6GSpecNet
Specialized Deterministic Connectivity for Demanding Markets

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Deterministic connectivity
bounded latency — reliable/safe - predictable
Need?

Today


Industrial automation

Network that supports requirements of industrial automation


Energy & power

Smooth functioning of energy production/distribution systems


Automotive

Safety-critical and real-time in-vehicle systems


Audio & video

Real-time, low latency distribution of audio and video


Transportation

Continuous train and trackside communication


Oil & gas

Timely communication for process and control networks


Aerospace

Precise time-stamped data acquisition and real-time traffic

Tomorrow

Tactile Internet

End-to-end (E2E) latencies < 5ms

Industrial automation

20us to 10ms latencies for M2M Ultra-reliable

Social roboverse / Collaborative robotics

Multi-sensory input to remote decision-making < 10-100ms

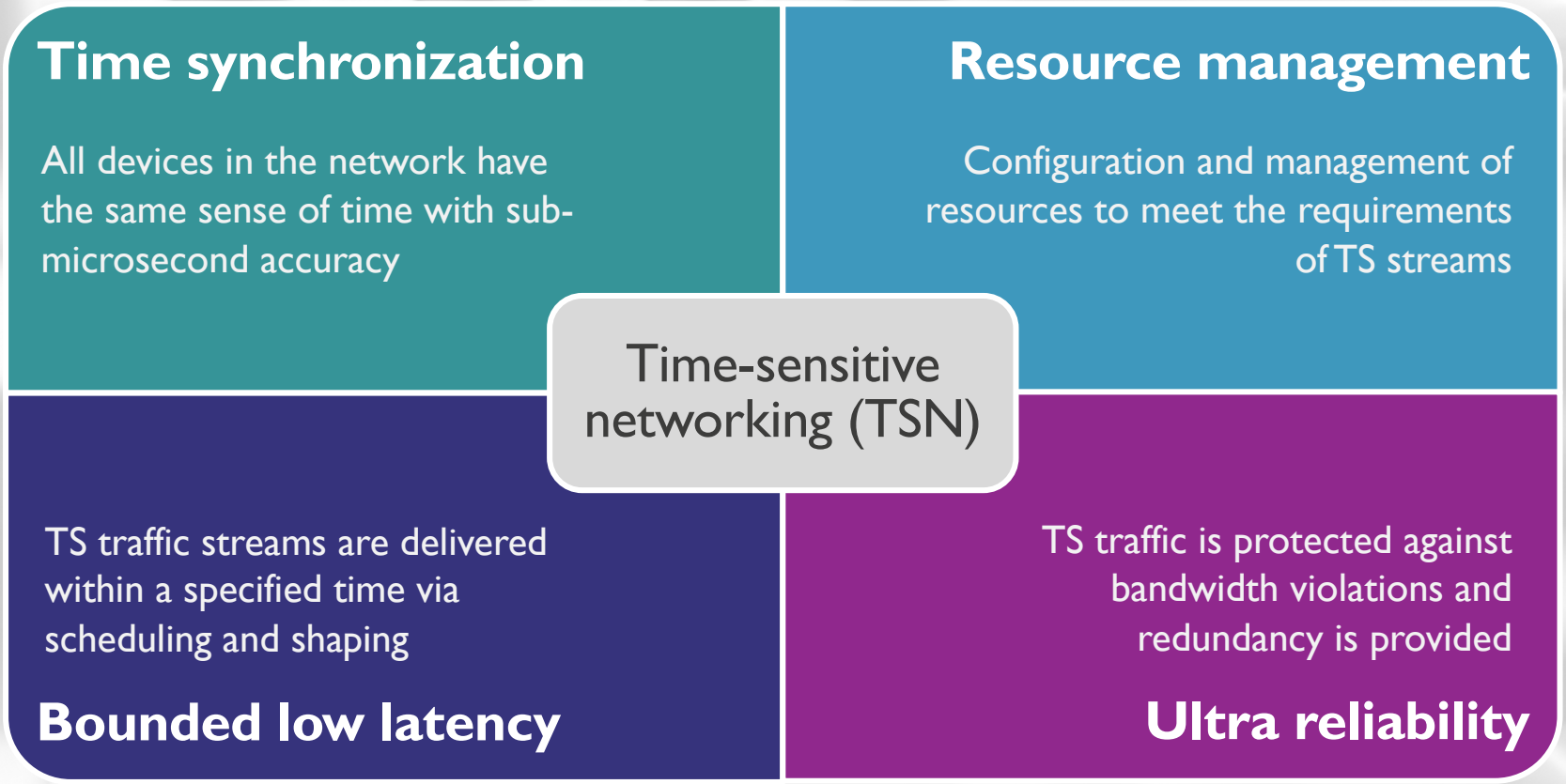
Holographic-type communications

E2E latencies < 20ms Gbps rates

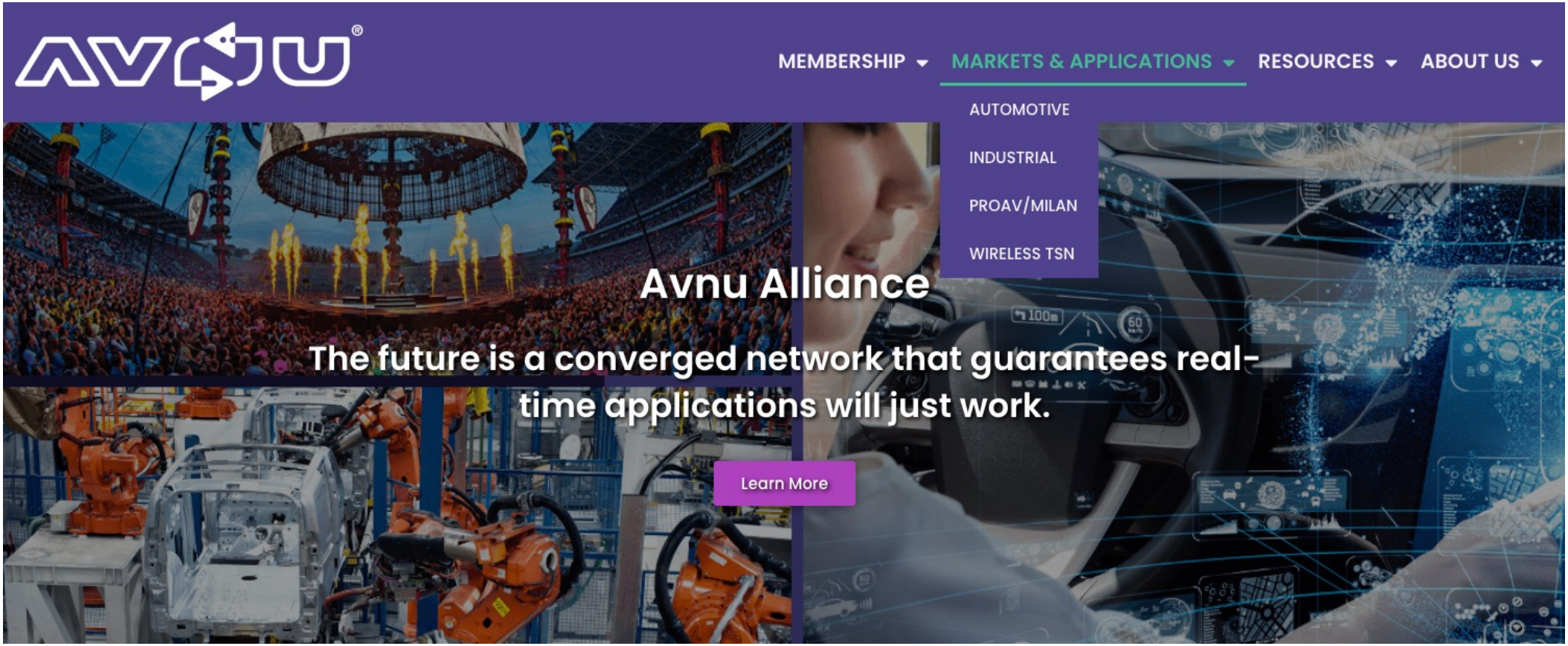
Image by Freepik

Deterministic connectivity

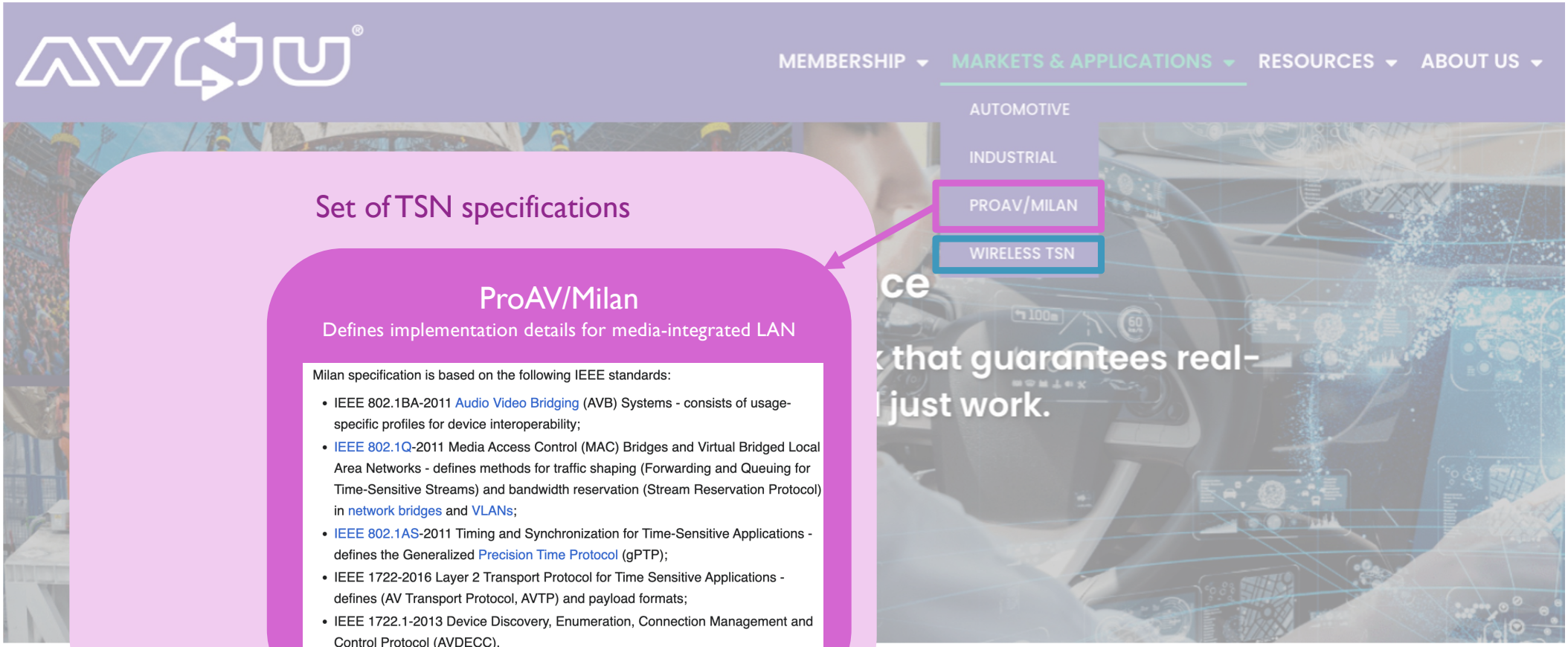
in the wired world



Set of IEEE 802.1 standards for deterministic transmission over Ethernet



Avnu interoperable ecosystem of low-latency, time-synchronized, highly reliable networking devices using the IEEE open standard



Set of TSN specifications

ProAV/Milan

Defines implementation details for media-integrated LAN

Milan specification is based on the following IEEE standards:

- IEEE 802.1BA-2011 Audio Video Bridging (AVB) Systems - consists of usage-specific profiles for device interoperability;
- IEEE 802.1Q-2011 Media Access Control (MAC) Bridges and Virtual Bridged Local Area Networks - defines methods for traffic shaping (Forwarding and Queuing for Time-Sensitive Streams) and bandwidth reservation (Stream Reservation Protocol) in network bridges and VLANs;
- IEEE 802.1AS-2011 Timing and Synchronization for Time-Sensitive Applications - defines the Generalized Precision Time Protocol (gPTP);
- IEEE 1722-2016 Layer 2 Transport Protocol for Time Sensitive Applications - defines (AV Transport Protocol, AVTP) and payload formats;
- IEEE 1722.1-2013 Device Discovery, Enumeration, Connection Management and Control Protocol (AVDECC).

WAN tech

Licensed spectrum

Public and private

LAN tech

Unlicensed spectrum

Indoor (80% of data consumed indoor)

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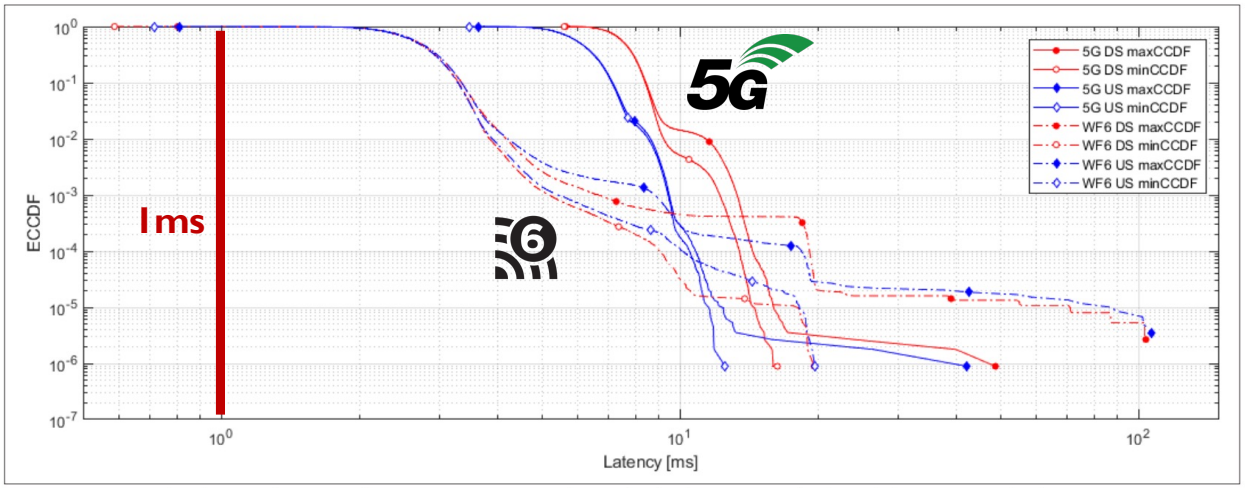


FIGURE 4. Latency distribution for 5G and Wi-Fi 6: ECCDF envelopes for both upstream (US) and downstream (DS).

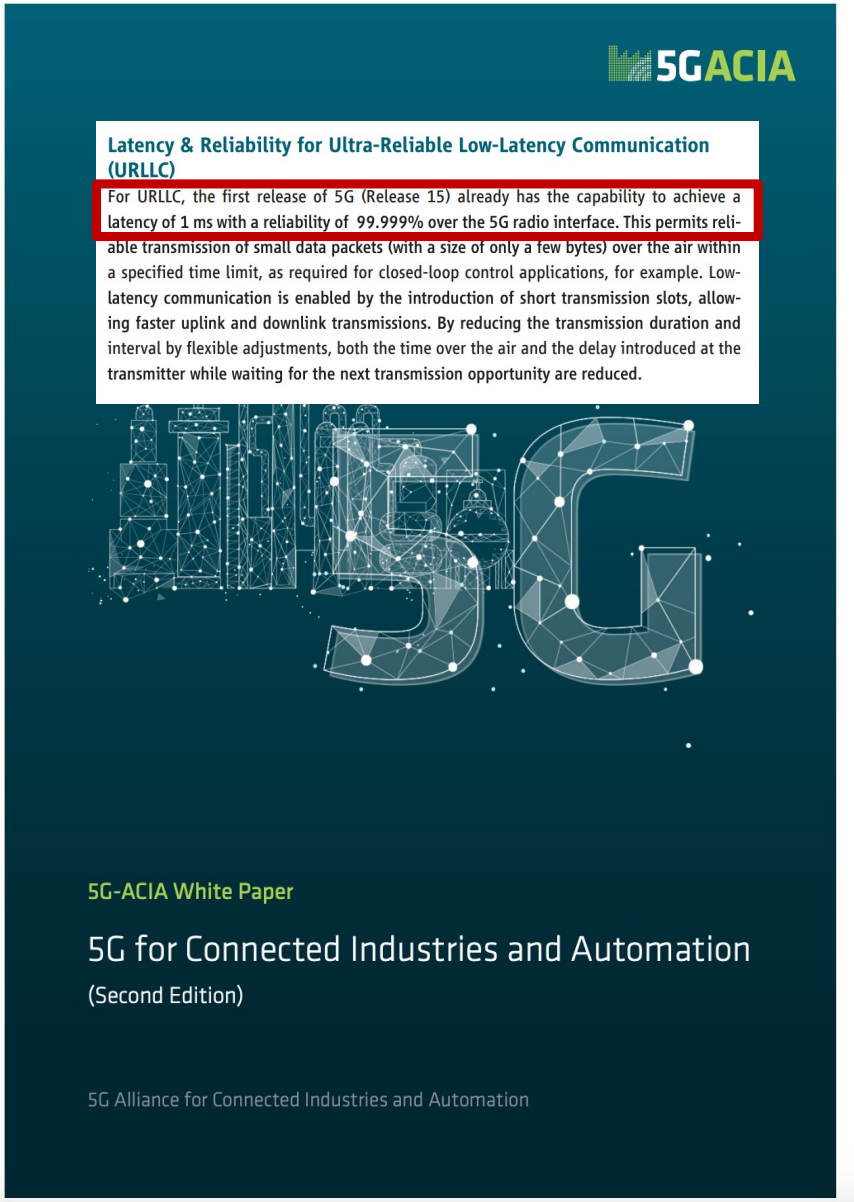
Based on: Zhibo Pang, "Functional Safety Communication over Deterministic Wireless Networks", NIST Industry Meeting on Advanced Technologies and Use Cases for High-performance Industrial Wireless Systems, Sep. 12 2024

5G in production

Does 5G technology the hen-egg-probiemi

5G is the first mobile communications standard ever to be tailored to the specific needs of industry. A broader range of hardware suitable for industrial use is on the horizon - if a sufficient number of users join in.

Source: ke Next 01 2023



eMBB

Increased data rates, high user density and very high traffic capacity

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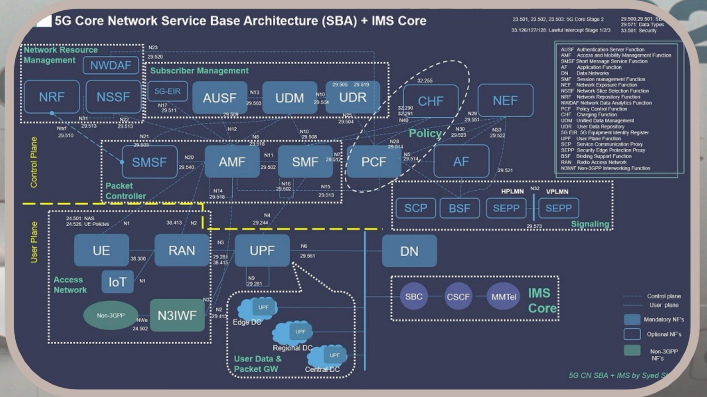
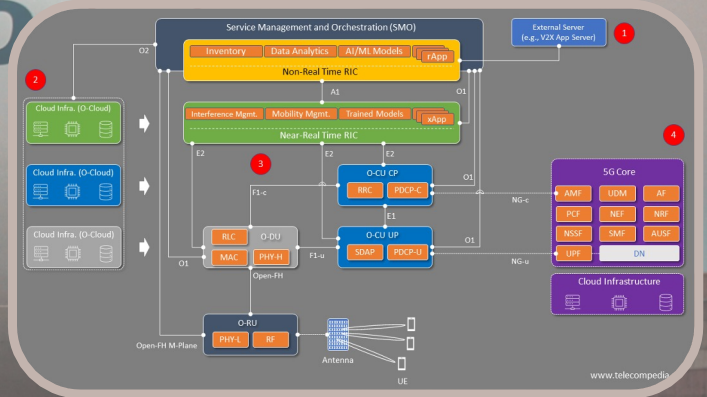
eMBB

Increased data rates, high user density and very high traffic capacity

Technology designed for a small number of extremely large national networks



Source: https://ssharizal.medium.com/5g-core-network-sba-ims-core-architecture-diagram-dcf0893d9bd9



https://telecompedia.net/open-ran-with-bullets-part-2/

URLLC

Delivering strict latency and reliability

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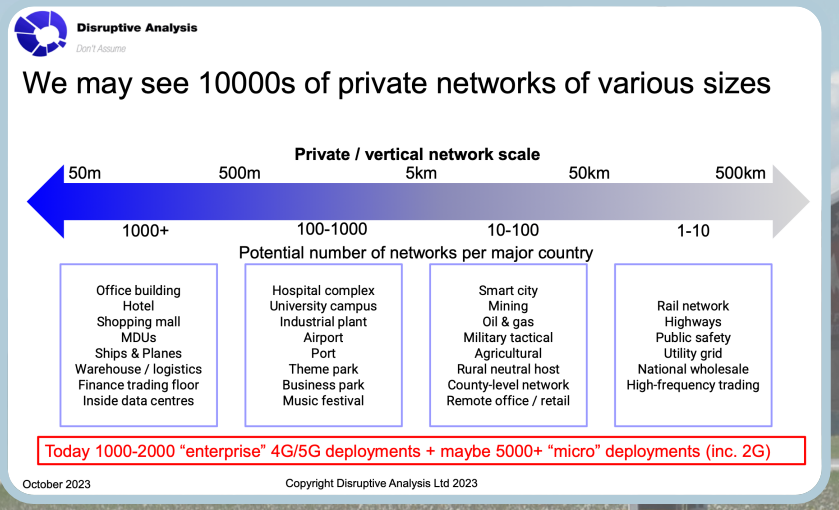
URLLC

Delivering strict latency and reliability



Source: Dean Bubley, Disruptive Analysis, "5G: Evaluating Hype vs. Reality", ICASA 5G Forum, October 2023

Features

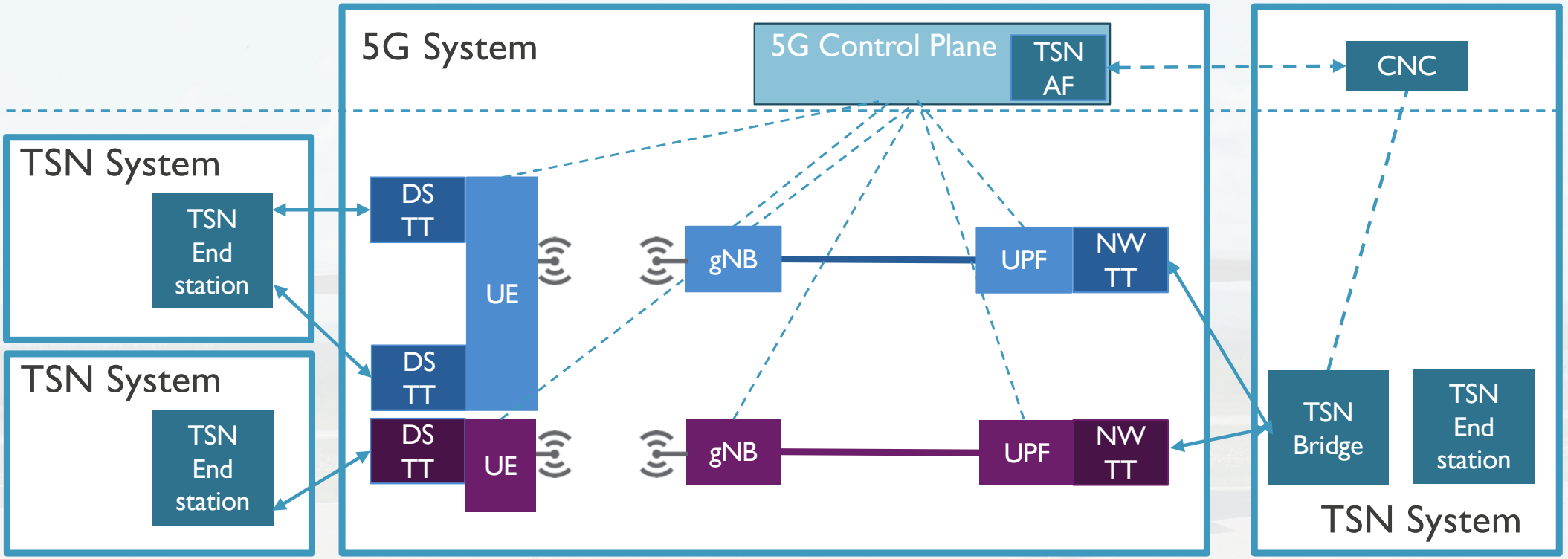
(preemption of eMBB traffic flows, re-transmissions without waiting for feedback, mini-slots and self-contained slots, inter-UE prioritization, etc.)

On top of a massively complex design that does not scale down well and that was driven by different needs*

* See also: Preston Marshall, "Evolving to 6G: the case for a new approach to 6G and beyond"

5G-TSN

5G = logical TSN bridge | translators & mappings



CNC – Central Network Controller | UPF – User Plane Function | AF – Application Function | DSTT – Device Side TSN Translator | NWTT – Network Side TSN Translator


6GSpecNet
Specialized, fit for purpose networks

TSN

Milan

Resource management: centralized / distributed / hybrid, stream reservation protocol, etc.

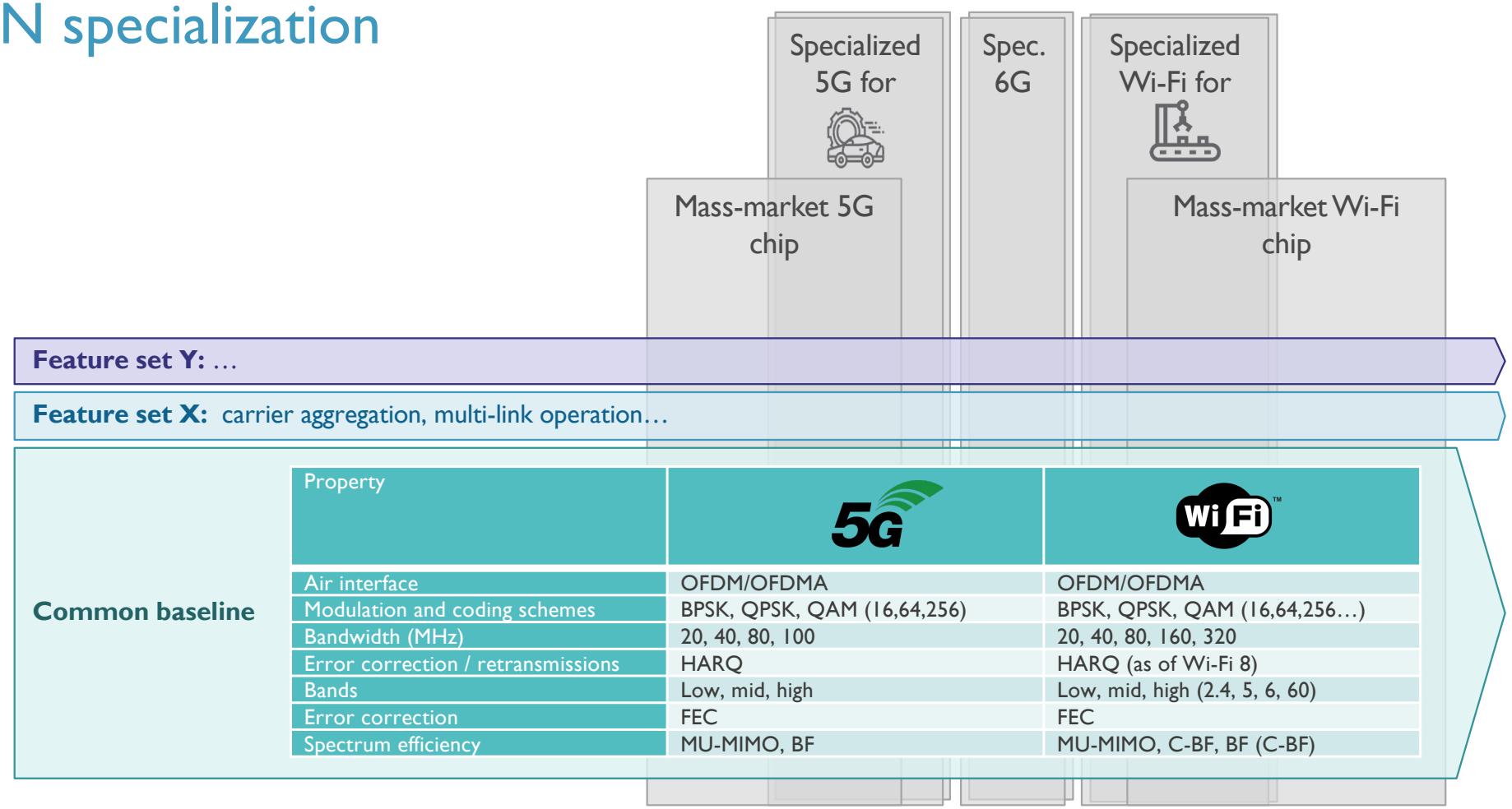
Bounded latency: time-aware shaper, credit-based scheduling, cyclic queuing and forwarding, etc.

Reliability: frame replication and elimination, path control and reservation, reliability for time sync, etc.

Common baseline: Ethernet

6G

RAN specialization



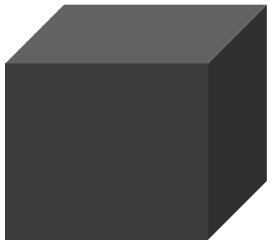
Property	5G	Wi Fi
Air interface	OFDM/OFDMA	OFDM/OFDMA
Modulation and coding schemes	BPSK, QPSK, QAM (16,64,256)	BPSK, QPSK, QAM (16,64,256…)
Bandwidth (MHz)	20, 40, 80, 100	20, 40, 80, 160, 320
Error correction / retransmissions	HARQ	HARQ (as of Wi-Fi 8)
Bands	Low, mid, high	Low, mid, high (2.4, 5, 6, 60)
Error correction	FEC	FEC
Spectrum efficiency	MU-MIMO, BF	MU-MIMO, C-BF, BF (C-BF)

+ customization capabilities

further tailoring to specific needs of TS use cases

evidence-based +

designs driven by proof

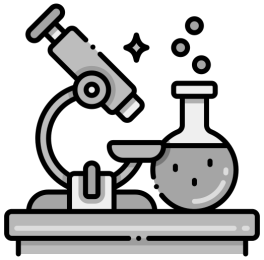


Application-network integration

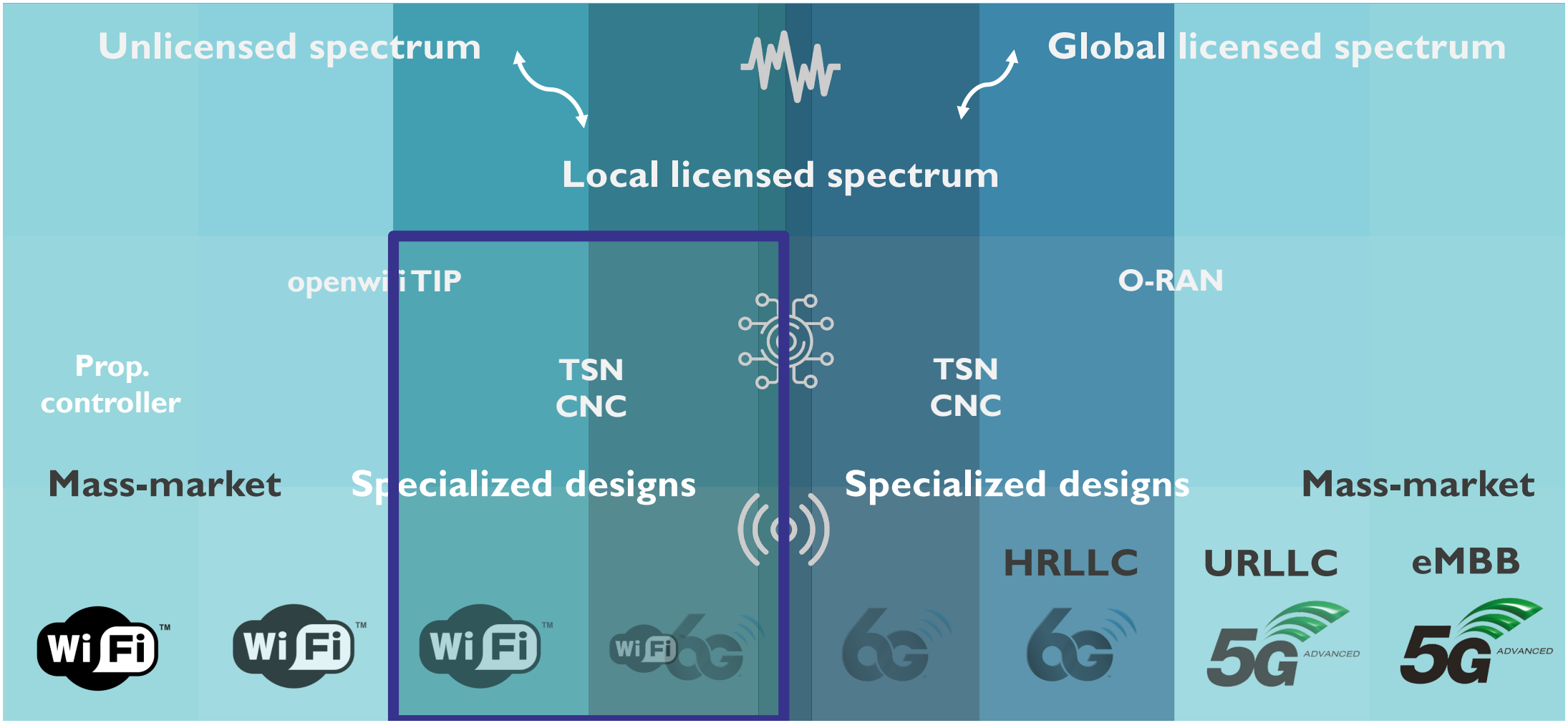
Low-level reconfigurability
Greater level of control over radio capabilities

Programmable hardware (FPGA)
Low-level customization & dynamic reloading

HW & SW



Bigger picture – specialized flavours of varying complexity



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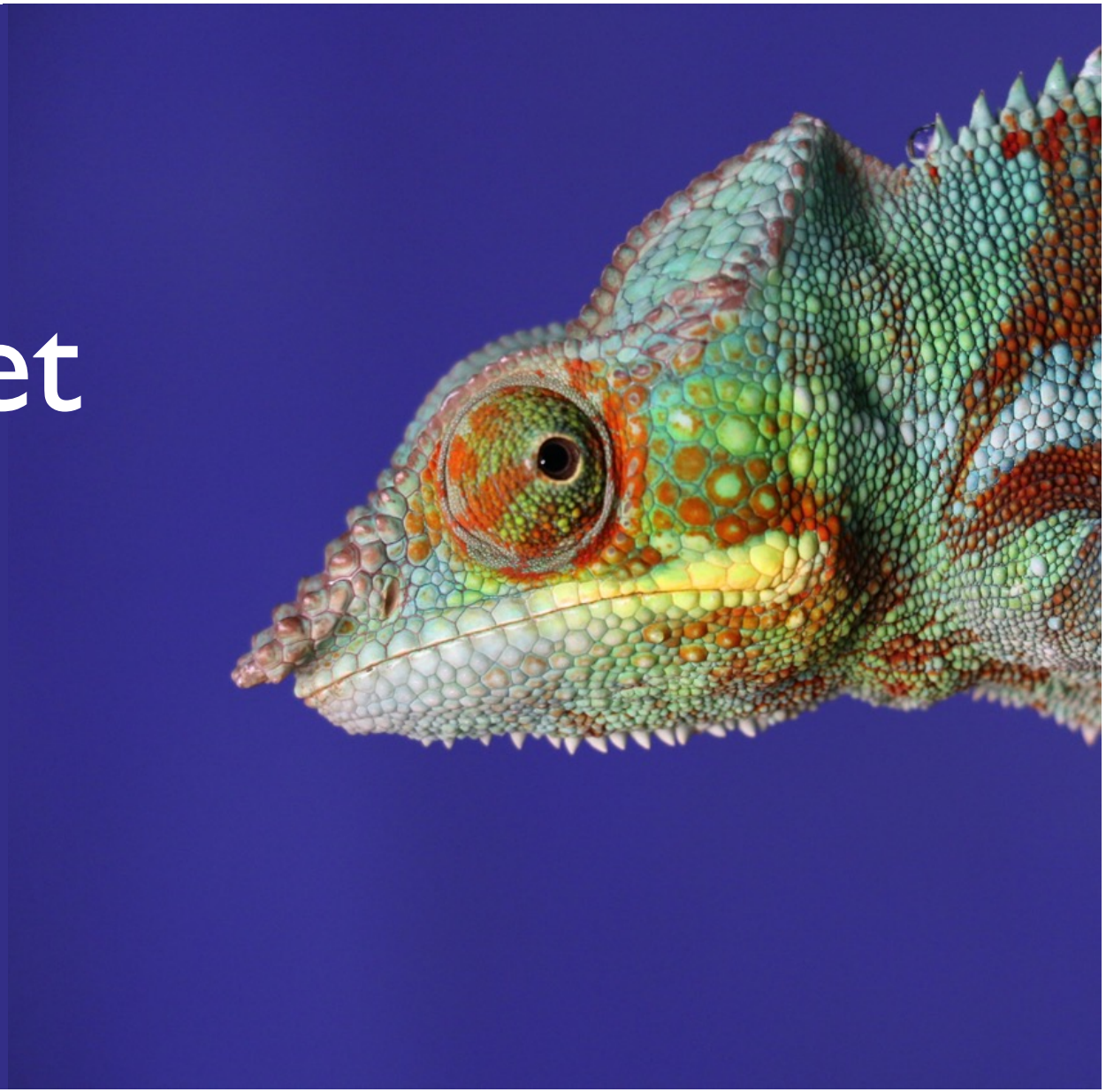
Openwifi



Today

Openwifi

open source initiative®

System-on-Chip

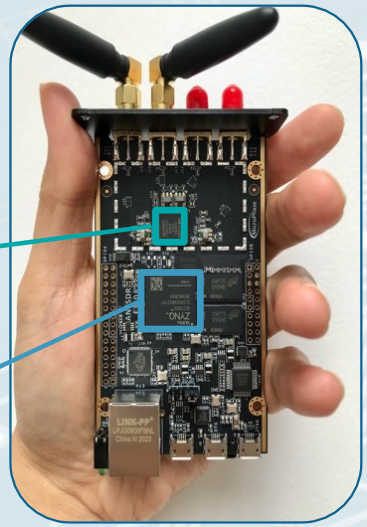
High MAC

PHY + low MAC

CPU processor

FPGA radio

RF FE

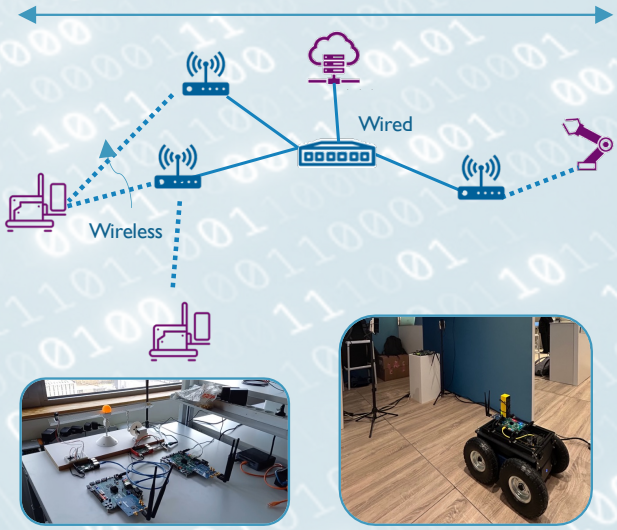


Key Wi-Fi features relevant for W-TSN

W-TSN features

- Time synchronization
- Gating mechanism
- Bootstrapping
- Deterministic handover
- In-band telemetry
- Time-trigger low-level reconf.
- …

Wireless-wired end-to-end guarantees



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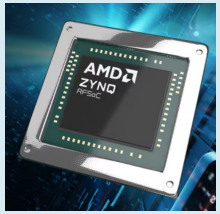
Tomorrow

Advanced platforms
(↑ BW, rate, range)



Local licensed spectrum

<< µs accuracy

Selected next-gen Wi-Fi features

Controller capabilities

TSN CNC

O-RAN ALLIANCE

OpenWiFi
TELECOM INFRA PROJECT


Over-engineering
(and complexity)
Specialization
(and simplification or focused complexity)
Openwifi
TSN
For serving various demanding markets

embracing a better life

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