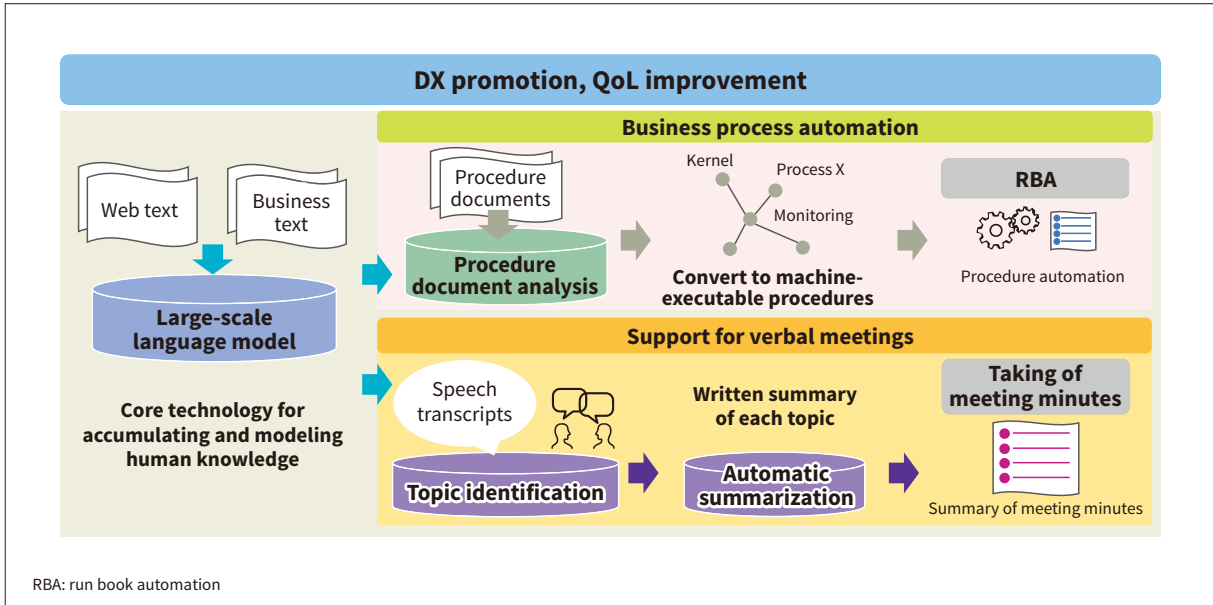


Lumada Ecosystem



1 Semantic analysis using language model

1 Natural Language Semantic Analysis Technique Using Large-scale Language Models

Use of natural language processing is growing in both the public and business realms, with advances in the technology being achieved using language models that model knowledge of human language by training neural networks on large quantities of text.

Given input text, language models can achieve high processing performance for tasks such as machine translation and automatic summarization. Hitachi, meanwhile, is seeking to achieve accurate understanding of written text through the development of core techniques that use language models. Examples include the development of techniques for converting business procedures into semantic representations that could be used by a machine or for summarizing the minutes of verbal meetings.

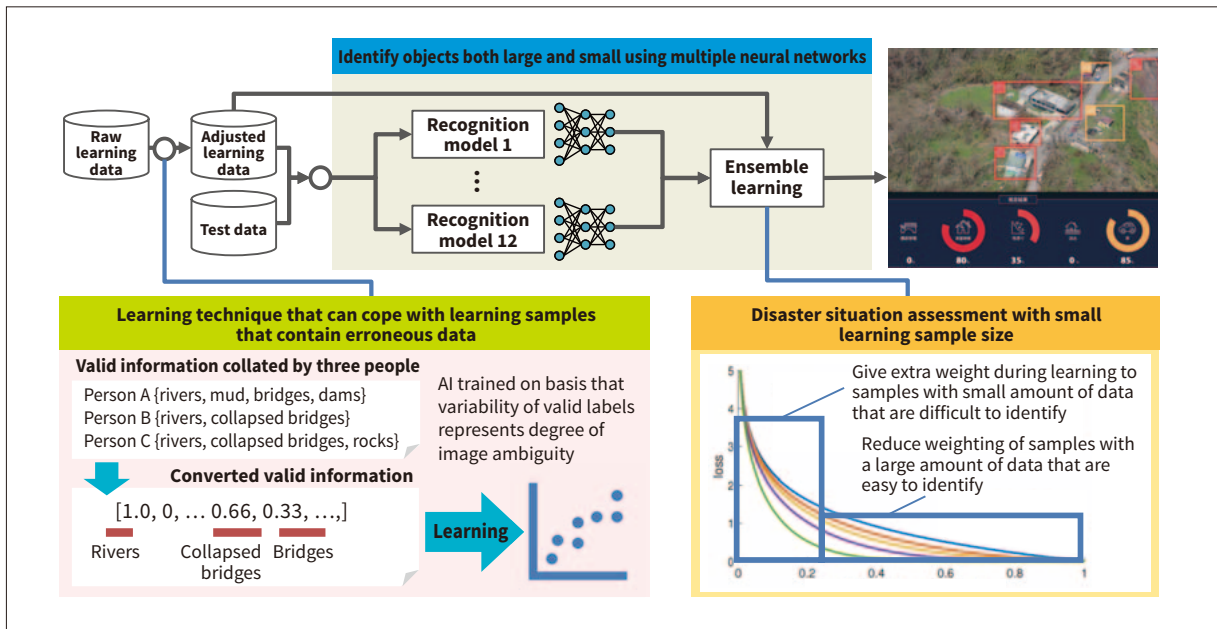
These core techniques that make use of language models are being developed through participation in international workshops that operate on a competition format, where they have performed well. In the future, Hitachi will deploy these new techniques in business to deliver improvements in people’s quality of life (QoL) through digital transformation (DX).

Note that the computational resources of the AI Bridging Cloud Infrastructure (ABCI) provided by the National Institute of Advanced Industrial Science and Technology (AIST) was used.

2 Video Content Analysis Technique for Disaster Situation Assessment Using AI

The use of artificial intelligence (AI) to analyze aerial video content is seen as a potential means of obtaining an overview of the situation in the immediate aftermath of a disaster that affects a large area, enabling rescue services and infrastructure recovery to happen quickly. One of the technical challenges to doing so, however, is that disaster situation assessment requires the identification of a wide range of circumstances and it can be difficult to obtain the data needed for AI learning.

A new video content analysis technique developed by Hitachi combines a number of different neural networks with different characteristics to achieve simultaneous identification of multiple situations, both large and small, that can occur during a disaster. The lack of learning data is addressed by including data weightings based on the number of samples, and by adding



2 Disaster video content analysis technique

ambiguity ratings to labels for learning data containing erroneous information. In this way, the technique is able to identify attributes that even people find difficult to recognize. It achieved one of the top scores on the disaster scene description and indexing task at the 2020 workshop of the Text Retrieval Conference (TREC) Video Retrieval Evaluation (TRECVID) run by the US National Institute of Standards and Technology.

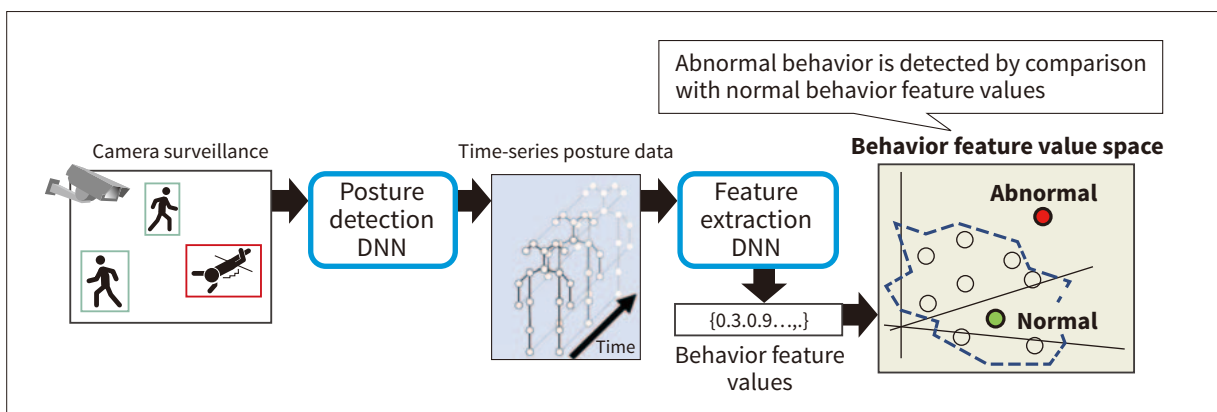
In its work on improving national resilience, Hitachi will continue contributing to the creation of a resilient society by pursuing solutions that can be deployed in the field.

protecting user safety at public transportation and other such facilities. Accordingly, Hitachi has developed an abnormal behavior detection technique that can rapidly identify suspicious individuals from the video collected across all of these cameras.

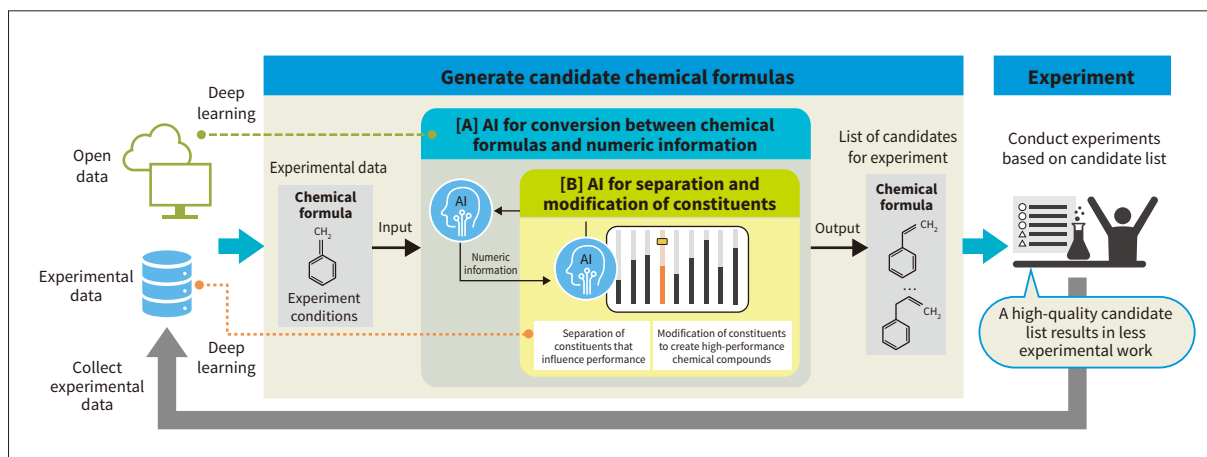
Given the many and varied definitions of what constitutes “abnormal,” detecting all such behavior would be difficult. Instead, the new technique trains a deep neural network (DNN) on video of routine behavior to automatically determine which region of behavior feature value space equates to “normal.” When used for detection, the behavior feature values for individuals who appear in surveillance video are compared with this region to classify whether their behavior is normal or abnormal. A feature of the new technique is that it can be enhanced to suit the specific conditions in which cameras are installed. This is because, rather than predefining a number of abnormal behaviors exhibited by video surveillance subjects, the technique only requires a few hours of footage from each

3 Abnormal Behavior Detection Technique

Currently, extensive security systems with large numbers of surveillance cameras are commonly used as a means of



3 Overview of abnormal behavior detection technique



4 Deep learning that generates chemical formulas for potential new high-performance materials from small amounts of experimental data

camera to automatically determine the scope of what constitutes normal behavior.

When used in tandem with Hitachi's IVSearch solution for the high-speed identification and tracking of individuals, the abnormal behavior detection technique enables both the identification of suspicious individuals and tracking of their subsequent movements. In the future, Hitachi intends to contribute to advances in surveillance and security through improvements to the speed and accuracy of detection techniques.

4 AI Technique for Accelerating Development of New High-performance Organic Materials

To improve the performance of materials informatics (the use of techniques such as AI and simulation to search for new materials), Hitachi has developed a new deep learning technique for use in the development of organic materials, which in the past has required large amounts of experimental data. The new technique can suggest chemical formulae for potential high-performance chemical compounds using only small amounts of experimental data (numbering in just the hundreds).

The technique is based on a nested structure in which a deep learning model trained on experimental data is embedded inside another deep learning model that has been trained on large amounts of open data. The amount of experimental data can be reduced due to the structure. It works by converting the text-format chemical formulae in the outer model to a numeric format that is then used in the inner model to generate chemical formulae with high performance by separating and modifying the constituents of a compound that influence its performance.

Along with experimentally verifying the performance

of chemical compounds, Hitachi also plans to deploy the technique in a service for assisting with the development of new materials that satisfy diverse market needs.

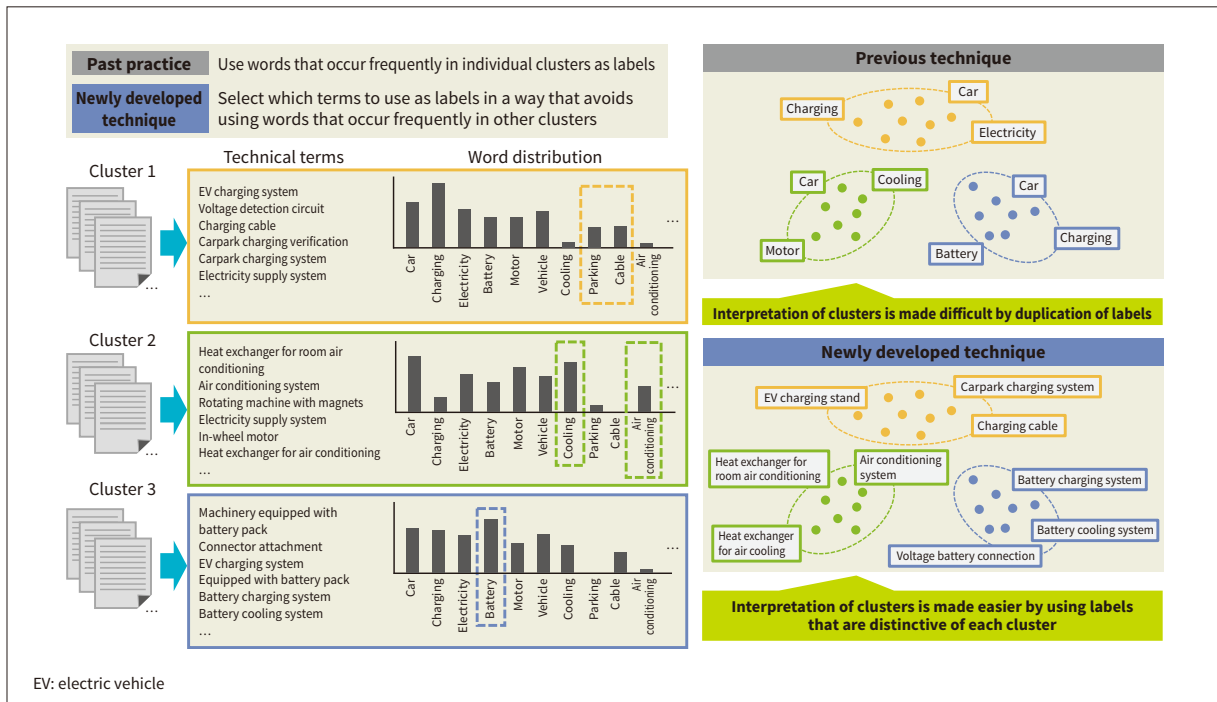
5 Clustering Technique for Analyzing Patent Trends

The increased use of intellectual property (IP) landscaping for utilizing information about the IP of companies in their business strategies has resulted in considerable activity around the development of patent analysis tools that use AI. This has included mapping functions that provide clustering and visualization for groups of patents returned by user searches, a classic example of a function for gaining an overview of patent trends. Past practice for clustering has involved tagging clusters with keywords that are representative of the patents they contain. The difficulty with this has been that it frequently results in commonly used terms being assigned as keywords, such that the duplication of keywords across different clusters makes it difficult to identify what is characteristic of each one.

Hitachi's new clustering technique summarizes text that selects keywords from among technical terms extracted from patent publications in a way that takes account of keyword duplication as well as how comprehensively the keywords represent the patents in each cluster. This makes it easier for users to determine the characteristics of a cluster.

The new technique is currently being incorporated into Hitachi's patent information provision service*, and plans for the future include making it faster and more accurate to enable more efficient patent searching.

* A service that provides accurate patent searching with support for highly accurate patent information from 98 different countries and regions.



5 Overview of clustering technique

6 Building of Largest 1.3-Mbit CMOS Annealing Prototype for Faster Combinatorial Optimization

Hitachi is developing technology for complementary metal-oxide semiconductor (CMOS) annealing that can obtain practical solutions to combinatorial optimization problems with high speed. CMOS annealing can help achieve social innovation through its use in enhancing environmental and economic value, such as large-scale scheduling optimizations or portfolio optimization, etc.

As societal challenges become larger and more complex, the associated combinatorial optimization problems also increase in size, creating a need for larger machines. To take on larger challenges, Hitachi has developed a way to use multiple interconnected chips and has built a

prototype system. The prototype has nine interconnected circuit boards, with nine 16-kbit CMOS annealing chips on each board. This creates a 1.3-Mbit CMOS annealing machine in which a total of 81 chips can perform annealing simultaneously. Hitachi is utilizing this machine in collaborative creation (co-creation) with users in order to identify potential applications and create new value by resolving increasingly complex societal challenges.

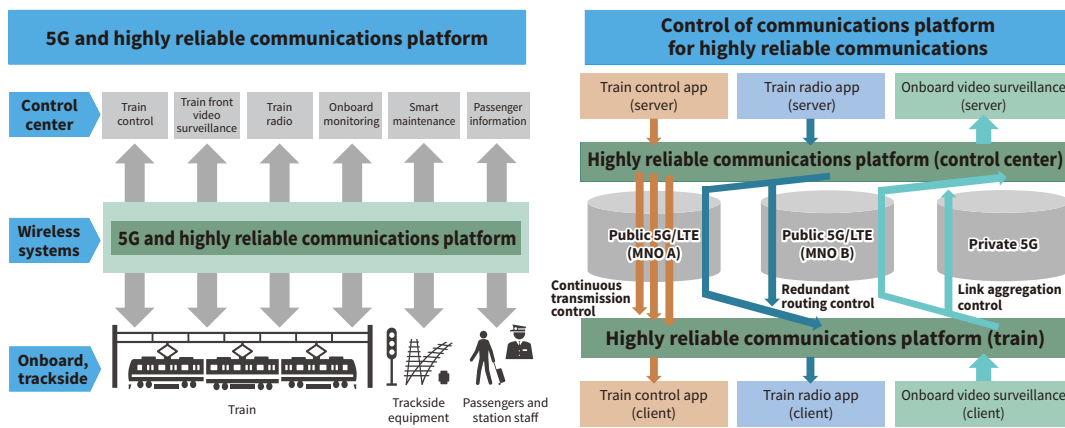
Part of this presentation is based on results obtained from the “JPNP16007” project commissioned by the New Energy and Industrial Technology Development Organization (NEDO).



6 1.3-Mbit CMOS annealing prototype with nine circuit boards connected together

7 Next-generation Communications Platform for Accelerating DX in Railway Operations

Railway operators are looking to DX as they are called upon to improve the efficiency of their operations amid a shrinking workforce and falling operational revenues. This also includes the use of fifth-generation (5G) telecommunications. To this end, Hitachi has built a prototype to assess the viability of a next-generation communications platform that enables the rapid provision of highly reliable and available communication services for a range of 5G applications for the DX of railways, such as autonomous driving, remote video surveillance, and smart maintenance. Companies have adopted a silo-based approach in the past with separate communication systems for each application. By using this platform to



LTE: Long Term Evolution MNO: mobile network operator

7 Next-generation communications platform for railways

consolidate these, the aim is to deliver both safe and secure train operations and operational cost savings that result from deploying fewer assets.

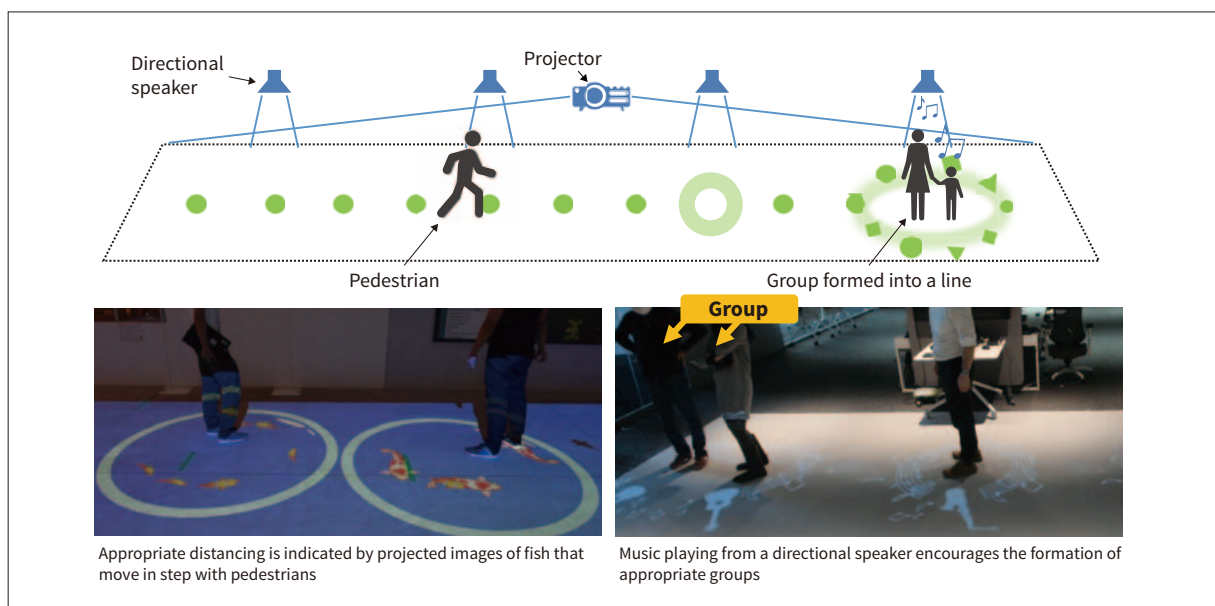
A 5G demo system for railways was developed based on this next-generation communications platform concept and implemented in the 5G testbed at the *Kyōsō-no-mori* facility of Hitachi's Central Research Laboratory. This included hosting railway applications that involve communication between the control center and train on a communication platform that utilized both private and public networks. Testing was then conducted to confirm that the applications continued to function even during a partial downgrading of communication system operation.

Development and real-world testing are proceeding in partnership with Hitachi's Railways Systems Business Unit in preparation for implementing the next-generation communications platform.

8 AR to Induce Physical Distancing

Measures such as imposing restrictions on people's movements in response to the spread of COVID-19 are creating difficult business conditions for service industries such as retail, hospitality, and tourism that are likely to involve closed spaces, crowded places, and close-contact settings.

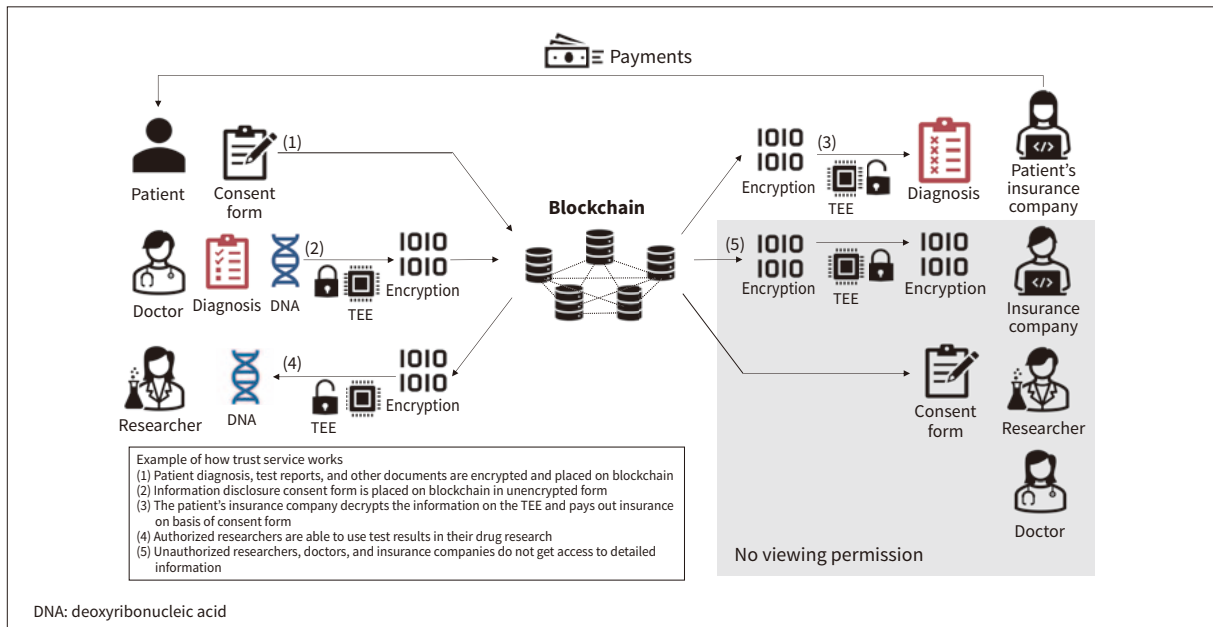
In response, Hitachi has developed a way of inducing appropriate behaviors by adjusting projected images and audio based on people's actions, using very accurate distance sensors for the measurement and analysis of people's movements as a means of detecting the distance between them, without determining their identity. The demonstration involved using a projector to project moving images of fish onto the ground around pedestrians and using a directional speaker to project sound to



Appropriate distancing is indicated by projected images of fish that move in step with pedestrians

Music playing from a directional speaker encourages the formation of appropriate groups

8 Demonstration of using augmented reality (AR) to induce physical distancing



9 Overview of trust service

particular locations. It was designed to promote behaviors that reduce infection risk, such as keeping families or other groups moving along together while maintaining physical distancing between separate groups, but to do so in a way that also provides an enjoyable experience for pedestrians. By operating in this way, the behavior inducement solution results in a natural tendency for pedestrians to act in both an enjoyable and safe manner.

Looking ahead to a time when the COVID-19 pandemic has passed or become endemic, Hitachi plans to expand its behavior inducement solution business and find the best ways to provide people with feedback from the results of measuring and analyzing their movements.

9 Trust Service Using Distributed Ledgers and Hardware Security Functions

With data becoming increasingly valuable as the well-spring of corporate competitiveness, the potential is growing for creating new services based on cross-referencing different forms of data from different industries. Data transparency is crucial to achieving this and the use of distributed ledgers are one way of ensuring this transparency.

However, as distributed ledgers make data available to all participants, some way of protecting confidential data is needed. In response, the Hyperledger* community has launched a development project for a function that ensures that encrypted information in distributed ledgers is only available to users with specific permissions. Specifically, the project is developing a function whereby only authorized users are able to encrypt data and run

programs on the distributed ledger, which is done using a trusted executed environment (TEE) that has been established using hardware security functions. Hitachi was among the first to get involved in this project and is developing the technologies needed for trust services in partnership with the community.

In the future, Hitachi intends to contribute to the wider adoption of trust services that create new value while also allowing for the safe sharing of confidential information.

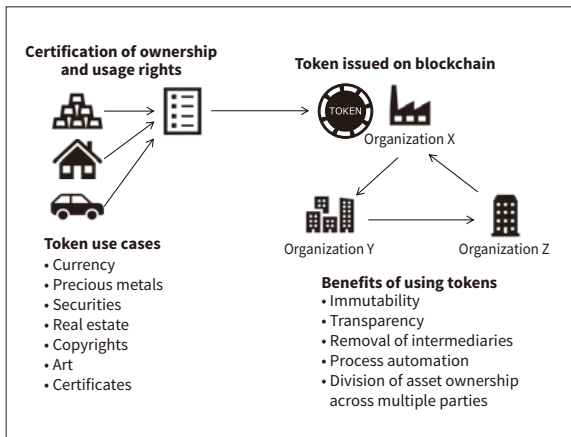
* See "Trademarks" on page 150.

* Hyperledger: <https://www.hyperledger.org/>

10 Development of Tokens that Use Blockchain and Contribution to Open Source Community

The trading of tokens that represent ownership and usage rights over digital content has become increasingly active in business-to-customer (B2C) areas such as sports and games. Blockchains are used to prevent tampering with data on tokens' ownership and trading history. When tokens are used in business-to-business (B2B) applications such as supply chain management and trading in environmental value, a lot of effort is required by the companies involved to reconcile the data content and functions in a way that suits their business requirements.

To make the reconciliation of token design more efficient, Hitachi has responded to this by producing a reference implementation that conforms to standard token specifications, and has made this available to Hyperledger. Hyperledger is an open-source community that focuses on blockchain development for enterprise applications



10 Issuing and distribution of tokens that use blockchain

and has approximately 200 corporate participants from around the world. Companies can make the design and development of tokens more efficient by customizing the open-source reference implementation to suit their specific requirements. In the future, Hitachi intends to work through the community to help create a new digital ecosystem that uses tokens.

in a way that complies with their respective data protection laws (including the protection of personal data).

With data increasingly being utilized in a range of public activities, there is a strong need for the strict management and appropriate use of personal data and other confidential information. This technology takes the form of a system that analyzes data containing personal or other confidential information without manual intervention in the country or region where it was created and then reformats it into analysis results that do not contain any personal data before transferring or collating it in some other country or region. When the system was implemented for testing at four sites in Japan, Australia, the USA, and Europe, it successfully reduced the amount of work required for the transfer of data to approximately one-sixth of what was needed when using past practices.

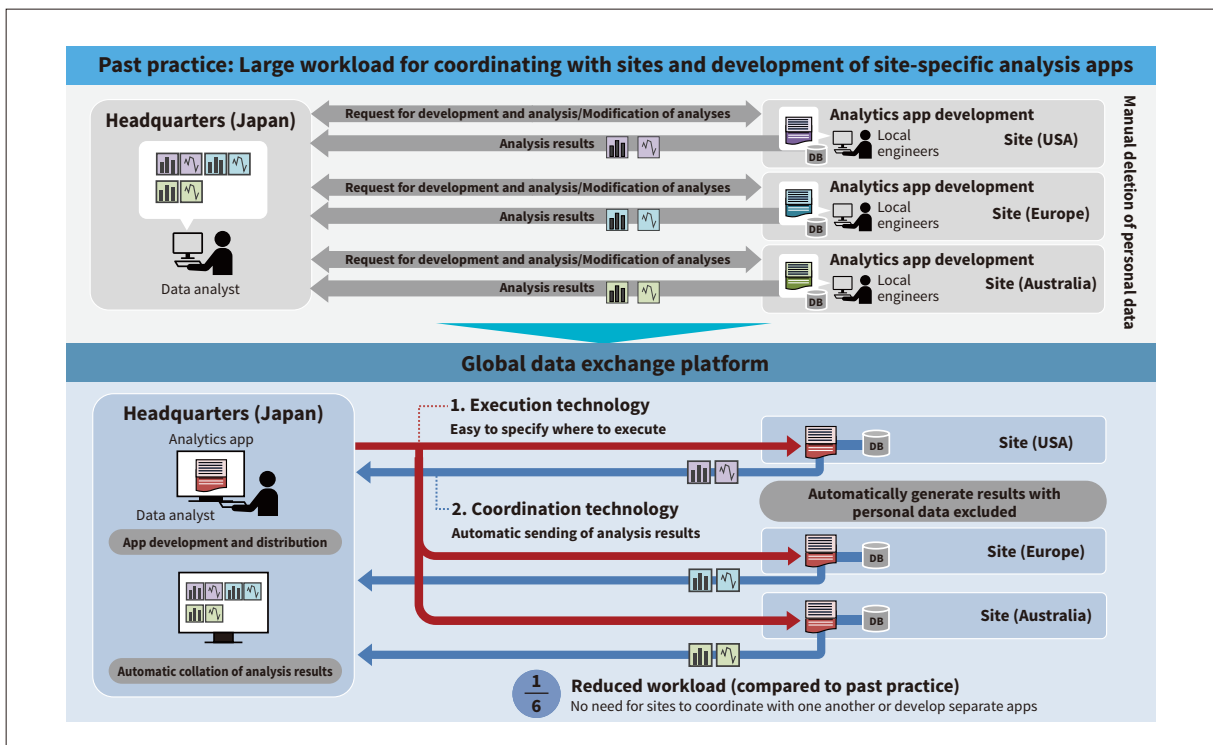
Through this technology, Hitachi intends to play its part in using digital technology to address a wide variety of societal challenges by encouraging the utilization of data generated in different parts of the world in ways that do not compromise data protection.

11 Technology for Global Data Exchange Platform

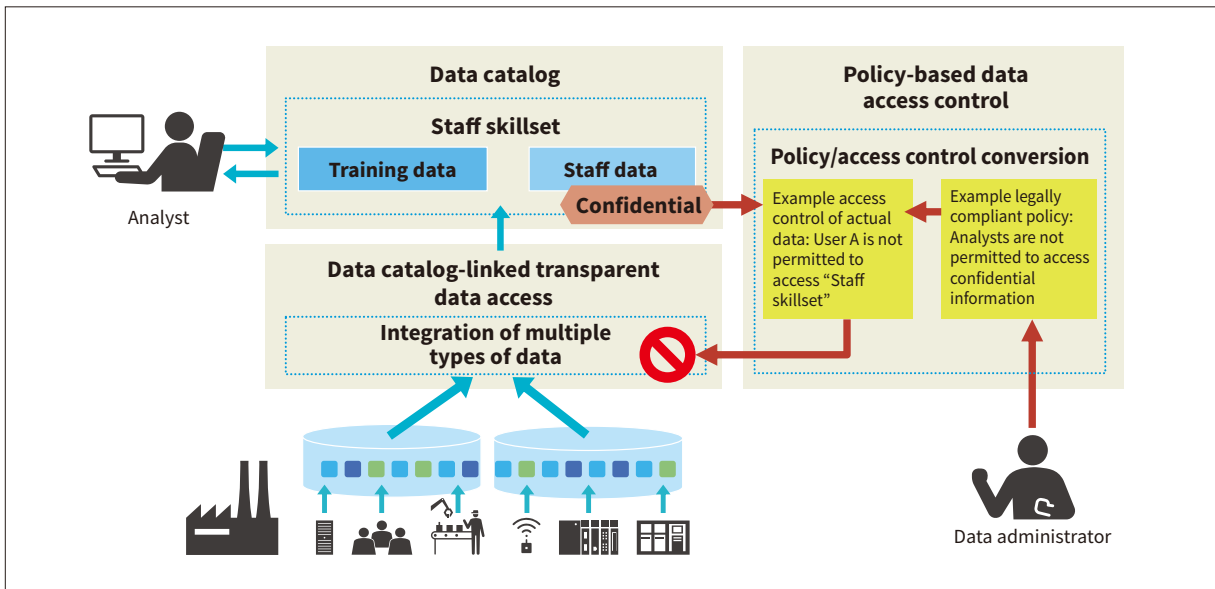
Hitachi has developed technology for a global data exchange platform that facilitates the processes of analysis and data sharing across different countries and regions

12 Data Catalog-linked DB Federation Technology Virtual Data Layer

Improving workplace efficiency and speeding up business decision-making through the use of data requires the



11 Global data exchange platform for facilitating data transfer with minimal workload



12 Data catalog-linked DB federation technology virtual data layer

searching and collation of relevant data and its analysis from a range of different perspectives. Along with centralized management using data catalogs, the ability to make use of data speedily and securely is a key consideration if good use is to be made of the data scattered around a company. Accordingly, Hitachi has developed the virtual data layer for the federation of databases (DBs) linking data catalogs.

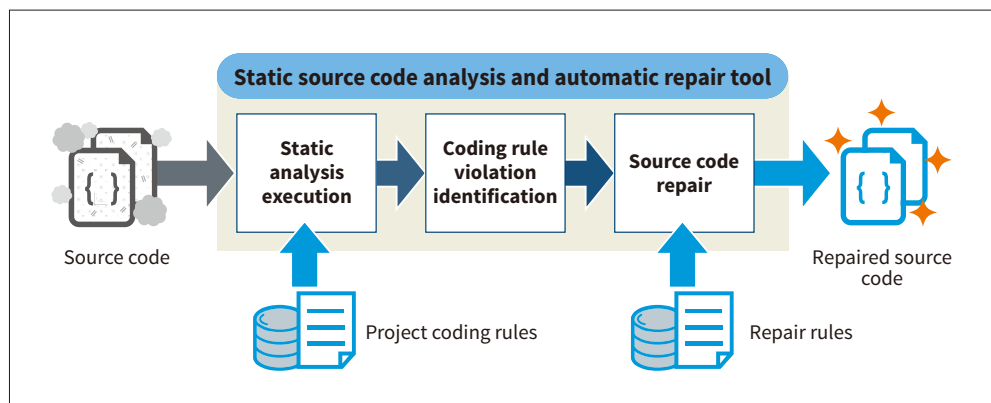
The data catalog-linked transparent data access provided by virtual data layer enables datasets combined by means of a data catalog to be provided to data analysts without their needing to be aware of where the different data are stored. Policy-based data access control, meanwhile, uses tags attached to the data to determine its confidentiality and restricts analysts' access to data by automatically converting predefined governance policies into data access restriction policies. This has the potential to accelerate the speedy and secure use of data.

13 Automatic Program Repair Technology for More Efficient Application Development

Debugging, the removal of faults in source code, is a part of application development. The larger the scale of the application, the more man-hours are required for debugging, so the rapid development of large applications requires more efficient debugging.

In response, Hitachi has developed an automatic program repair technique that automates the steps from identifying bugs in source code to fixing them. It uses existing static analysis tools to find bugs and uses predefined repair rules to eliminate any identified bugs such as coding rule violations or potential errors.

Since October 2021, this new feature has been made available as one of the functions of the Hitachi Application Framework. In the future, Hitachi intends to contribute to more efficient application development by adding automatic repair of bugs found in software testing as well as bugs caught by static analysis.



13 Automatic program correction