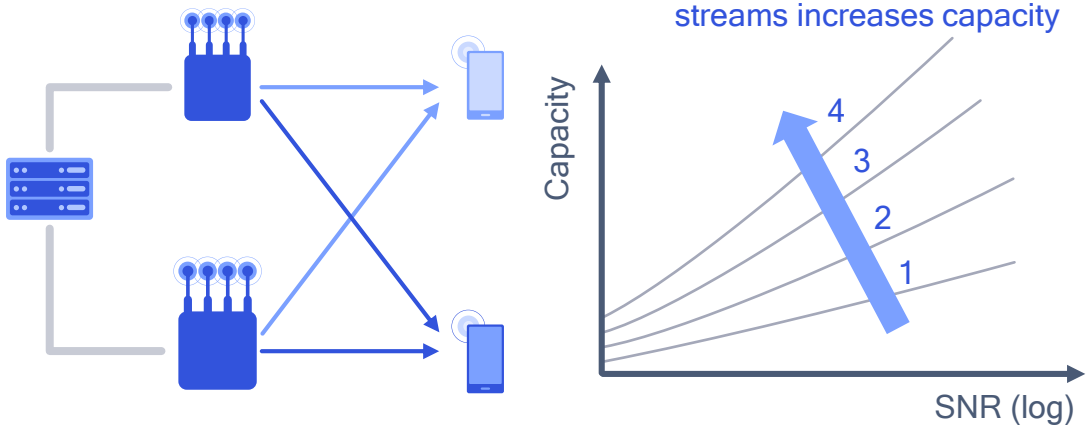
- Frequency diversity does not address RF blockage/shadowing
- Time diversity limited as ultra low latency dictates timing

1. One of the performance requirements for “Discrete automation, motion control” in 3GPP TS 22.261 V16.3.0 Table 7.2.2-1

Ultra reliability using CoMP



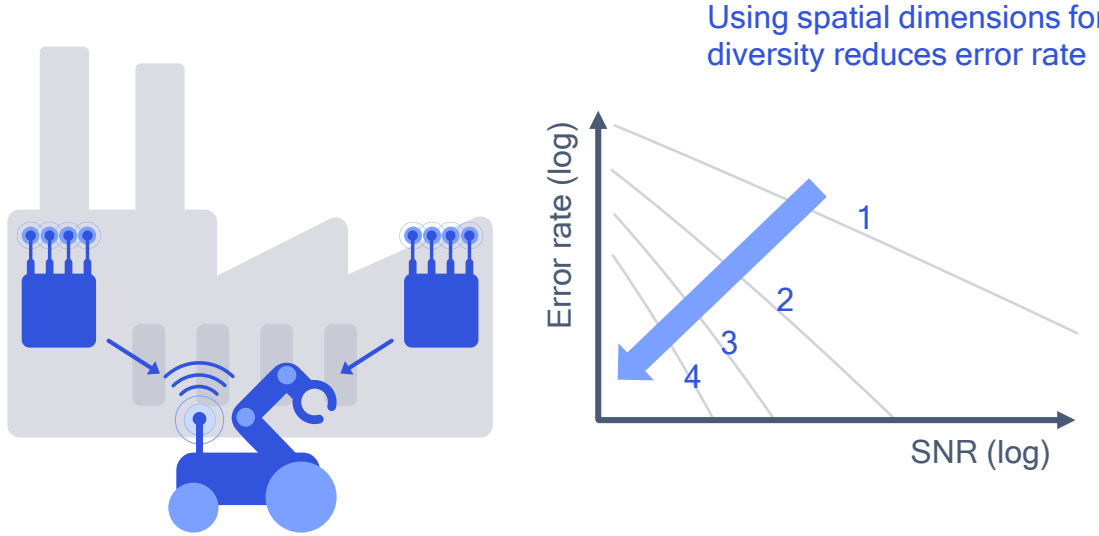
CoMP expands 5G: capacity or ultra-reliability tradeoff



Capacity from spatial multiplexing

Allows multiple transmissions at the same time to multiple location without interfering

Can also be used to by multiple operators to share spectrum more efficiently

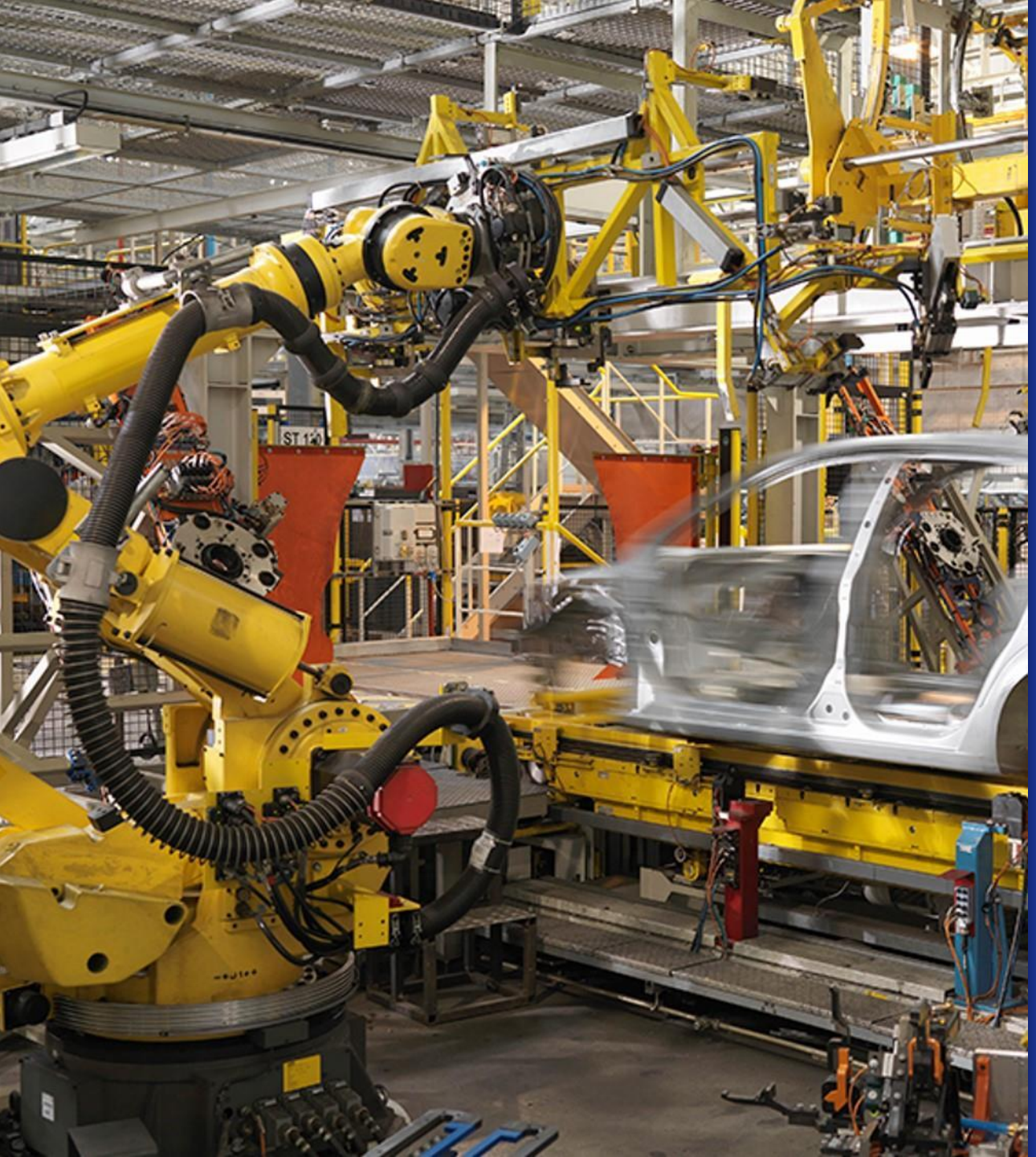


Reliability from spatial diversity

Spatial diversity can overcome radio shadowing in challenging radio environments

Key for URLLC[1] to meet 99.9999% reliability and challenging industrial IoT applications

1) Ultra reliable low latency communication

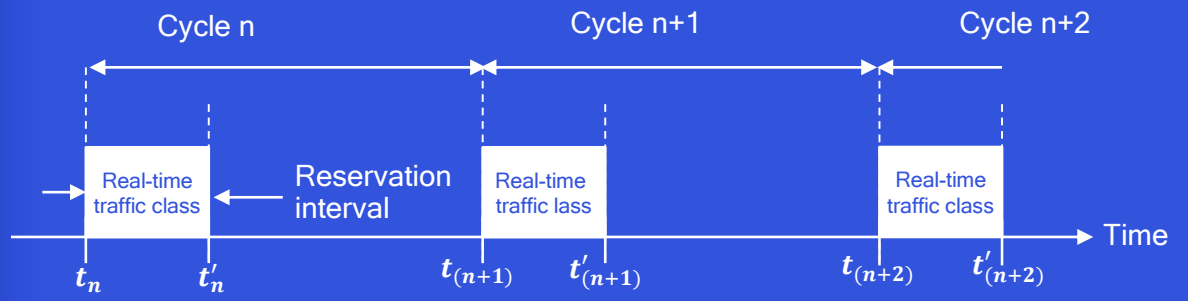


Industrial Ethernet using Time Sensitive Networking[1]

Enables time synchronization of machines

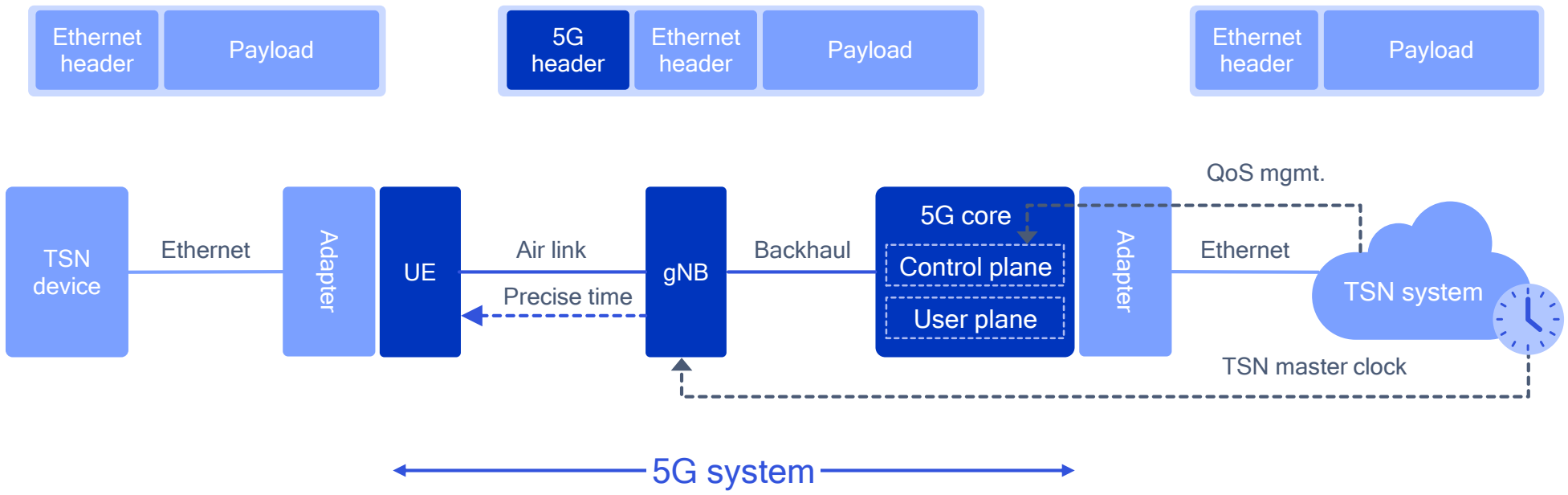
Deterministic packet delivery

Reserved time slots allow co-existence with best effort traffic



1) Time Sensitive Networking (TSN) is a collection of IEEE 802.1Q standards

Adapting 5G to support Time Sensitive Networking (TSN)



Ethernet over 5G

- Transport Ethernet frames over 5G
- Efficient transport of broadcast packets, including loop prevention
- Automatic address discovery

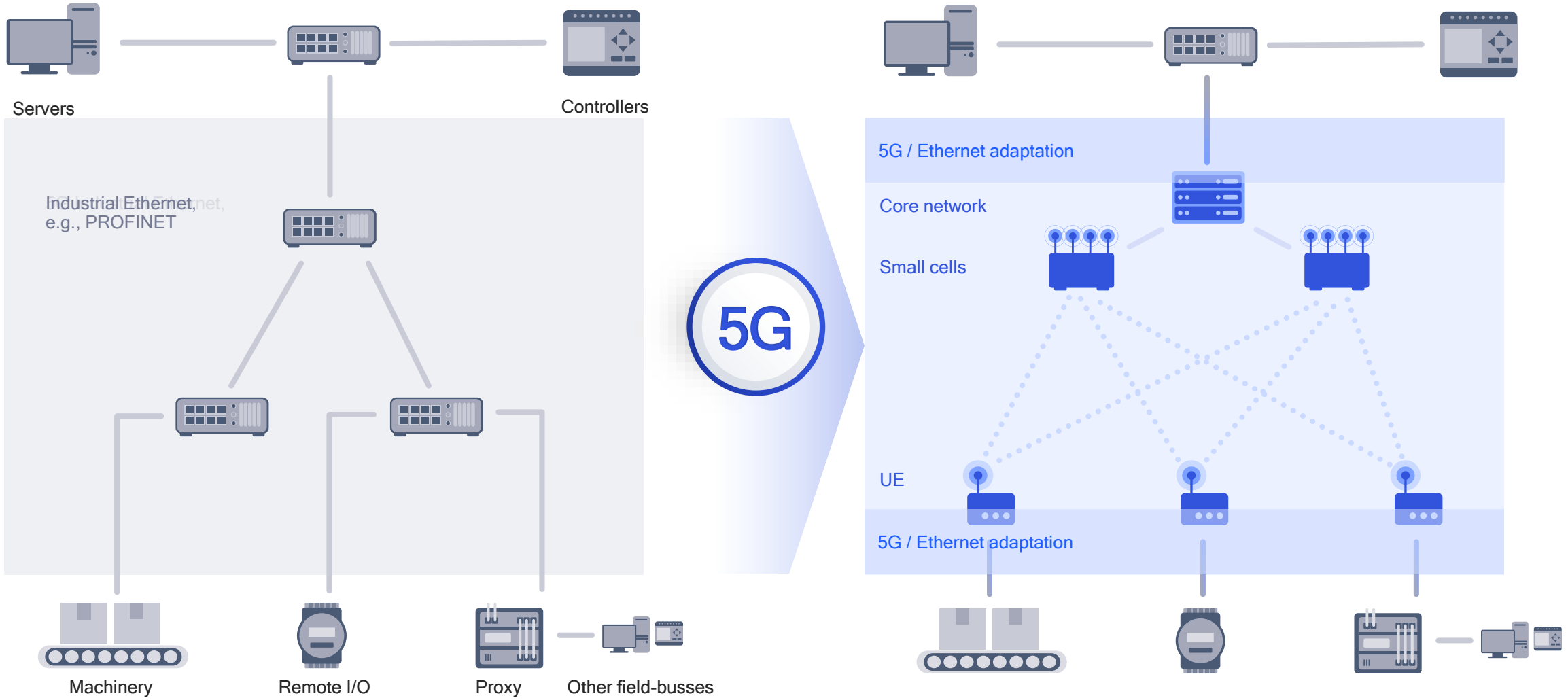
Quality of Service (QoS)

- Interface between 5G control plane and TSN for QoS management
- Define new 5G QoS identifier for industrial Ethernet
- Admission control & interaction with TSN QoS framework

Time synchronization

- Time synchronization architecture
- Microsecond synchronization for all nodes
- Broadcasting precise time by gNB

Upgrading existing industrial networks with wireless 5G



Private 5G NR networks can use different spectrum types

Providing a wide range of new services including URLLC

Licensed spectrum

Operators can allocate a portion of their spectrum in a specific area, e.g., at an industrial plant

Dedicated spectrum

In some regions, spectrum is dedicated for specific use such as 3.7 GHz in Germany for industrial

Unlicensed/shared spectrum

3GPP Rel-16 adds support for unlicensed spectrum (5G NR-U) including standalone operation; can support URLLC services in non-public locations controlled by tenant/owner

New sharing paradigms

CoMP with spatial sharing can provide significant capacity gains, predictable QoS and URLLC services

5G NR in unlicensed spectrum (NR-U) part of 3GPP R16

For wide range of deployments – also opportunity for new sharing paradigms

Evolutionary path: NR-U

NR unlicensed (NR-U)–existing coexistence rules

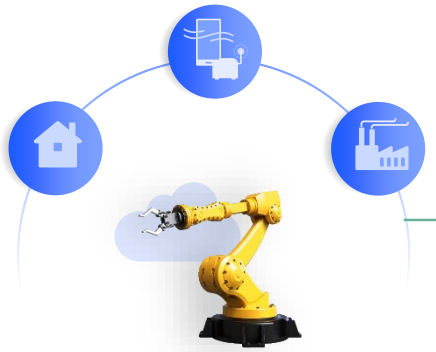
5G

Revolutionary path: NR-SS

NR spectrum sharing (NR-SS)–potential for new rules

LAA NR-U

Stand-alone NR-U



Time synchronization

- Predictable resources
- 5G CoMP[1]
- Spatial domain multiplexing
- mmW spatial sharing

1. Coordinated Multi-Point

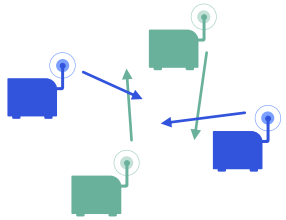
Boosting existing deployments by aggregating with licensed spectrum

Expanding 5G market with new types of deployments such as industrial IoT

Significant capacity or reliability, and ability for predictable resources while sharing spectrum. Utilizes 5G NR CoMP indoor OTA test network

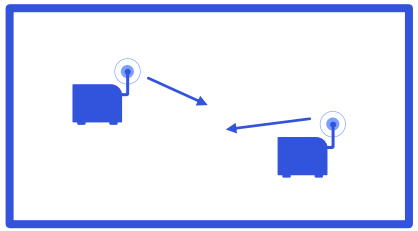
Unlicensed spectrum can support demanding Industrial IoT

Not possible with regular LBT[1] using random access



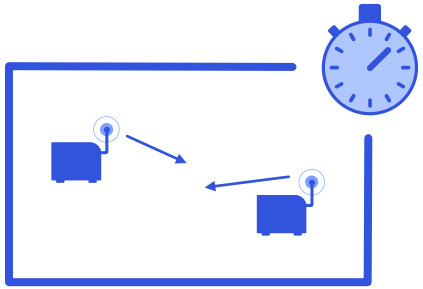
Results in random delays – demanding IIoT[2] apps require predictable latency

Controlled private environment improves latency



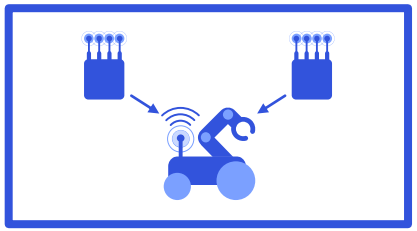
No interference from other networks, but still random delays within private network

Synchronization in time is key for predictability



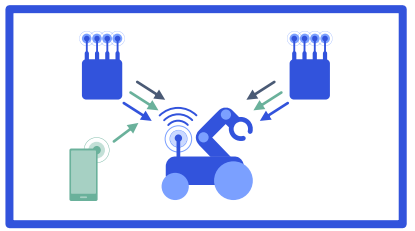
Current regulation allows synchronized FBE[3] based sharing for predictable low latency

CoMP improves capacity and reliability



Time synchronization also allows for spatial 5G COMP – a key technology for URLLC

Frequency diversity adds more reliability



Frequency diversity provide reliability against rouge devices trying to access

1) Listen before talk (LBT) with load based equipment rule (LBE), such as CSMA/CA (Carrier Sense Multiple Access/Collision Avoidance); 2) Industrial IoT; 3) Frame Based Equipment

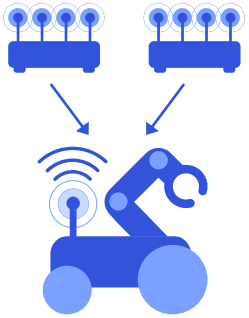
URLLC services feasible using time synchronized NR-U in controlled environments and today's regulation rules

Key industrial IoT functionality targeted for 3GPP rel. 16

Requirements

Multiple verticals including industrial IoT

URLLC

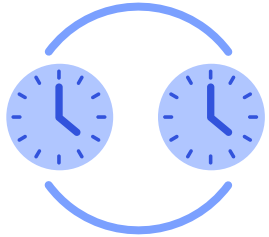


Sub-ms latency and 99.9999% reliability

Time Sensitive Networks (TSN)

Handling of Ethernet switch functions

Enhanced Quality of Service (QoS)



Microsecond time synchronization

Spectrum

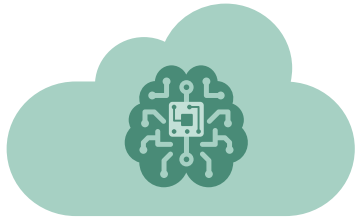
5G NR in unlicensed or shared spectrum

5G NR is being designed to meet Industrial IoT requirements


Sensing
Immediacy
Data stays local
New experiences
Privacy
Autonomy
Security
Tailoring
Extract local value
Personalization
To scale,
intelligence must be distributed
to the wireless edge
Trillions of connected things
Massive amount of data

On-device capabilities complemented with edge cloud at wireless edge

Central cloud

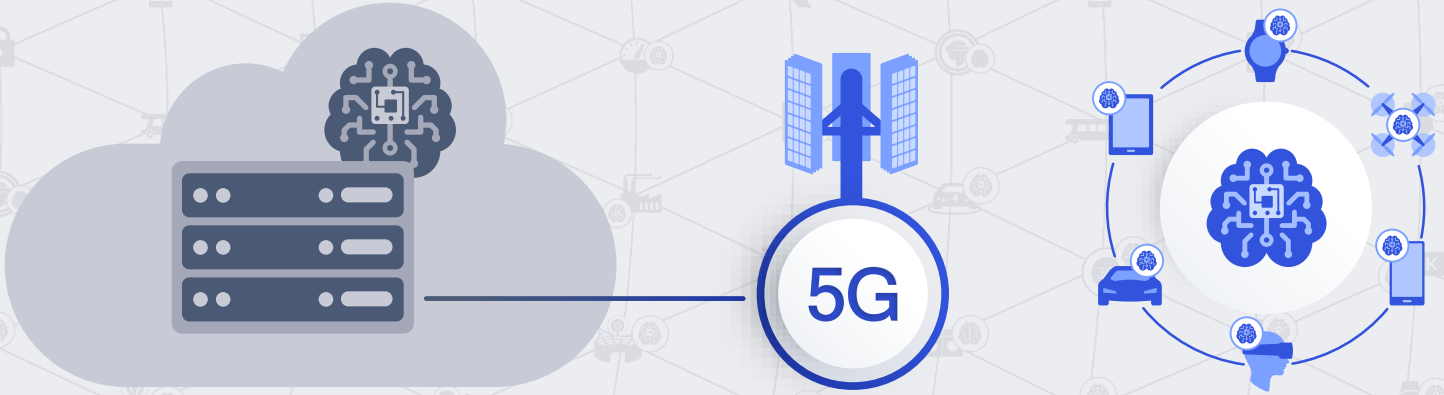


Edge cloud

Distributed/virtualized core[1],
mobile edge compute[2], cloud RAN, …

On-device

Sensing, processing, security, intelligence



Synergistic balance

- Ultra-low latency–key to 5G use cases
- Processing to augment on-device
- Local content, analytics, management
- Opportunity to provide tailored value

- Privacy as data stays on device
- Immediacy–tasks on device
- Efficient use of bandwidth
- Personalization with privacy

1. Such as distributed packet gateway functionality for low latency; 2. Also related MEC Multi Access Edge Computing as defined by ETSI

Wireless edge for the industrial IoT

Cloud services

Cloud analytics and virtualized core network functions

Local network at edge

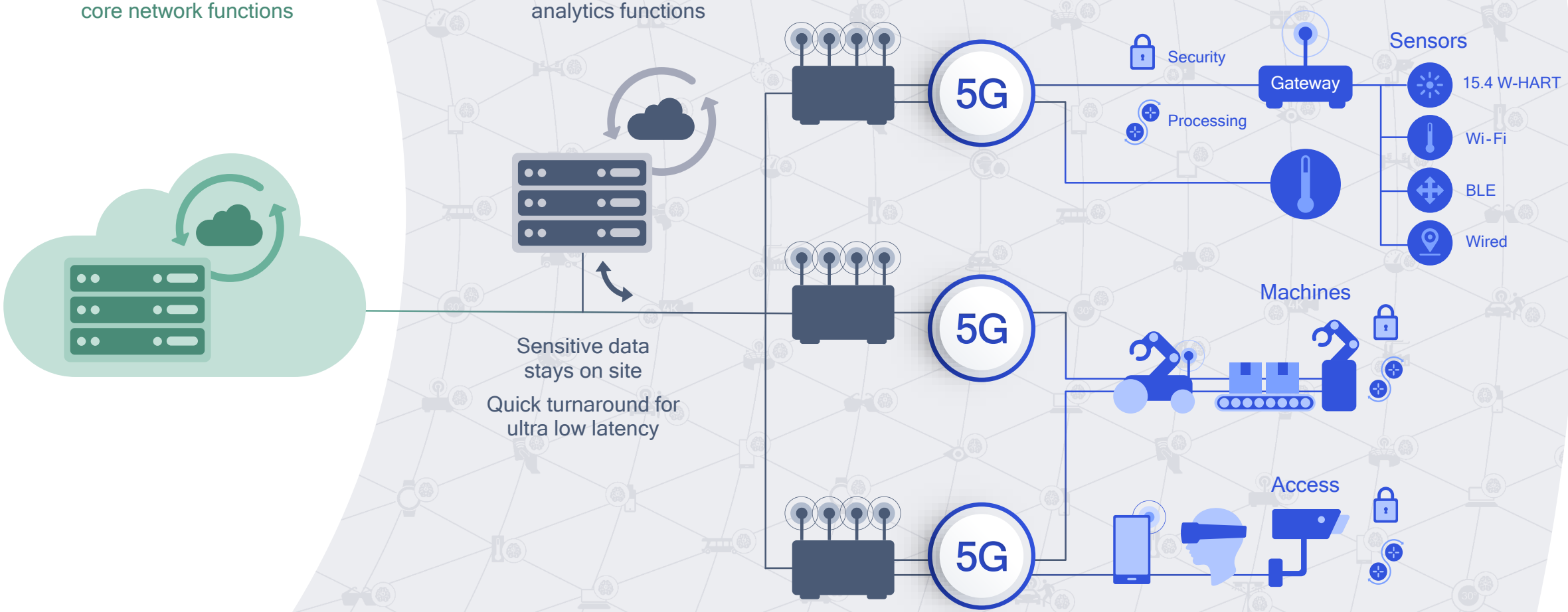
RAN, core network and analytics functions

Sensitive data stays on site

Quick turnaround for ultra low latency

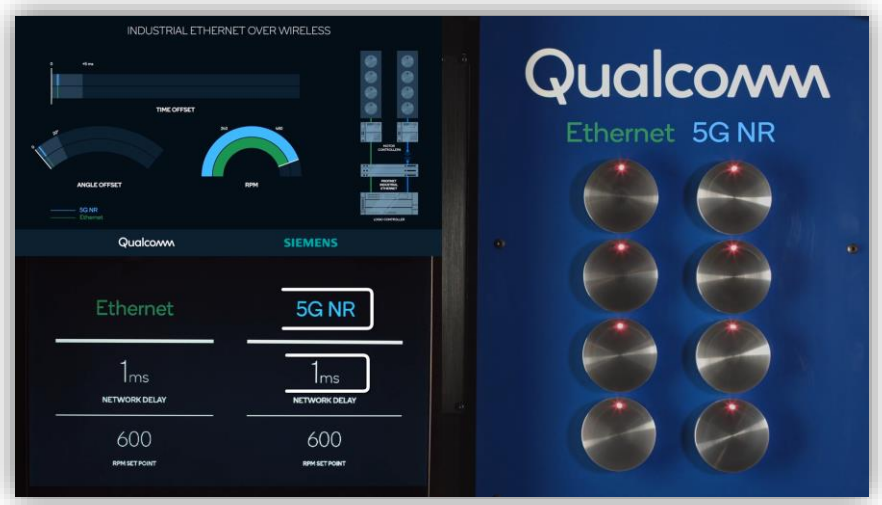
Industrial IoT devices

Sensing, processing, security, intelligence



Demonstrating ultra-reliable low latency capabilities (URLLC)

MWC 2018: Low latency

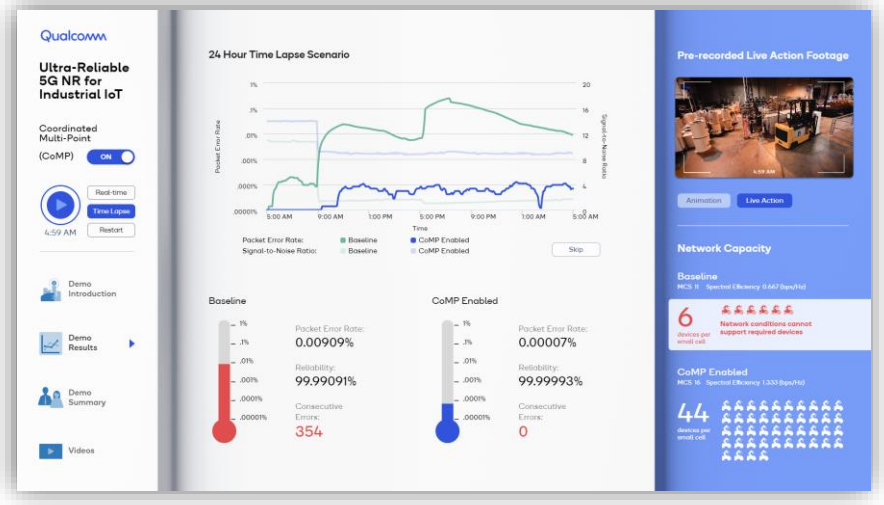


Sub-millisecond latency[1]

Industry-first demo of PROFINET industrial Ethernet over 5G NR

Demonstrated benefits of 5G NR low latency for stringent command-and-control using factory automation equipment by Siemens

MWC 2019: Ultra-reliability



99.9999% reliability[1]

Industry-first demo of ultra-reliability in a 5G NR over-the-air testbed with CoMP

Coordinated Multi-Point (CoMP) provides spatial diversity that can overcome blocking in challenging radio environments

1. One of the performance requirements for eURLLC as specified in “Discrete automation, motion control” in 3GPP TS 22.261 V16.3.0 Table 7.2.2-1

Qualcomm Technologies, together with Nokia, were selected as the technology provider by the Hannover Messe to provide the 5G over-the-air connectivity for the demonstrations in the 5G Arena.

Qualcomm

Thank you!

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