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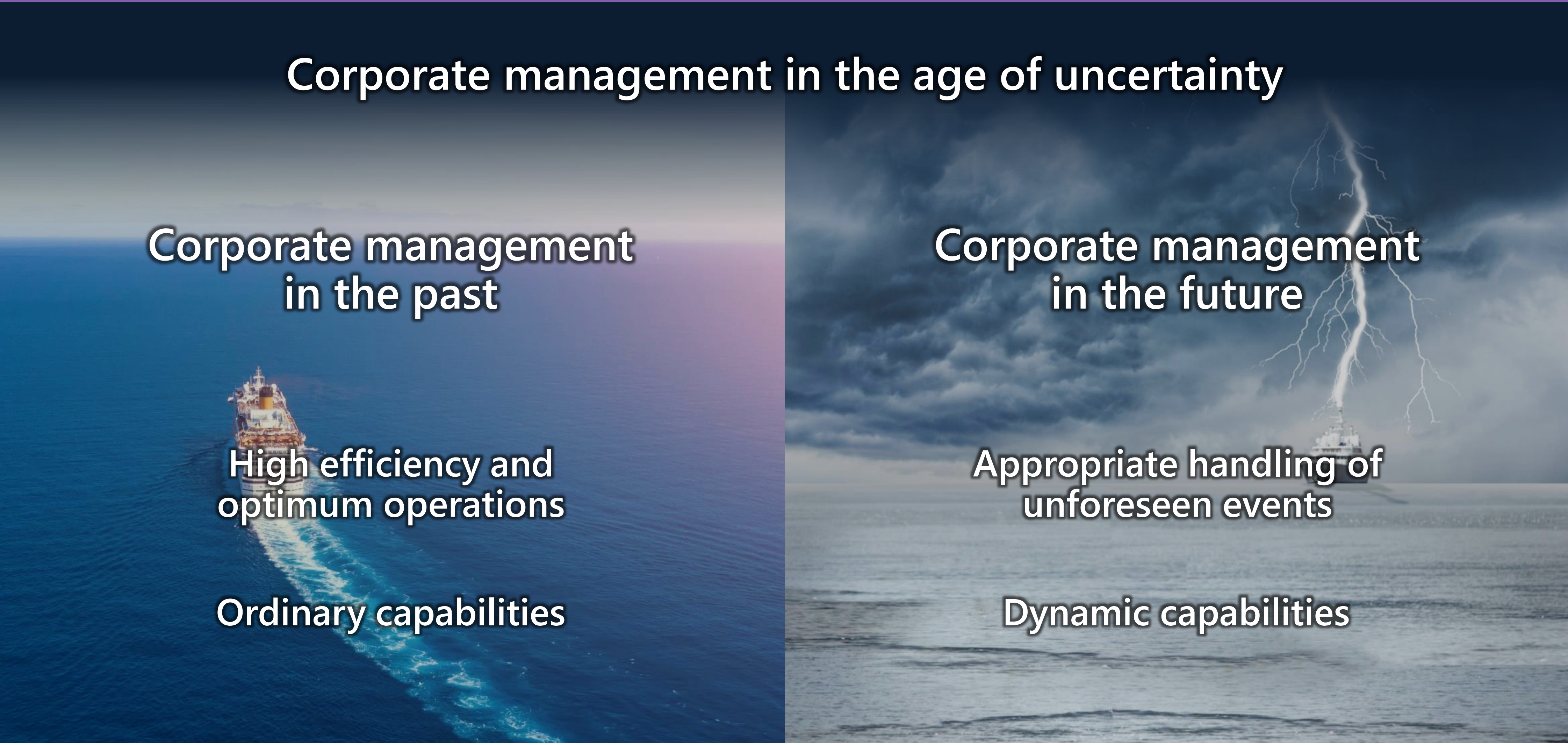
Implementing mission critical IoT with

Symbiotic Evolution Architecture

Website about Symbiotic Evolution Architecture for implementing mission critical IoT

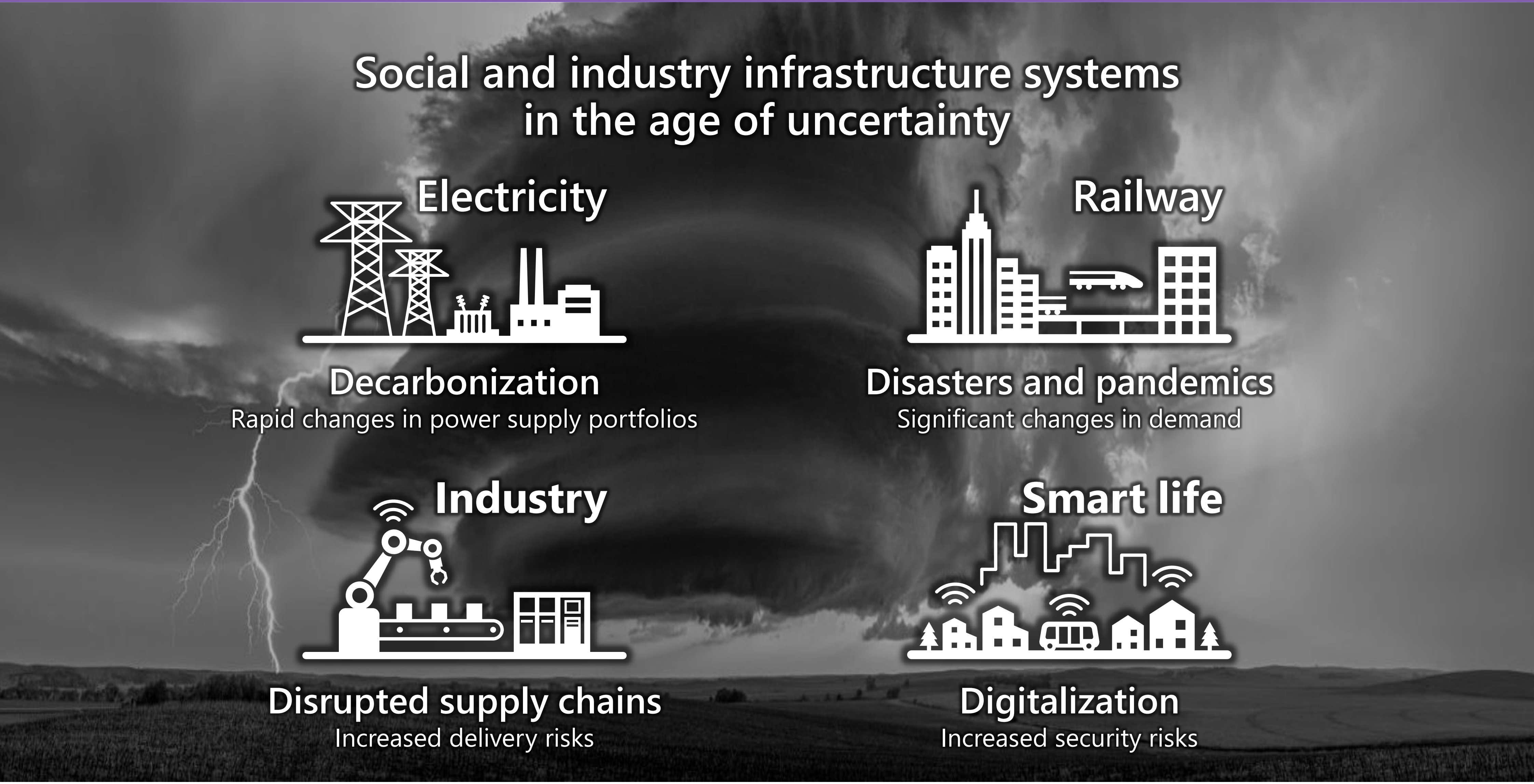
Content



In the past, ordinary capabilities were needed to ensure efficient and optimum use of corporate resources.
Currently, however, the world is facing rapidly increasing uncertainties due to a rapid shift to a decarbonized society, natural disasters and pandemics such as COVID-19, disruption in global supply chains, and rapid progress of digitalization. Business organizations must have dynamic capabilities so they can handle unforeseen events appropriately.

Note: Dynamic capabilities are classified into the following categories:
- **Sensing** capabilities to detect threats and danger
- **Seizing** capabilities to capture opportunities and reorganize existing assets, knowledge, and technologies to gain competitiveness
- **Transforming** capabilities to revamp and transform the entire organizational structure in order to maintain a competitive edge

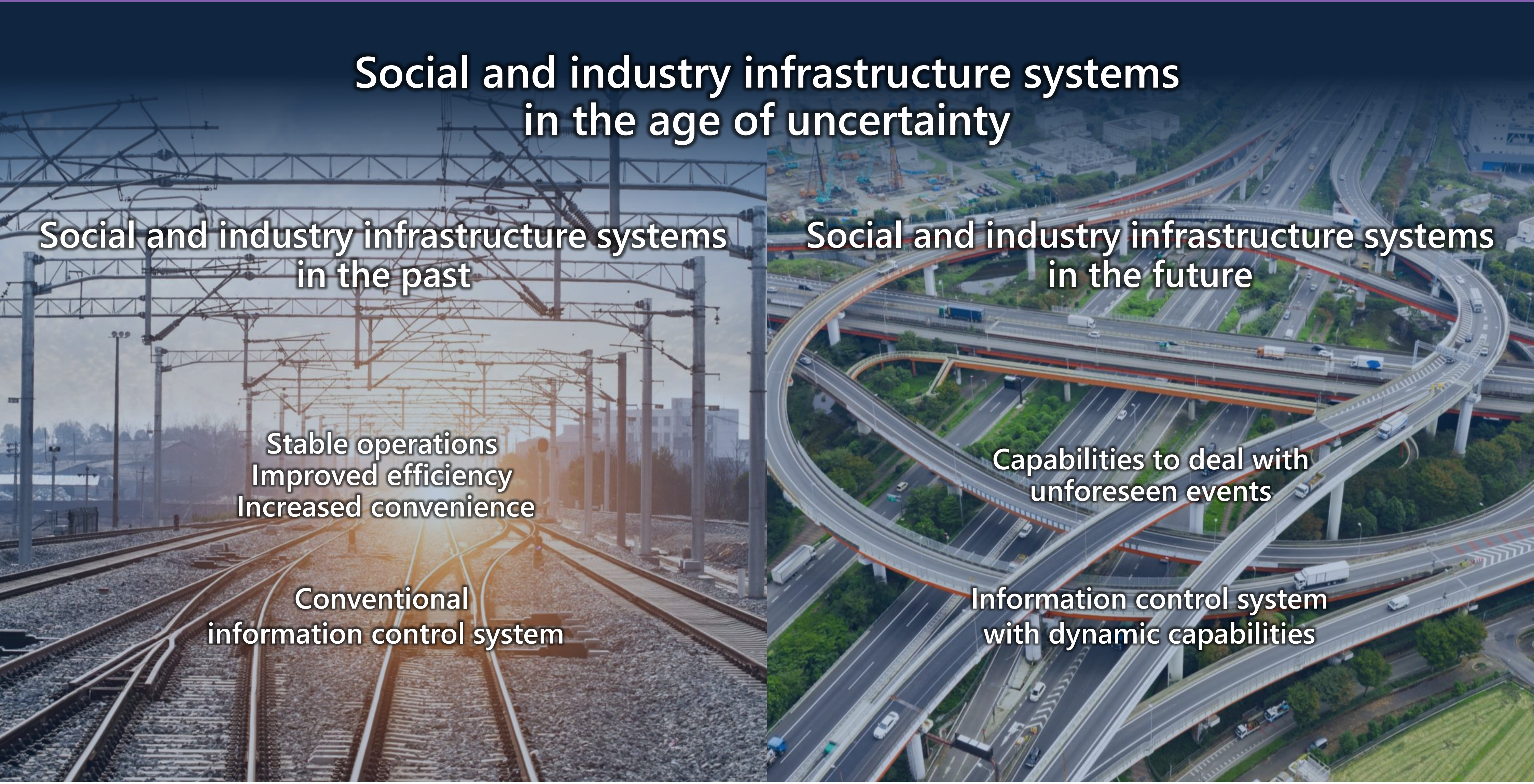
Source: *Monozukuri Hakusho* (White Paper On Manufacturing Platforms) for FY 2020, Ministry of Economy, Trade and Industry



Social and industry infrastructure systems in different industrial sectors must be able to address uncertainties that might arise in the world.

- Electricity sector: The power supply portfolio is rapidly changing as we move toward decarbonization.
- Railway sector: Demand is significantly changing due to the COVID-19 pandemic.
- Industrial sector: There are growing risks with product delivery due to disrupted supply chains.
- Smart life sector: Security risks are increasing due to rapid progress in digitalization.

Social and industry infrastructure systems in the age of uncertainty



In the past, social and industry infrastructure was intended to ensure the consistent provision of services to general users and to improve convenience. Such infrastructure was built on information control systems, which were primarily intended to ensure stable operations.
In the future, such information control systems must have dynamic capabilities to deal with unforeseen events in the age of uncertainty.

Use cases of information control systems with dynamic capabilities

This material describes use cases of information control systems with dynamic capabilities.
For example, as society moves towards decarbonization, the railway sector is being requested to use electricity more efficiently and proactively use renewable energy sources by controlling power generation, train schedules, and facilities such as railway station buildings.
In the meantime, the industrial sector is being requested to respond immediately to changes in demand by implementing production management and logistics management.
By addressing these requests, Hitachi believes it can contribute to improving social value related to the environment, resilience, safety and reliability.

Environment	1 Managing energy for a decarbonized society
Resilience	2 Enabling uninterrupted business operations
Resilience	3 Connecting systems to respond immediately to changes
Resilience	4 Using robots to ensure safety and availability
Safety/reliability	5 Integrating and increasing the sophistication of social infrastructure systems

1. Managing energy for a decarbonized society

Implementing optimum control of energy usage based on flexible provision of resources by multiple departments in real time

There is a growing expectation for social infrastructure operators that they should maximize the efficient use of natural energy, which has a low burden on the environment. For example, railway operators can use electricity effectively if they speed up a train while another train slows down.

Traditionally, however it was difficult for railway operators to make such adjustments during the time periods when the train schedule was not busy, and if there was a temporary excess or shortage of power, they used power storage facilities near railway tracks to make adjustments. In addition, their systems ran separately and independently. The operation control system and the electricity control system were used to ensure on-time train operations, whereas the facilities control systems in station buildings and other facilities were used to ensure convenience for passengers.

Based on the use of existing systems, our Symbiotic Evolution Architecture for mission critical IoT can ensure on-time train operations and comfortable passenger experiences, maximize the use of natural energy, and maintain and manage resilient social infrastructure that meets market needs and business needs.

IoT: Internet of Things

1. Managing energy for a decarbonized society

Implementing optimum control of energy usage based on flexible provision of resources by multiple departments in real time

Connecting running systems, sharing data in real time

The Symbiotic Evolution Architecture can be used to connect multiple running systems to enable mutual sharing of data on those systems.

For example, this architecture can be used to connect the operation-control systems for trains and the facilities-control systems for station buildings, so these systems can share data on energy shortages and excesses in real time. The railway operator can transmit energy from facilities or trains that have ample energy to other facilities or trains that need additional energy. This enables railway operators to use energy effectively and broadly. This architecture provides responses within defined time periods during system operation and, when transmitting energy, it matches excess-energy systems with insufficient-energy systems. This architecture also manages sharing of the latest data in the system to ensure that real-time data is always used. In this way, the architecture can ensure stability in mission-critical site operations.

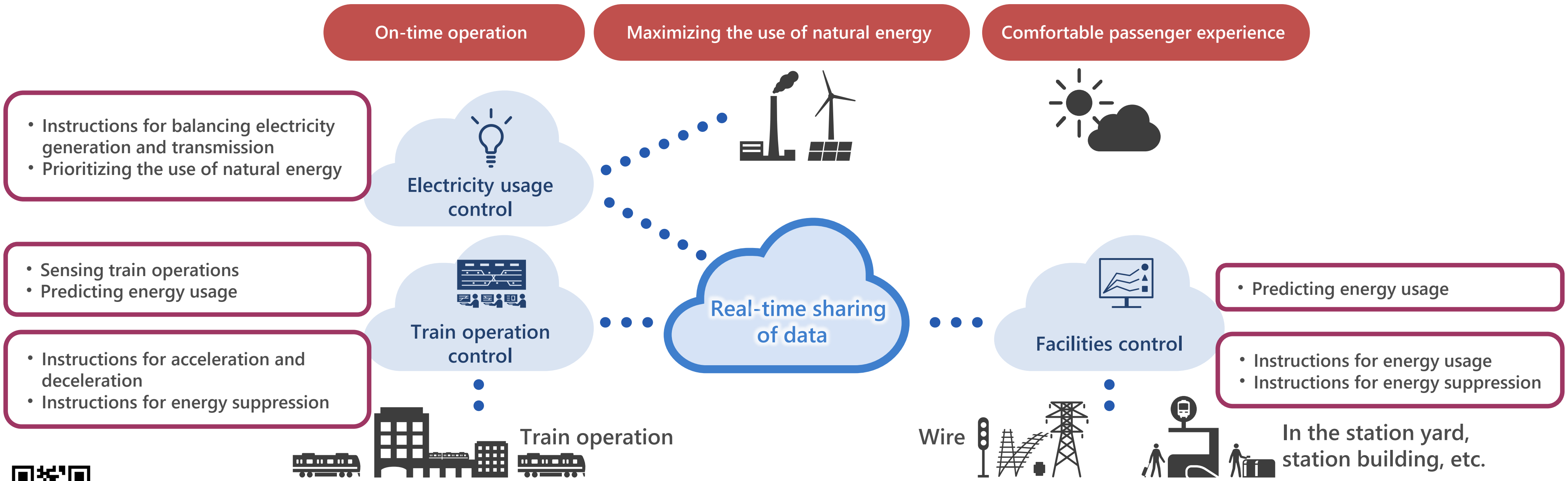
Maximizing the use of natural energy

If you wish to evolve your system to enable the use of natural energy sources, you can use the Symbiotic Evolution Architecture to share site data in real time and examine the current conditions of the site to perform predictive simulation and intelligence processing on the DX system to meet the needs of the site.

This architecture analyzes factors (such as movement of clouds) and estimates the amount of energy suppliable from solar energy and hydroelectric energy. This architecture can also be used to investigate fluctuating energy demands in real time, and can create a plan for optimum energy usage.

In this way, the architecture enables optimum use of electricity generated from natural energy sources in a way that meets the needs of the site.

DX: Digital Transformation



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2. Enabling uninterrupted business operations

Controlling multiple connected systems in real time

In recent years, a growing trend is to connect multiple systems in social infrastructure systems to improve convenience of services. In addition, there is a growing demand for the ability to address problems on the fly and ensure uninterrupted operations without stopping services.

For example, if multiple railway lines are connected to provide a through service, such railway lines are usually managed by different operation control systems, and the trains run in accordance with time schedules that are planned separately for each railway line. If the train schedule for one of the railway lines is disrupted, the railway line operator cannot change the train schedule for the other railway line. They are forced to stop the through service and switch to a shuttle service in each of the lines until the train schedule returns to normal. Disruption in train schedules can also cause problems in allocating train cars and train crews. For example, the railway operator might be forced to give up moving their train cars to the train depot for inspection.

If the Symbiotic Evolution Architecture is used, operation management systems for different railway lines can share train schedules of those lines in real time. As a result, if the train schedule for one of the railway lines is disrupted, the railway line operator can reschedule their train schedule, taking into consideration the changes in the train schedule of the other railway line.

The Symbiotic Evolution Architecture can be used to maintain train operations while maintaining efficiency, and can link multiple systems in real time to provide new services to customers.

2. Enabling uninterrupted business operations

Controlling multiple connected systems in real time

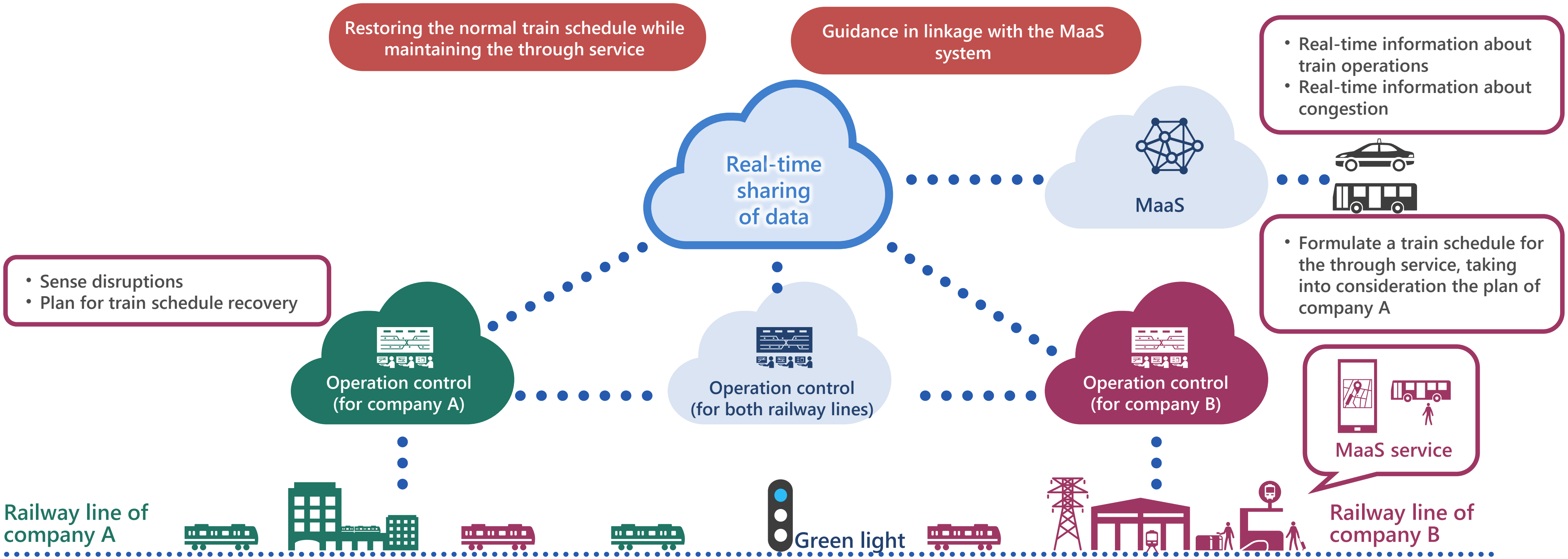
Restoring the normal train schedule while maintaining the through service

Even if a train schedule is disrupted, the railway operator does not need to stop the through service or provide shuttle services. They can restore the normal train schedule while maintaining the through service and thus minimize the negative impact on allocations of train cars and train crews.

Improving convenience for passengers

Information such as the train schedule, the schedule recovery plan, and train congestion is shared in real time in the MaaS system. This improves passenger convenience because the railway operator can estimate train schedules and train congestion, and can provide users with train operation information and train tickets.

MaaS: Mobility as a Service



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3. Connecting systems to respond immediately to changes

Connecting different systems to control production in real time

In recent years, there is a growing need for production systems to have sophisticated data visualization capabilities for identifying work progress with high accuracy and for estimating product quality.

Ordinary production management systems manage the progress of work in each process. For example, such systems record the start time after the required materials, tools, and work drawings have been prepared according to work instructions. The systems also record the work end time when the work finishes and the product status is detected. Such a production management method of recording only the work start time and the work end time of a process is not enough to identify irregular incidents that occur in the process. For example, if someone drops a product during the process, the manufacturer might be forced to delay product delivery, or a defective product might be delivered because the manufacturer cannot immediately determine whether the dropped product is damaged or how many substitute products need to be prepared.

As AI and image analysis technologies evolved in recent years, production systems have developed the capability to detect errors in work procedures and products. Production systems can also use sensors to monitor vibration and sound from equipment and detect problems in production machinery.

By using our Symbiotic Evolution Architecture, you can connect your running system with other systems, so that the systems can share data with each other. In addition to sharing real-time values and accumulated past values, this architecture enables the sharing of sound and video, because the architecture supports meaningful data such as signal names, timestamps, and data length.

The architecture can be used to send videos from security cameras of a defect detection system at a site and data on sound and vibration from equipment to the production management system in real time. By doing so, this architecture can visualize the progress and status of each work process, which cannot be identified by production management systems alone. This architecture can also detect erroneous operations and defective products in real time, provide estimates, and control work quality, so your production management system can allocate or increase site workers effectively.

AI: Artificial Intelligence

3. Connecting systems to respond immediately to changes

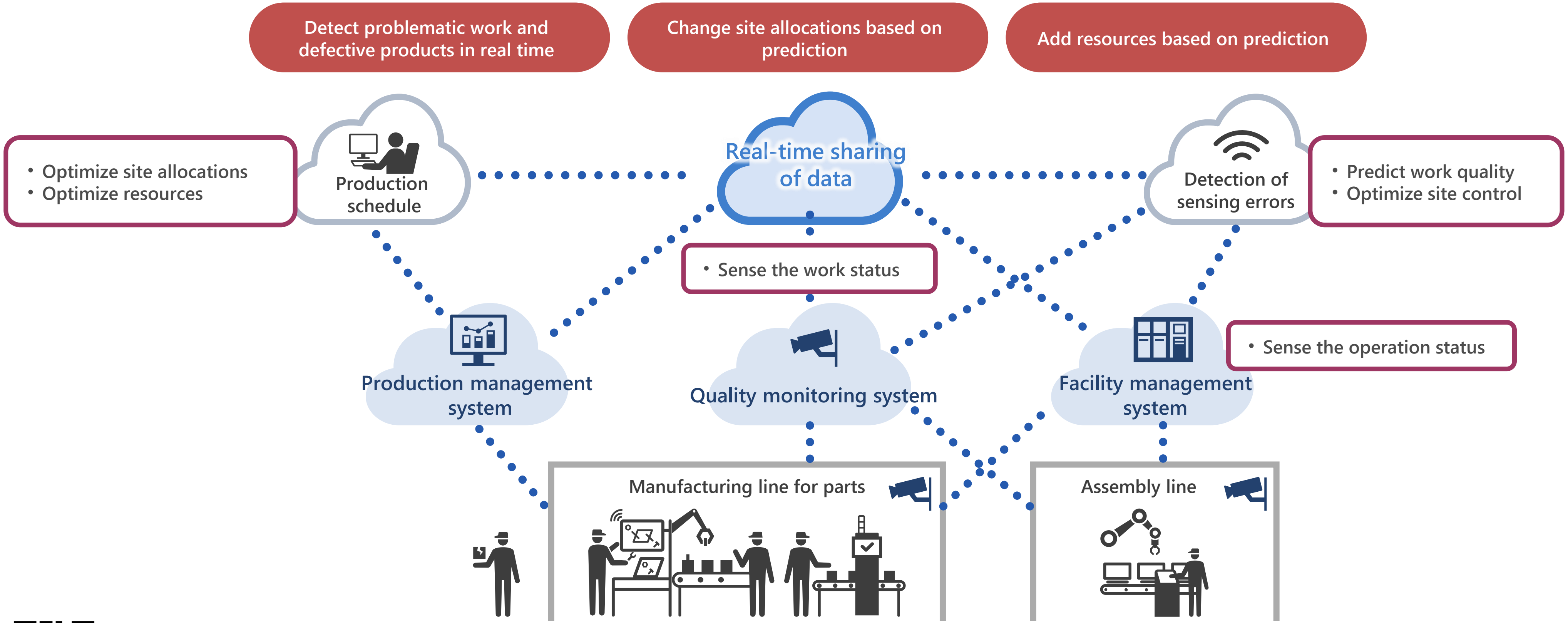
Connecting different systems to control production in real time

Visualize production progress in real time and optimize production sites

You will be able to check in real time whether products are stuck in a process, whether the actual work hours exceed the planned work hours, and whether someone is doing irregular work.

Predict work quality by comparisons with video of normal operations

You can predict mistakes at work by comparing the videos from security cameras with video of normal operations. In this way, the Symbiotic Evolution Architecture can improve production sites.



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4. Using robots to ensure safety and availability

Autonomous robots entering into or leaving from systems

In recent years, factories face the need to implement automation and flexible production systems, so communication between factories and warehouses is becoming increasingly important. Communication between sites is also becoming increasingly important.

At the same time, manufacturing companies face the need to introduce automated guided vehicles (AGVs) so that the AGVs can go back and forth between multiple sites. They also face the need to make sure that site workers and AGVs work safely together.

To ensure that AGVs can travel smoothly between sites, manufacturing companies must use their site-management system to collect information such as locations of equipment, movement of workers, and traveling routes of other AGVs and thereby take control of AGVs and other equipment. They must also ensure safety by blocking people from entering the traveling routes of AGVs. As a result, there are restrictions on the scope of jobs and travelling routes of AGVs in factories and warehouses.

By using our Symbiotic Evolution Architecture, you can connect your running system with other systems, so that the systems can share data with each other. You can use the Symbiotic Evolution Architecture to share data by AGVs and multiple site management systems, and thereby eliminate the restrictions on the scope of jobs and travelling routes of AGVs. In this way, the Symbiotic Evolution Architecture contributes to safety in collaborative operations and highly efficient robot operations with fewer restrictions.

4. Using robots to ensure safety and availability

Autonomous robots entering into or leaving from systems

Expand the scope of travel for AGVs

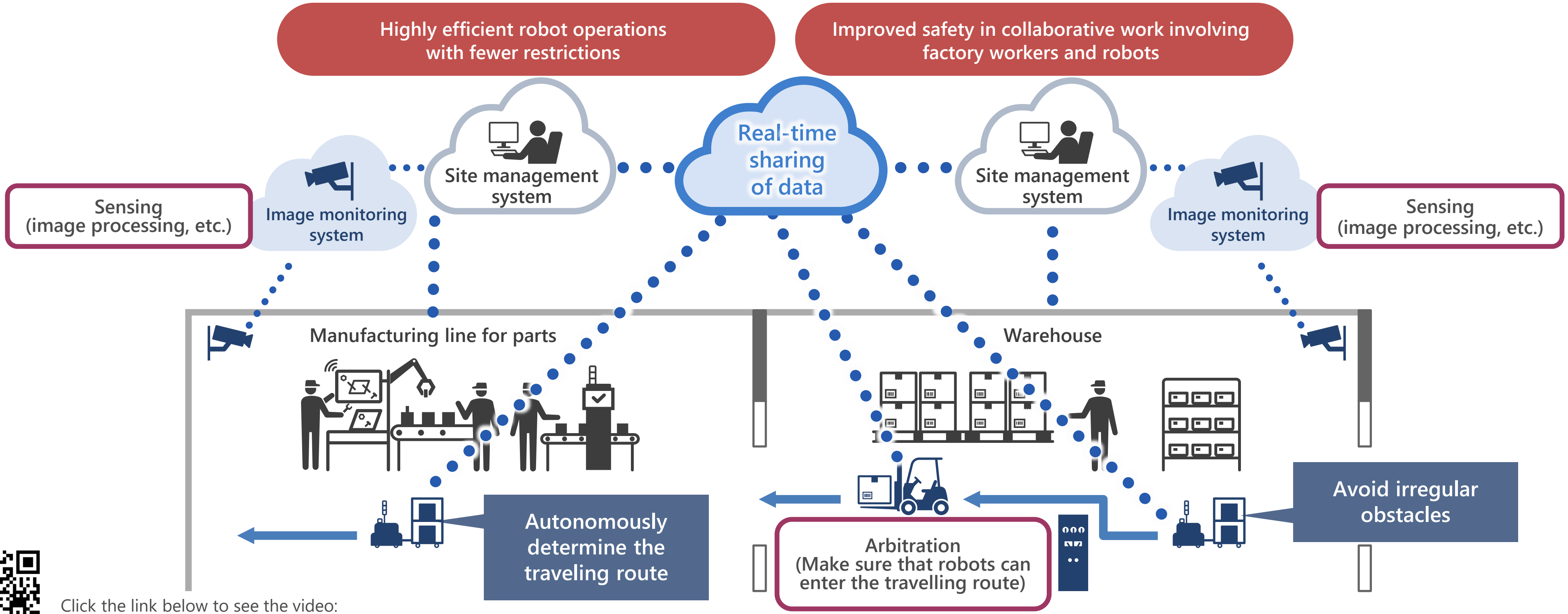
Automated guided vehicles (AGVs) and site management systems share information about traveling routes (for example, traveling directions and traveling speeds). They also share information about floor layout in buildings and traveling routes of other AGVs. Sharing the same data contributes to widening the scope of travel by AGVs.

The systems can utilize data from collision prevention sensors in AGVs and thereby determine transportation routes in a way that prevents collisions. This facilitates the planning of safer operations.

Use image monitoring to manage information about robot locations

The Symbiotic Evolution Architecture enables sharing of real-time data values and accumulated past data values. This architecture also enables sharing of tagged data (such as signal names, timestamps, and data lengths) and other data including voice and video. This means you can easily use the footage from installed security cameras to monitor worker safety.

Image monitoring systems analyze the security camera footage. Image monitoring systems and AGVs share information about the locations, traveling directions, and speed of other AGVs and workers in the area. AGVs determine whether there are other robots and workers on the traveling routes. In this way, you can achieve a safe collaboration environment.



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5. Integrating and increasing the sophistication of social infrastructure systems

Integrating and expanding social infrastructure systems while ensuring uninterrupted operation

In recent years, demand for consolidating social infrastructure in broad areas is growing because of factors such as a growing need for effective use of infrastructure to optimize operational costs and a decreasing number of skilled workers due to declining birth rates and aging population.

If multiple local governments want to consolidate their water processing systems, usually they must develop a new infrastructure system to run and monitor multiple facilities. If systems are consolidated to cover broader areas, inspectors will have to spend much more time on traveling to the places where the systems are installed. It is also becoming more difficult to have skilled workers accompany all the inspectors because the number of skilled workers is declining.

The Symbiotic Evolution Architecture enables business operators to link with other systems during operations and ensure that the systems constantly share data while ensuring the data is up to date. In this way, business operators can carry out centralized operations and monitoring of the monitoring operation system without stopping equipment.

By using the Symbiotic Evolution Architecture, business operators can easily link systems for site operations, add features, and optimize costs without stopping the social infrastructure systems.

Business operators can also add robots and monitoring sensors to sites to acquire data and use the sensing data for other control systems. In this way, business operators can link up multiple sites and perform infrastructure operations more efficiently.

5. Integrating and increasing the sophistication of social infrastructure systems

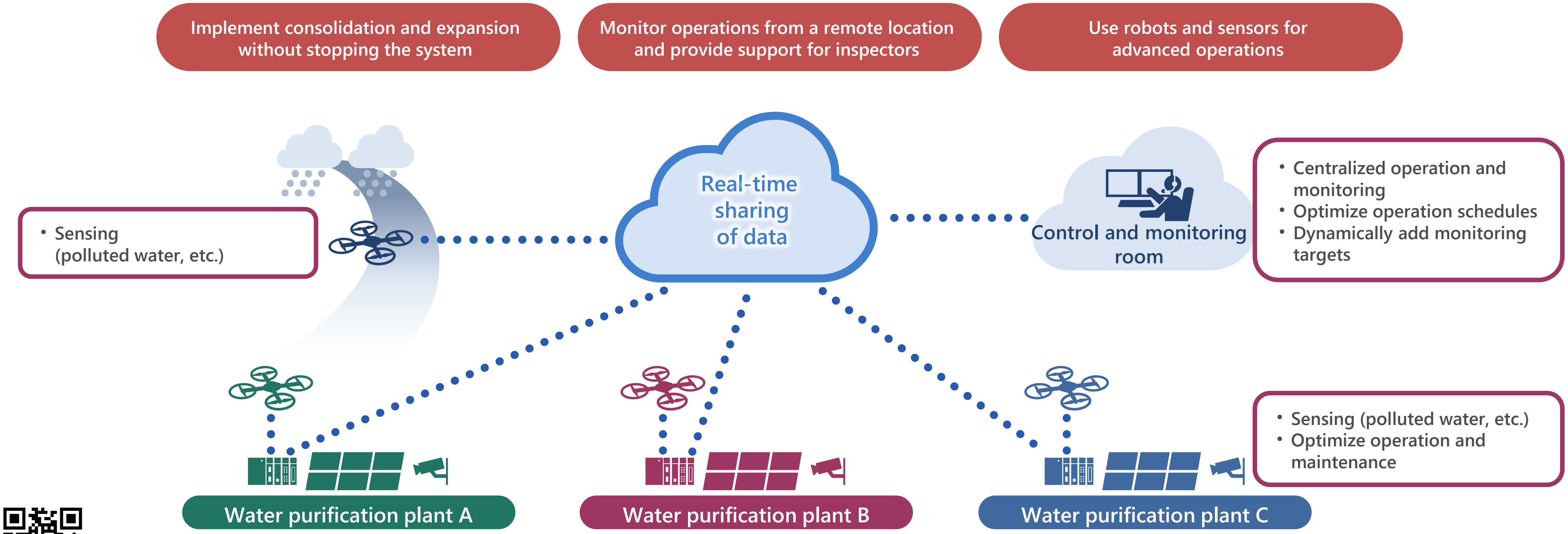
Integrating and expanding social infrastructure systems while ensuring uninterrupted operation

Monitoring operations from a remote location and providing support for inspectors

If data is shared, operators can monitor operations either from the site or from a centralized control and monitoring room. Even if they must monitor additional facilities and equipment, they do not need to stop other running systems before starting to renovate a system.
The Symbiotic Evolution Architecture enables sharing of various data including voice and video, as well as real-time measurements and previously accumulated values. This architecture also enables sharing of data that monitoring robots collect from sites and hazardous locations. Operators can monitor operations from remote locations and provide support for inspectors.

Advanced infrastructure management

If monitoring sensors are added to monitoring robots and cameras in one control system in a treatment plant, the sensing data can be shared with other linked control systems. For example, the water provider can get information about water pollution from images of the water treatment plant along the upper reaches of a river and make improvements to the capabilities of the water treatment plant along the lower reach of the river. In this way, you can use the Symbiotic Evolution Architecture to implement advanced infrastructure management.



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Information control system in the era of uncertainty
Mission critical IoT

Challenges in the use of site data

Traditional information control systems have used data from sites and core IT systems to improve business efficiency and optimize business operations. However, it was difficult to apply data from core IT systems directly and safely to control and manipulate devices on sites, because of concerns over whether the data was credible and up to date.

In order to ensure optimum operation of social infrastructure in the future era of uncertainty, business operators need to implement mission critical IoT to carry out data analysis using big data and AI, and thereby sense, seize and flexibly respond to various changes.

Implementation of mission critical IoT in social infrastructure

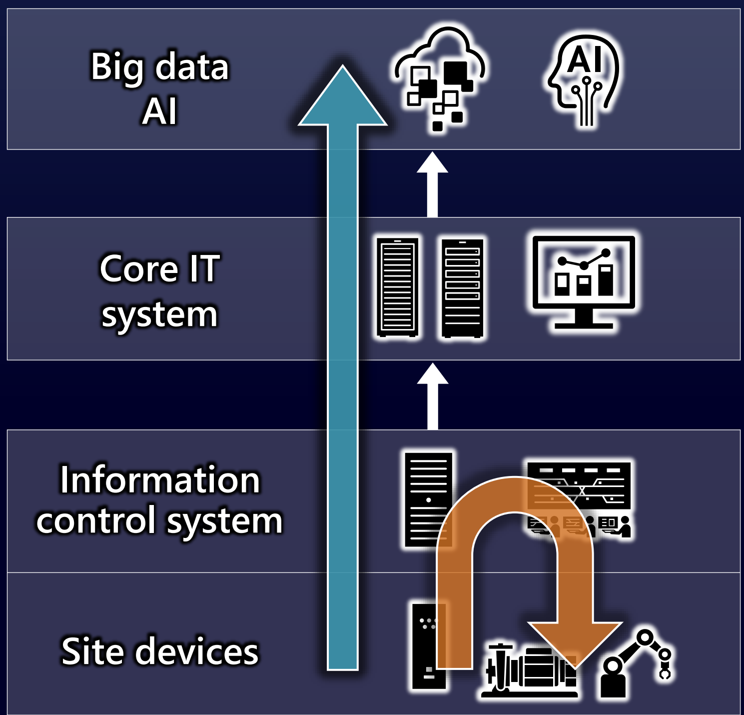
Hitachi can implement mission critical IoT in information control systems to sense, seize, and respond flexibly to various changes.

Mission critical IoT systems use site data in the following order:

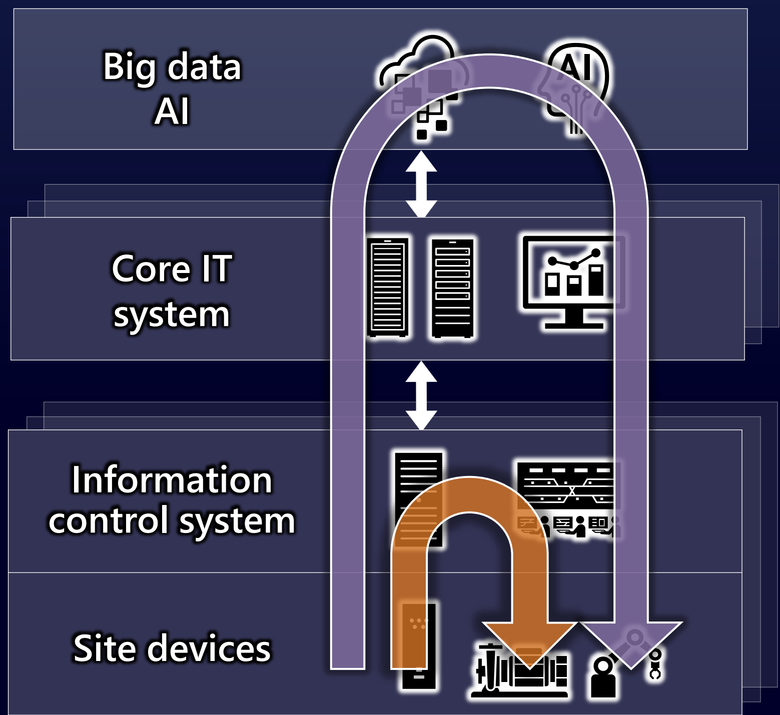
- Ensures that systems can share various data collected from site devices and core IT systems.
- Analyzes the collected big data by using AI or other technologies.
- Finds and applies optimum solutions to control site devices in real time.

In this way, information control systems with mission critical IoT need to have the ability to share site information appropriately with core IT systems and AI, and need to apply the optimum solutions safely and flexibly to control site devices.

Utilizing data from sites to the core IT system, streamline and optimize business



Build a self-adaptive system that can sense and seize various changes



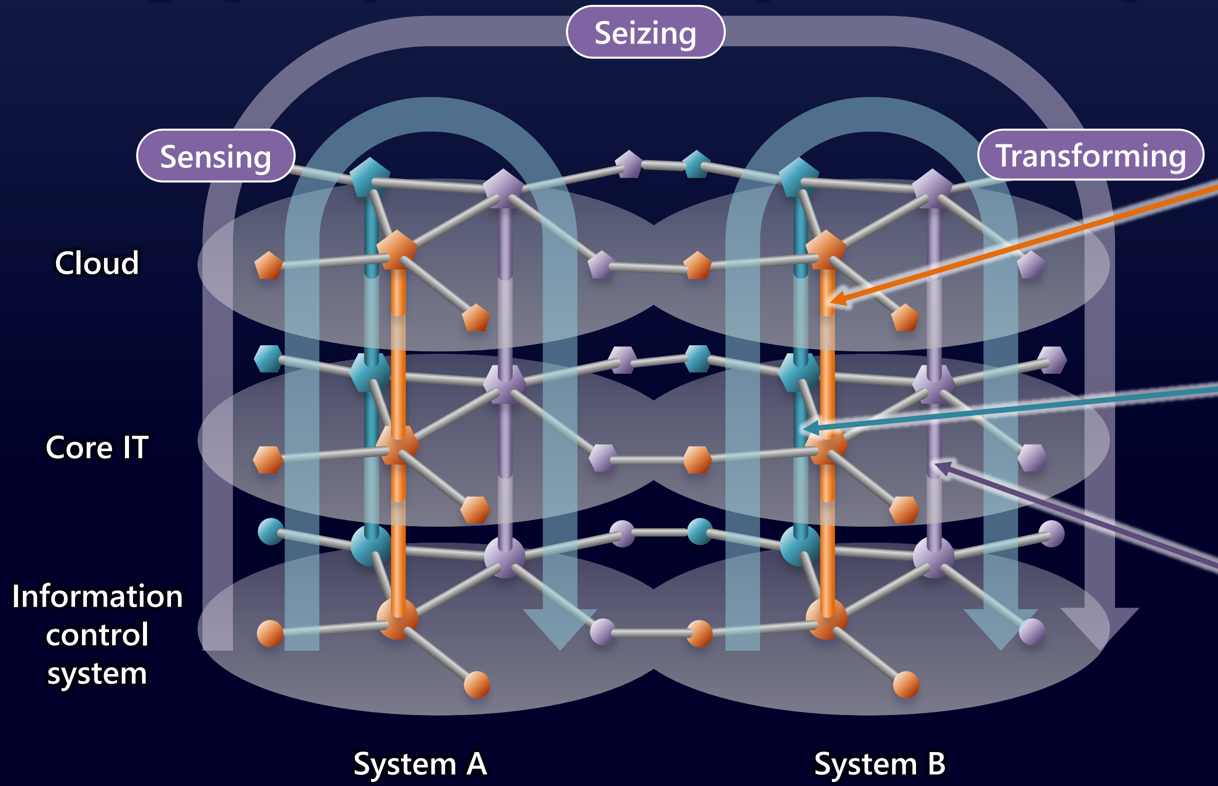
Symbiotic Evolution Architecture for mission critical IoT

Social infrastructure platforms are built on three layers: the information control layer, the core IT layer, and the cloud layer. Traditionally, platforms have been developed based on architecture definitions, as each platform has its own requirements.

To implement mission critical IoT for social infrastructure, it is essential to share data from various systems and conduct data analysis using big data and AI to sense, seize, and transform changes. For this purpose, it is extremely important to connect platforms in layers vertically and connect different systems horizontally, so that data is shared in a flexible and secure manner. The three factors below are especially important in achieving such system linkage and data sharing. The terms enclosed in parentheses refer to technological factors that need to be implemented to solve problems.

- Data credibility (Trust)
- Data understanding (Openness & Seamlessness)
- Online functional changes (Evolution)

Connecting layered platforms vertically and horizontally



Data credibility

- Zero trust security
- Sending information about data validity from one system to another

Data understanding

Virtualized data fields

Online functional changes

Control orchestration

Hitachi's special technologies

1. Trust

Hitachi delivers solutions to ensure the robustness of systems required for mission critical IoT, in addition to ensuring high reliability and real-time data for controlling site devices. Hitachi also delivers DX security to cloud environments and information control systems on edge computing environments.

i. **Technologies for redundant systems**
ii. **High reliability and real-time data**
iii. **DX security**

2. Openness & Seamlessness

Hitachi provides an abstracted data interface to facilitate data understanding so that cloud systems can understand and utilize data from various sites. Hitachi also provides online-addable context, which is used to report on data validity (for example, validity of the data generation processing and freshness of the data) in real time and thereby provide feedback safely to control site devices. Hitachi also provides a flat and transparent data linkage platform that enables different systems to share the data.

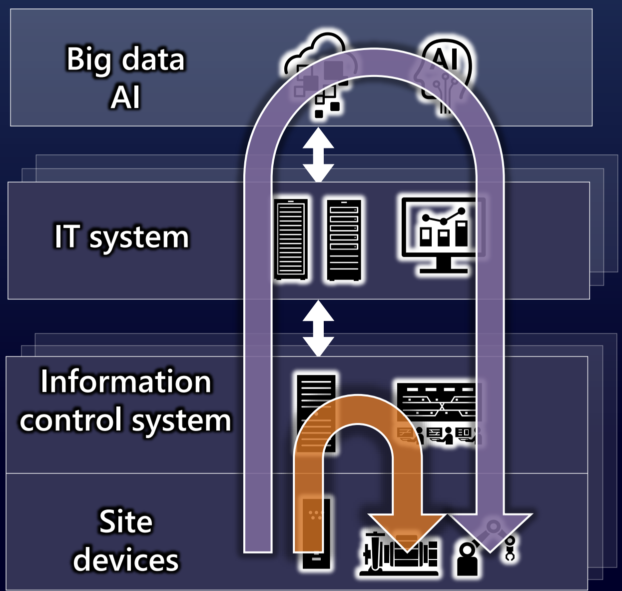
i. **Abstracted data interface**
ii. **Online-addable context**
iii. **Flat and transparent data linkages**

3. Evolution

To evolve into systems that can adapt to changes, control systems must have the ability to change functions online based on big data analysis and AI. To ensure this, Hitachi provides flexibility in system components.

i. **Orchestration**
ii. **Data fields**

Deliver self-adaptive systems for the era of uncertainty



1 Trust	Robustness of system components	i Technologies for redundant systems
	Data credibility and real-time data	ii High reliability and real-time data iii DX security
2 Openness & Seamlessness	Data understanding between the cloud and sites	i Abstracted data interface
	Use of cloud data for sites	ii Online-addable context
	Distribution of data from one system to another	iii Flat and transparent data linkages
3 Evolution	Ability to change functions online, based on analysis of big data and use of AI	i Orchestration
	Flexibility in system components	ii Data fields

1-i. Technologies for redundant systems

- Combine different communication networks into multiplex or redundant configurations to ensure transmission of critical data in the event of a failure
- Transmit data through a network in multiplex or redundant configuration and ensure communication quality even when communication speeds are unstable

Ensure autonomy of site devices and deploy wireless technology for communication in the factory

In traditional systems, control devices for performing processing were usually placed in fixed locations. In addition, wired communications were primarily used because of stable communication quality.

We assume that there will be a growing need for control devices to flexibly change their locations in response to changes in the production line. We also assume that control systems will need to be autonomous devices that can move by themselves and transmit data from the site. Therefore, an increasing number of systems will use wireless communications.

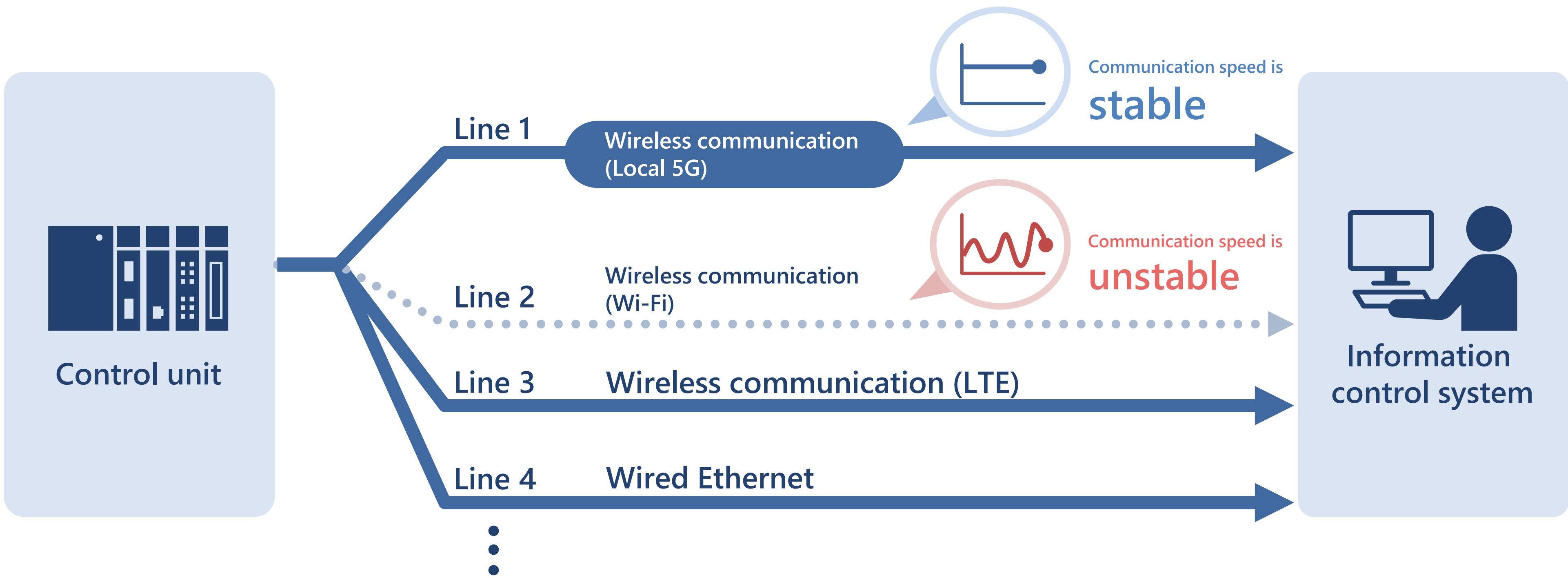
Demand for reliable transmission of data

Mission critical IoT systems must be able to issue instructions to control devices in real time, although the quality of wireless communication varies significantly depending on the communication environment.

Therefore, stable wireless communication lines are needed to ensure reliable transmission of critical data.

Features provided by Hitachi

Multiple communication lines are used to implement a communication network in multiplex or redundant configurations. Stable communication is achieved because data can be received via multiple communication routes and can use normal data even if a control device is located in a place where communication is unstable (for example, if a control device is hidden behind other objects blocking radio waves) or if a failure occurs on a communication route.



1-ii. High reliability and real-time data

- **Monitor moving autonomous systems, locations of virtualized nodes, and communication routes and define appropriate communication routes**
- **Perform end-to-end monitoring to monitor communication data, and perform detection of and notification about communication routes where data linkage does not occur within a set period of time**

Constant changes in device locations and communication routes

In traditional systems, control devices for performing processing were usually placed in fixed locations. In addition, devices primarily used wired connections for communication. If data communications were disrupted, service persons could easily identify abnormalities such as broken wire as long as the scope of the abnormality was identified, because communication routes between devices were predefined.

In contrast, in information control systems for mission critical IoT, communication routes can always change because nodes do not remain in fixed locations. Situations such as the following are more likely to be encountered:

- Virtualized business software and use of cloud systems are more common, and execution nodes can change for each processing.
- Nodes such as robots and drones can move by themselves.

Communication routes can also change as a result of the use of the internet and wireless network in a mesh configuration.

Highly reliable real-time processing required for devices used in facilities

High reliability is necessary for controlling devices used in facilities and for issuing instructions to infrastructure. The following conditions need to be fulfilled to ensure highly reliable real-time processing:

- The processing needs to be started or completed at a specified time
- The processing needs be completed within a specified period of time

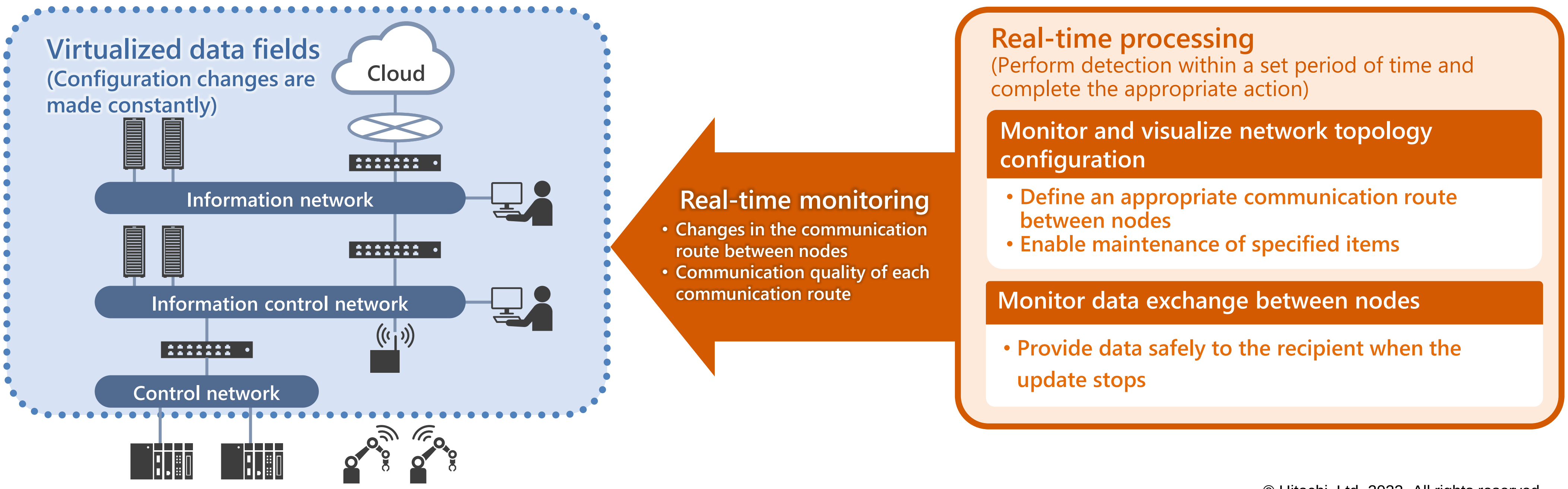
To ensure that multiple processes work together for real-time processing, inter-process communication must finish and data must be received by the recipient within a set period of time. In addition, transition to a safe state must occur within a set period of time to prevent negative impacts on external entities if an abnormality such as the following are detected:

- Abnormal calculation
- Abnormal data
- Failure to execute the process by the specified time or at the specified timing

Therefore, when inter-process communication is in progress, data communication disruptions and data delays must be detected within a set period of time, and transition to a safe state must be ensured.

Features provided by Hitachi

End-to-end monitoring is performed to monitor changes in communication routes between devices and the communication quality of each communication route. This enables detection of and notification about data blocking or data delays within a set period of time and ensures transition to a safe state. This also helps you identify abnormalities and items requiring maintenance and facilitates prompt recovery and expansion of communication routes.



1-iii. DX security

- Leverage real-time authentication and encryption and decryption technologies to ensure zero trust for data communications between business processes
- Implement a trust chain to ensure reliability of data and communication routes to deliver a mission critical CPS

Need for fast transmission with minimum delay

In ordinary IT systems, zero trust is achieved by encrypting communication data and implementing end-to-end authentication.

On the other hand, mission critical IoT systems provide behavioral and operational instructions to site facilities and infrastructures and do not allow any delay, even those caused by ordinary authentication processing. Therefore, security processing such as authentication processing must be performed in the vicinity of nodes (such as equipment or robots).

Emphasis on continuous operations

Numerous control systems on sites were not developed with the assumption that the systems would work in conjunction with cloud systems and core IT systems. As there is a strong demand for information control systems to be consistently available, you cannot add or change trust information frequently in information control systems, because such an operation can cause the systems to stop. Therefore, it is not realistic to embed authentication information about site devices in information control systems.

Features provided by Hitachi

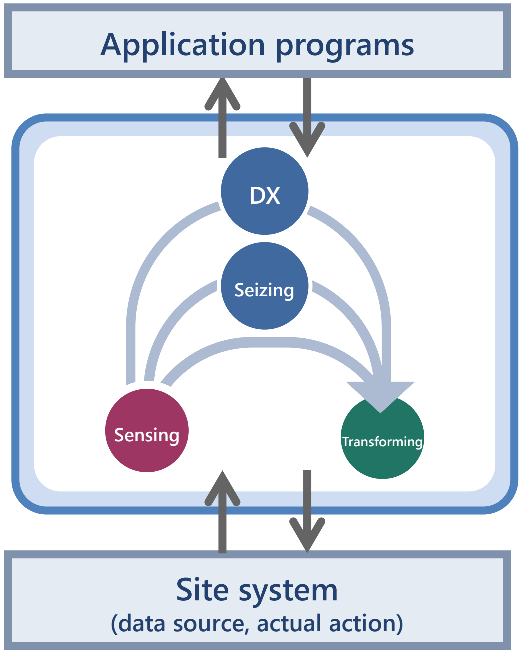
Hitachi provides a feature to enable site devices and control systems to retain authentication information of upper-level systems and create a trust chain. This delivers the following benefits:

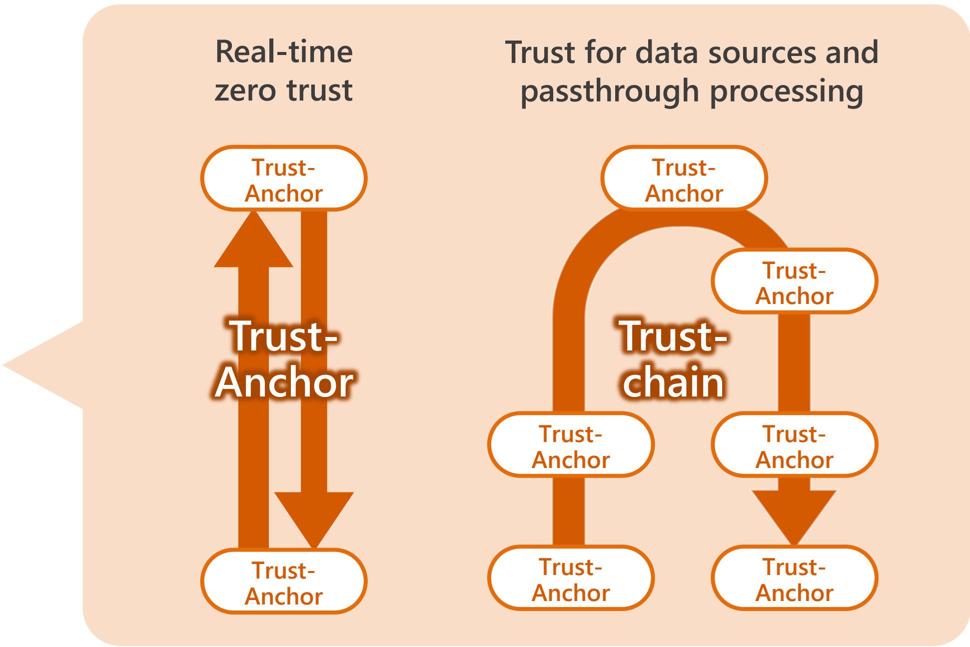
- Faster authentication at each node
- Minimized risk that control systems might stop

This feature contributes to building a trust chain to verify the integrity of temporary data, which does not require a high level of real-time data that is required for software updates conducted through OTA wireless communications.

As a result, Hitachi can deliver highly reliable mission critical IoT capabilities in real time.

CPS: Cyber-Physical System,
OTA: Over the Air





2-i. Abstracted data interface

- Add context (semantic data) to site data
- Facilitate sharing of data to which information is added to enable the recipient to verify the validity of the data

Need for a mechanism to ensure that the meaning and formats of data is properly inherited

To ensure that applications can share and use data, the system should have a mechanism to facilitate the use of data regardless of the timing of system development and the differences among layers.

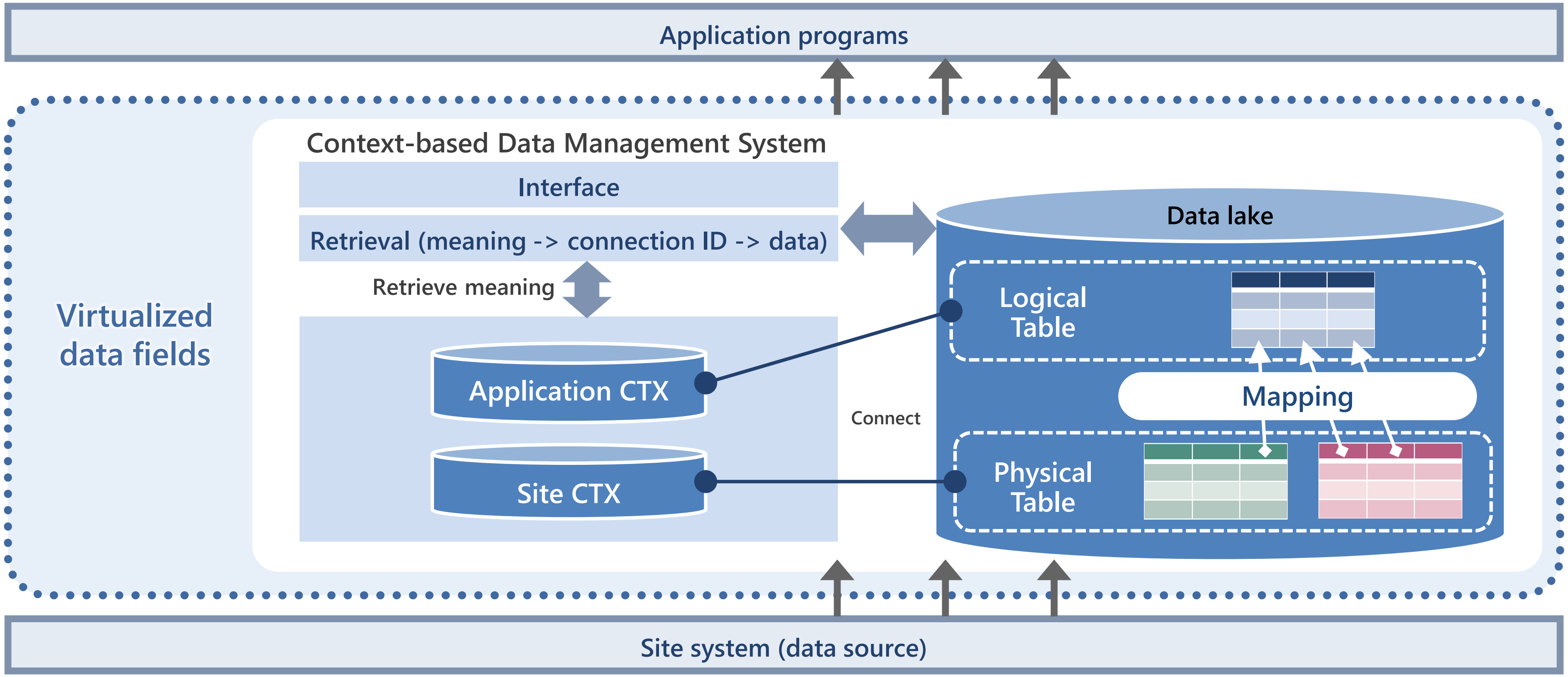
For example, it is extremely difficult for application developers to interpret the detailed format and meaning of raw data collected by site systems such as control units. In particular, if several years have already passed since the development of a site system, it is very likely that the engineers who developed the system are no longer engaged in the project and thus other engineers might require a significant amount of time to understand the data. These engineers might also misunderstand the data. In addition, there might be conflicts among the data.

Features provided by Hitachi

An abstracted data interface enables the use of data to which context is added. This facilitates the transfer of data meaning between different layers or between different applications that were developed at different times. In addition, by using data catalogues to which context information is added, you can provide context and not just a data list. This facilitates data retrieval and data understanding, and encourages the use of data.

In addition, information such as freshness, the expiration date, the output processing name and the version can be added online as context to the data that will be transmitted, so the recipient can recognize the validity of the data. This contributes to safe and reliable use of data.

CTX: Context



2-ii. Online-addable context

- Add information about the node and the processing online to data and transmit the data to the post-processing node
- Provide information about the processing details and the processing time to facilitate highly reliable and secure use of data

Need to ensure data credibility and effectiveness of processing

To issue behavioral or operational instructions to site facilities and infrastructure, mission critical IoT systems use data processed in IT areas such as cloud systems. However, there is a time lag from the observation of that data to the input. If the data processing takes time, the site situation might change, or AI might use a learning model that no longer fits the current situation.

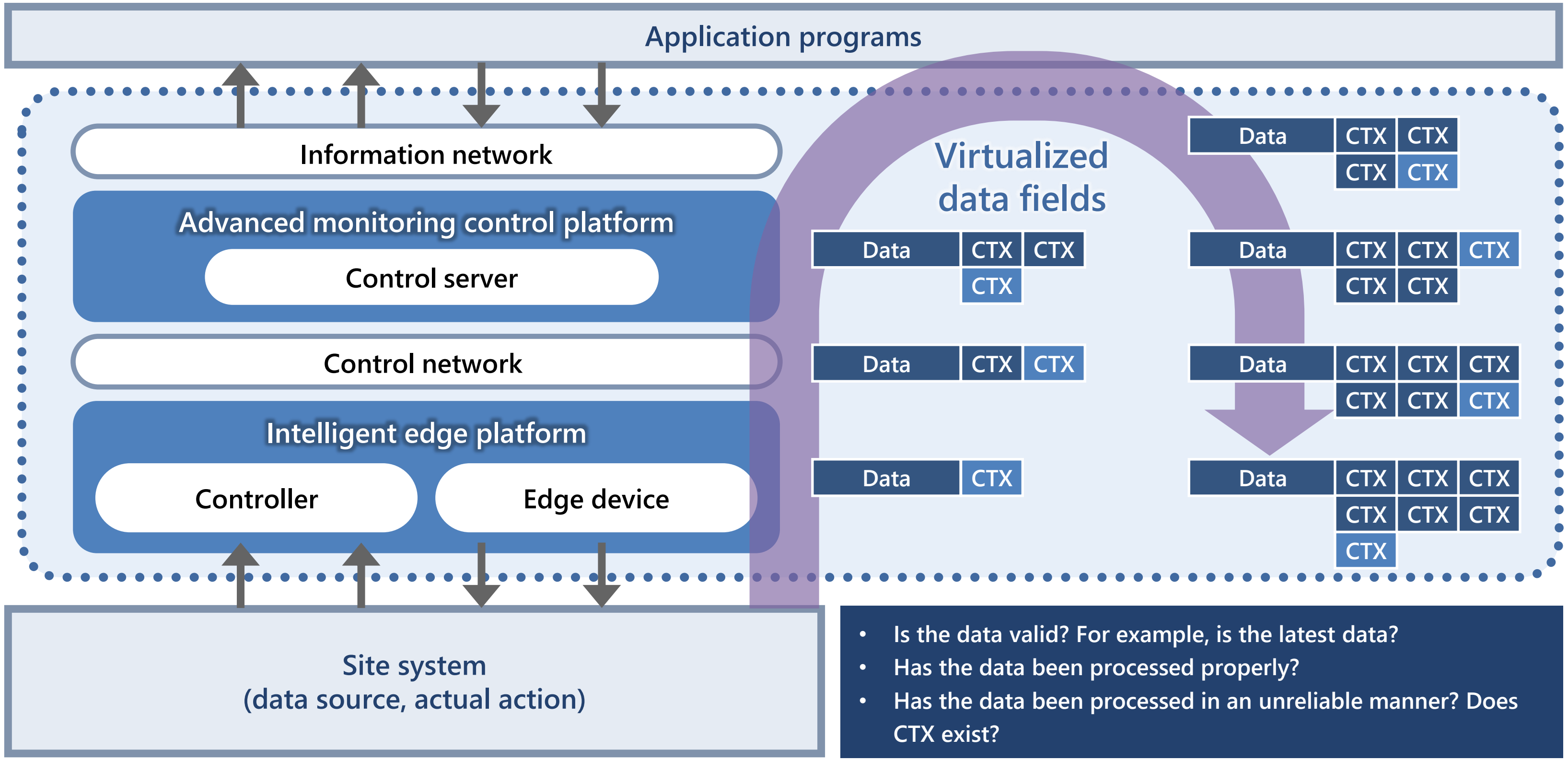
To safely provide feedback to control site devices, it is important to ensure the credibility of data and the effectiveness of the processing.

- Processing for generating cloud input data from raw data, and the history of the processing
- Processing in the cloud, or the AI model used for the processing
- Processing performed after the processing is finished in the cloud until the data reaches the site facility or infrastructure, and the history of the processing

Features provided by Hitachi

Hitachi provides a feature for the online addition of the context of data sent to nodes, so that information about the credibility of data and the effectiveness of processing is provided to the post-processing node. In this way, information about the integrity of the node performing the preprocessing, the processing time, the processing details, and the AI model can be sent to the post-processing node. For example, by adding the application ID and version information to the data, the system can verify that the only data that arrives is data that passed through the assumed processing.

In addition, because the processing time is added, the post-processing node can verify the freshness of data and execute processing while maintaining real-time data.



2-iii. Flat and transparent data linkages

- Share data by using virtualized data fields without recognizing the locations of nodes
- Use virtual unicast communication to distribute data to the node that needs it in real time

Sharing of the latest data between nodes by using data fields

The autonomous decentralized architecture is based on the concept of data fields. Each item of the latest data is published in a multicast manner from each node of the data field to the communication segment. The other nodes can freely reference the latest data. In this way, existing systems can be enhanced safely and easily even if they are running online.

Difficulty in multicasting in IoT systems in which data passes through multiple networks or systems

In recent years, in a growing number of mission critical IoT systems and ordinary IoT systems, data passes through multiple networks or systems. This makes it difficult to identify communication routes.

- For some of the processing in cloud systems, it is impossible to identify the process execution node and the communication route.
- In the system, one or more nodes travel across multiple communication routes
- Open communication routes such as wireless communications and the internet are used.

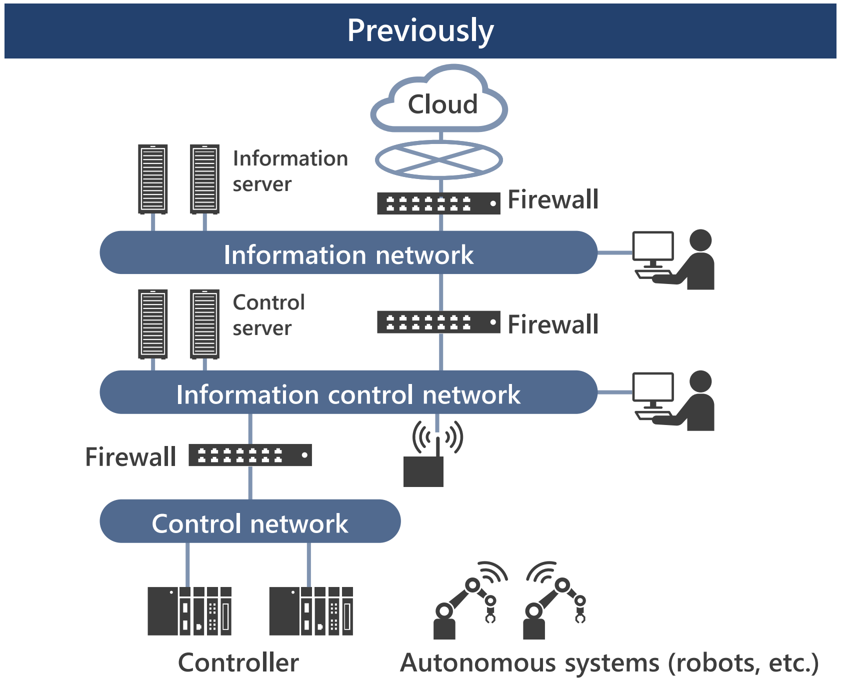
Features provided by Hitachi

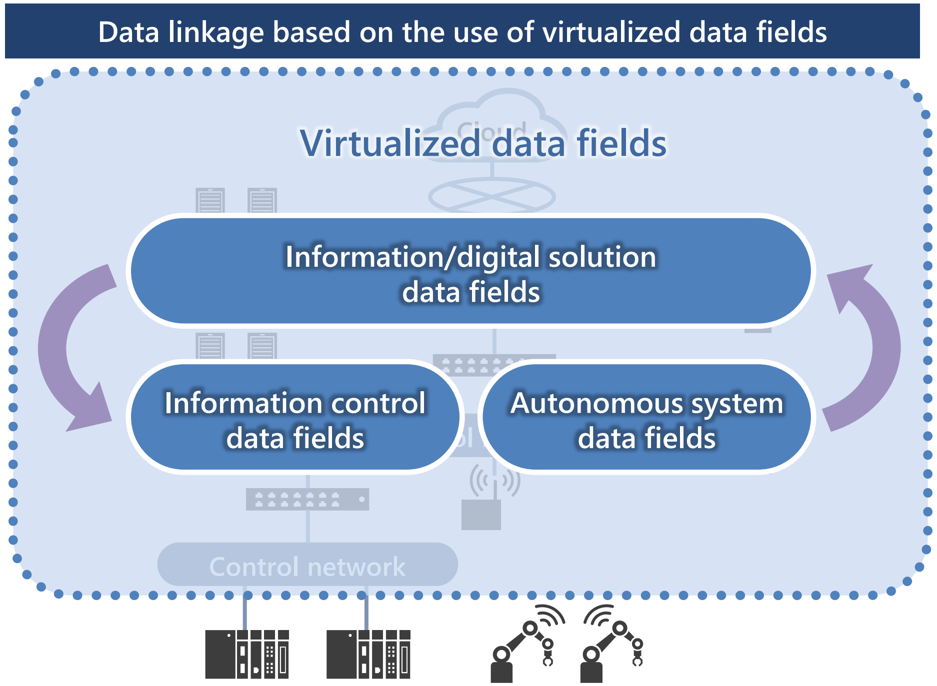
Communication routes between nodes are virtualized, and virtualized data fields are provided. Virtualized data fields contain information about nodes in communication routes.

Nodes in virtualized data fields publish data about themselves as data catalogues. Nodes requiring data reference the data catalogues and request the required data. On virtualized data fields, virtual unicast communication is used to distribute data to the nodes that need it in real time.

This enables data to be shared in a highly reliable manner in real time by applications on cloud systems or by systems controlling nodes of autonomous systems. In addition, application developers can add or change functions without needing to know where the application will run.

Reference: Autonomous decentralized system
https://www.hitachi.com/products/it/control_sys/platform/ads_net/index.html





3-i. Orchestration

- Share context data and perform online arbitration of application program processing and the interface
- Automatically adjust the timing for adding or updating application programs and adjust application program processing and the interface

Safe and secure online job updates in mission critical IoT systems

In information systems, a common practice is to perform agile updates of functions and to automate management of software settings by orchestration such as by software delivery. However, ordinary orchestration methods cannot be used to ensure secure updates of functions of mission critical IoT systems. Such IoT systems are combination of site information control systems and other information systems (such as the core IT system and the AI system). If a conflict occurs between the existing and running control system and the updated function, the infrastructure functions might not work properly.

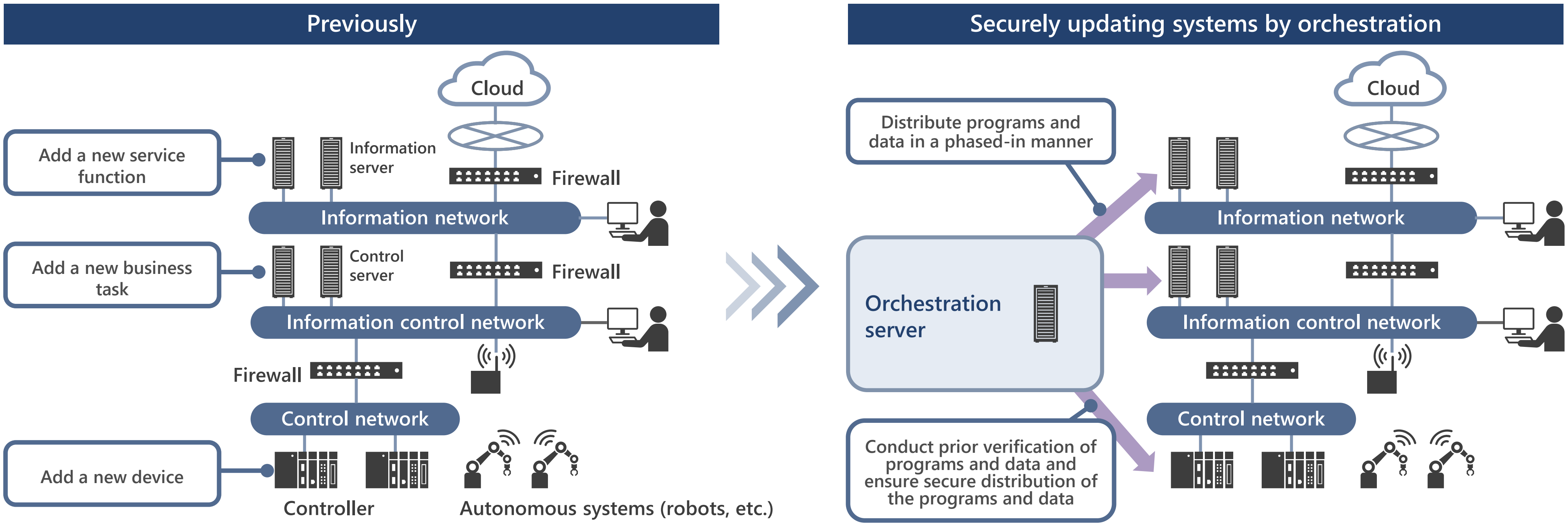
To ensure that existing software continues operation, it is necessary to ensure data integrity and connectivity to the interface to the new software. For example, it is necessary to add functions or update control software or AI models while their output results are not being processed by any control process.

Features provided by Hitachi

Hitachi provides an orchestration feature to simplify making system enhancements and adding or updating functions, while maintaining stable operations of existing systems. To prevent conflicts among nodes on the control, information control and information networks, the orchestration feature uses the following methods to automate updates of data and programs:

- Control the order in which functions are added or changed (for example, add functions or change functions in the control node first and then in other nodes)
- Notify each node that the data interface has been changed
- Add or change functions to nodes that receive data, while maintaining the new and old data interfaces

When nodes are updated, online tests and parallel runs will be carried out for quality verification, and strategies such as blue/green deployment (a method for managing software generations) are used to ensure uninterrupted business operations and facilitate secure enhancement of system functions.



3-ii. Data fields

- **Data in data fields is shared if a message is issued with a transaction code.**
- **As each subsystem runs autonomously, the entire system continues to run without malfunctioning, even if a failure occurs or a subsystem is added.**

Features provided by Hitachi

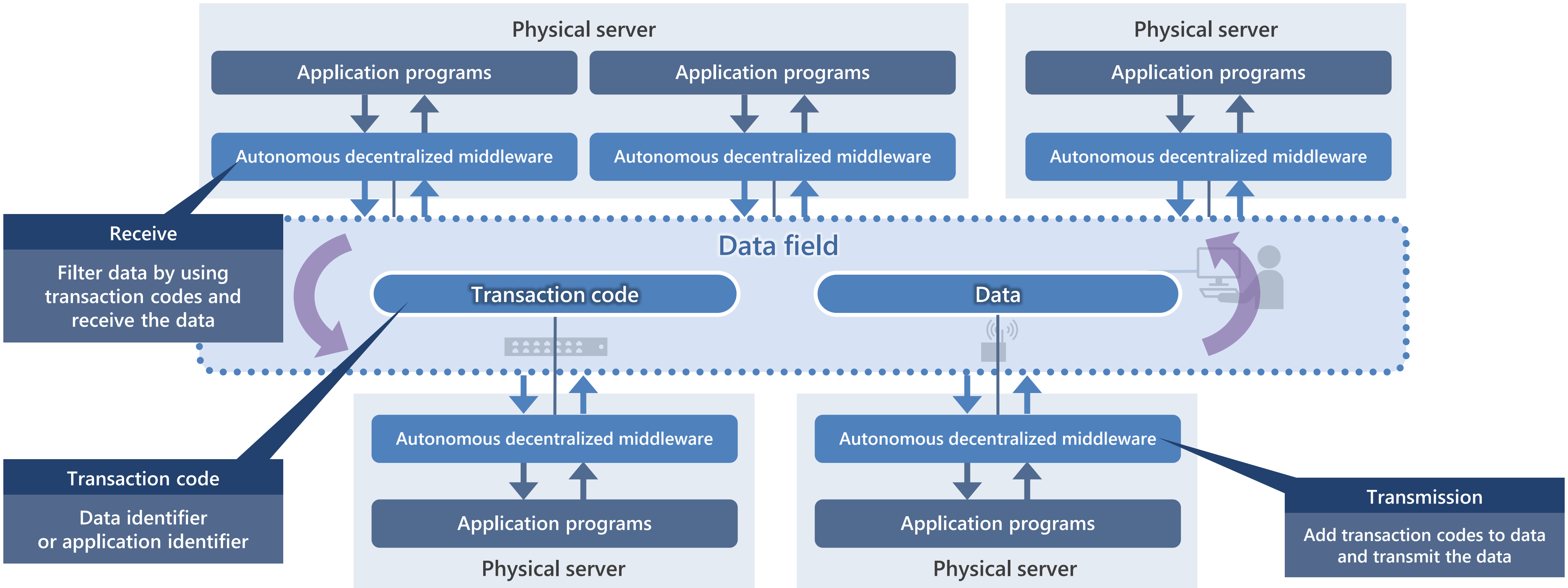
Based on an autonomous decentralized framework, application programs connected with a data field add transaction codes to data and release the data to the data fields, so that the data is shared with other applications. This way of data sharing does not require direct communication between applications and thereby improves scalability, reliability, and serviceability of the system.

Before receiving the necessary data, the receiving application filters data in the data field by using a transaction code.

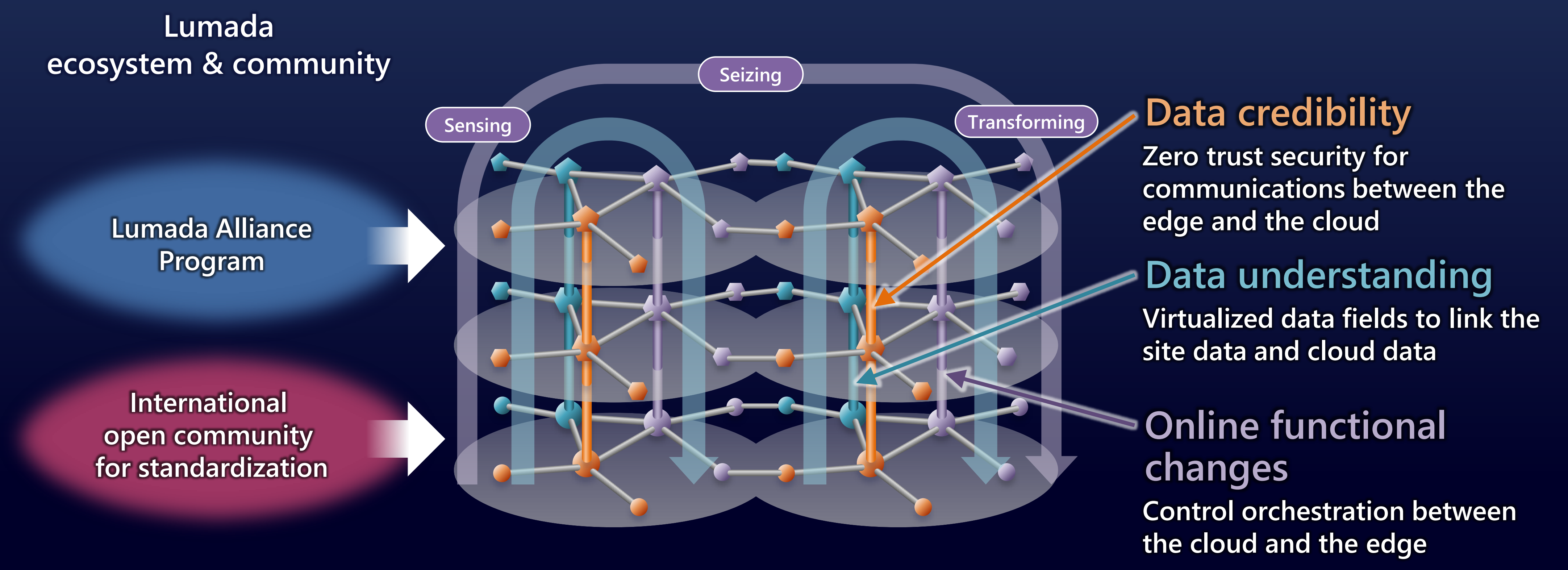
The sending application and the receiving application are loosely coupled via data fields. This contributes to improved scalability, reliability and serviceability because, even if part of the system stops, the entire system will not be affected. You can also add or remove applications without stopping the entire system.

Note that transaction codes include the identifier of the sending application and an identifier of the data.

Reference: System concept (ADS-net)
https://www.hitachi.com/products/it/control_sys/platform/ads_net/index.html

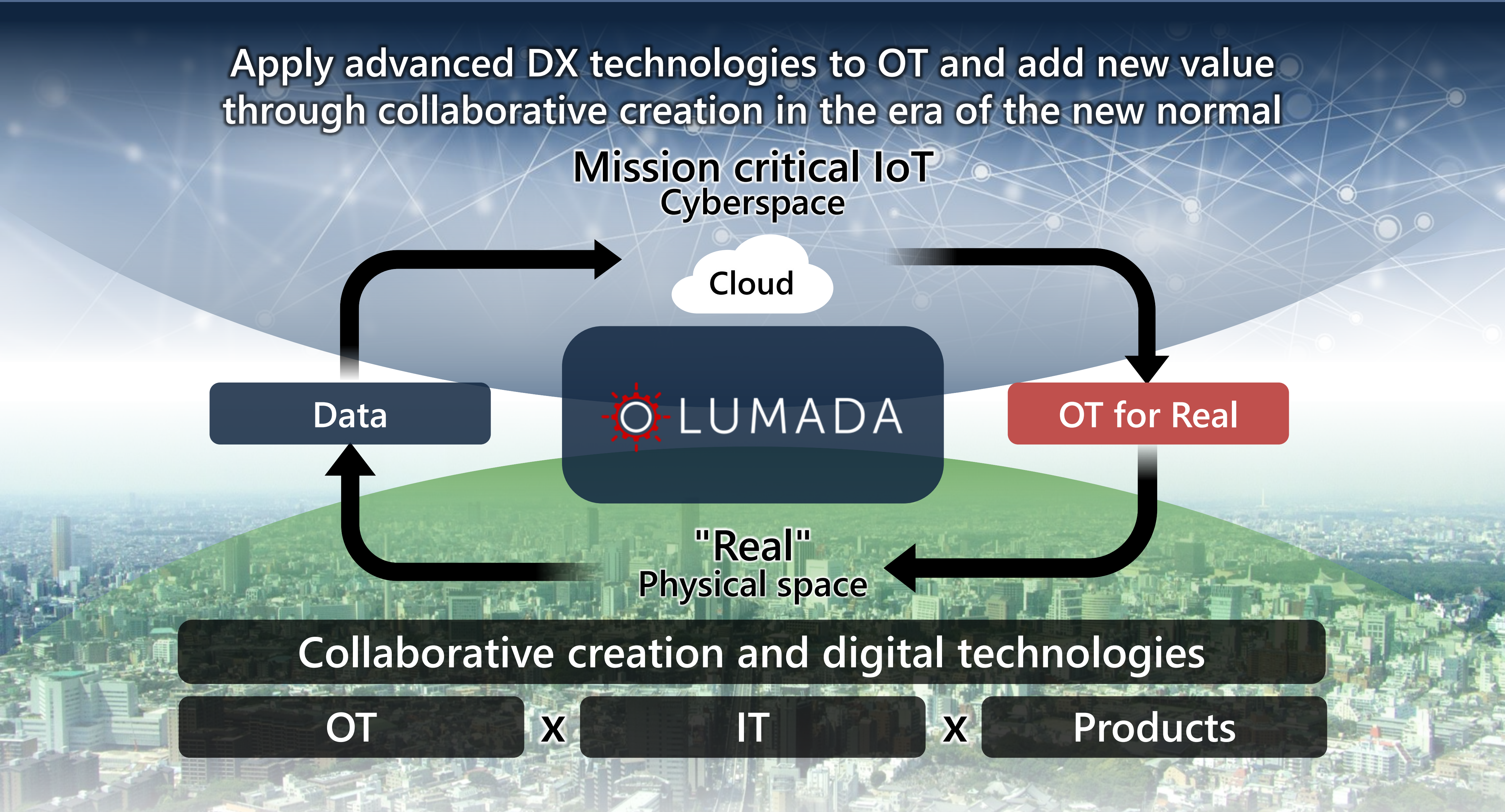


Leveraging our ecosystem to implement mission critical IoT



With the aim of implementing mission critical IoT, the Hitachi Group will develop technologies and leverage the Lumada ecosystem and open communities.

The Hitachi Group will also continue to collaborate with international standardization groups and open source communities in areas such as security, data standardization, and execution environments.



Our societies face growing uncertainties. In this situation, Hitachi can deploy an Symbiotic Evolution Architecture to implement mission critical IoT, apply advanced DX technologies to OT for various types of social infrastructure, and thereby add new value through collaborative creation with our customers and various partners.

OT: Operational Technology

Implementing mission critical IoT with

Symbiotic Evolution Architecture

Implementing mission critical IoT with Symbiotic Evolution Architecture

https://www.hitachi.com/products/it/control_sys/architecture/index.html

Hitachi, Ltd. Control System Platform Division

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