CEC Continuing Education Center

DesignNews

5G Tech for Industrial Automation

# DAY 2 : IIoT Network Architecture

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# Louis W. Giokas

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# Course Overview

In this course we will analyze the impact of 5G technology on the industrial automation space. 5G has the ability to replace all of the wireless, and most of the wired, technologies in in the IIoT (Industrial Internet of Things), providing direct connection to the cellular infrastructure. This brings with it a simplified and more robust network architecture. It allows direct connection to remote computing resources including cloud computing. We will look at how this will roll out and what the near future will bring as 5G evolves rapidly.

# Class Overview

In this class we look at the network architecture choices available, specifically targeting the IIoT. This includes the layers of devices and connectivity choices. 5G adds flexibility to the network architecture and resilience.  By unifying the communication technologies, 5G adds new considerations to planning and implementation.

# Agenda

- Overview
- Cellular Architecture
- Time Sensitive Networking
- Edge Processing
- External Connections

# Overview

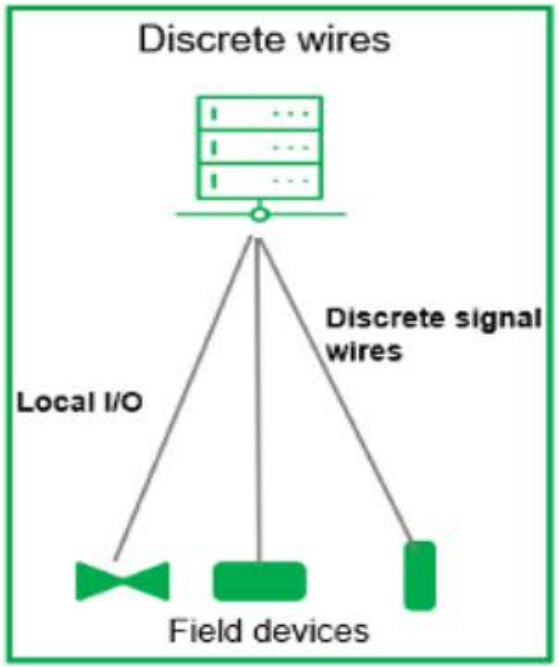
- In this class we look at the networking aspects of 5G IIoT.
- The general strategy is to first give an overview of the cellular aspects of 5G and options available there.
- We next look at the critical technology for IIoT, time sensitive networking.
- We will then move out from the things to edge processing options.
- Finally we will look at connectivity to resources such as data centers and the cloud.

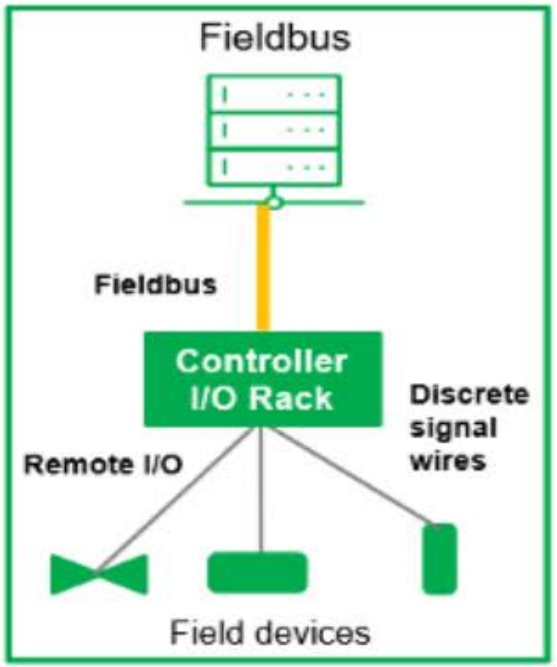
# Overview

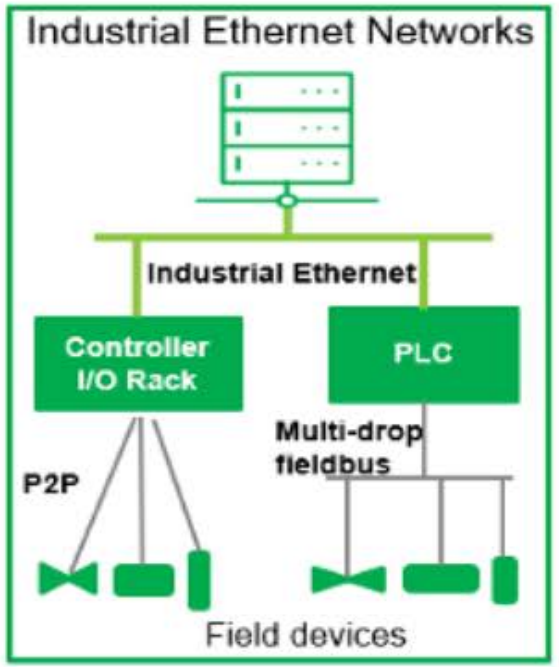
- 5G networks can be set up for roaming, or non-roaming scenarios.
  - The later is the environment we will usually run into in the IIoT.
- The implementation of 5G networks in this scenario allows us to eliminate most wired infrastructure.
- The standards developed leverage those for wired systems.
- Our goal is not to understand all the details of the internal workings of 5G, but to establish the context for using 5G in an industrial setting.

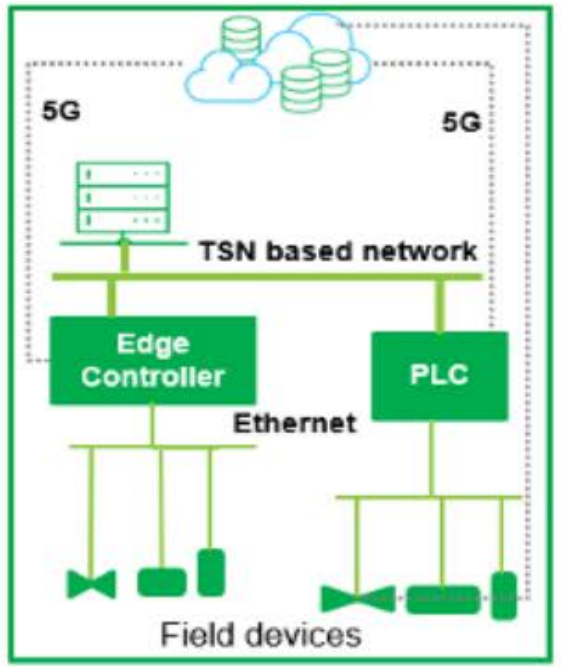
# Overview

1980s → 1990s → Today → 2020s



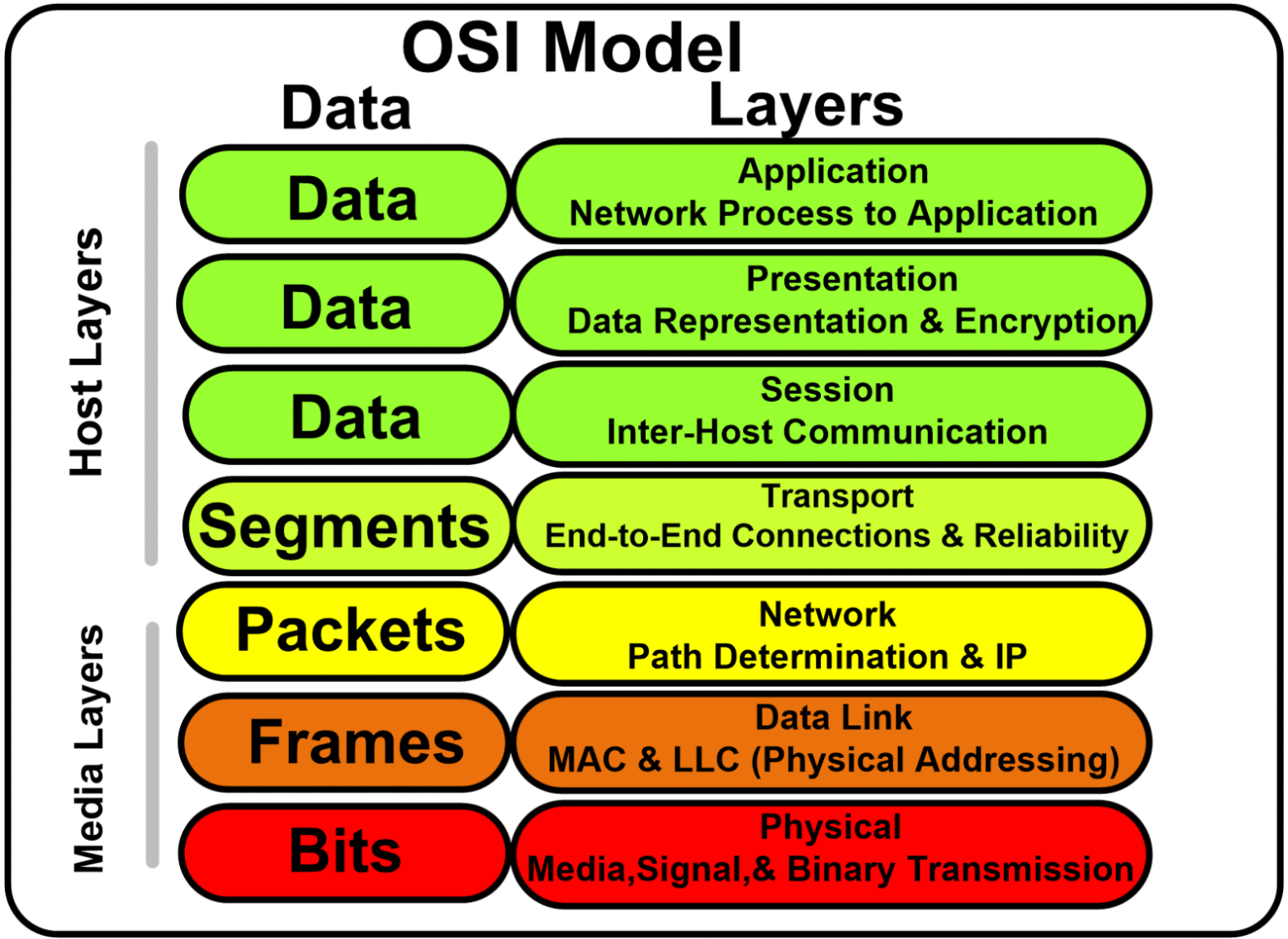



# Cellular Architecture

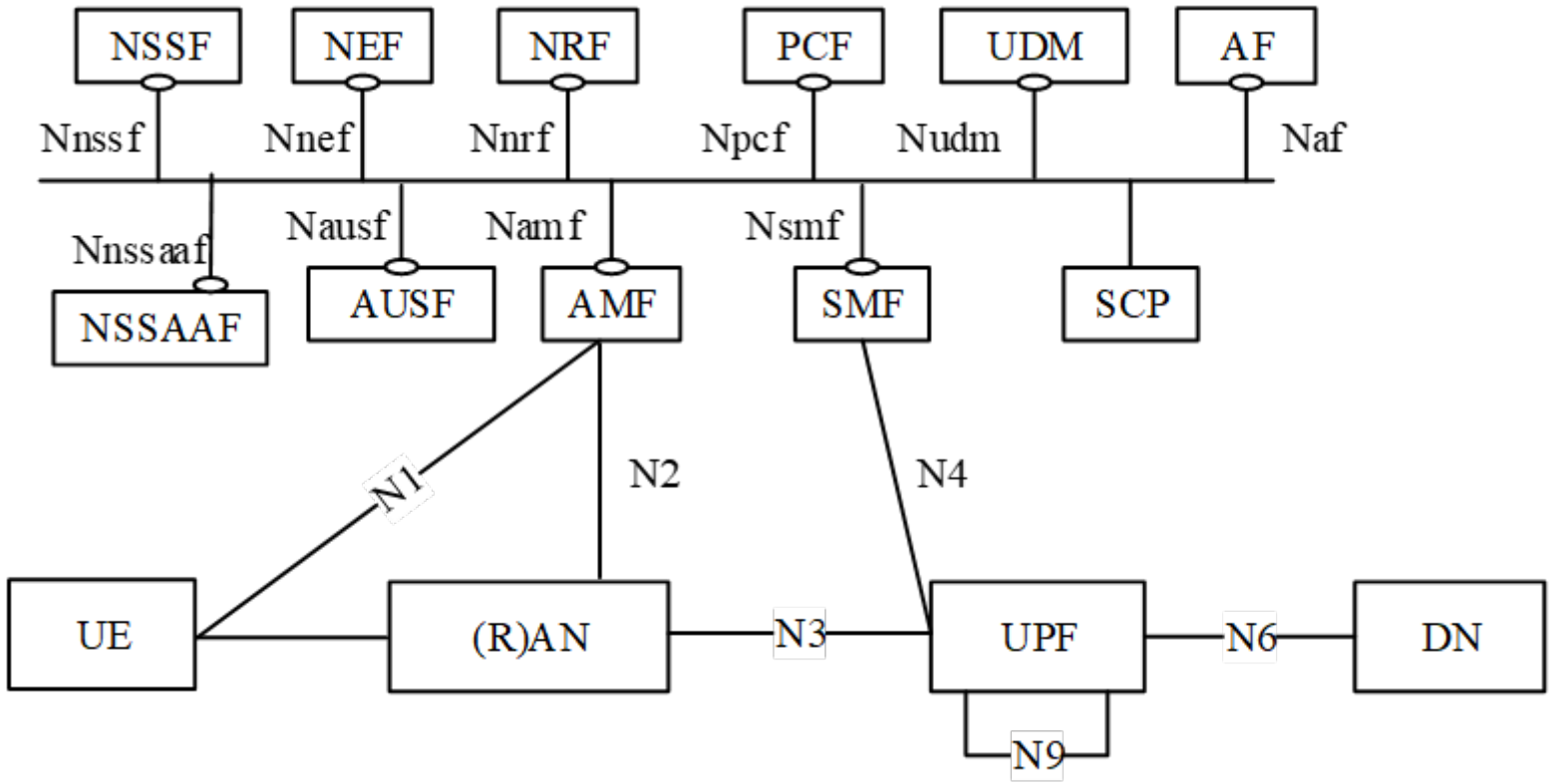
- In the context we are considering, cellular communications are simply another transport mechanism.
- The transport mechanism, or network, does have an effect on the architectures we implement.
- For our purposes we will look at the basic cellular architecture in the context of a non-roaming environment, and can thus avoid the issues of cell hand-off, etc.

# Cellular Architecture

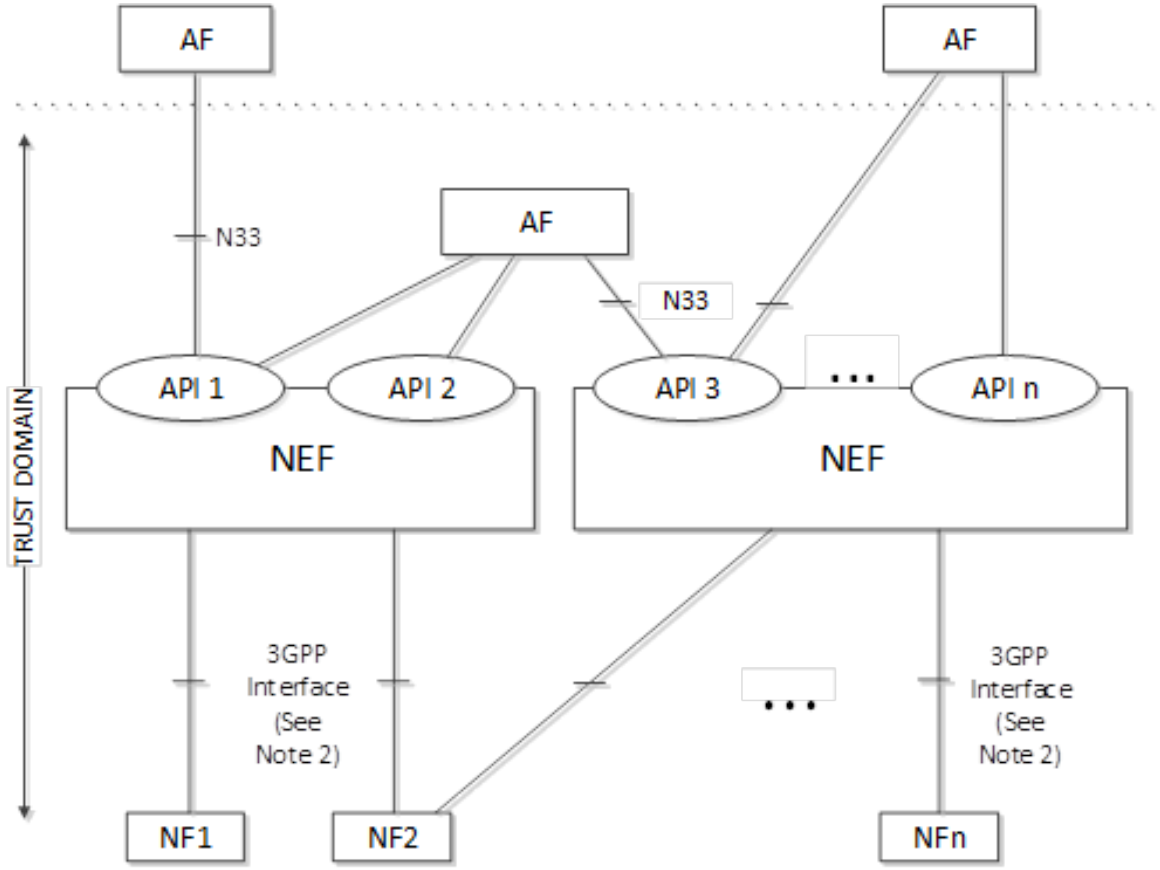
For reference, the 5G Network covers the Media Layer part of the model.



# Cellular Architecture: Non-Roaming Reference



# Cellular Architecture




AF: Application Function
NEF: Network Exposure Function
NF: Network Function

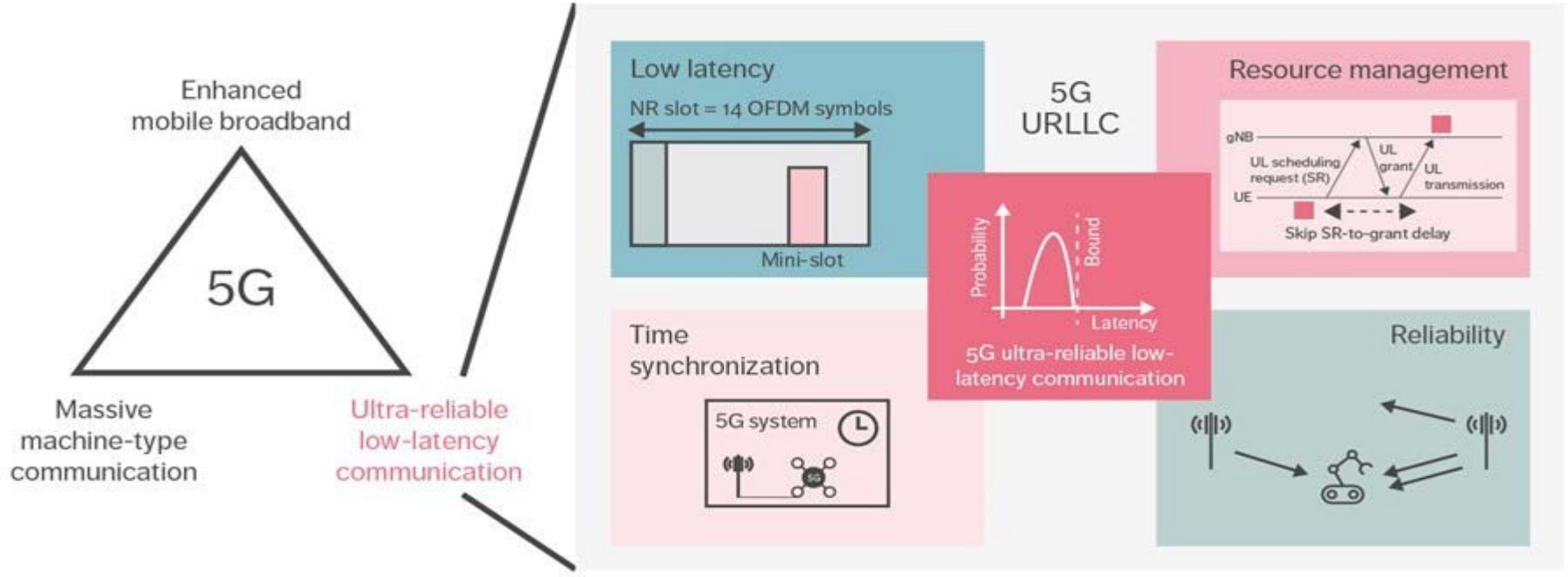
# This slide is a placeholder for a participant question.

Please use it in each position you would like a participant question included. It will be hidden in the live presentation and replaced with the interactive question you submit.

# Time Sensitive Networking

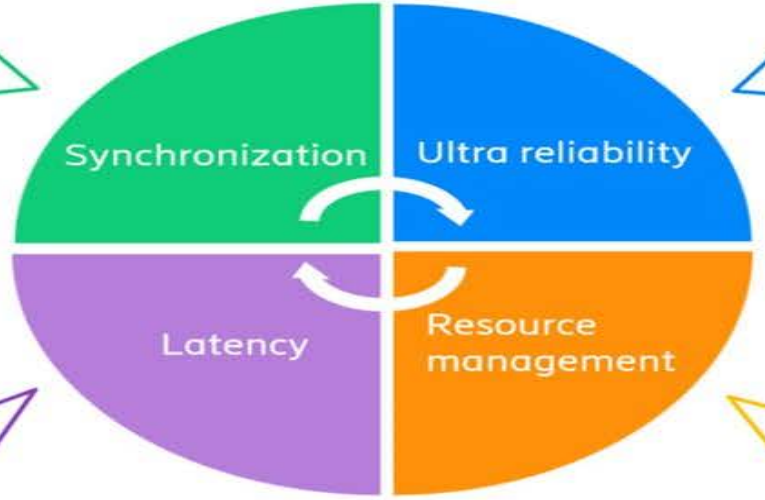
- TSN (Time Sensitive Networking) is the term used in the standards world to describe deterministic services.
- Original application and standards were geared toward Ethernet wired services (IEEE 802.3).
- There are a number of IEEE Standards and extensions to existing standards involved.
- The enabling 5G feature is URLLC

# Time Sensitive Networking



# Time Sensitive Networking

**Time Synchronization:**
Timing and Synchronizations (802.1AS) includes a profile of IEEE 1588 (revision ongoing: P802.1AS-Rev)




**Ultra reliability:**
Frame Replication and Elimination (802.1CB)
Path Control and Reservation (802.1Qca)
Per-Stream Filtering and Policing (802.1Qci)
Reliability for time sync (P802.1AS-Rev)

**Bounded low latency:**
Credit Based Shaper (802.1Qav)
Frame preemption (802.1Qbu)
Scheduling Traffic (802.1Qbv)
Cyclic Queueing and Forwarding (802.1Qch)
Asynchronous Traffic Shaping (P802.1Qcr)

**Dedicated resources & AP**
Stream Reservation Protocol (802.1Qat)
TSN configuration (802.1Qcc)
Basic YANG (802.1Qcp)
Link-local Registration Protocol (P802.1CS)
Resource Allocation Protocol (P802.1Qdd)
YANG for CFM (P802.1Qcx)
YANG for LLDP (P802.1ABcu)
YANG for Qbv, Qbu, and Qci (P802.1Qcw)
YANG & MIB for FRER (P802.1CBcv)
Extended Stream Identification (P802.1CBdb)

Note: P upfront of an ID indicates ongoing Project

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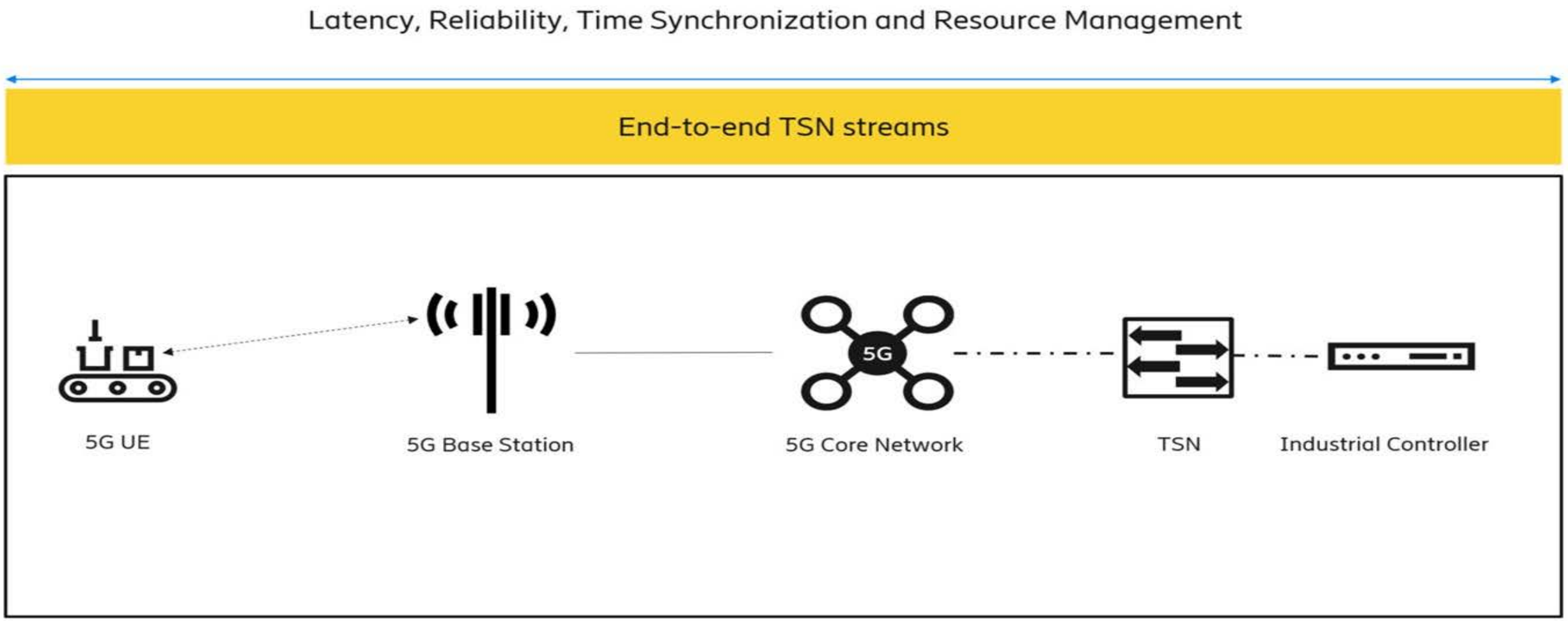
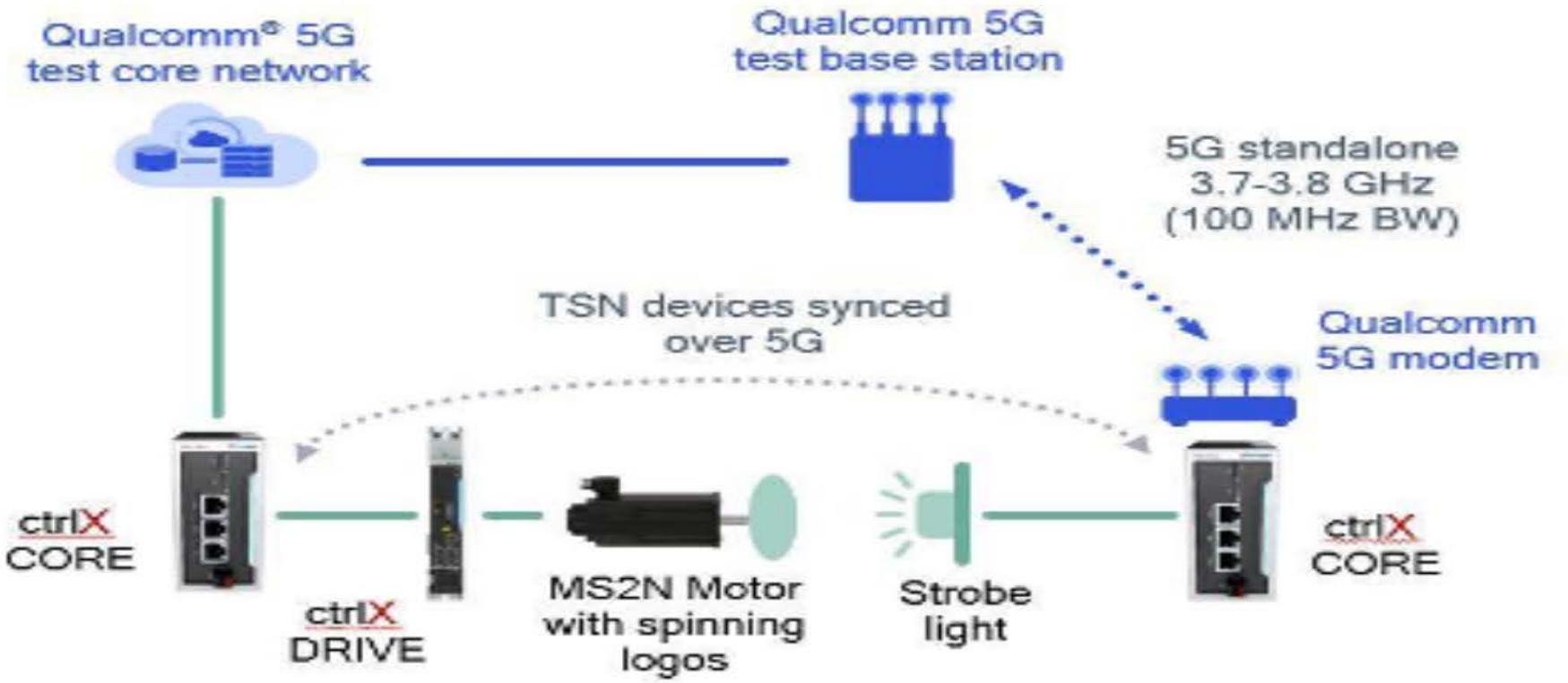
# Time Sensitive Networking



# Time Sensitive Networking: A Reference System

Qualcomm

rexroth
A Bosch Company




Qualcomm 5G test network and 5G industrial test device with 5G modem

Bosch Rexroth ctrlX CORE controllers, ctrlX DRIVE, MS2N motor and strobe light

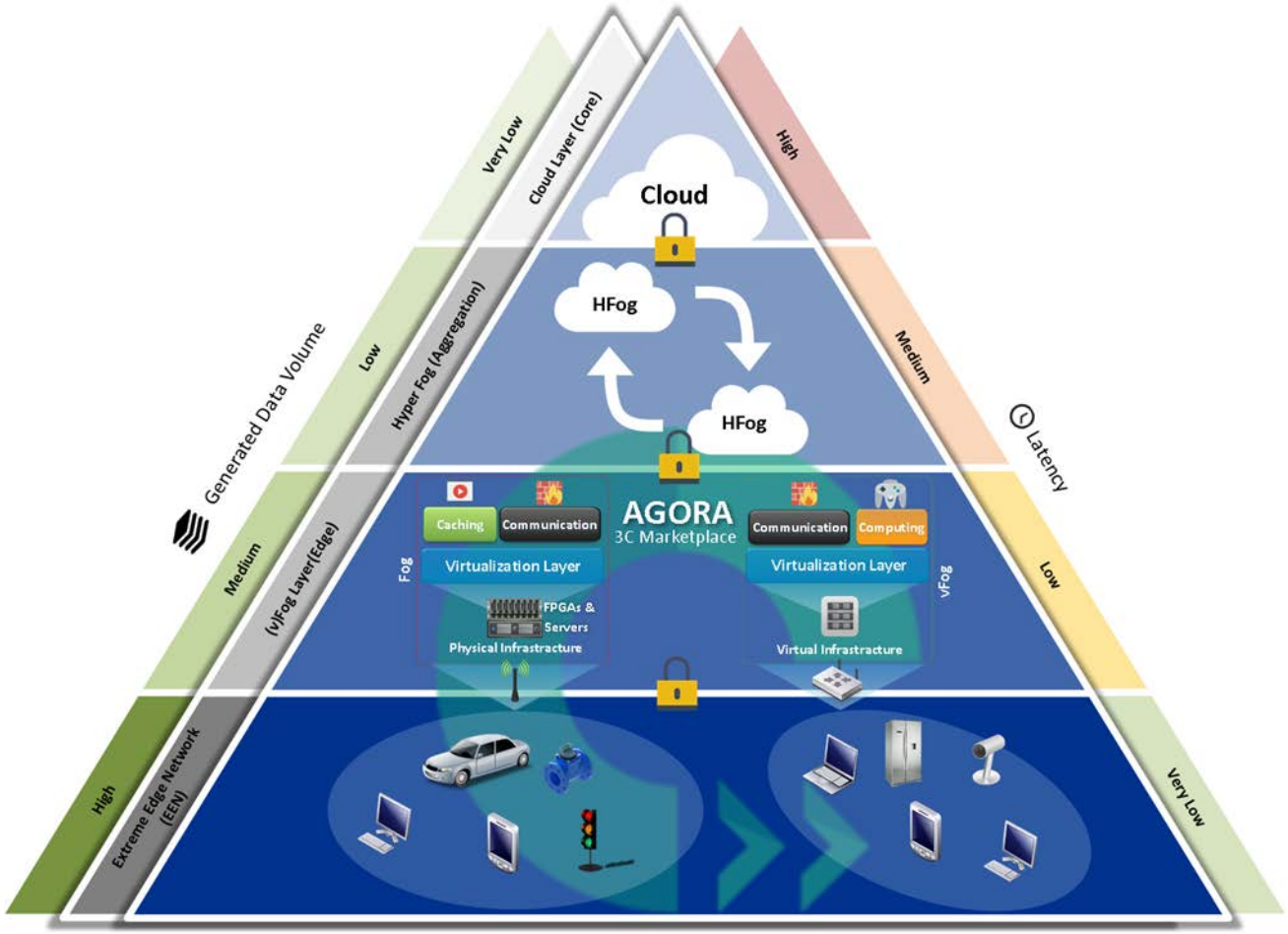
## Edge Processing

- Edge processing allows us to bring processing power closer to the application environment, rather than relying on a data center or the cloud.
- New and powerful processing elements allow the implementation of complex algorithms (such as Machine Learning) into the industrial setting.
- I have given CEC courses on both these topics:
  - Edge Processing for the IoT (2017)
  - IoT and Analytics (2016)
  - IoT Algorithms (2016)
- These might need some updating, but provide a valuable reference for understanding the use of edge processing in this setting.

# Edge Processing

- We can use edge processing in this context to move equipment and functions away from environments that might be hostile to computing elements and thus harder and more expensive to implement.
- Edge processing also allows us to use more powerful processors and to implement several functions on one processing element.
  - Allows enhanced functionality by coordinating many machine functions more effectively.

# Edge Processing: A Reference Architecture



# Edge Processing

- Device Types
  - Conventional CPUs, both single core and multi-core.
  - FPGAs (Field Programmable Gate Arrays)
    - Fast signal processing
    - Configurable
    - Often combined with CPUs
  - GPUs (Graphics Processing Units)
  - Novel and new processor types such as chips designed to implement Neural Networks.

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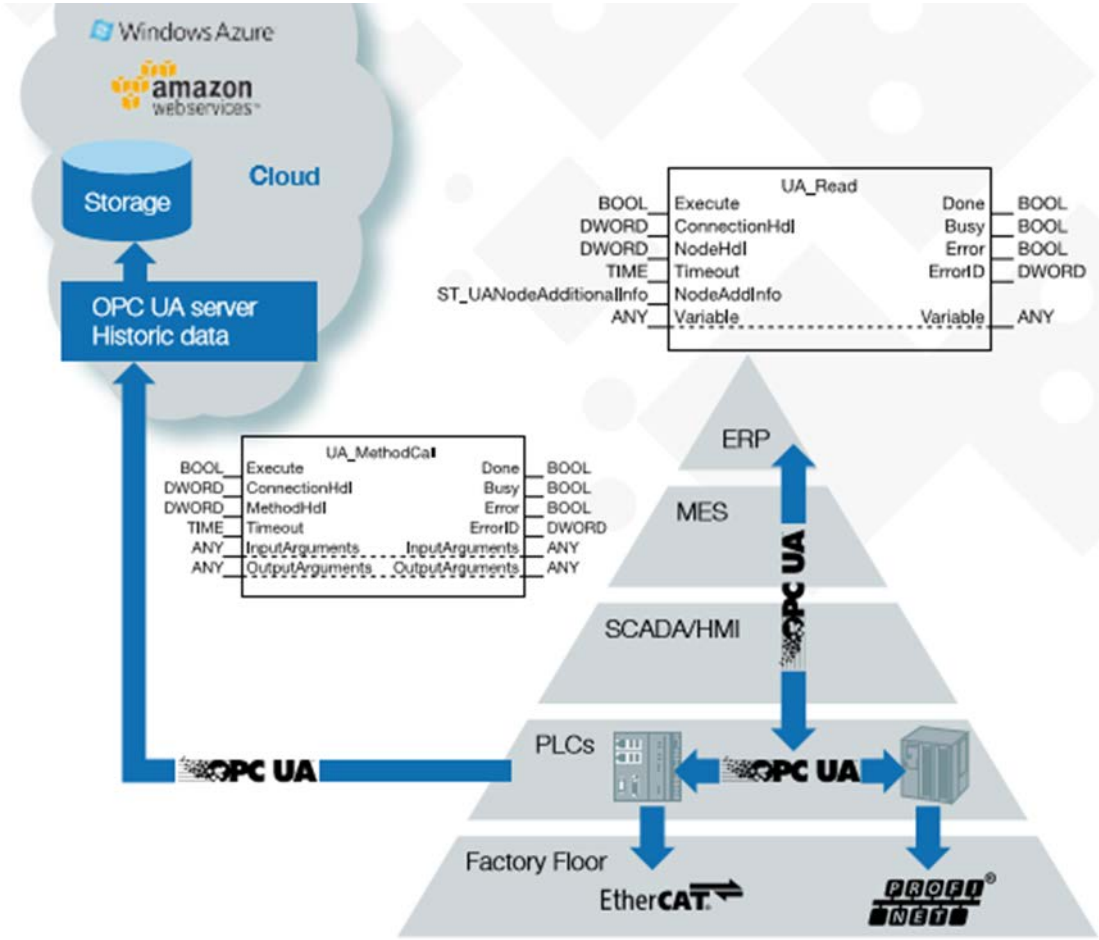
# External Connections

- In many cases we want to access other networks, as well as remote computing resources.
- For networking we will use gateways to wired, or increasingly wireless, connectivity.
- A private network in a plant can be connected, as needed to, the public 5G network, as well as to the Internet
- Allows access to resources such as the cloud for long term storage and analytics.

# External Connections

This is a reference architecture connecting an industrial site with functions such as ERP and cloud resources.
Using 5G we can eliminate many of the wired components.



# Thank you for attending

Please consider the resources below:

- For 5G details see the 3GPP site.
- IEEE has resources for the standards, references in the previous class.

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# Thank You

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