The Future of 5G on the Factory floor

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HMS Industrial Networks

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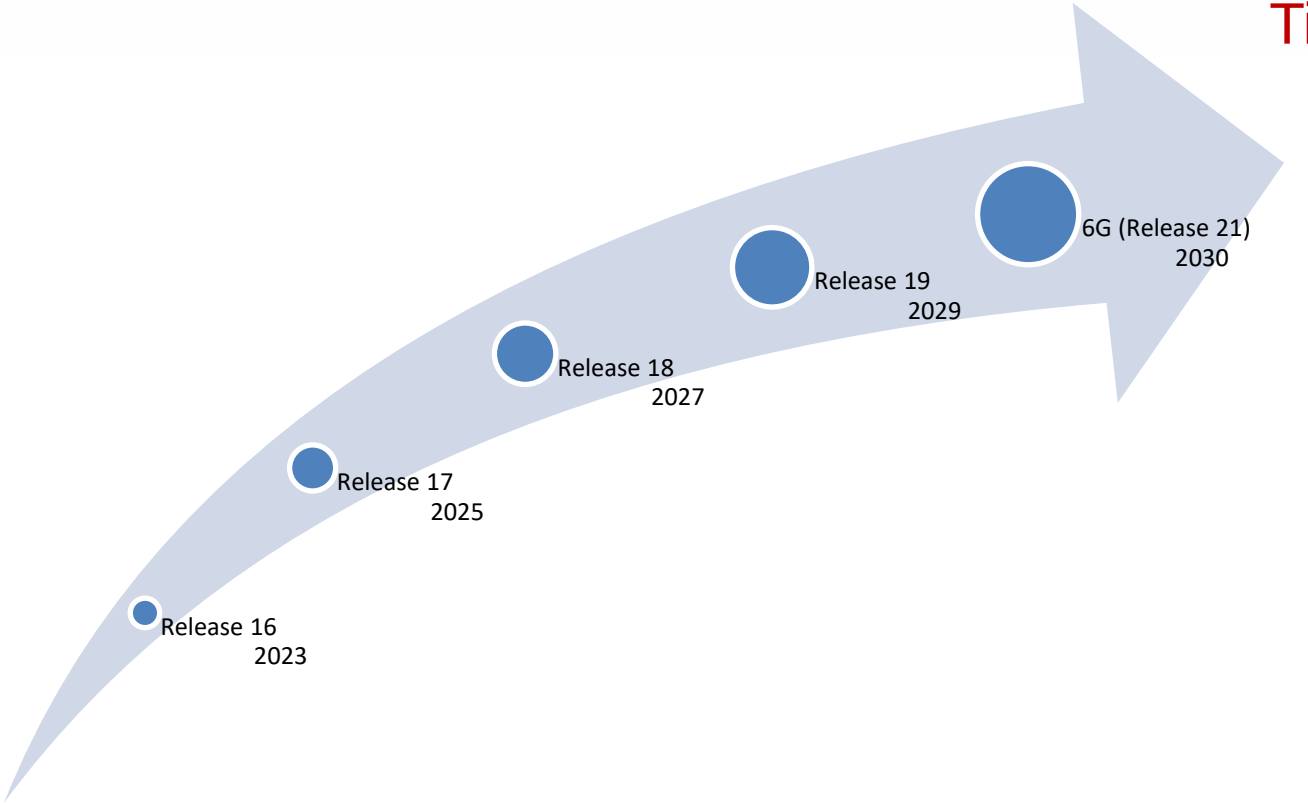
Timeline



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Release 16 Technologies

- URLLC enhancements
  - Traffic Scheduling enhancements
    - Priority of priorities
  - IP routable compression
  - Reliability enhancements through downlink sub-slot monitoring

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Release 16 Technologies

- URLLC enhancements

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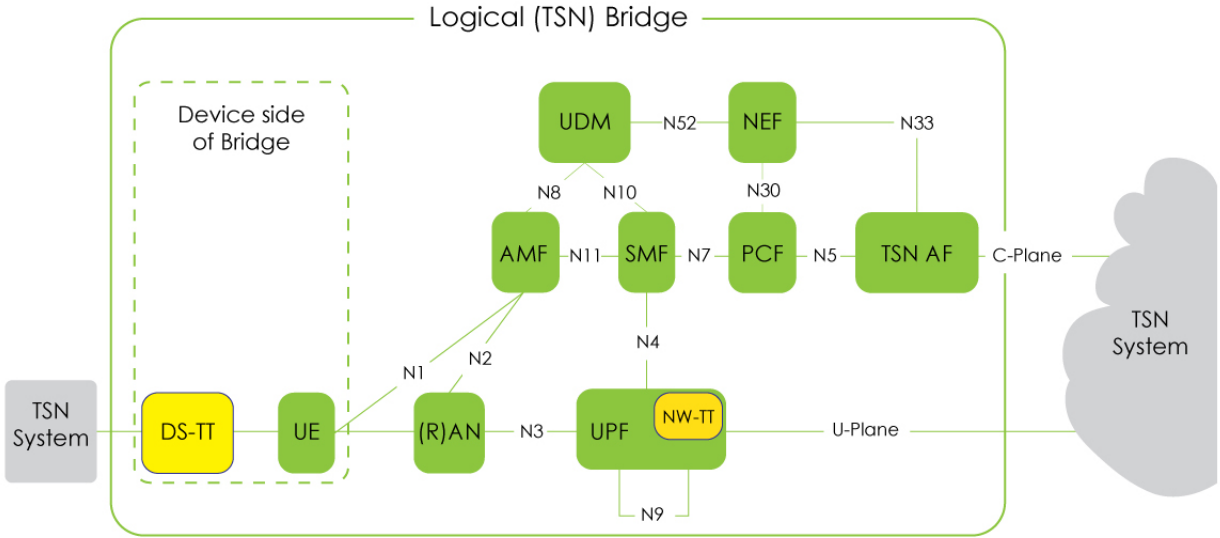
TSN Enablement



System architecture view with 5GS appearing as a Time-Sensitive Networking bridge

TS 23.501

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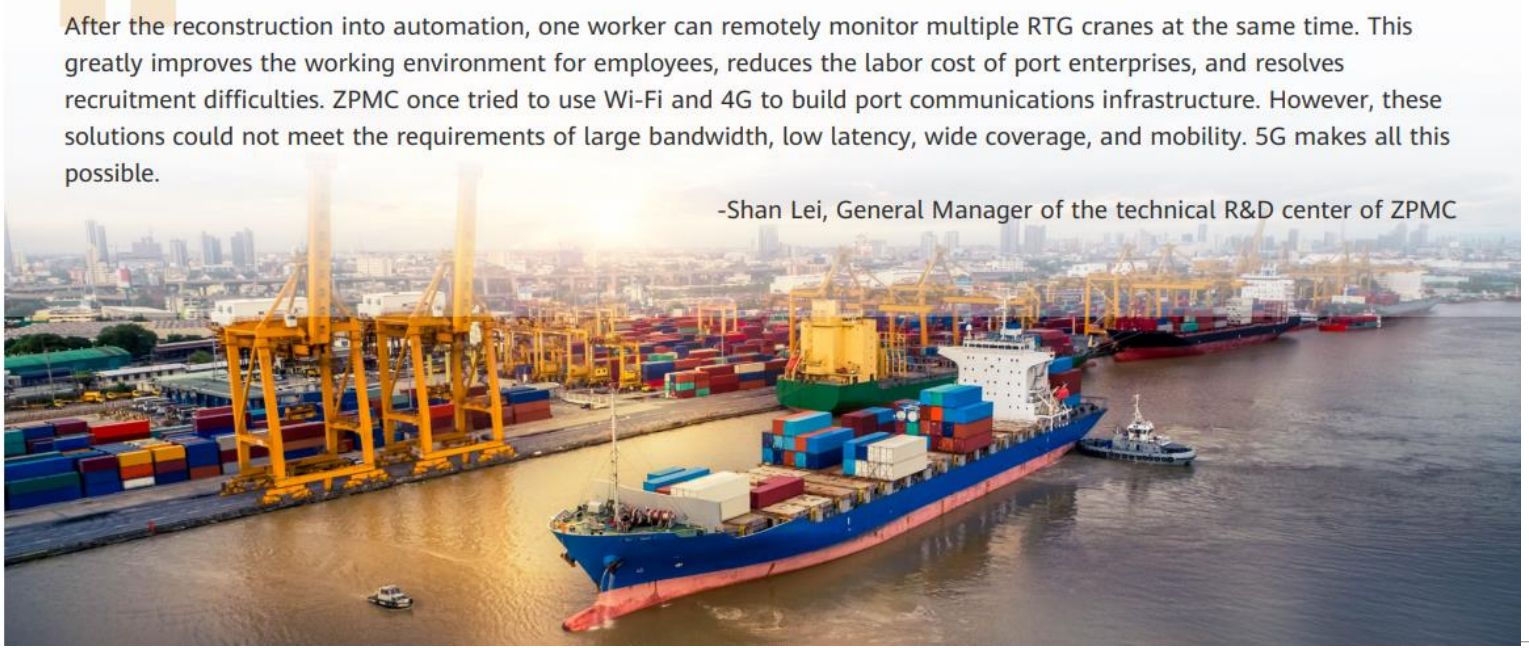
TSN Enablement

> After the reconstruction into automation, one worker can remotely monitor multiple RTG cranes at the same time. This greatly improves the working environment for employees, reduces the labor cost of port enterprises, and resolves recruitment difficulties. ZPMC once tried to use Wi-Fi and 4G to build port communications infrastructure. However, these solutions could not meet the requirements of large bandwidth, low latency, wide coverage, and mobility. 5G makes all this possible.
>
> -Shan Lei, General Manager of the technical R&D center of ZPMC



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Continued Challenges

- IP routing challenges
  - SGMP Snooping
  - Discovery protocols
  - DLR
    - Layer 2 protocols

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Continued Challenges

- IP routing solutions
  - Ethernet PDU's
  - GRE
  - VXLAN

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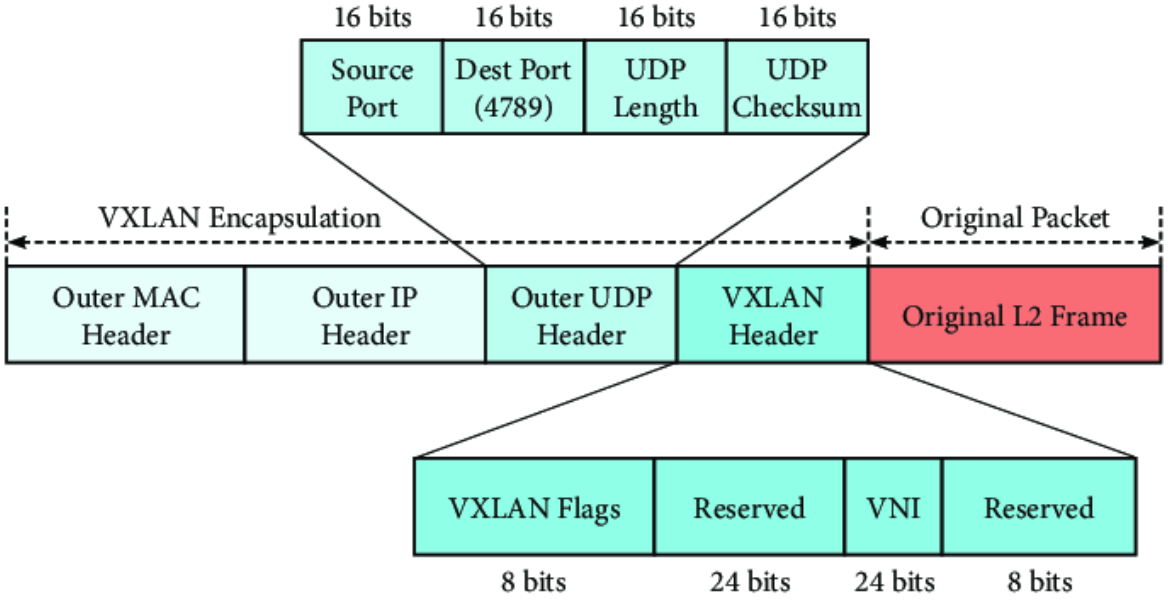
Continued Challenges



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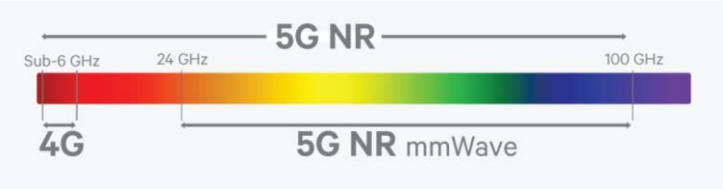
mmWave Enhancements

- Higher frequency, shorter lengths
  - Beamforming can increase this
- Much larger Bandwidth
  - 40x Compared to 4G



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mmWave Enhancements

- Within mmWave range
- Short or long packet processing necessary
- Possible control loop thru 5G

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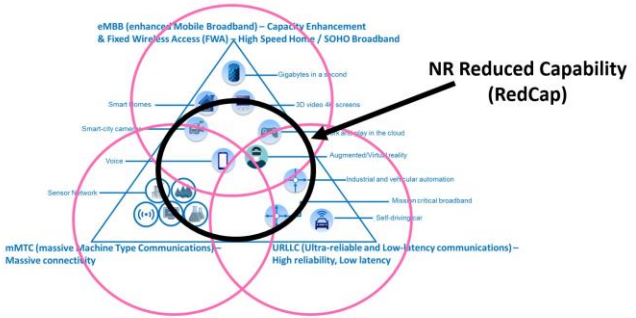
Reduced Capacity (RedCap)

- Power efficient 5G
- Better determinism, lower cost products
- Reduced cost, battery powered sensors

Release-17: Motivation for NR Reduced Capability



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URLLC Enhancements

- Enable Timing principles on the Transport network
- Timing Synchronization status and reporting
- Service time based on Subscription

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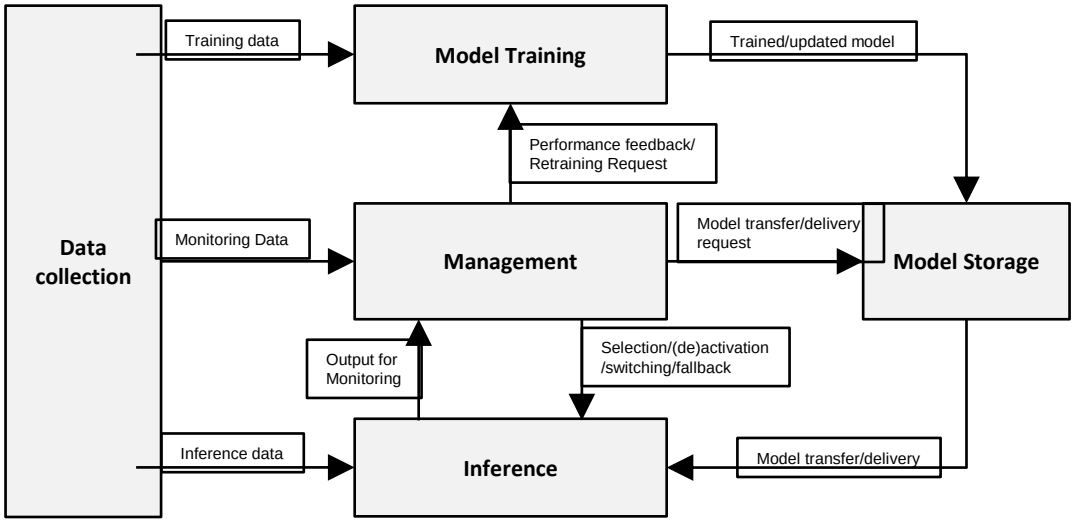
AI/ML Framework



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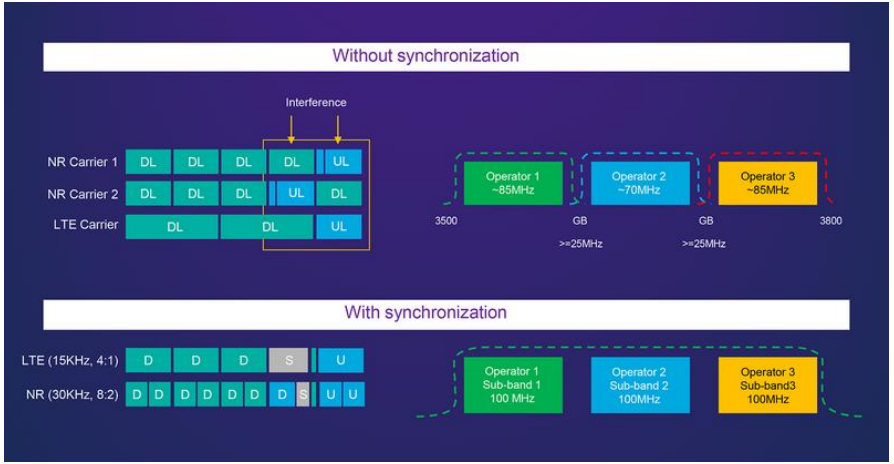
URLLC Enhancements

Timing Synchronization status and reporting



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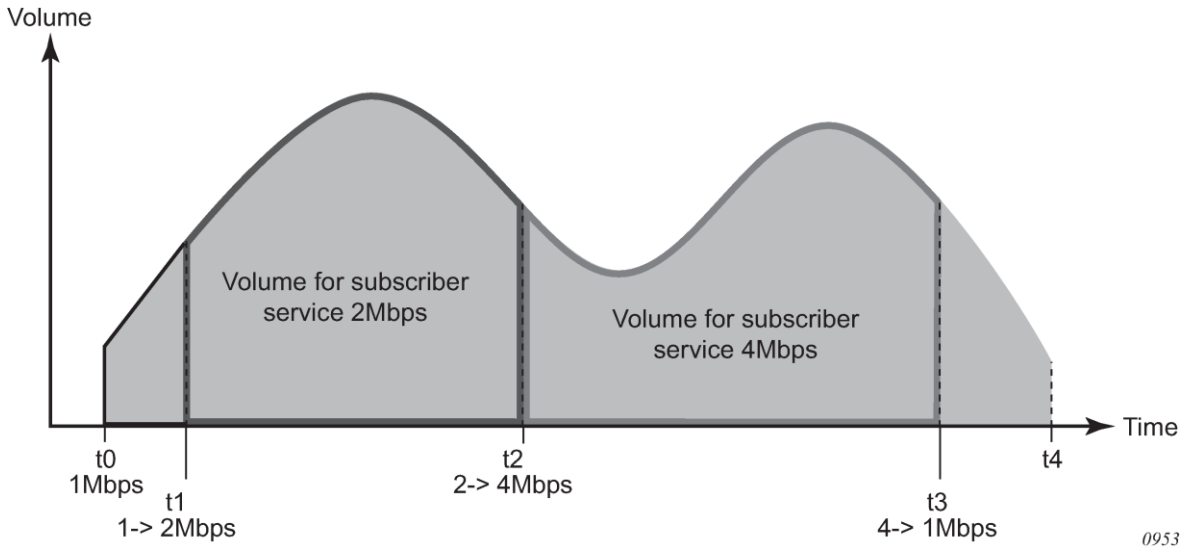
Service time based on Subscription



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- Ambient IoT
- Batteryless Connectivity
- Overall Goal: Integrated sensing and communication

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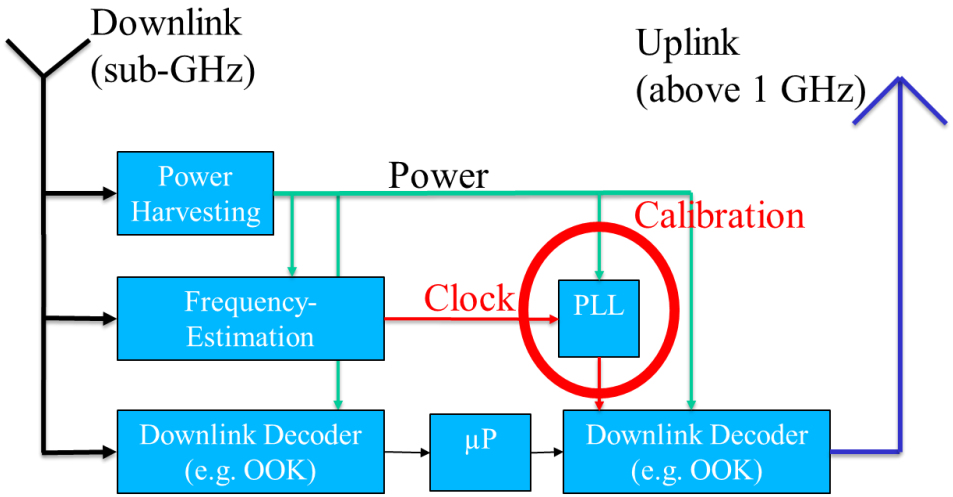
- Biggest Energy consumer is crystal Oscillator
- Use the signal!



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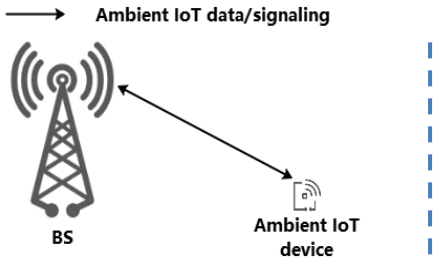
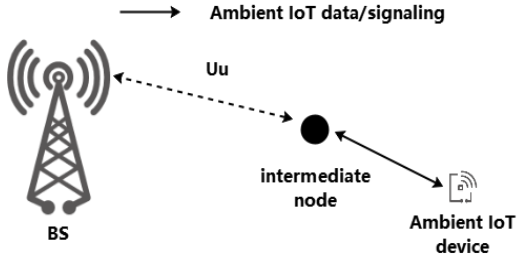
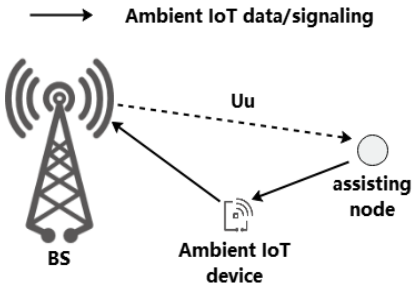
Topologies



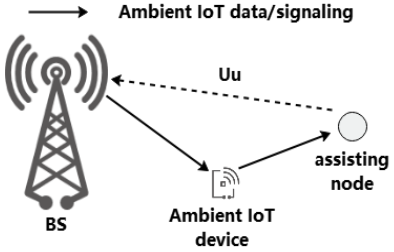
Topology 1



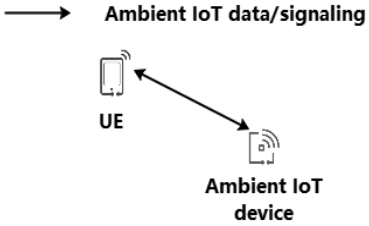
Topology 2



Topology 3a with downlink assistance



Topology 3b with uplink assistance



Topology 4

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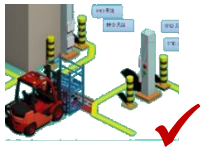
Failure of RFID

RFID only fits short range single-point operation, still needs human resource



RFID does not support large area continuous coverage, infeasible to meet industry demand of whole-process automation

Source: Global RFID Sensor Market, Global Industry Analysis, Size, Share, Growth, Trends and Forecast, 2021–2031

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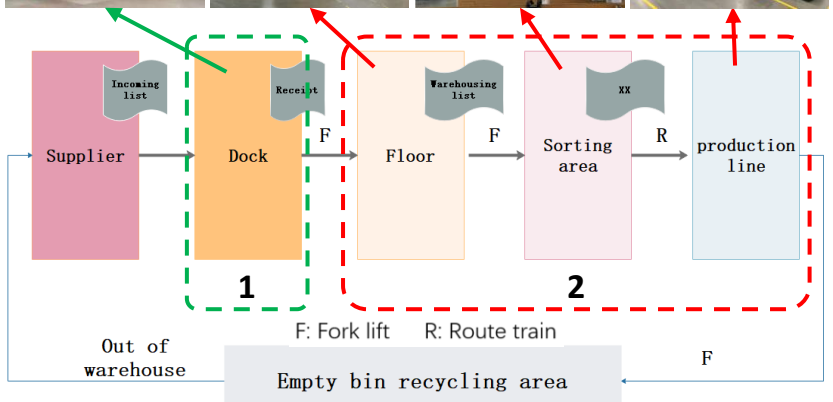
Ambient IoT for Intralogistics in Automobile Manufacturing

Dock
- **Fast Reading for non-stop forklift**
  - 100 tags/s
- **In/out detection of forklift**
  - Tag moving direction

Floor, Sorting area, Production line
- **Block detection of containers**
  - Positioning to detect the block in which a dedicated tag is placed, with accuracy of 1~3 meters
- **Seamless coverage**
  - Simple deployment and network planning
- **Real-time inventory**
  - Thousands of tags read in a few minutes



Typical plant covers a total area of around 400,000 ~ 600, 000 square meters

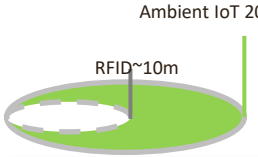
Commercial deployment of RFID in dock area of factory 1

RFID has been commercially deployed in the dock area :
- Short communication range is not a problem as all tags go through gates

	Equipment	Maintenance	Tag	Total
RFID in dock area	X	2X	4.6X	7.6X

30 Readers @ 20 gates; 800,000 tags

Extension to all areas of factory 2

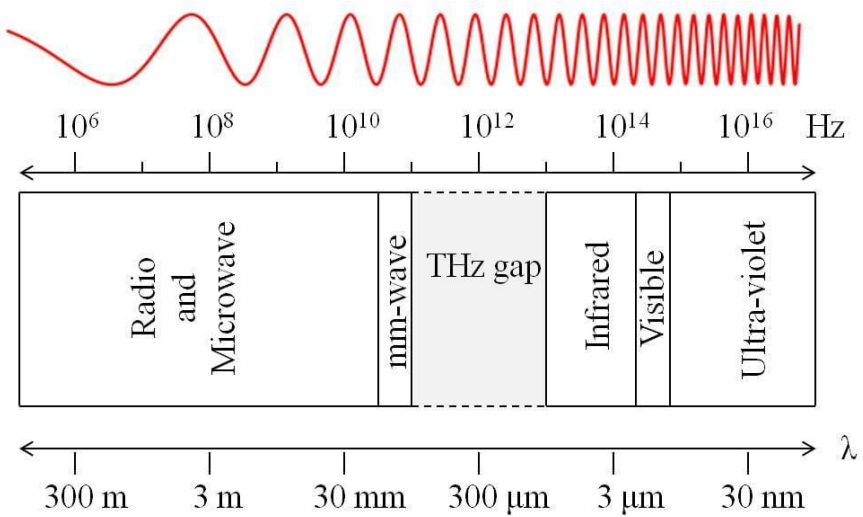


To cover a total area of 1300*18m*18m, the cost of RFID and Ambient IoT are as follows

	Equipment	Maintenance	Tag	Total
RFID Coverage: 8m*8m	223X	7.6X	4.6X	235.2X
	6581 Readers and 800,000 tags			
Ambient IoT Coverage: 18m*18m Positioning:1~3m@90%	44X	7.6X	4.6X	56.2X
	1300 Readers and 800,000 tags			

- RFID is only suitable to be deployed in dock area, a small part of factory
- Seamless coverage and positioning are key requirements for mature solution

- More data, less distance
- Deterministic gap



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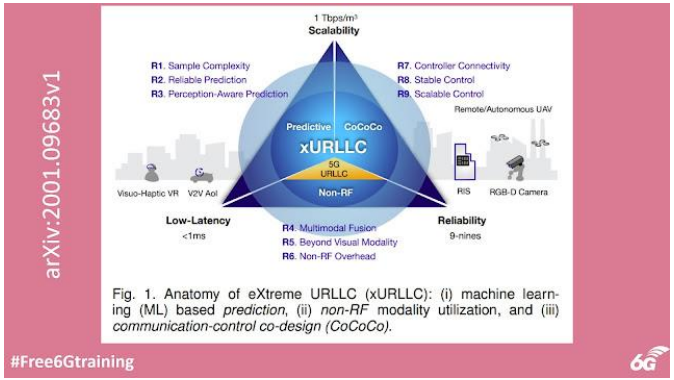
Sub URLLC

- Embedded machine learning
- RF & non-RF
- Joint communication & Control Design



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