FLEXIBLE FACTORY PARTNER ALLIANCE

Digitalization of manufacturing sites

Industrial revolution starts with wireless communications

Manufacturing environments are rapidly changing due to current trends of labor shortages, decreased numbers of skilled workers, diverse customer needs, and intense global competition. To cope with these changes, factories are entering a new stage of evolution, linking people, materials, equipment, and systems via data, and creating new added value from relations between people and technology. The use of wireless communications in factories is essential to handle the increasing flow of data, while supporting flexible operation and management of facilities, and coordinating the work of people and machines.

The Flexible Factory Partner Alliance (FFPA) is promoting the standardization of a wireless platform called the SRF (Smart Resource Flow) wireless platform. The SRF wireless platform features high reliability to never fail even in congested and dynamic wireless environments, high capacity to accommodate many diverse types of wireless systems, and high maintainability to allow management without IT experts.

FFPA aims to develop an open ecosystem, creating business opportunities for equipment vendors and system integrators, improving convenience for users (operators) , and contributing to increased productivity through digitalization of manufacturing sites.

1. Introduction

1.1. Expectations for the use of wireless communication at manufacturing sites

Manufacturing sites face human resource problems, such as shortage of manpower and decrease of skilled workers. It is also necessary to respond to rapid changes in the market such as diverse customer needs and intense global competition. In the past, “Kaizen” by various local or case-by-case methods have been done to maintain the competitiveness of manufacturing sites.

Today, however, factories are entering a new stage of evolution, linking people, materials, equipment, and systems via data, and aiming to create new added value from relations between people and technology. IoT technology enables the collection of information in real time from production facilities and various environmental sensors. ICT can improve productivity, for example by feeding back the results of data analysis by AI to the manufacturing site. In the building of production facilities that use ICT, wireless technology is essential for flexible operation and management of facilities and coordinating the work of people and equipment.

Wireless communication does not require the installation of network cables, so it can reduce the cost of adding IoT functionality to existing equipment. Also, since rewiring of cables is not necessary, the use of wireless communication can reduce the construction costs of changing the layout of production lines for changes of production type and process improvements, and also reduce the stoppage times of production lines. In addition, people (workers) and Automated Guided Vehicles (AGVs) require mobile communication via wireless communication (Fig.1). As these

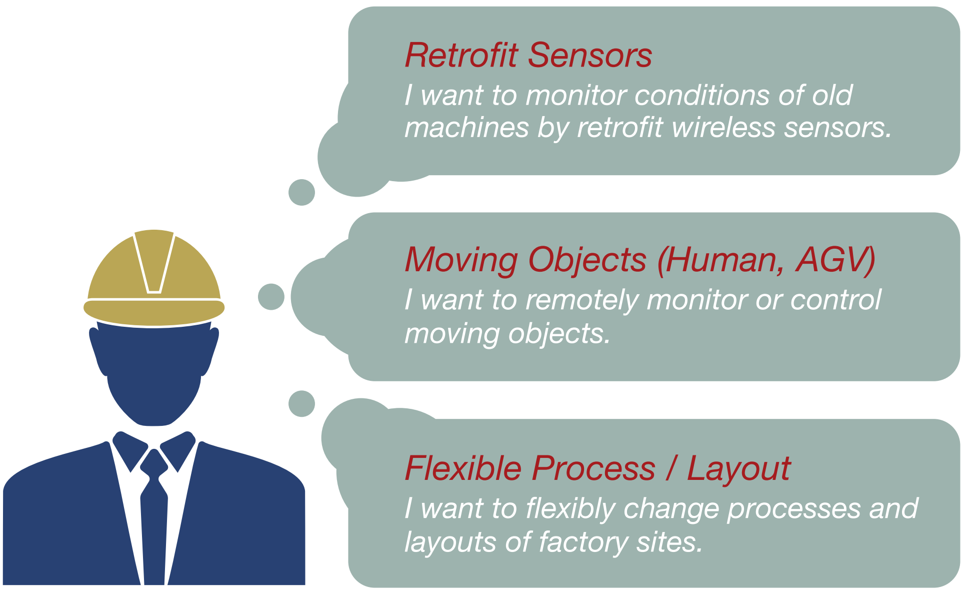

Fig.1. User expectations for wireless communication at manufacturing sites

examples show, wireless communication has many advantages and the utilization of wireless communication at manufacturing sites is promising.

Currently, the share of wireless communication is only 6% of the communication used at factories, but the market size is growing by an annual rate of 32% (Fig.2). The markets for industrial Ethernet and fieldbus are still growing, but the market for wireless communications is growing faster. We can see that there are great expectations for wireless communication as a means of communication in factories.

Fig.2. Wireless communication trends [1]-[3]

1.2. Use cases of wireless communication

Here we describe use cases of wireless communication at manufacturing sites, with examples from a machine assembly plant and a high temperature work site. (Fig.3).

(1) Quality: quality control

Wireless communication is used to send data to servers for quality monitoring and control - inspection data from large numbers of workbenches, operation sequences in Programmable Logic Controllers (PLC) used for machine control, error information and environmental information. Also, work tools such as torque-wrenches acquire and send data to servers - data such as the number of wrench operations and the success of wrench operations, and even time series data such as vibration and torque waveforms.

(2) Resource Management: environment, facilities, materials, people

Temperature and humidity sensors and particle sensors are used for environmental monitoring in places such as paint shops and clean booths. Wireless communication enables the monitoring of sensor data from a separate room without installing cables through walls. It is also easy to retrofit wireless sensors in a clean booth. Other kinds of resources, such as facilities, materials, and people also need to be managed property.

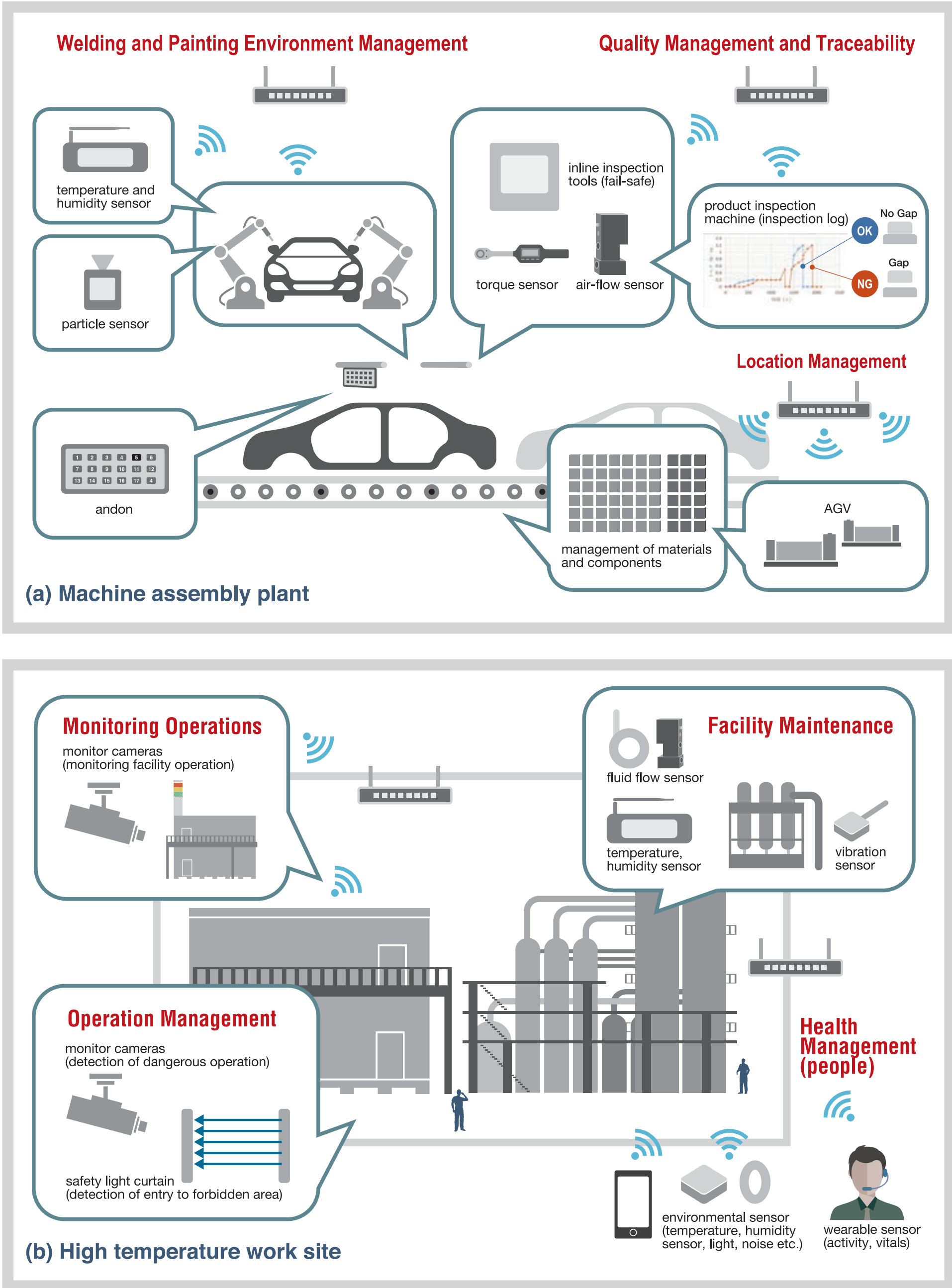

Fig.3. Use cases of wireless communications

(3) Display: production management, work support

Wireless communication is used in production management systems to send data to display systems, such as “Andon” display boards, for real-time display of production status information, such as production schedule, production progress and production line operation status.

(4) Control: control signals, location information

An AGV operates with automatic sensing of position and path. The AGV communicates with a navigation management system via wireless communication to report position and motion information or get operation instructions.

(5) Safety: monitoring of workers

In production sites such as chemical plants and steel plants, there are intrinsic physical dangers due to collisions and falls, and extreme environments with high temperature and high humidity. Monitoring each worker's location and condition using visual images and vitals sensor data is important for worker safety. Wireless communication is essential for collecting worker data as workers move around the plant.

Table 1 shows a summary of use cases in general categories and corresponding purposes [4]. In the manufacturing field, wireless communication is utilized in a variety of applications including quality control, environment management, display systems, equipment control, and safety management.

Table 1. Category and purpose of wireless communications in factories

Category	Purpose
Quality	• Check that products are being produced with correct precision • Check that production is proceeding with correct procedure and status
Resource Management	• Check that the production environment is being appropriately managed • Monitor movement of people and things • Check the management status of equipment and materials (stock) • Check that the production equipment is being maintained • Record work and production status
Display	• Provide work support information • Visually display whether the process is proceeding without congestion or delay • Visually display the production status
Control	• Operate and control production equipment and auxiliary equipment
Safety	• Ensure the safety of workers
Other	• Cases other than the above

The requirements for wireless communication depend on the particular purpose. Table 2 shows examples of quality requirements for wireless communication at a manufacturing site [5], The examples show that a manufacturing site can be a heterogeneous system with a variety of communication quality requirements.

Table 2. Examples of communication requirements

Category	Communication Quality Tolerance							
	Latency (msec)			Bandwidth (kbps)			Packet Loss	
	<100	100~1000	>1000	>1000	100~1000	<100	Loss-less	Non Loss-less
Quality	●	●	●	●	●	●	●	
Resource Management		●	●	●	●	●	●	●
Display		●	●	●	●	●	●	●
Control	●	●				●	●	
Safety	●		●	●	●	●	●	●
Others		●	●	●			●	●

2. Responding to market needs

2.1. Vision

In many existing manufacturing sites, large amounts of data and information may be under-utilized, restricting the accumulation of know-how for quality control and production management, because the implementation, operation and maintenance of the communication network is costly and troublesome. If wireless communication is used to satisfy the needs of various applications, such as described in the previous section, with low cost of implementation and maintenance, "digitalization" of factory information will advance, enabling "visualization" and "integrated management" to increase productivity (Fig.4).

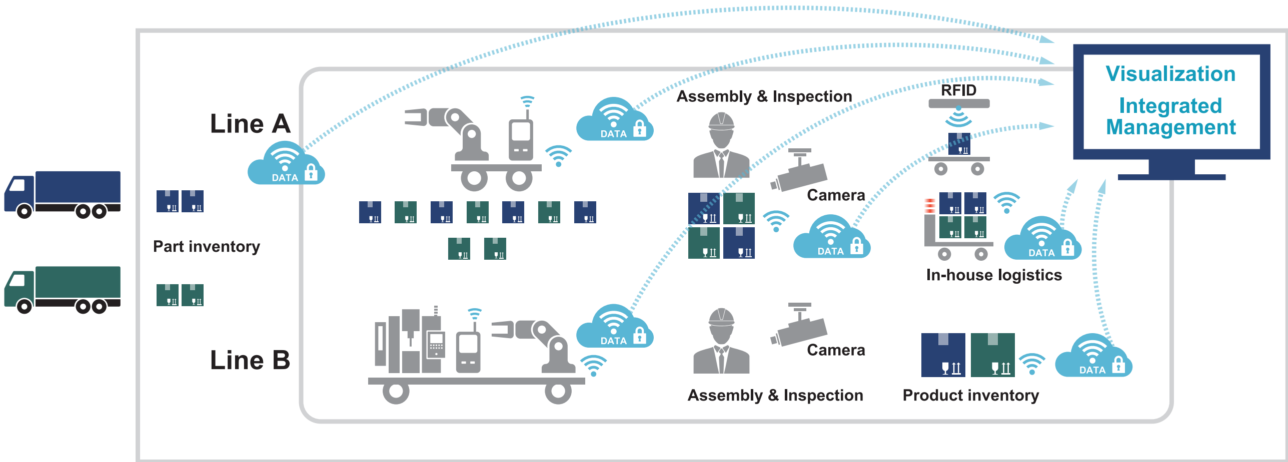

Fig.4. Visualization and integrated management by digitalization of manufacturing sites

Even if manufacturing sites can be totally monitored to enable visualization and integrated management, operation will not be satisfactory if trouble-shooting and improvements of individual processes cannot be handled locally on-site. It is necessary to enable flexible operation of individual processes as well as monitoring of the whole factory site.

The Flexible Factory Partner Alliance (FFPA) is promoting the use of wireless communications at manufacturing sites as a means of flexibly collecting data and information with little effort and low cost. In addition, FFPA engages in standardization activities and the promotion of coordination control technologies that enable stable communication in environments where multiple wireless systems coexist.

Realization of a platform enabling visualization and total management of data in manufacturing sites

FFPA is promoting the development and use of a wireless platform called the Smart Resource Flow (SRF) wireless platform, as the key to realizing the visualization and integrated management of factory site data (Fig.5). The concept of SRF is to

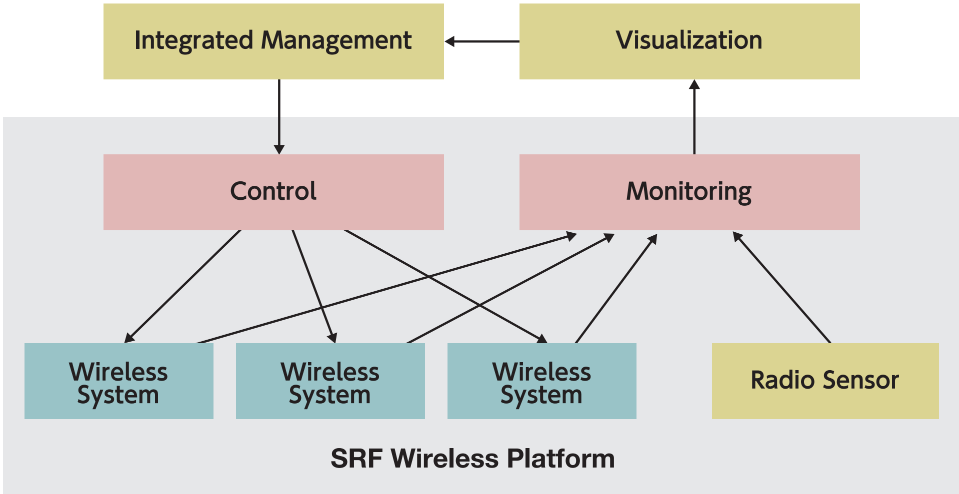

Fig.5. Scope of the SRF wireless platform

optimally manage manufacturing resources (including humans, devices, equipment, materials, energy and communication) to flow smoothly during manufacture. While wireless communication is expected to be useful for data collection and control in manufacturing sites, it is also necessary to ensure high reliability, large system capacity, stability and maintainability. In response to these issues, FFPA is advancing the development of the SRF wireless platform for data collection in manufacturing sites using wireless communication. A technical explanation is presented in a later section.

Global Collaborations

While various devices and services with wireless communication are used in manufacturing sites worldwide, the use of radio waves is regulated in each country and the radio spectrum resources are limited. Rational rules are needed to properly utilize spectrum resources, and it is important for stakeholders to cooperate and share knowledge to make effective rules. While working toward the standardization of functions and interfaces of the SRF wireless platform, FFPA is building partnerships internationally and promoting the use and cooperation of various existing wireless systems.

As examples of collaboration, events have been held in Europe with partners of the 5G Alliance for Connected Industries and Automation (5G-ACIA) and the German Mechanical Engineering Industry Association (VDMA).

2.2. Issues for the deployment of wireless communications

Wireless communication is useful for a variety of purposes in manufacturing sites, as described in Section 1.2, and there are many cases where wireless communication has already been installed. The need to consider the compatibility with legacy wireless communications when installing new wireless communications may be an issue that limits deployment in manufacturing sites.

In manufacturing sites it is common for some manufacturing equipment to be continued to be used for many years while investment in new equipment is also proceeding. As a result, it is common for old and new equipment to exist together (Fig.6), with various types of wireless devices, including legacy wireless communication standards. In the future, as digitalization of information progresses, and more and more types of wireless communications are used in manufacturing sites, problems due to the co-existence of a complex mixture of various wireless communication device types and various communication standards may become more severe. As it is necessary for many vendors to provide many different types of devices and equipment in a factory, it is necessary for vendors to cooperate to overcome such problems.

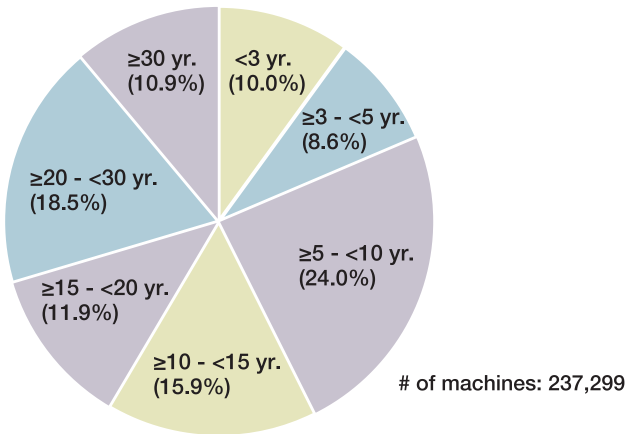

Fig.6. Production facilities holding period [6]

2.3. Features of wireless communication in manufacturing sites

Key features of wireless communication that must be considered in manufacturing sites are as follows.

- Dynamic changes of wireless environments
  - msec to sec/minutes: Motions of materials, parts, products, and carriers in a closed space.
  - Hours to days: Retooling, equipment changeovers, and systems switching on/off.
  - Months to years: Layout reconfiguration, and installation of new production lines.
- Variety of wireless environments: Variety of types of manufacturing, equipment, wireless devices and communication types, signal obstructions, and noise sources.

Considering these features when deploying wireless communication systems can be expected to accelerate the utilization of data and information in manufacturing sites and contribute to the improvement of productivity.

2.4. Ecosystem and its benefits

FFPA aims to standardize open interfaces for safe and secure wireless communication based on the SRF wireless platform in order to resolve restrictions on the deployment and use of wireless communication (Fig.7).

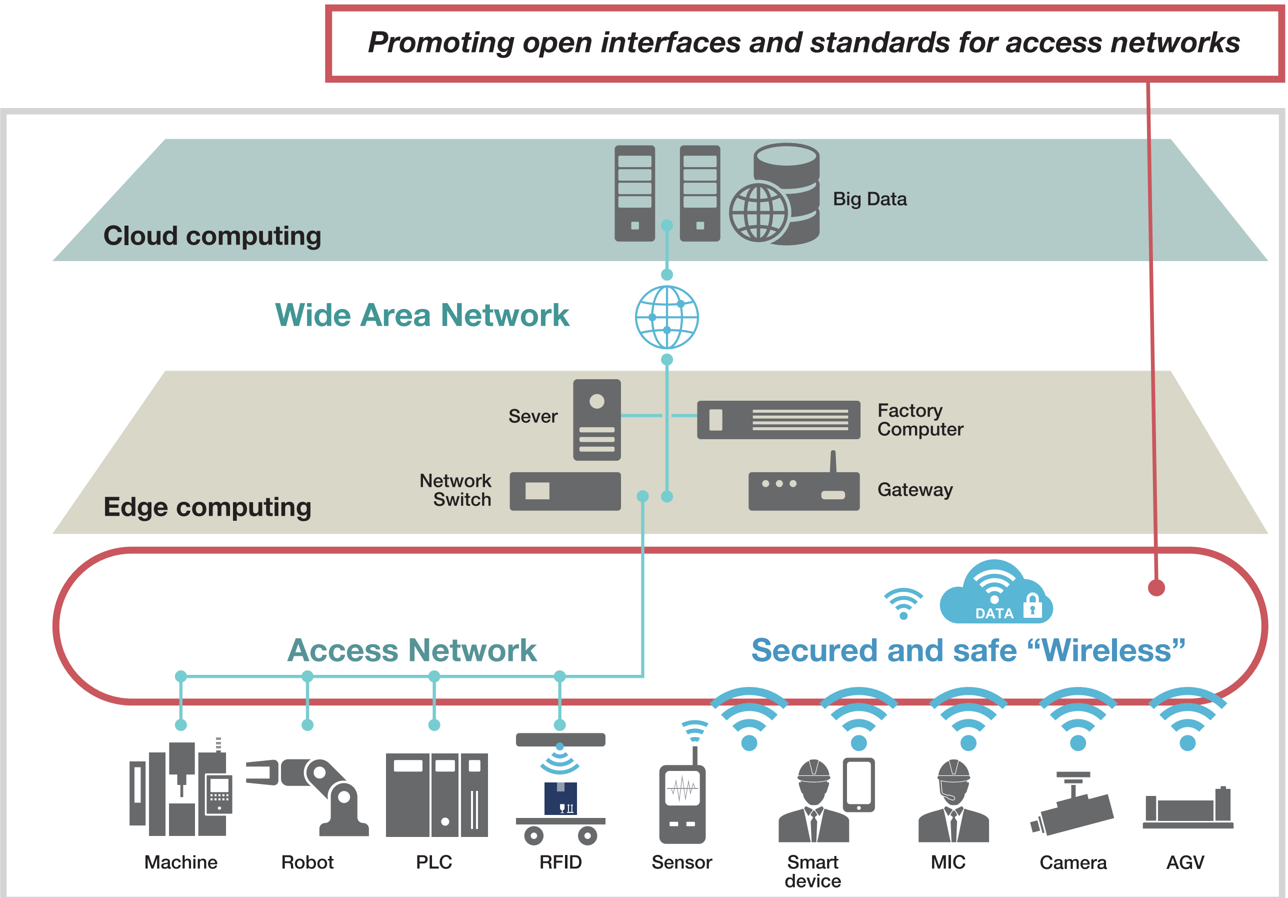

Fig.7. Secure and safe open interface for wireless communications

An ecosystem based on the SRF wireless platform will encourage market growth. The SRF wireless platform will enhance business opportunities for devices vendors and system integrators, and enhance convenience for users (operators).

- Device/Equipment Vendor

  Guaranteeing safe and reliable operation of products with wireless communication.

• System Integrator

  Reduce design and installation burden, to realize low-cost and scalable network infrastructure.

  Simplify troubleshooting and problem solving.

• User (Operator)

  Operation and maintenance based on more detailed management information.

FFPA aims to achieve standardization, certification and interoperability testing of the SRF wireless platform. Furthermore, FFPA is planning to certify products and factories based on the introduction of the SRF wireless platform.

2.5. VoC Community

Users wish to share issues and use cases of ICT in manufacturing sites and cooperate to find solutions for common needs. However, there are few places to exchange such information.

In order to respond to the needs of users, FFPA established the VoC (Voice of Customer) Community as a user group promoting the utilization of ICT in the manufacturing sites (Fig.8). User needs identified from the information exchange in the VoC Community are reflected in the products and services provided by FFPA member companies.

Fig.8. FFPA & VoC Community

3. Technical Requirements of SRF Wireless Platform

3.1. Architecture

In manufacturing sites where various kinds of wireless applications use various wireless systems operated independently in un-licensed frequency bands, wireless systems suffer reduced performance due to interference of radio waves, and as the result, wireless applications cannot work properly. Such problems are increasing in manufacturing sites as the volume and variety of wireless communications increase (Fig.9).

The SRF wireless platform has a coordination control mechanism which considers the communication quality requirements of each and every wireless application, and controls radio resources of frequency, time and space according to these requirements.

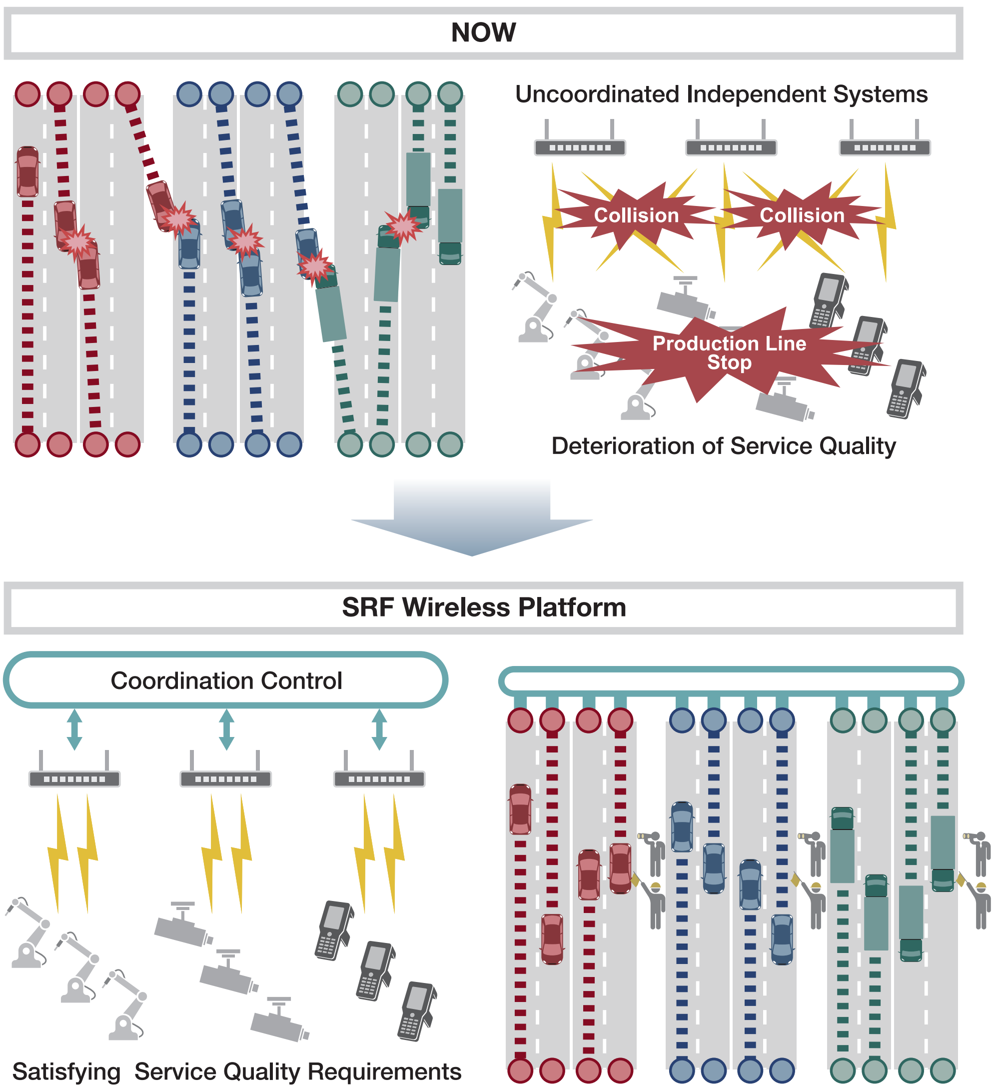

Fig.9. Image of coordination control at SRF wireless platform

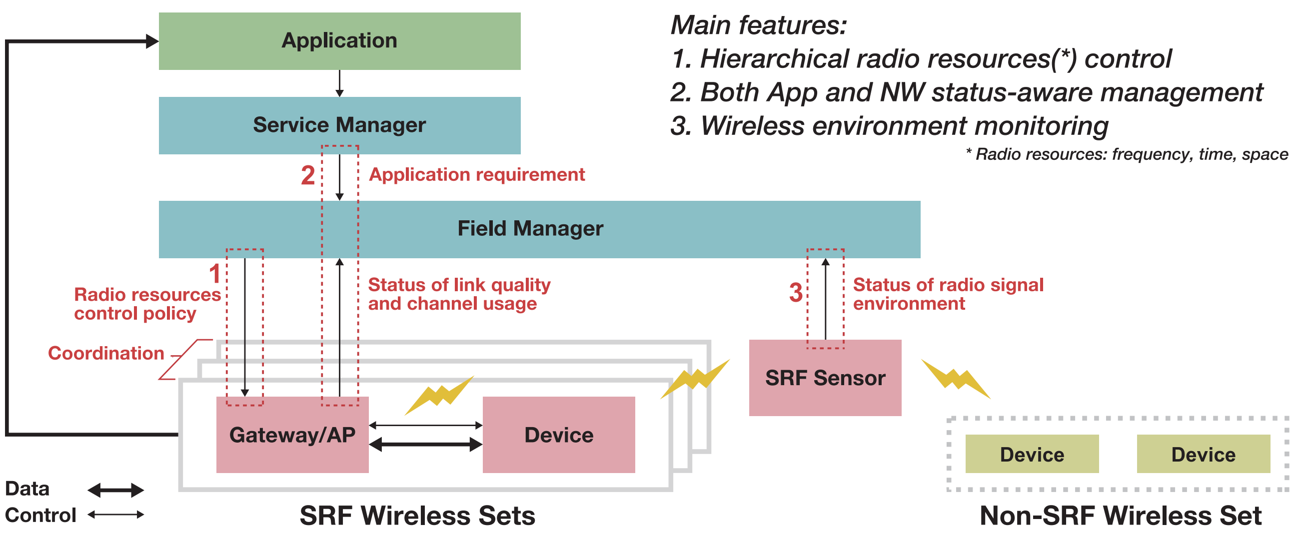

Fig.10. Architecture of SRF wireless platform (implementation example)

Figure 10 shows an example of the implementation of the SRF wireless platform architecture. A Field Manager conducts the coordination control (called global control) of radio resources for multiple wireless applications consisting of gateways and devices. Global control achieves stable and efficient operation of various wireless applications by the following means:

(1) Assigning a radio resource control policy to every wireless application to allocate radio resources.
(2) Coordination control based on the status of wireless networks (link quality, channel using status, etc.) and the status of applications (application requirement, etc.).
(3) Monitoring of the radio environment.

According to the radio resource control policy, the Gateway/Access Point (AP) conducts autonomous fine control (called local control) of radio resources to adapt promptly to local rapid changes of radio environment.

3.2. Advantages

SRF wireless platform uses dynamic hierarchical radio resource control (Fig.11) consisting of global control and local control to achieve (i) optimal management of radio resources adapting quickly to changes of radio environment, and (ii) integrated management of various wireless applications which have a variety of communication quality requirements (bandwidth, delay, etc.).

Current performance targets of the SRF wireless platform are:

- 100msec (max) delay, lossless transmission.
- 3-times increase in spatial density of sensor nodes.
- Visualization of wireless communications, cooperation with legacy devices.

The achievement of these targets will establish an ideal platform for manufacturing sites, providing (1) reliable wireless access with stable communication performance even in congested and dynamically changing radio environments, (2) system capacity which can accommodate many and various wireless systems that enhance production quality and productivity, and (3) system operability and maintainability which does not rely on IT experts for the management of data flows and the radio environment.

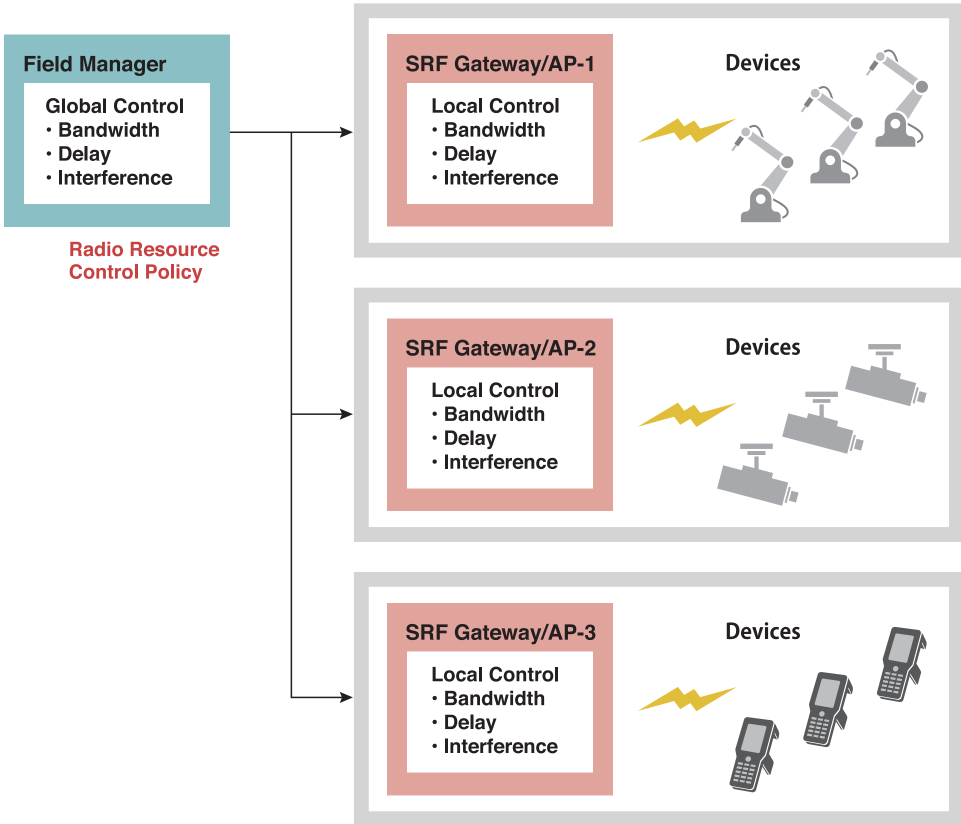

Fig.11. Hierarchical radio resource control (global control / local control)

4. Milestones

Technical Specifications(Ver.1): September, 2019
Certification Program: Scheduled in 2021

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