Wireless Communications in the Manufacturing Fields

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Author(s):

Name	Company	email
Hasegawa, Akio	Advanced Telecommunications Research Institute International (ATR)	ahase@atr.jp
Ohsawa, Tomoki	BRID Inc.	tohsawa@brid.co.jp
Hasegawa, Jun	Fujitsu Kansai-Chubu Net-Tech Limited	hasegawa.jun@jp.fujitsu.com
Naito, Shoji	Fujitsu Kansai-Chubu Net-Tech Limited	naito.shoji@jp.fujitsu.com
Ohhashi, Masahiko	Fujitsu Kansai-Chubu Net-Tech Limited	m.ohashi@jp.fujitsu.com
Yamazaki, Hiroaki	Fujitsu Kansai-Chubu Net-Tech Limited	yamazaki.h@jp.fujitsu.com
Nishikawa, Takurou	Fujitsu Limited	nisikawa.taku@jp.fujitsu.com
Sato, Shinichi	Fujitsu Limited	sato_shinichi@jp.fujitsu.com
Kato, Toshio	Mobile Techno Corp.	kato.toshio@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
Ezure, Yuichiro	NEC Communication Systems, Ltd.	ezure.yc@ncos.nec.co.jp

Author(s):

Name	Company	email
Ito, Chikashi	NEC Communication Systems, Ltd.	ito.chk@ncos.nec.co.jp
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
Tsuji, Akira	NEC Corporation	a-tsuji@bq.jp.nec.com
Zein, Nader	NEC Europe Ltd.	Nader.Zein@EMEA.NEC.COM
Saito, Keisuke	OMRON Corporation	keisuke@ari.ncl.omron.co.jp
Yamada, Ryota	OMRON Corporation	ryamada@ari.ncl.omron.co.jp
Amagai, Akihiro	Sanritz Automation Co., Ltd.	amagai@sanritz.co.jp

Introduction

- There are some applications to ensure End-to-End(E2E) latency in the factories.
- However, users would like to use wireless communications for “last hop” of their manufacturing systems.
- If there are wireless communications in the systems, it makes difficult to ensure E2E latency in the systems.
- Thus, this presentation has been prepared to share how wireless communications are used at factories.

Observations

- We have evaluated wireless environment at several factories in operation and found issues to be resolved.

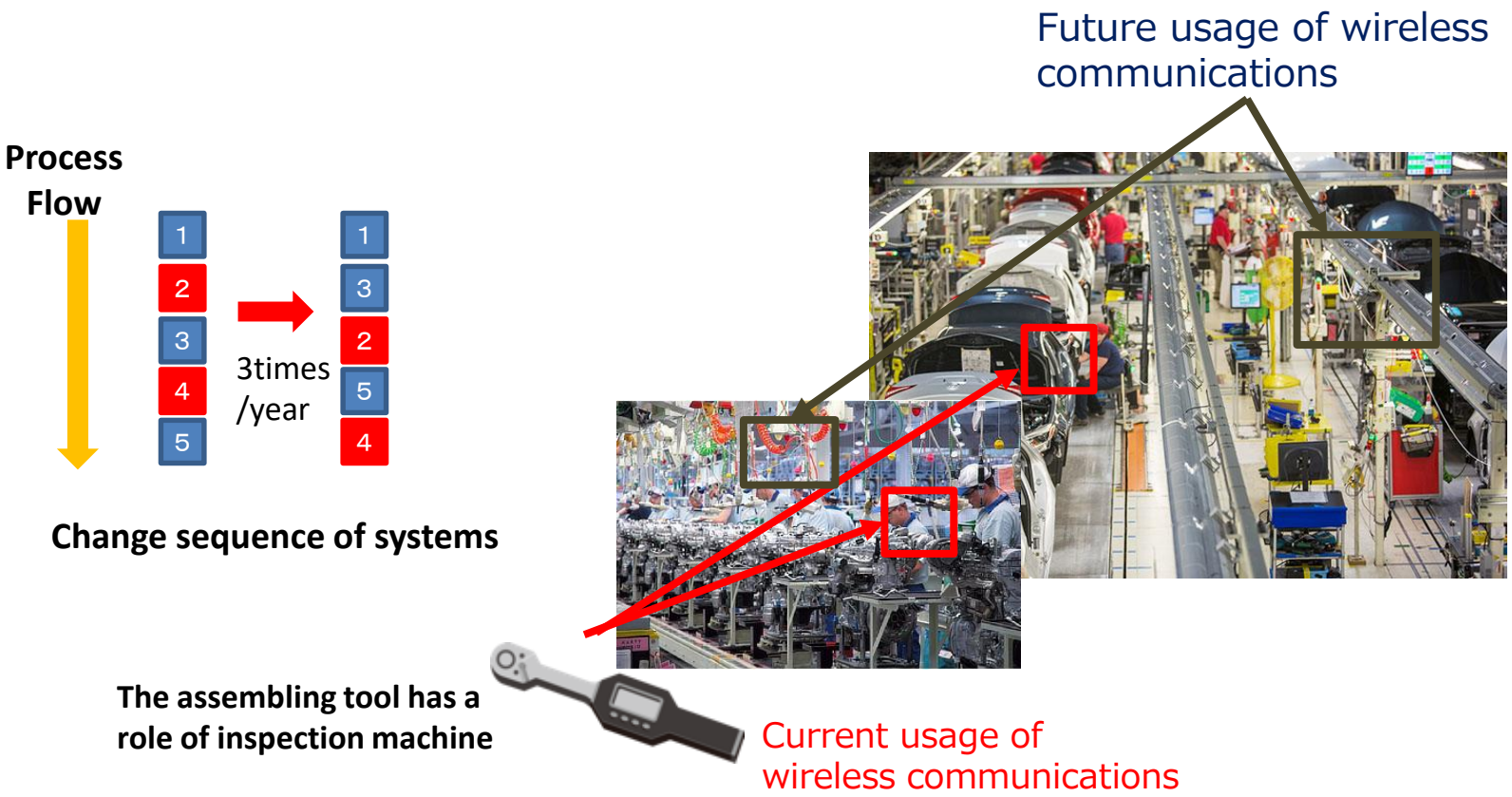
More Information https://www.nict.go.jp/en/press/2017/03/01-1.html

Today's Talk

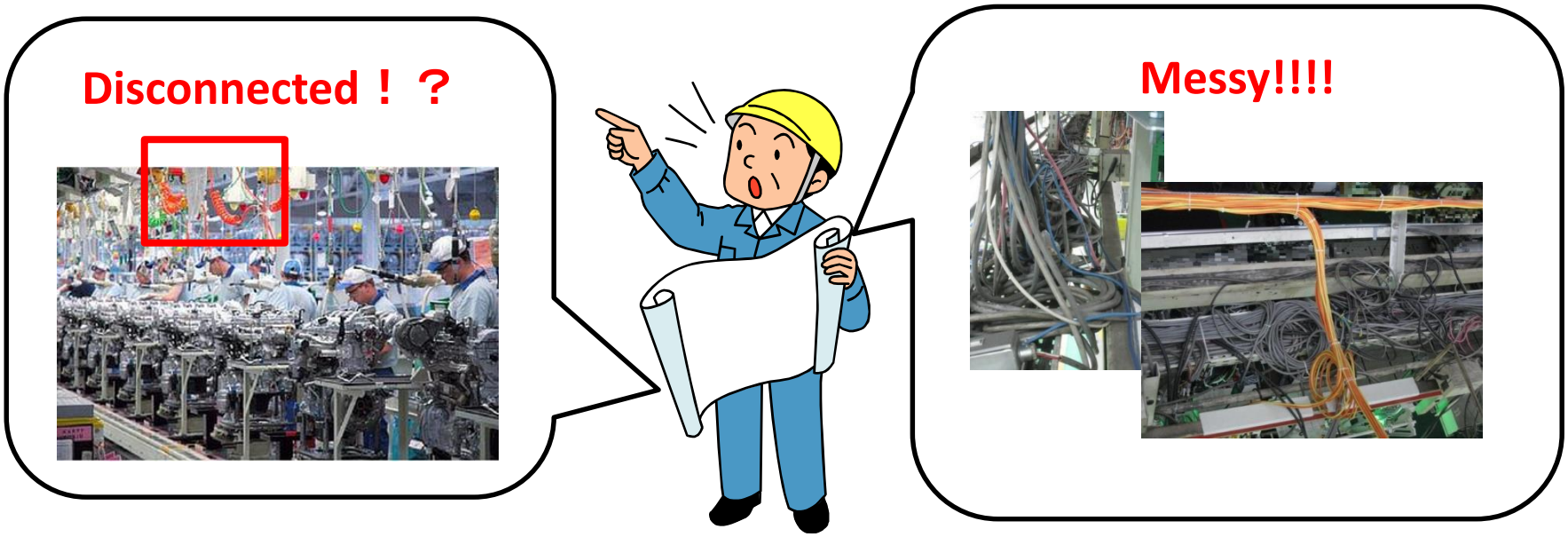
- Background – why wireless?
- Three features of wireless communications in the factory.
- An issue we would like to bring in IEEE 802.1.

Reconfiguration of Production Line

- Inspection process in the production line often changes.



Why not Wired?

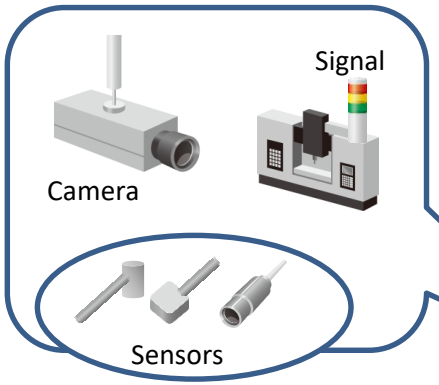


Power Supply Cable ≠ Communication Cable

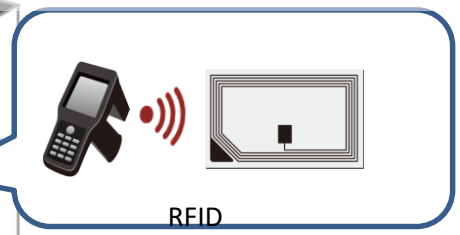
Example 1: Metal Process Factory

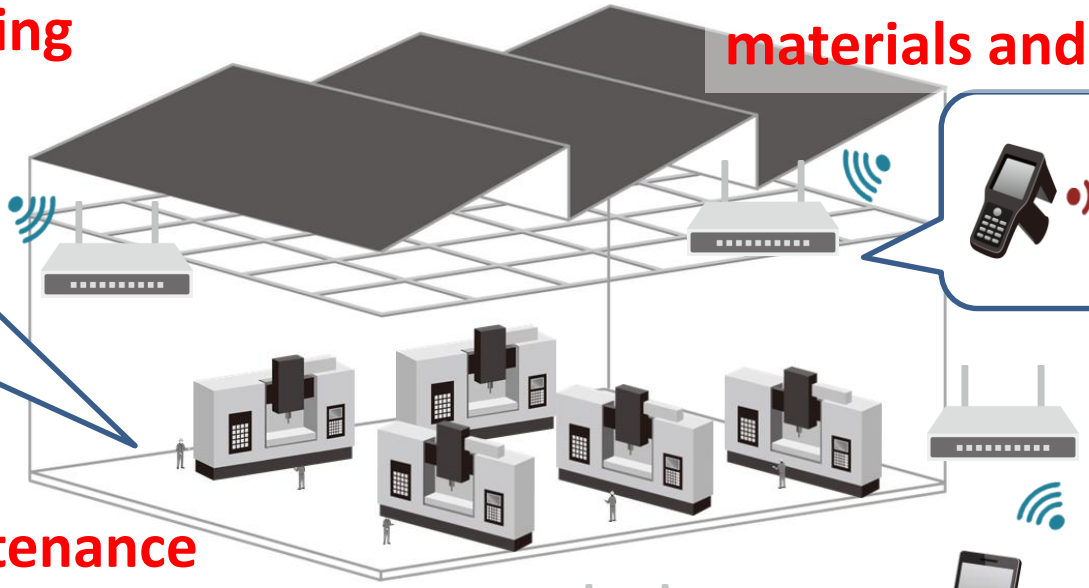
Applications for wireless communication are ….

machine monitoring

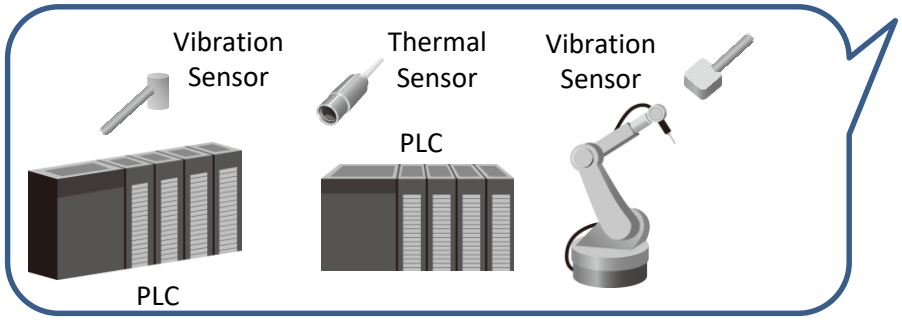


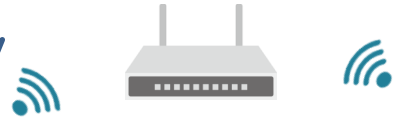
management of materials and products





preventive maintenance





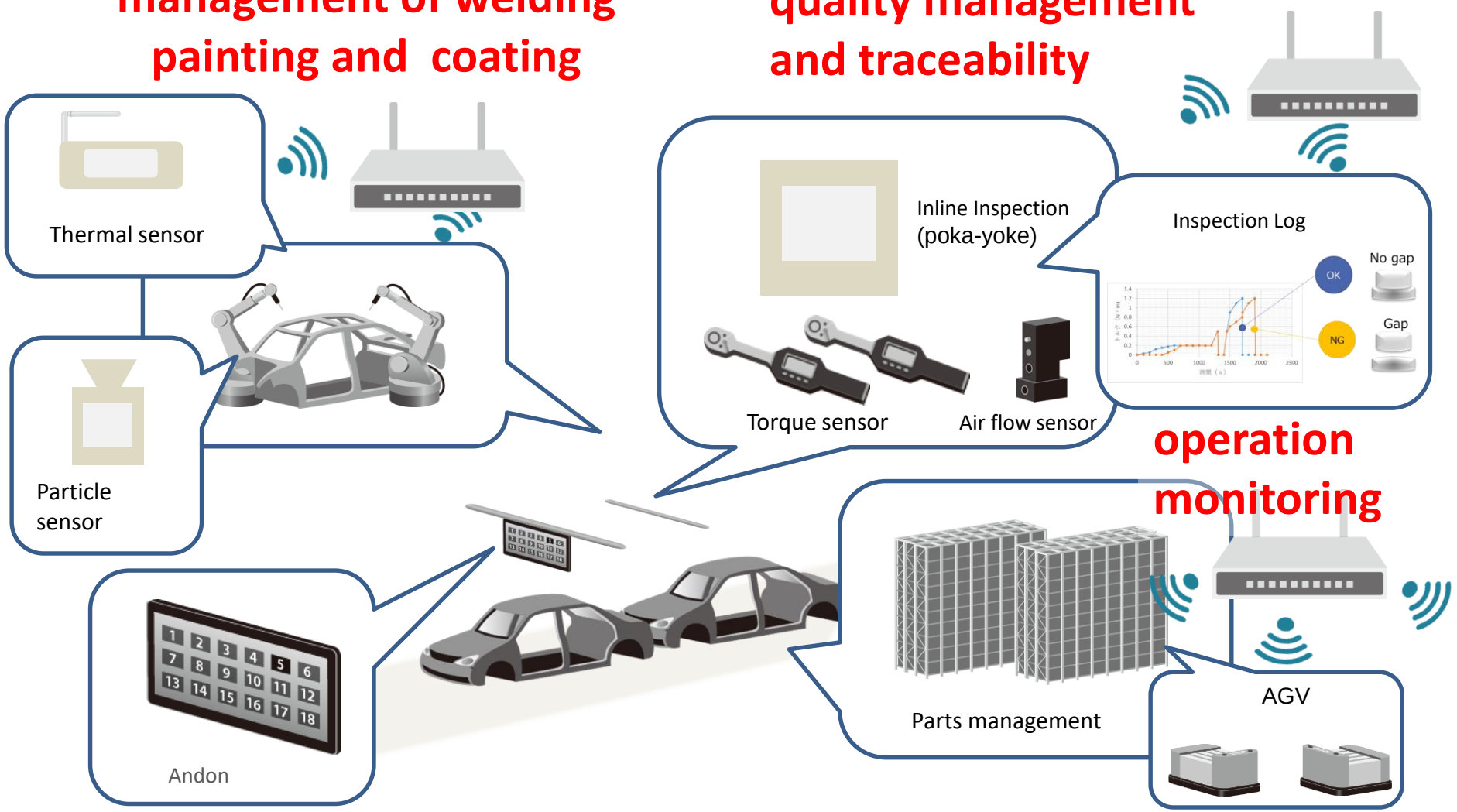
flow line analysis

Example 2: Machine-Assembly Factory

Applications for wireless communication are ….

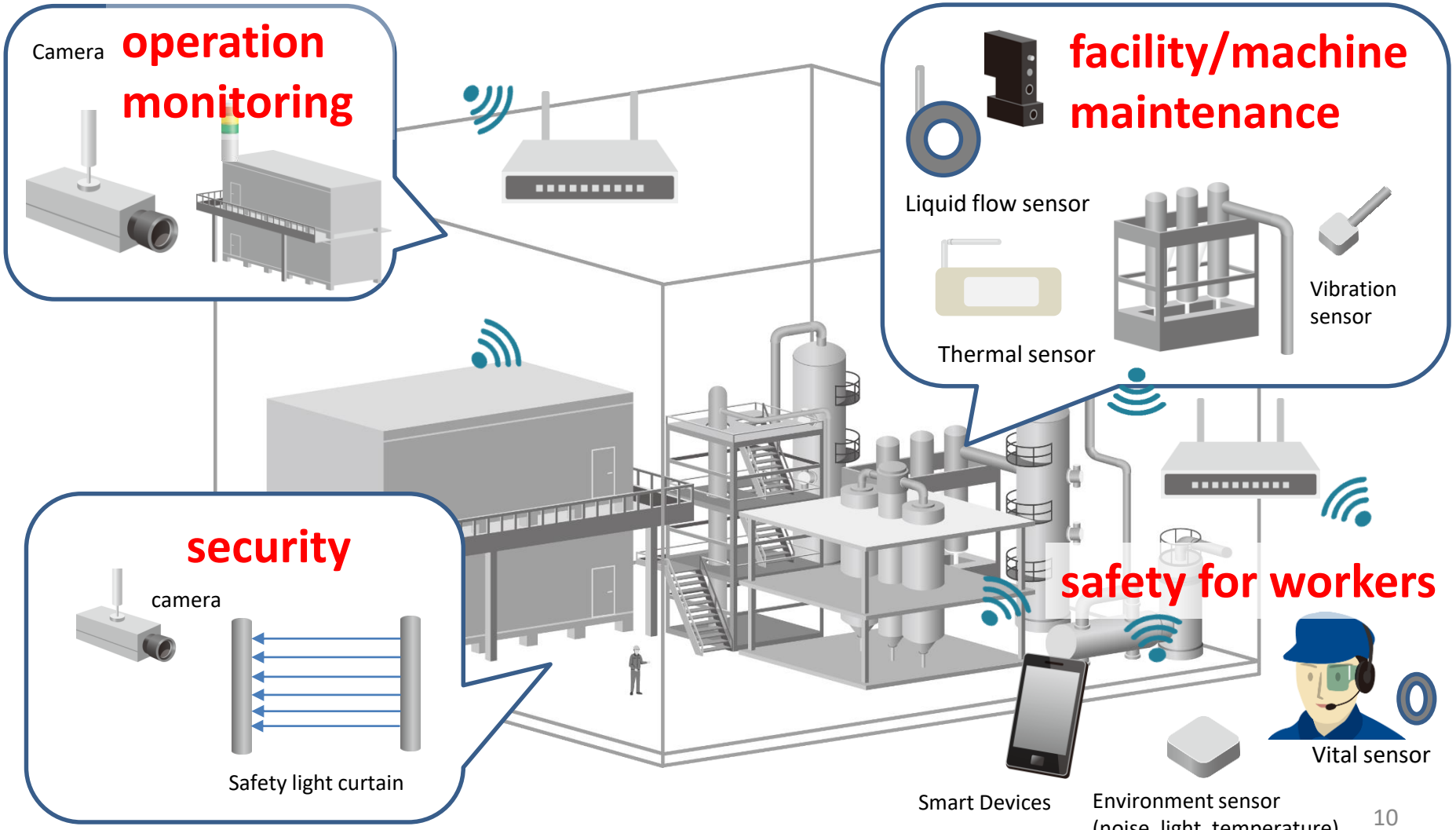
management of welding painting and coating

quality management and traceability



Example 3: High Place/High Temperature

Applications for wireless communication are ….



Features of Wireless Communication in Factories

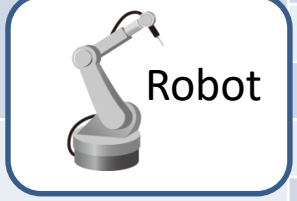
- **Wide Variety** of Applications
- **Severe Environment** for Wireless Communication
- **Uncoordinated** Independent Systems

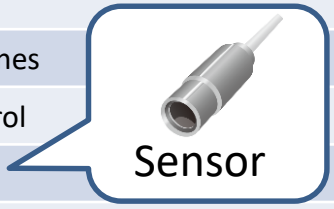
(1) Wide Variety Wireless Applications

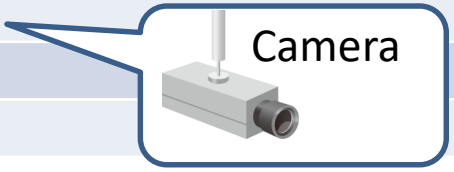
5 categories with different types of applications are extracted by survey.

Wireless applications used or to be used

Category	Wireless Applications
Control	Machine, Robots
	AGV w/wo Rails
	Rotary Equipment
Quality	Inline Inspection, Pokayoke (notifying process failure or stop process)
	Machine Operation/Production Recoding
	Logging
Management	Preventive Maintenance for Tools and Machines
	Positioning, Motion Analysis, Inventory Control
	Facility Environment Control
Display	Work Instruction
	Andon (notifying quality or process problems to managers and workers)
Safety	Dangerous Behavior Detection
	Vital Sign Monitoring
	Emergency Warning







Source: Flexible Factory Project

(2) Severe Wireless Environment

- Wireless propagation is diverse and depending on: location, scale of the facility, obstacles for radio propagation, machine noise in microwave frequency and evolutional stage for wireless utilization, time by time.
- In some places, we observed tough environments for radio propagation.

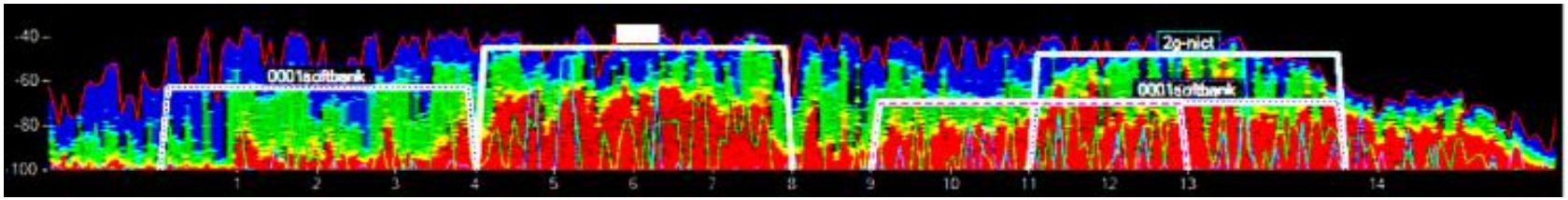
List of Evaluated Factories in Operation

Factory #	Process	Scale	Residential Areas	Shielding Objects	Noise from Machines	Unwire Stage
1	Printed circuit board assembly	Small	Near	No	No	②
2	Large-machine assembly	Large	Isolated	Yes	No	③
3	Large-machine assembly	Large	Isolated	Yes	No	②
4	Large-machine assembly (same as #2, measured half year later)	Large	Isolated	Yes	No	③
5	Printed circuit board assembly	Medium	Isolated	No	No	②
6	Large-metal mold casting	Large	Isolated	Yes	Yes	①
7	Large-metal	Large	Isolated	Yes	Yes	②
8	Large-metal processing(same as #7)	Large	Isolated	Yes	Yes	②
9	Large-metal processing(same as #7)	Large	Isolated	Yes	Yes	②
10	Large-machine assembly (same as #2, measured 1.5 year later)	Large	Isolated	Yes	No	③
11	Large-metal press	Large	Isolated	Yes	Yes	①
12	Large-metal welding	Large	Isolated	Yes	Yes	①
13	Printed circuit board assembly	Large	Isolated	No	No	②
14	Steel works	Large	Isolated	Yes	Yes	
15	Food Manufacturing	Large	Isolated			
16	Medium-size metal parts assembly	Large	Isolated	Yes	No	
17	Medium/large-metal forging	Large	Isolated	Yes	Yes	

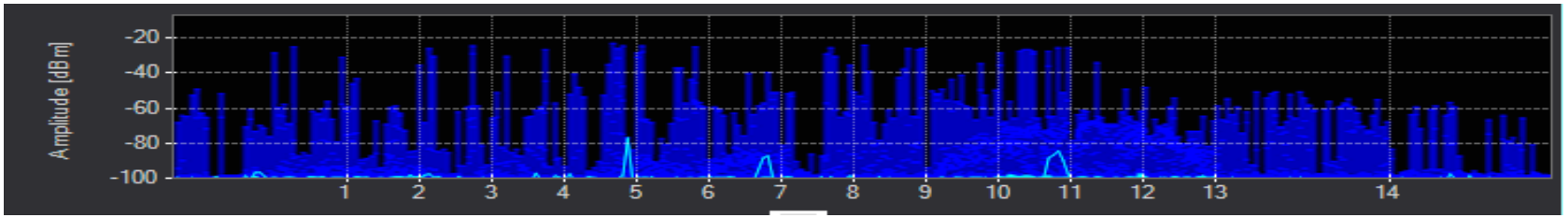
Noise

External and internal noises at 2.4GHz

- Wi-Fi access points placed in residential area near the factory.
- Inverters of motors in equipment in the factory.



Factory for printed circuit board assembly near residential area



Factory for large-metal mold casting

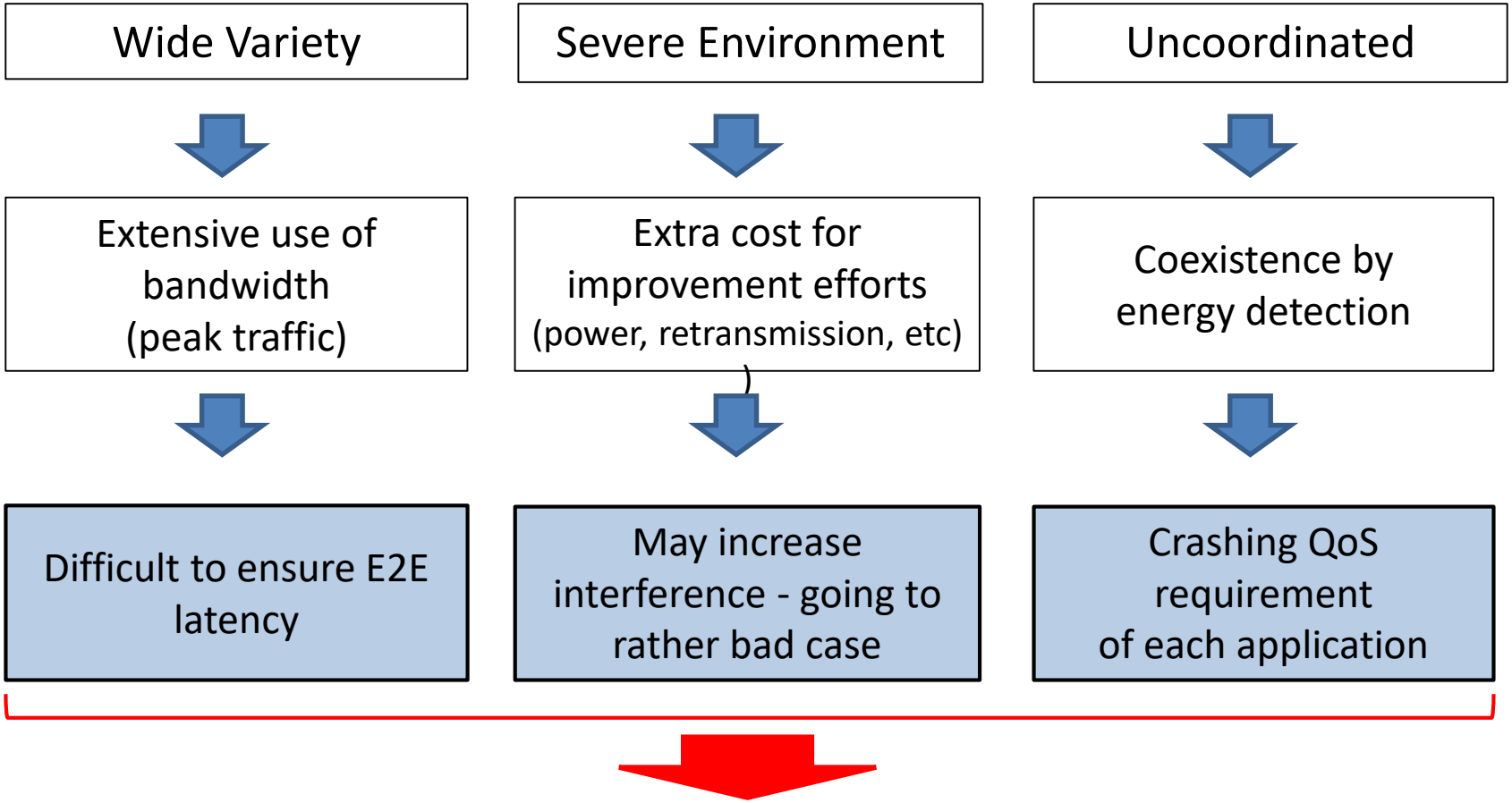
(3) Uncoordinated Independent Systems

- Wi-Fi, Bluetooth, Zigbee, and small-power specified wireless systems have been actually seen in the factories.
- Replacing all wireless devices seems to be difficult since some of them are embedded in machines which operate more than twenty years or more.

Industry specific and applicable wireless standards

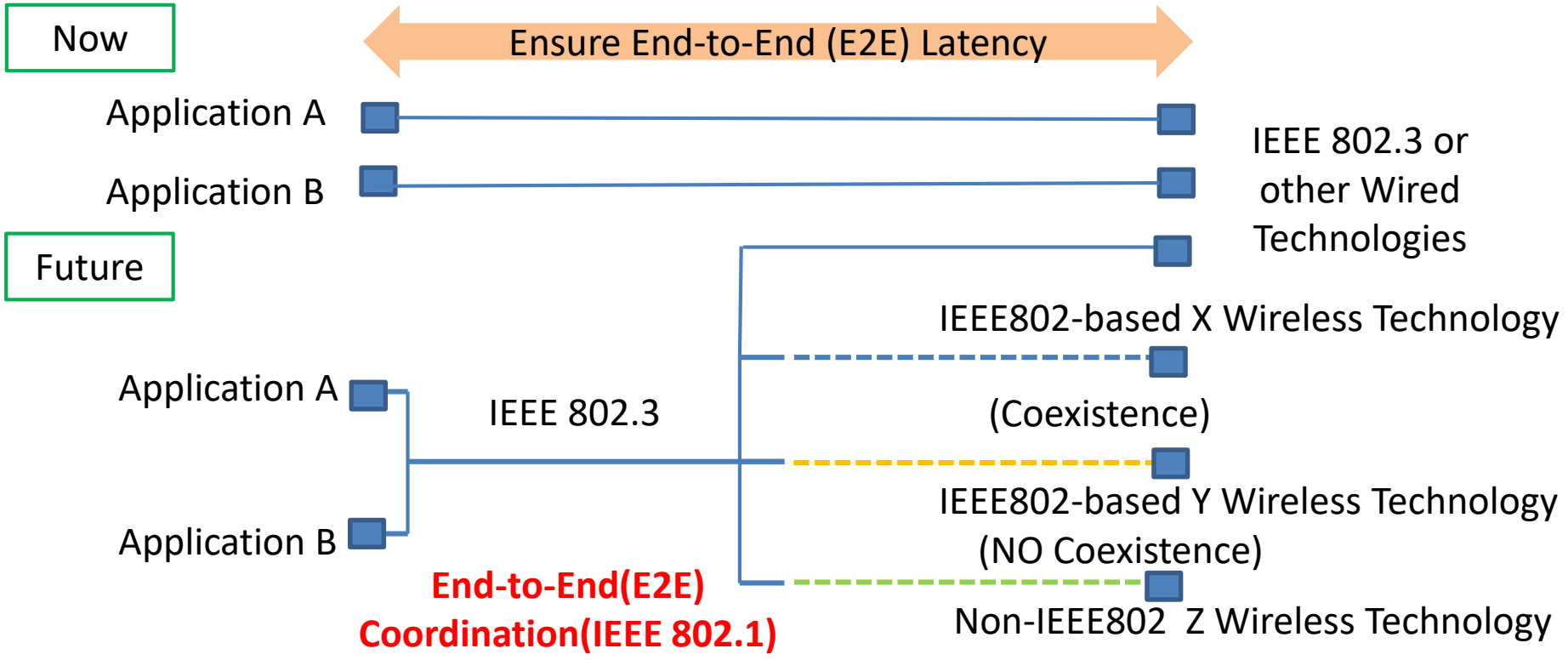
Frequency Band	Industry specific	Industry applicable	IEEEE802 Standard
920MHz		Wi-SUN SIGFOX LoRa Wi-Fi/HaLow	IEEE802.15.4e/g IEEE802.11ah
2.4GHz	WirelessHART ISA100.11a WSAN	Wi-Fi Bluetooth, BLE Zigbee	IEEE802.11 a/b/g/n/ac IEEE802.15.1 IEEE802.15.4
5GHz		Wi-Fi	IEEE802.11 a/b/g/n/ac
60GHz		Wi-Fi/WiGig	IEEE802.11ad

What are Happening or will Happen?



E2E Network Topology for Factory IoT

- E2E network topology for a factory today is configured by combination of wired LAN, such as 802.3, IEEE802-based and non-IEEE802 wireless technologies.
- In order for factory IoT system to work well under such network topology, data frame is treated in a mix of different technologies by high-level E2E coordination.



Factory IoT current and future environment

- We have evaluated wireless environment at several factories in operation and found issues to be resolved.

Wide Variety of Applications -> straining available bandwidth

Severe and Dense Environment for Wireless Communication -> requiring better and more efficient utilization of radio resources

Uncoordinated Independent Systems -> compromising **E2E latency** requirements and required QoS delivery for underlying applications

More Information https://www.nict.go.jp/en/press/2017/03/01-1.html

Potential Solution **Standardized Sophisticated coordination mechanism is required.**

Factory IoT will be discussed under the IEEE 802® Network Enhancements Industry Connections Activity.
Please join our discussion!