Data Attributes for QoS Control in Factory Scenario

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Author(s):

Name	Company	email
Hasegawa, Akio	Advanced Telecommunications Research Institute International (ATR)	ahase@atr.jp
Kondo, Yoshihisa	Advanced Telecommunications Research Institute International (ATR)	kondo@atr.jp
Hasegawa, Jun	Fujitsu Kansai-Chubu Net-Tech Limited	hasegawa.jun@jp.fujitsu.com
Naitou, Syouji	Fujitsu Kansai-Chubu Net-Tech Limited	naito.shoji@jp.fujitsu.com
Hamaminato, Makoto	Fujitsu Laboratories Ltd.	hamamy@jp.fujitsu.com
Nishikawa, Takurou	Fujitsu Limited	nisikawa.taku@jp.fujitsu.com
Sato, Shinichi	Fujitsu Limited	sato_shinichi@jp.fujitsu.com
Wang, Hao	Fujitsu R&D Center Co., Ltd	wangh@cn.fujitsu.com
Su, Yi	Fujitsu R&D Center Co., Ltd.	yisu@cn.fujitsu.com
Kato, Toshio	Mobile Techno Corp.	kato.toshio@jp.fujitsu.com
Murata, Syuuichi	Mobile Techno Corp.	murata.syuuichi@jp.fujitsu.com
Yoshimura, Masahiro	Mobile Techno Corp.	yoshimum@jp.fujitsu.com
Tomita, Hisanori	Murata Machinery, Ltd.	hisanori.tomita@koa.muratec.co.jp
Itaya, Satoko	National Institute of Information and Communications Technology (NICT)	itaya@nict.go.jp
Kojima, Fumihide	National Institute of Information and Communications Technology (NICT)	f-kojima@nict.go.jp
Koto, Hajime	National Institute of Information and Communications Technology (NICT)	h-koto@nict.go.jp
Mochinaga, Mika	National Institute of Information and Communications Technology (NICT)	m-mochinaga@nict.go.jp
Ohori, Fumiko	National Institute of Information and Communications Technology (NICT)	fumiko@nict.go.jp
Ohsawa, Tomoki	National Institute of Information and Communications Technology (NICT)	tohsawa@nict.go.jp

Author(s):

Name	Company	email
Hirabayashi, Chiaki	NEC Communication Systems, Ltd.	hirabayashi.ch@ncos.nec.co.jp
Ikenoue, Yuichi	NEC Communication Systems, Ltd.	ikenoue.yc@ncos.nec.co.jp
Hayashi, Takeshi	NEC Corporation	h-lin@ap.jp.nec.com
Hidaka, Youichi	NEC Corporation	y-hidaka@bq.jp.nec.com
Inoue, Takamichi	NEC Corporation	t-inoue@cj.jp.nec.com
Kato, Rintaro	NEC Corporation	r-kato@bk.jp.nec.com
Kobayashi, Tsukasa	NEC Corporation	t-kobayashi@fa.jp.nec.com
Maruhashi, Kenichi	NEC Corporation	k-maruhashi@bl.jp.nec.com
Nakajima, Taketoshi	NEC Corporation	nakajima@cp.jp.nec.com
Okayama, Yoshimitsu	NEC Corporation	y-okayama@bl.jp.nec.com
Osuga, Toru	NEC Corporation	t-oosuga@ce.jp.nec.com
Zein, Nader	NEC Europe Ltd.(NLE GmbH)	Nader.Zein@emea.nec.com
Fujimoto, Takuya	OMRON Corporation	takuya_fujimoto@omron.co.jp
Ikumo, Masahiro	OMRON Corporation	masahiro_ikumo@omron.co.jp
Saito, Keisuke	OMRON Corporation	keisuke_saito@omron.co.jp
Yamada, Ryota	OMRON Corporation	ryota_yamada@omron.co.jp
Ohue, Hiroshi	Panasonic Corporation	ohue.hiroshi@jp.panasonic.com
Amagai, Akihiro	Sanritz Automation Co., Ltd.	amagai@sanritz.co.jp

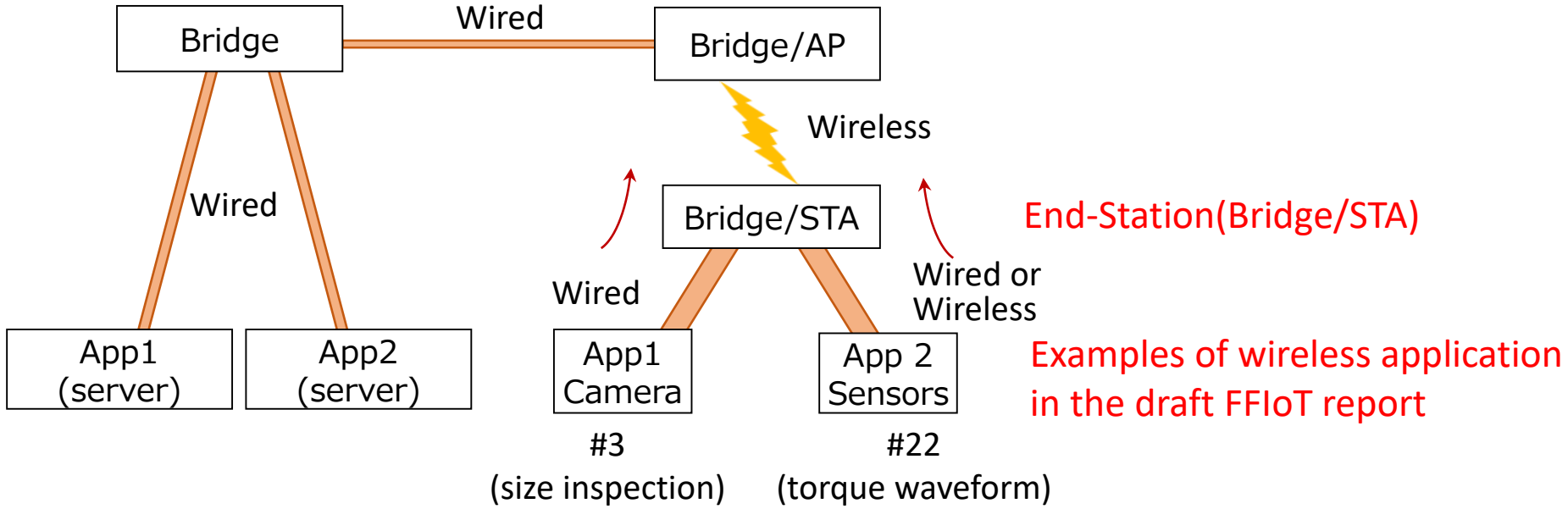
Introduction

- This document is prepared to explain:

  Why data attributes are needed in Factory network where bandwidth of a link along its E2E path cannot be maintained at the required minimum, while serving multiple streams with varying QoS requirements along the same path

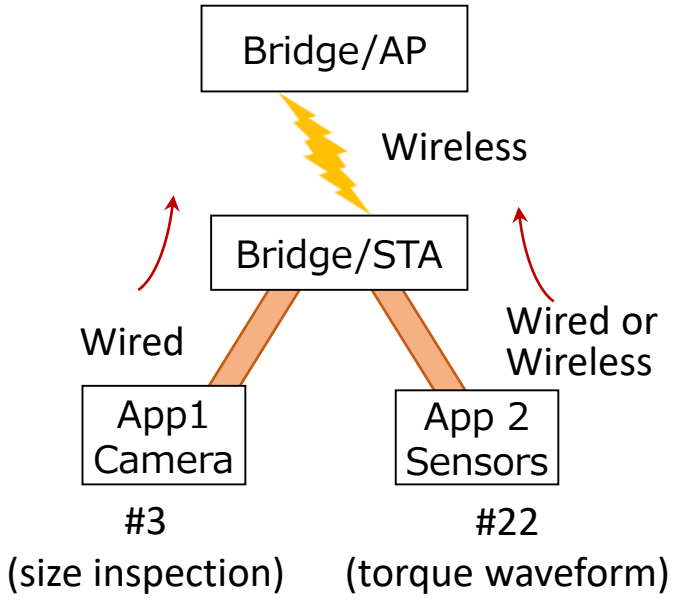
Network Model

- Factory network consists of bridged topology.
- data ingress to End-Station with bridge function (Bridge/STA), is the connected devices.
- In this topology, End-Station cannot condition data streams to match the traffic load in the network.

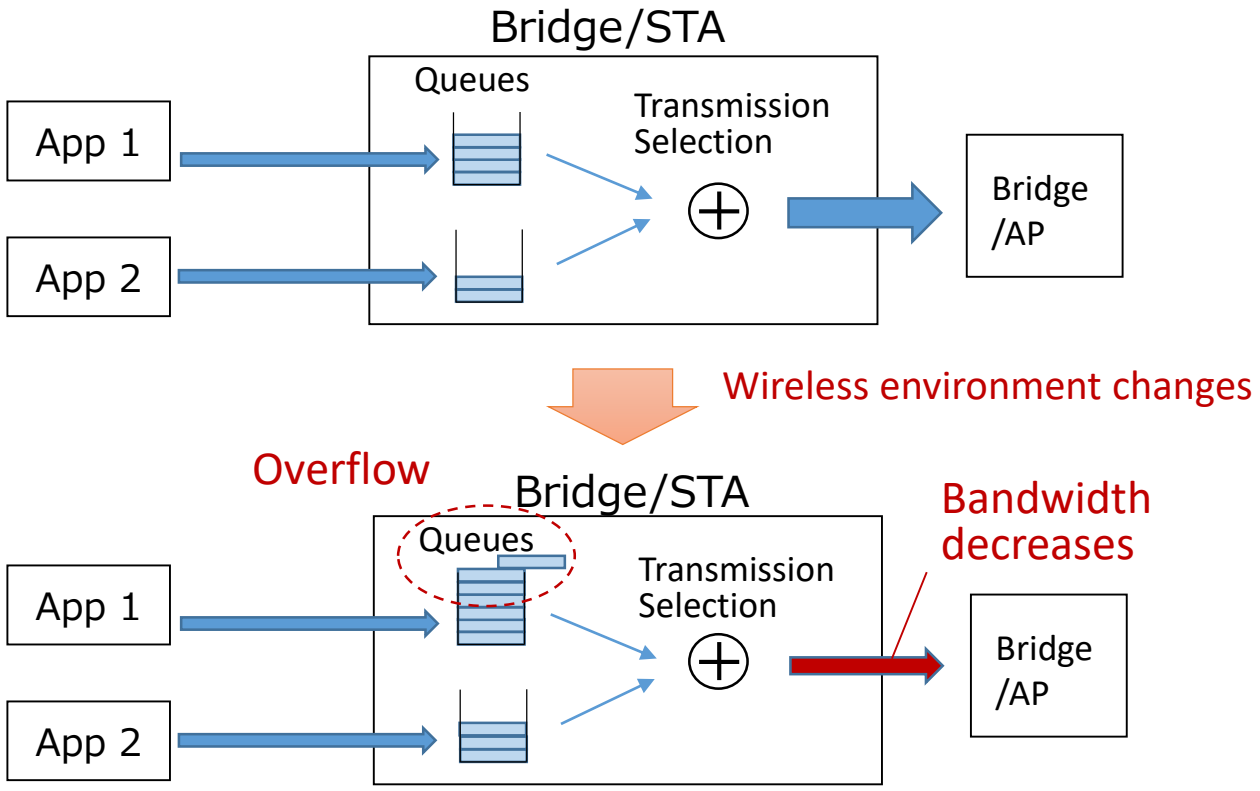


Example

- Traditional issue of queues overflow when bandwidth decreases.



Data flow model



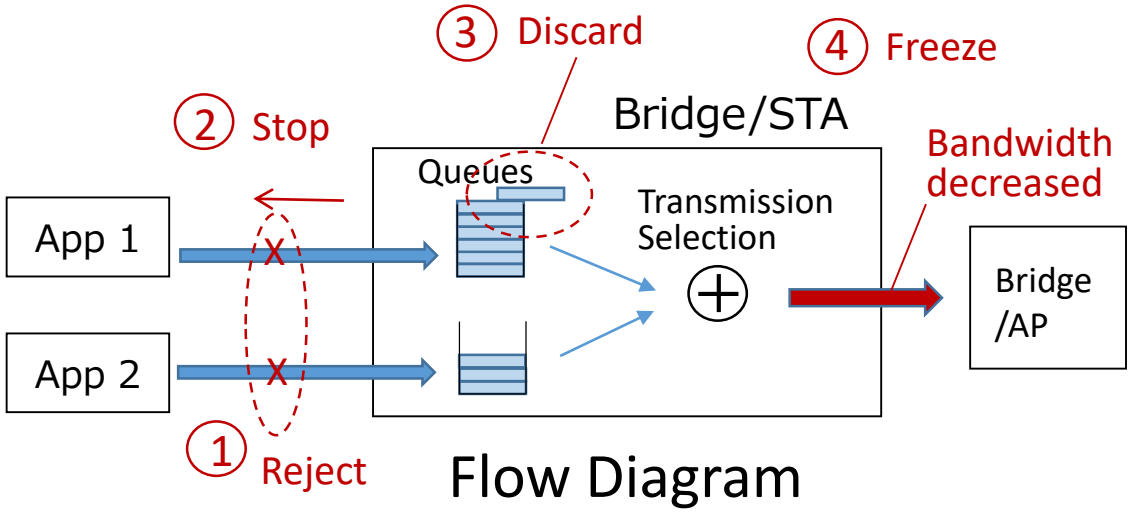
Flow Diagram

How to React?

- Possible reaction depending on implementation:
  - ① Reject further data input -> stop all or forward selected queues following priority
  - ② Request to stop data input (e.g. PFC*) -> stop one link following priority
  - ③ Discard data -> ignore QoS requirements**
  - ④ Freeze operation -> fall into system-down

*Note that PFC stops one link in another bridge (not in the case of this diagram)

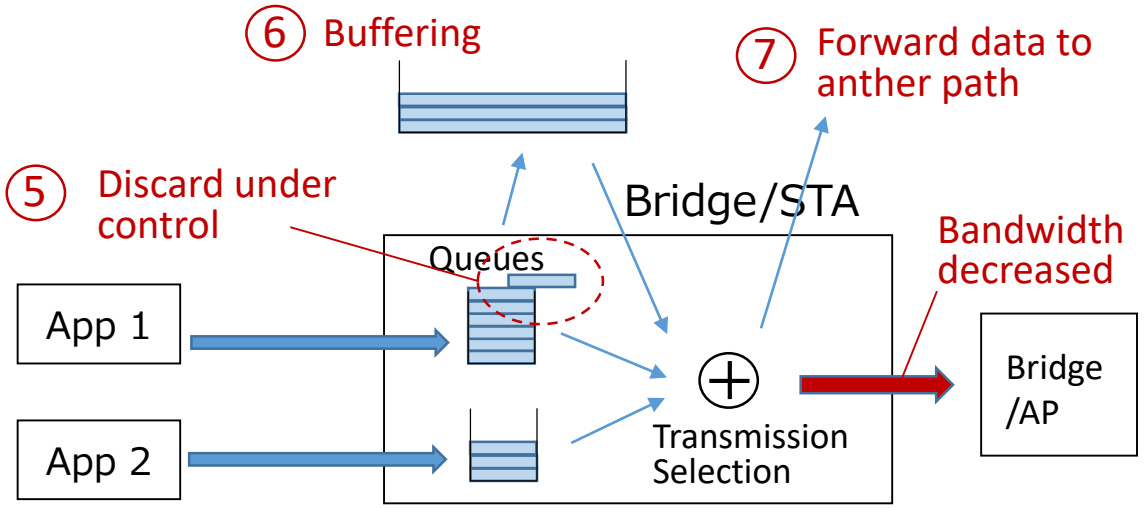
**Frame loss is described in Std. 802.1Q (6.5.2)



Flow Diagram

Better Ways

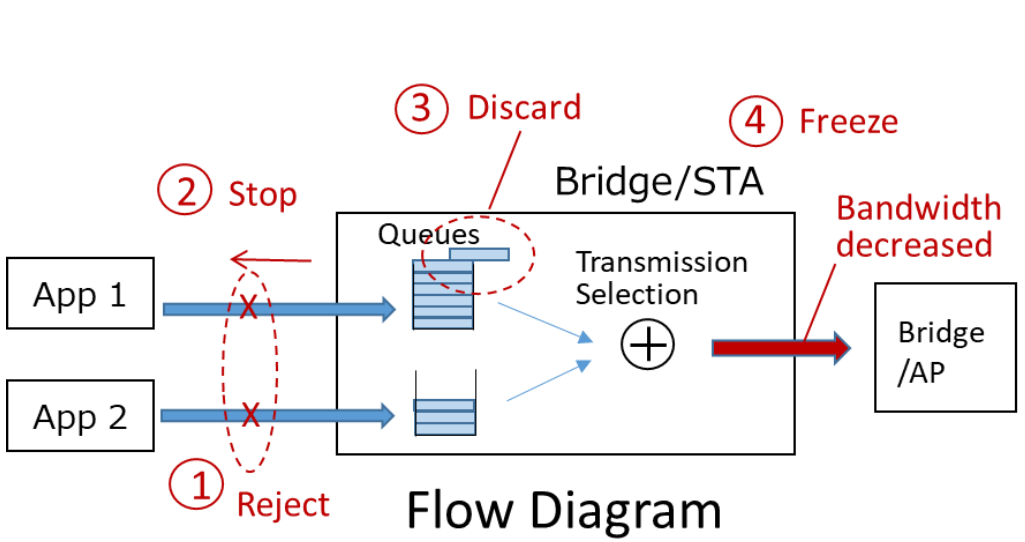
- Sophisticated methods:
  - ⑤ Discard under control -> reduce data considering required QoS
  - ⑥ Buffering -> use additional buffer to peak-rate shaving
  - ⑦ Forward data to another path -> use another path or link aggregation

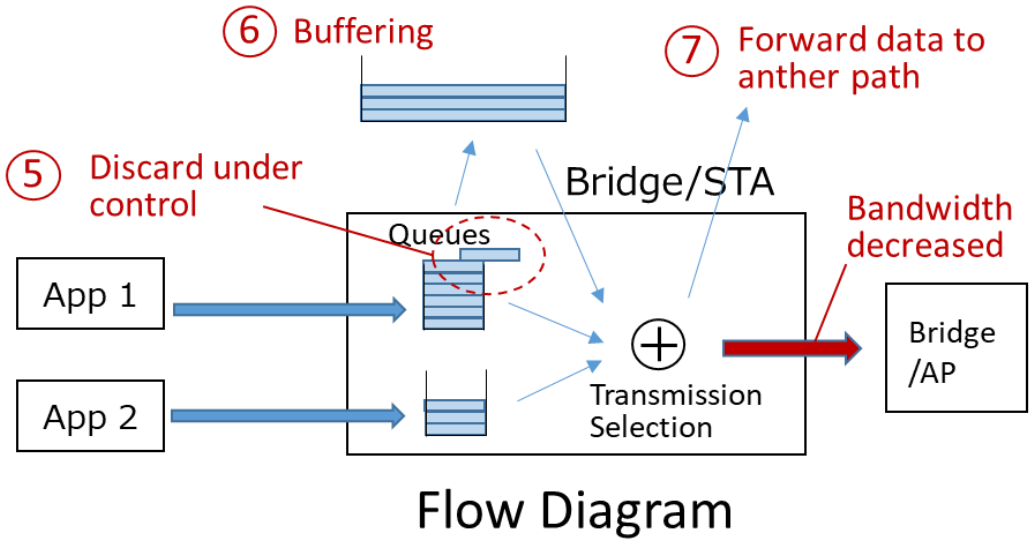


Flow Diagram

How to decide at Bridge/STA

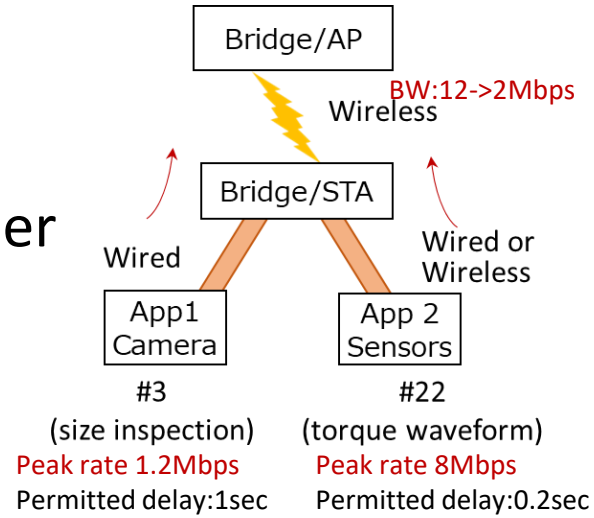
- Priority is key parameter to maintain data flow. However we need to consider the large number of traffic types in factory network.
- For this purpose, common data attributes needs to be defined to assist with appropriate actions at Bridges/STA.





Example of Real Scenario

- Bridge/STA accommodates two applications(#3 and #22) with corresponding attributes as shown in the table below and the diagram.
- The question is which application should be assigned the higher priority to these?
  - ✓ If bandwidth is sufficient, #22 shall have higher priority, because of low-delay requirement.
  - ✓ If bandwidth is insufficient, #3 shall have higher priority, while some action from previous slide 8 shall be considered for #22.

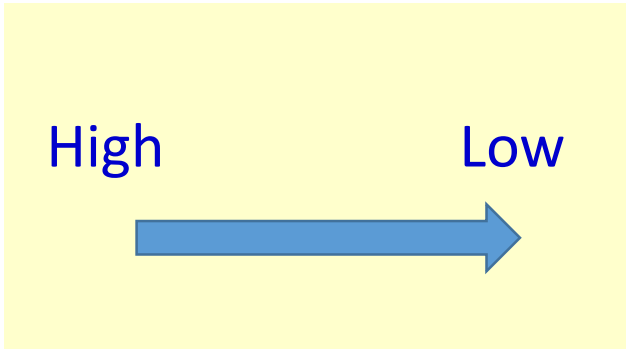


# of wireless application in FFIoT Report	FFIoT Report (Nendica)			Designed parameters		
	Data size (Byte)	Rate (/sec)	Delivery time tolerance (sec)	Transmission time(sec)	Peak rate (bit/sec)	Permitted delay at bridge (sec)
3	30K	1	5	0.2	1.2M	1
22	100K	0.1	1	0.1	8M	0.2

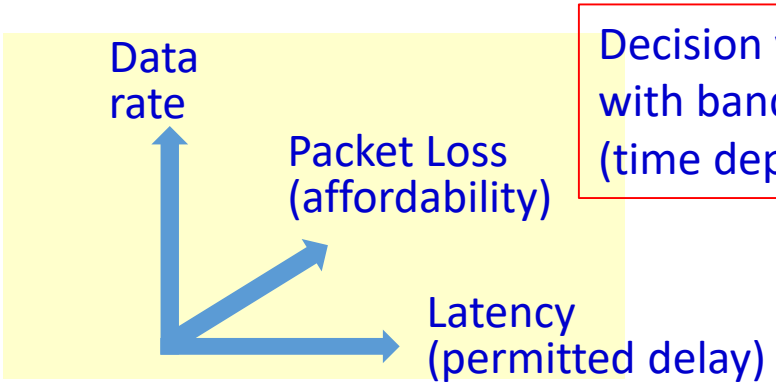
Shortfalls of Conventional Priority

- In factory scenario of a network with multiple applications with varying QoS requirements, if the bandwidth of the link is reduced below the minimum for all applications, conventional priority from high to low would not work well.
- A better approach will be to set priority for each application based on selected multiple requirement attributes, e.g. data rate, latency, affordability of packet loss. The priority setting for each application depends on the instantaneous bandwidth available.

  That is priority is set dynamically depending on data attributes of each applications and the instantaneous available bandwidth.

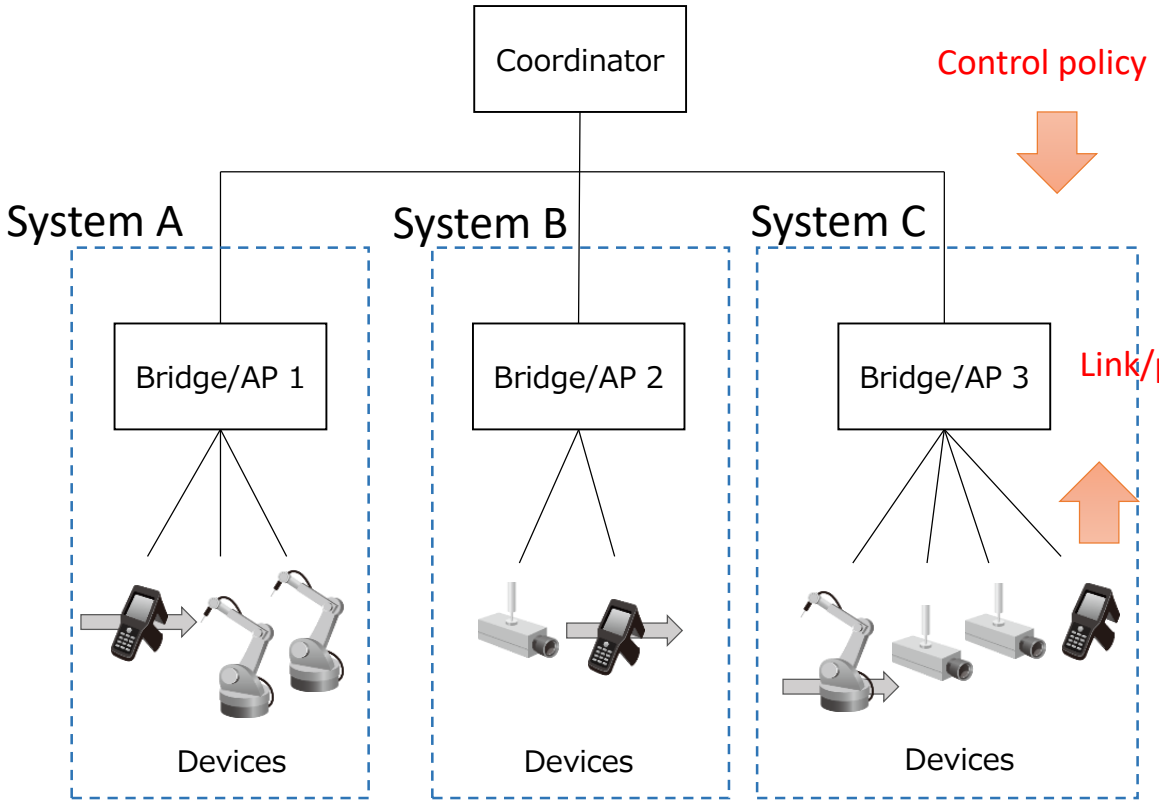


Conventional Priority



Priority in Factory Scenario

Coordination of Distributed Systems



Data Rate*: kbps to Gbps
Delay: msec to beyond second
Packet loss affordability: 0 to 100%

* Data rate depends on wireless systems.

Support for Wide Variety of Traffic Types in Factory Network

- The example below shows different categories of applications with a maximum of 12 data attributes even for coarse resolution in QoS tolerance.
- These data attributes can be used to assist setting the instantaneous priority classes at the bridge.

Category of Wireless Applications	QoS Tolerances							
	Latency (msec)			Bandwidth (kbps)			Packet Loss	
	<100	100~1000	>1000	>1000	100~1000	<100	Loss less	Non-Loss less
Equipment Control	✓	✓				✓	✓	
Quality Supervision	✓	✓	✓	✓	✓	✓	✓	
Factory Resource Management		✓	✓	✓	✓	✓	✓	✓
Display		✓	✓	✓	✓	✓	✓	✓
Human Safety	✓		✓	✓	✓	✓	✓	✓
Others		✓	✓	✓			✓	✓

2 3 2

2 x 1 x 1 = 2
3 x 3 x 1 = 9
2 x 3 x 2 = 12
2 x 3 x 2 = 12
2 x 3 x 2 = 12
2 x 1 x 2 = 4

Source: draft FFIoT report

Data Attribute Tag (DA Tag)

- Proposal: Define a DA Tag in a data frame to indicate data attributes.
- DA Tag can assist rapid decision locally at bridges.
- Frequent communication with a coordinator can be avoided to mitigate use of network resource.
- Need to analyze how many bits are required for data attributes.
  - For small bits, data attributes can be put in DA Tags.
  - For large bits, an identifier in a DA Tag and corresponding data attributes should be distributed to bridges in advance. Control at each bridge is made by the identifier in the DA Tag in corresponding data frames.

Prospects

- SRP is mechanism for end-to-end management to guarantee Quality of Service.
- A variety of QoS needs to be considered in Factory Scenario.
- In the wired/wireless bridged network, local management at the bridge by incorporating data attribute contribute to reinforce SRP.
- Enhancement of SRP shall be further discussed in IEEE 802.1.

Next Step

- Suggested by OmniRAN TG Chair:
  - Traffic types have been well defined in 1CF with TSN people: Prioritized best effort (BE) traffic, Rate constraint (RC) traffic and Time-trigger (TT) traffic. Stream models are established to assign factory applications (selected from FFIoT report in Nendica) to traffic types with consistency. This may help understand why data attributes are necessary with confidence.
  - Communication with TSN starts (e.g. joint meeting between TSN and OmniRAN) to get response.