ISO/IEC JTC 1/SC 6 **N 17531**

ISO/IEC JTC 1/SC 6 "Telecommunications and information exchange between systems"
Secretariat: **KATS**
Committee Manager: **OH Jungyup Mr**

PWI proposal on Deterministic Wireless Industrial Network

Document type	Related content	Document date	Expected action
General document / Other		2021-07-13	**COMMENT/REPLY** by 2021-08-13

Replaces : N-17529 NWIP on Industrial Wireless Network

Description

Source: Korean NB

This document is circulated for review and consideration at JTC 1/SC 6 meeting in August-September 2021.

Preliminary Work Item Proposal on Deterministic Wireless Industrial Network

July 1, 2021

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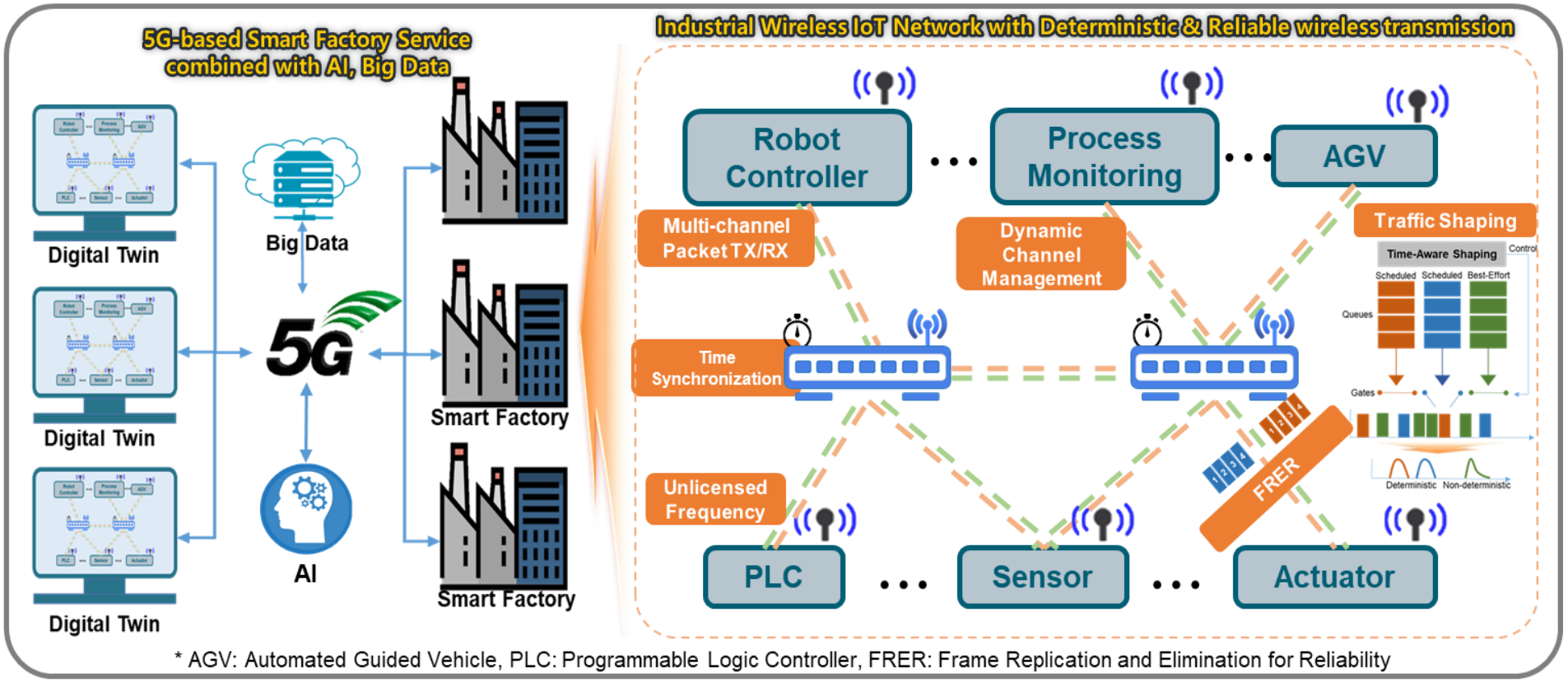
ETRI, KOREA

Wireless Industrial Network (I)

- Use case of wireless industrial network
  - wireless network in factory automation



Wireless Industrial Network (II)

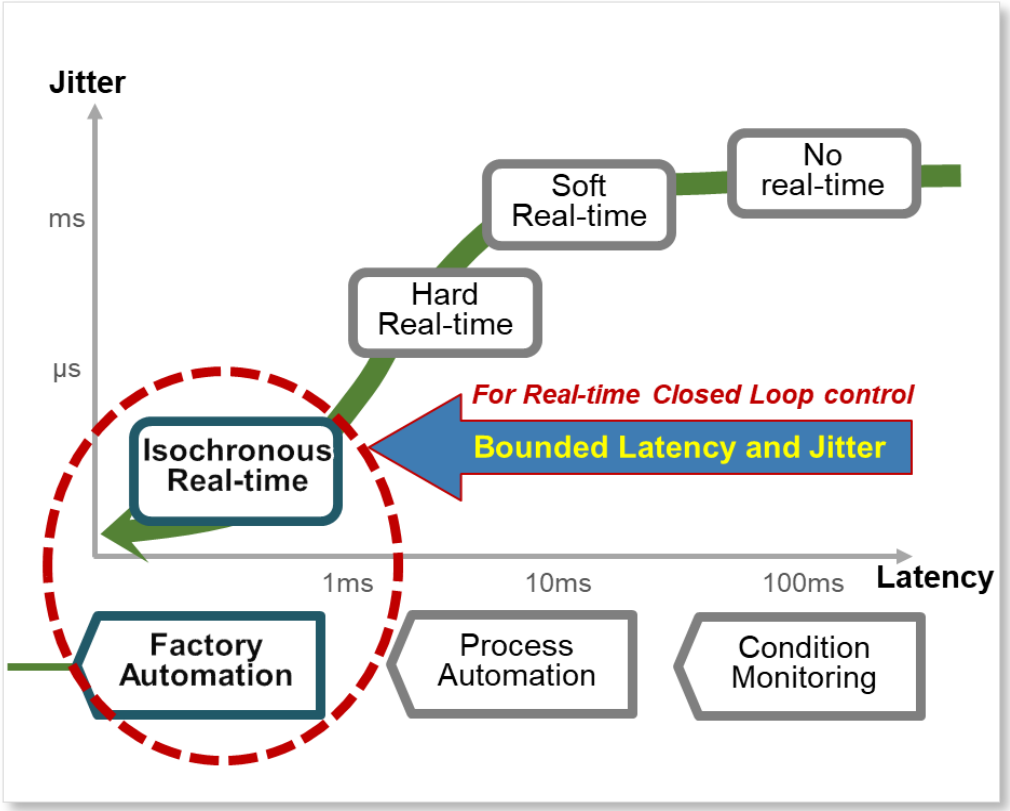
- Requirements of industrial applications & real-time classes
  - factory automation, process automation, condition monitoring

	Number of end nodes	Cycle time [ms]	Data size [Byte]
FA	2 - 50	0.25 - 30	15 - 64
PA	100 - 300	1 - 5000	30 - 1500
CM	100 - 1000	100 - 10 000	30 - 1500

< Requirements of industrial applications >

Real-time class	Type of control	Real-time requirements Latency	Jitter
No real-time	CM	≥100 ms	-
Soft real-time	CM & PA	10 - 100 ms	-
Hard real-time	PA & FA	1 - 10 ms	≤1 ms
Isochronous real-time	FA	≤1 ms	≤1 µs

< Requirements of industrial real-time classes >



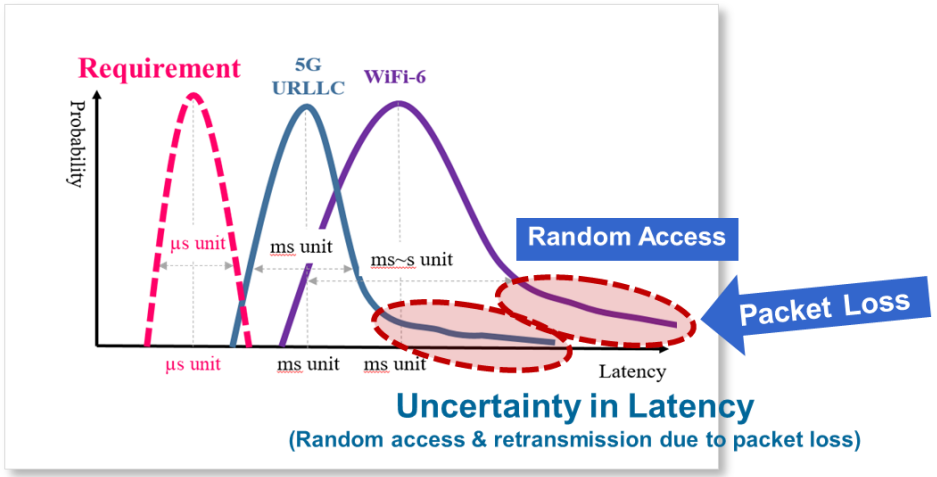
source: S.Dietrich, G. May, O. Wetter, H. Heeren, and G. Fohler, "Performance indicators and use case analysis for wireless networks in factory automation, " IEEE International Conference on Emerging Technologies and Factory Automation(ETFA), 2017

Wireless Industrial Network (III)

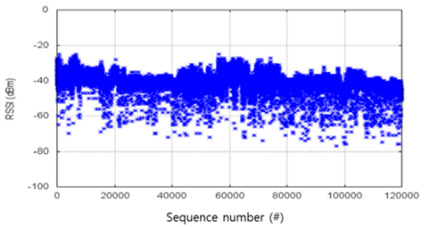
- Requirements on wireless industrial network
  - deterministic & reliable wireless transmission for closed loop feedback control
    - Isochronous real time shall be supported
  - bounded latency and jitter
    - latency <1ms
    - jitter < 1us
    - cycle time = 0.25~30ms
  - high reliability
    - packet error rate $<10^{-6}$
  - multi nodes(sensor/actuators)
    - max. 120 nodes
  - ISM band
    - private local network

Isochronous Real Time for real-time closed loop control
: No retransmission opportunity due to short latency allowed

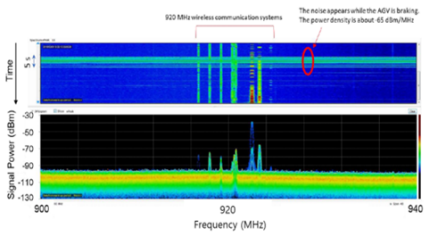
Characteristics of Deterministic Latency



Uncertainty in Wireless Channel in factory environment



< RSSI fluctuation in factory >

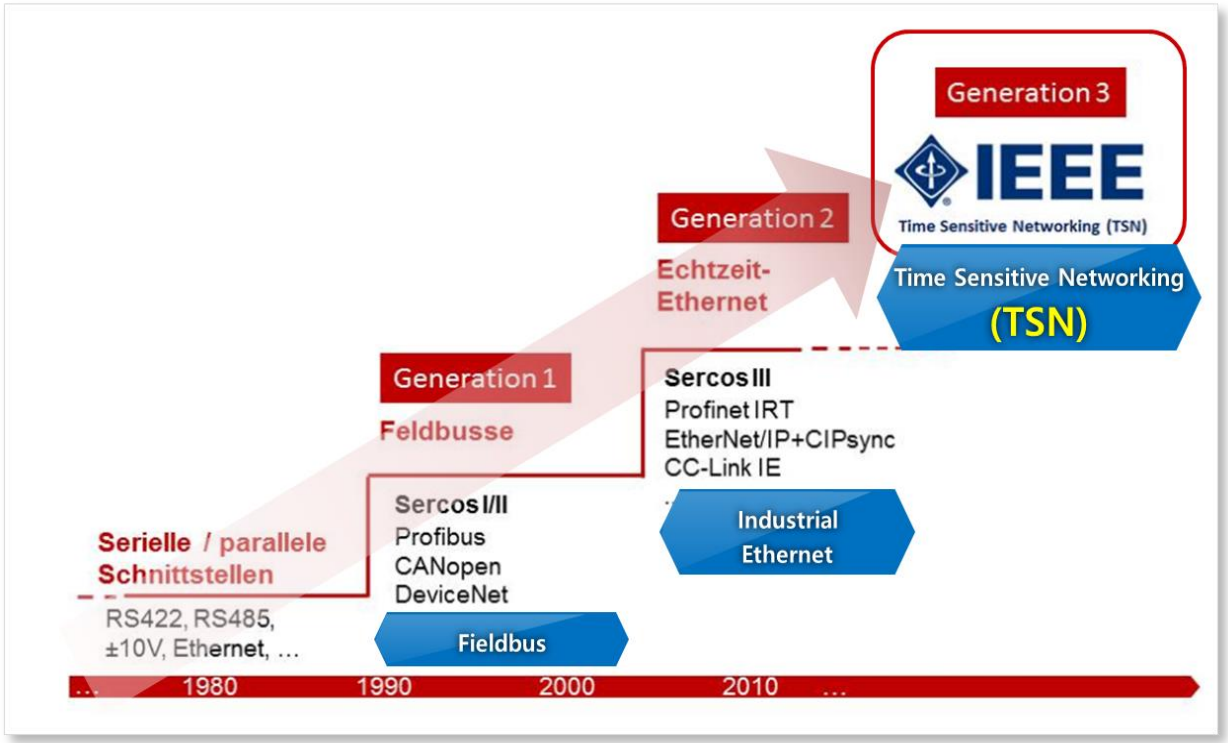


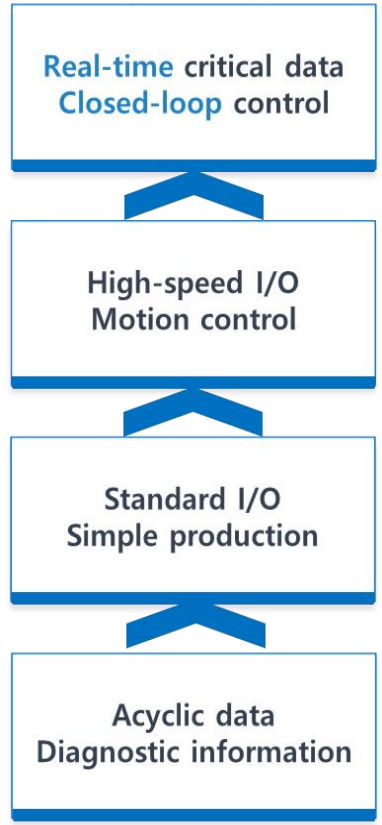
< Noise spectral density in factory >

source: IEEE-SA Industry Connections Report, IEEE 802.1-19-0026-03-ICne

Standardization on Industrial Network (I)

- Evolution of wired industrial network
  - towards time sensitive network
    - Isochronous real-time for closed-loop control is an essential requirement for industrial network

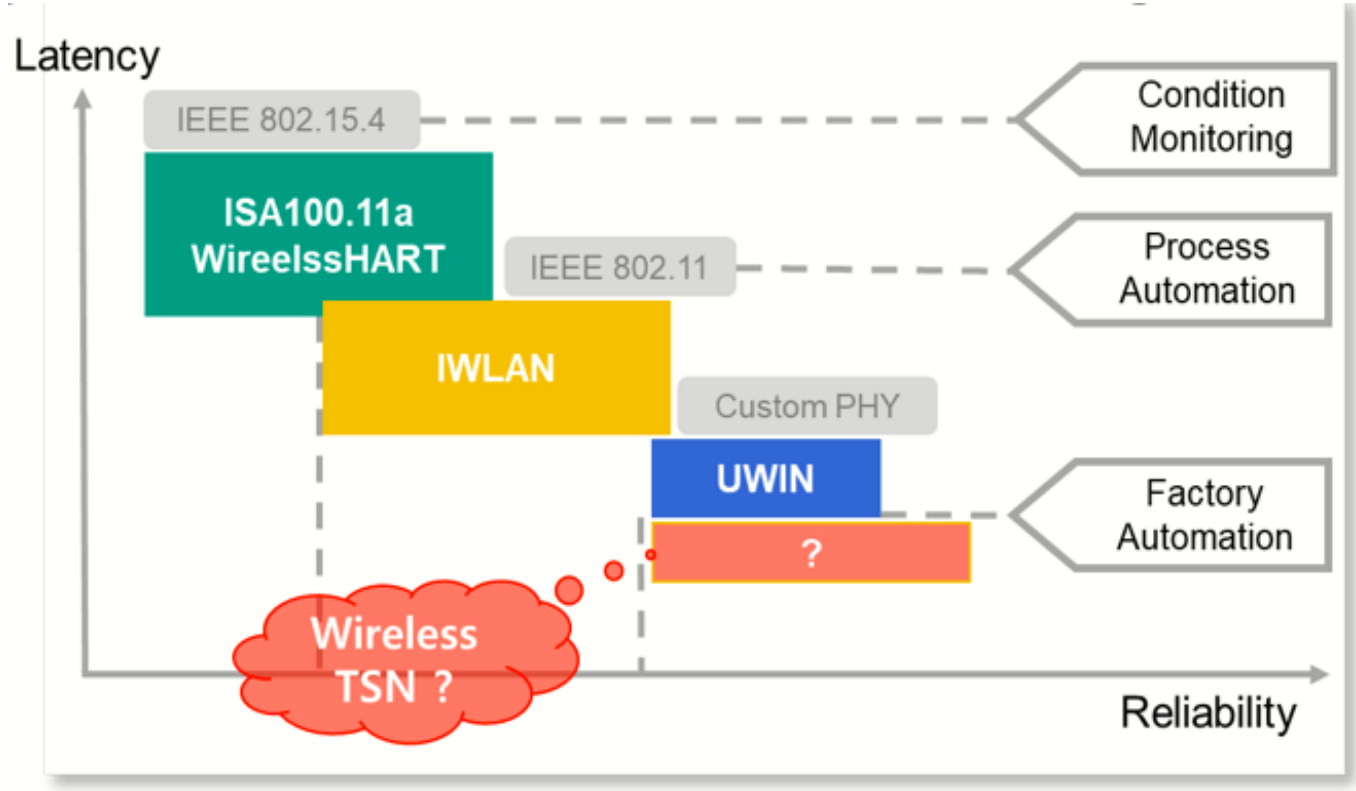




source: www.sercos.org

Standardization on Industrial Network (II)

- wireless industrial network for providing isochronous real-time service
  - not yet standardized



ISA100.11a / WirelessHART

- Addition of upper layer for frequency hopping in IEEE802.15.4-2006
- Technology for monitoring and process Automation

IWLAN (Germany, Siemens)

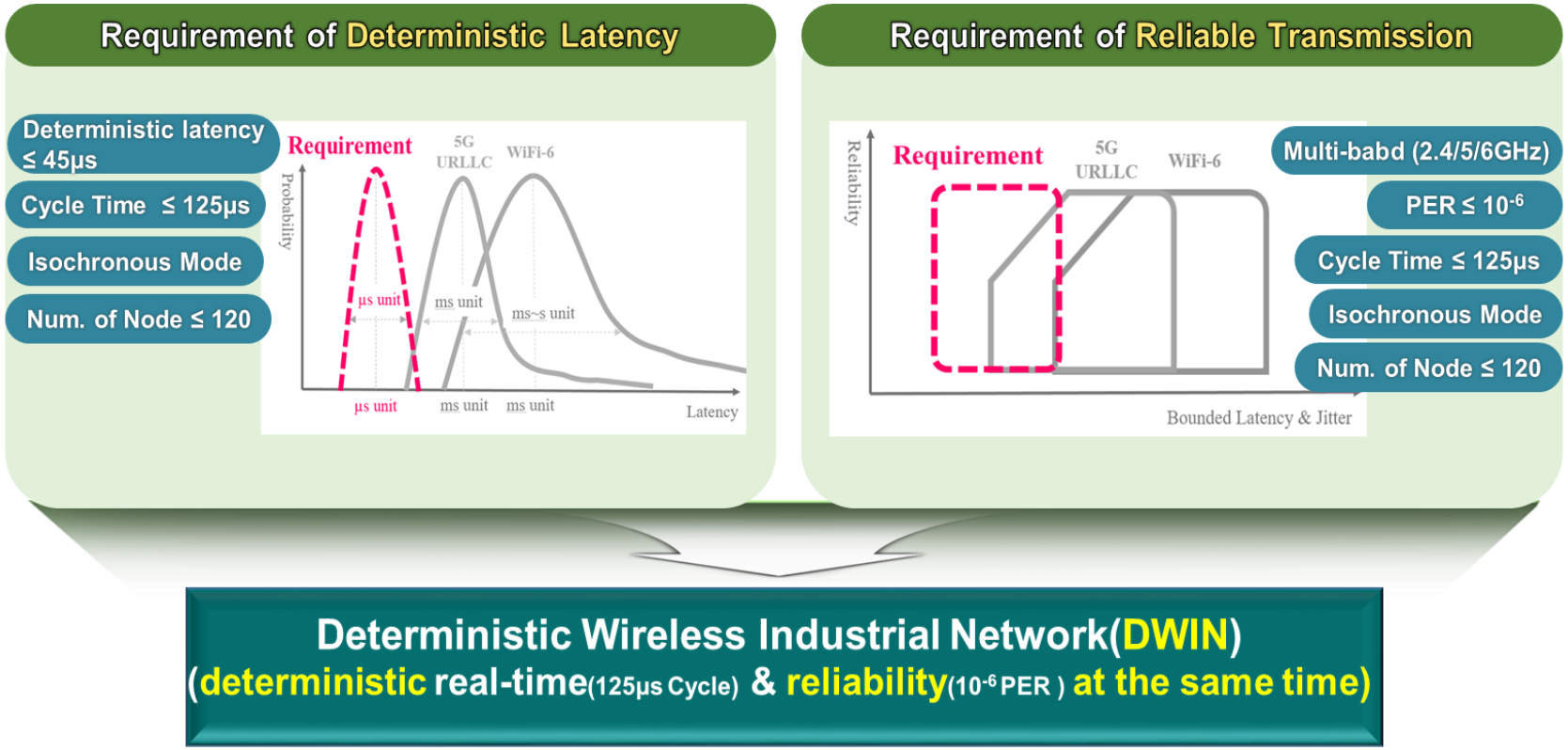
- Technology based on IEEE 802.11 PCF
- Limited application due to limitations in real-time and wireless connectivity at factory

UWIN (Germany, fraunhoper)

- Under development of UWIN(Ultra low latency Wireless Industrial Network) based on custom PHY for providing Isochronous communication mode
- Known as Lab demo level

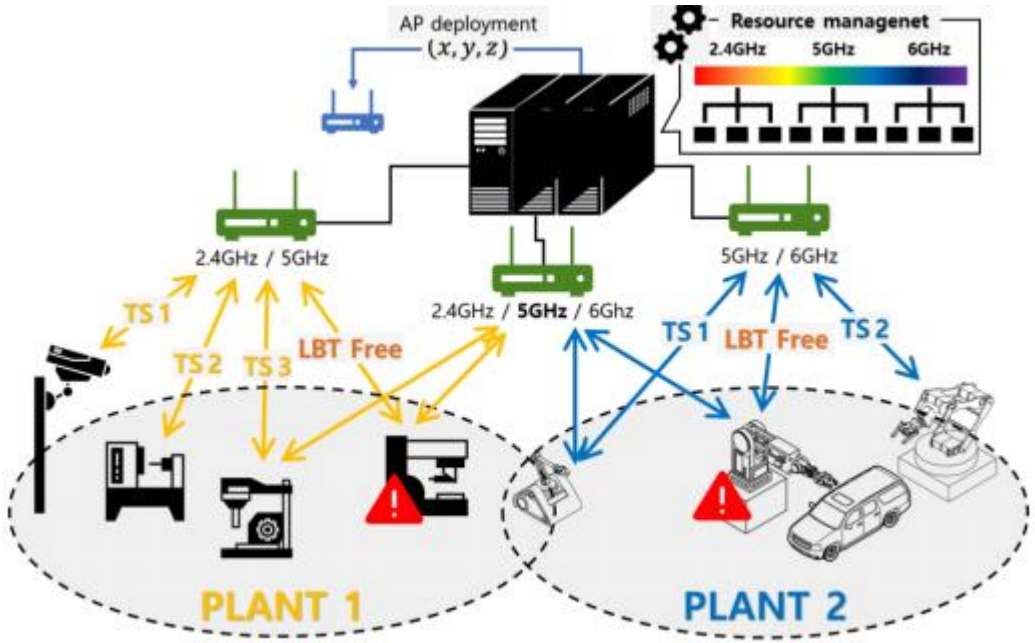
Preliminary Work Item Proposal on Deterministic Wireless Industrial Network

- standardization on the wireless industrial network for closed-loop feedback control
  - wireless network can guarantee deterministic latency and reliable transmission simultaneously
  - Deterministic Wireless Industrial Network (DWIN) for smart factory automation



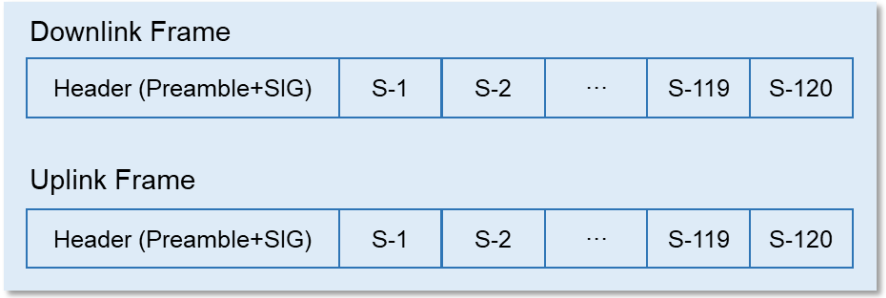
Technical Specification of DWIN (I)

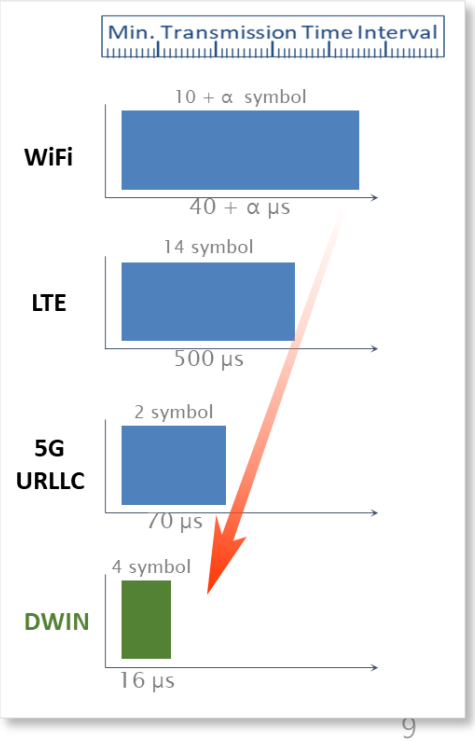
- DWIN architecture
  - network server, access point, end node
    - optimal wireless channel allocation and spatial resource allocation
    - time aware traffic shaping based on high-precision network synchronization
    - multi-channel, multi-band, multi-AP aggregation



Technical Specification of DWIN (II)

- Wireless packet transmission guaranteeing deterministic latency
  - Time Division Multiplexing for multiple short packet transmission
    - very short transmission interval is allowed
      - ✓ For example, only 16μs is allowed for each node when 120 nodes in 2ms frame
    - static reservation of time slot to remove uncertainty in latency
    - PHY PDU aggregation for efficiency
    - representative UL preamble
    - fast AGC/CFO/preamble for short packet transmission
    - high-precision uplink synchronization



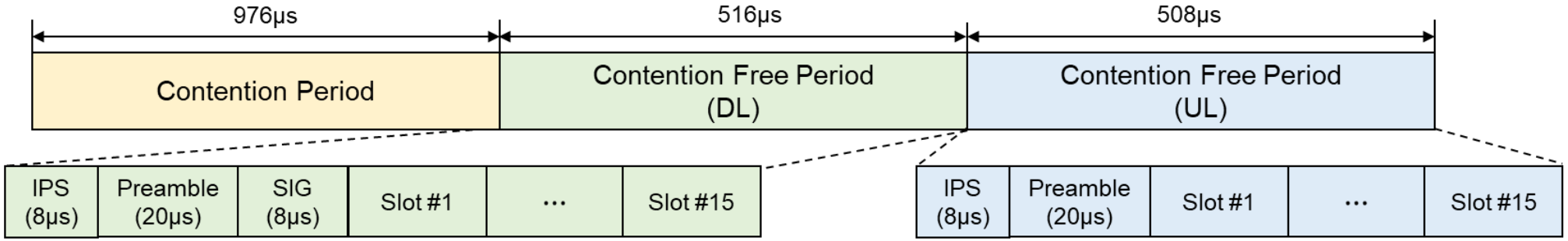


Technical Specification of DWIN (III)

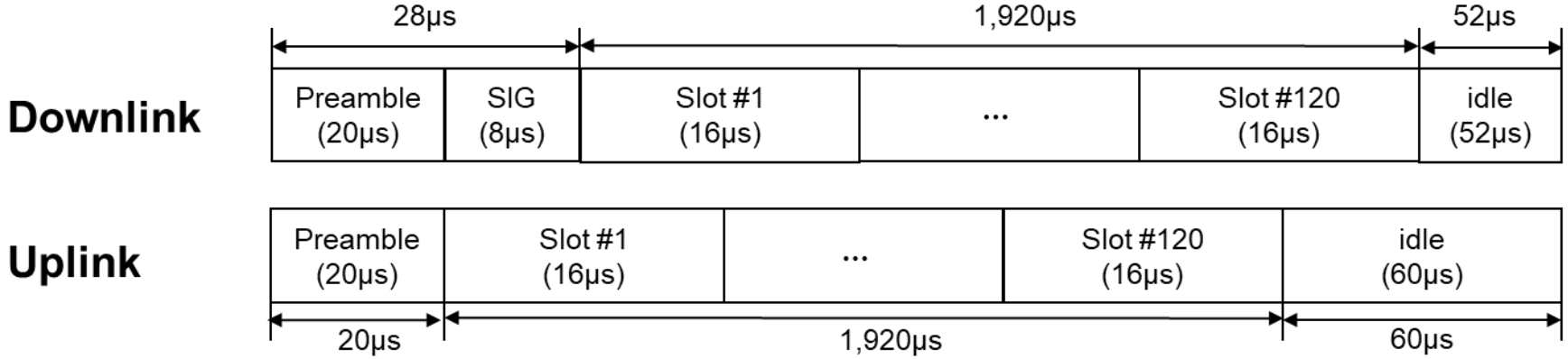
- Flexible frame structure for supporting various industrial applications
  - Single channel with TDD frame structure
    - network where non-isochronous & isochronous application co-exist
    - relatively long cycle time and small number of nodes
  - Multiple channel with FDD frame structure
    - dedicated network isochronous application only
    - short cycle time and large number of nodes

Technical Specification of DWIN (IV)

- Example of TDD frame

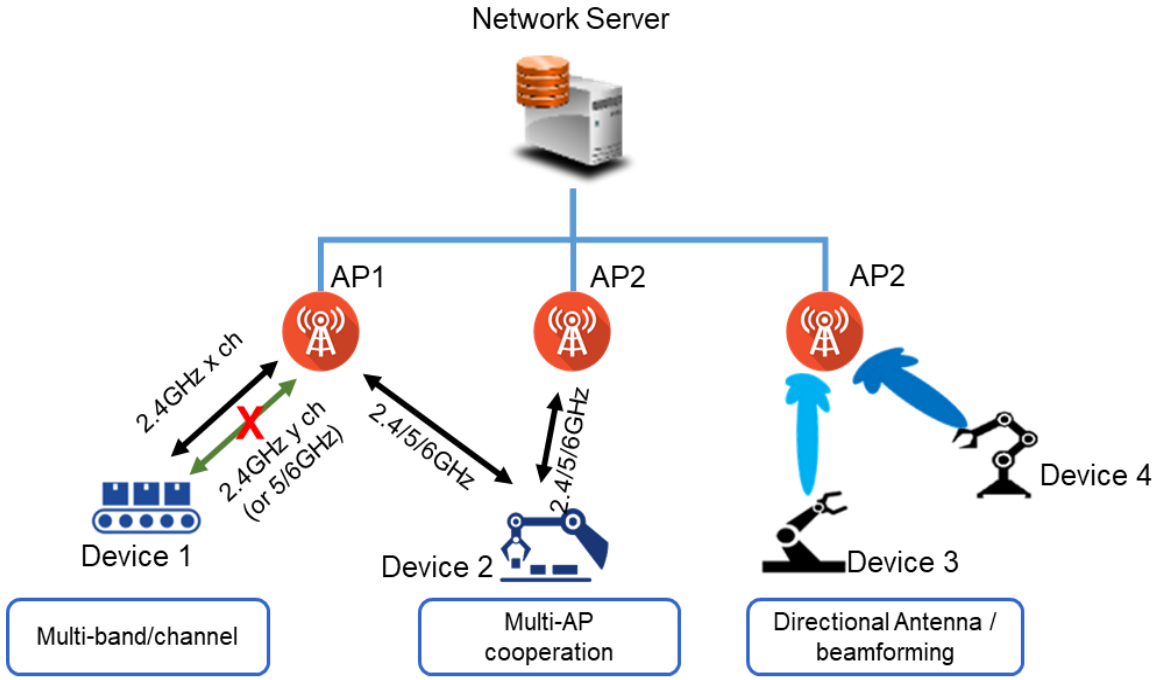


- Example of FDD frame



Technical Specification of DWIN (V)

- Combined diversity technologies for guaranteeing high reliable transmission
  - Time/Frequency/Space diversity
  - multi-channel/band(2.4/5/6GHz)/AP transmission
  - directional antenna, beamforming, FEC optimization, etc
  - synchronized resource reservation through control plane between network control server and access point



Summary of Technical Specification

- DWIN physical layer operation
  - Frame structure to support requirements on the cycle time and number of nodes
  - Uplink/Downlink time/frequency synchronization
  - Modulation and FEC optimized for small packet transmission
  - Time/frequency/space diversity

- DWIN MAC layer operation
  - DWIN MAC frame structure
  - Contention/reservation based channel access
  - Priority based queue management & Time based traffic scheduling for deterministic transmission
  - Control plane functions (registration, connection management, resource allocation, etc)
  - Network synchronization

- DWIN network management
  - Control plane functions between network control server and access point
  - AP & End node management
  - Network resource management

A Preliminary Work Item Proposal (I)

- ISO/IEC JTC1 SC6
  - working in WG1

- Title
  - “Information technology - Telecommunications and information exchange between systems – Deterministic wireless industrial network”

- Scope
  - This document focuses on networking issues to provide the isochronous real-time wireless channels for closed-loop control in factory automation
  - This document specifies:
    - the physical layer
    - the medium access control layer
    - the network management

A Preliminary Work Item Proposal (II)

- Structure of Working Draft
  1. Scope
  2. Normative references
  3. Terms and definitions
  4. Abbreviated terms
  5. DWIN general description
     - isochronous real-time wireless network
     - time-aware wireless network overview
     - components of DWIN architecture
  6. DWIN physical layer
     - deterministic short cycle time for FA
     - DWIN preamble
     - DWIN PPDU format
     - DWIN modulation
     - DWIN signal and data
     - high reliable wireless channel for FA
     - DWIN RF channel model
     - DWIN channel resource allocation
     - DWIN diversity
  7. DWIN medium access control layer
     - time synchronization
     - discovery
     - association
     - traffic scheduling
     - preemption
  8. DWIN management
     - network synchronization
     - network resource allocation
     - traffic management

  Annex

  Bibliography

A Preliminary Work Item Proposal (III)

- Time Plan
  - Aug. 2021 : presentation of a preliminary work item proposal, register a PWI
    - preparation of a Form-4 document and an initial WD text
  - Mar. 2022 : review stage 0 report and the initial WD text
    - initiate a NP ballot by Korean NB
  - Oct. 2022 : progress to WD stage, NP ballot comment resolution, update WD
    - initiate CD ballot
  - Aug. 2023 : progress to CD stage, CD ballot comment resolution, update CD
    - initiate DIS ballot
  - Mar. 2024 : progress to DIS stage, DIS ballot comment resolution, update DIS
    - initiate FDIS ballot or publish IS

Request WG1 Resolution

- Resolution 6.1.x Approval of PWI and Request for Contributions
  - SC 6 authorizes the Preliminary Work Item listed below.
  - SC 6 instructs its Secretariat to circulate the document below for study and comment prior to the next SC6 plenary meeting in March 2022.

Document	Designation	Title	Project Editors
WG1 Nxxxx	PWI-DWIN	Preliminary Work Item Proposal on Deterministic Wireless Industrial Network	Seong-Soon Joo