May 2025 Technical Information

Digital Systems & Services

Research & Development

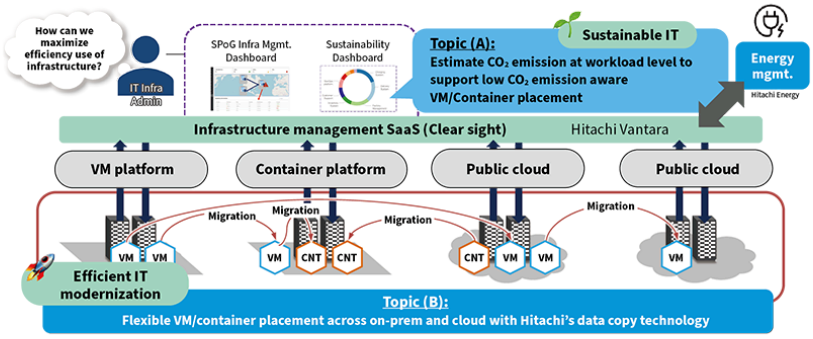
#Supply Chain Transformation #Innovation Creation #Co-creation and Open Innovation #Generative AI #IoT/Data Utilization #Digital Solutions #IT Products #Research & Development

1. Efficient IT Modernization and Sustainability Enhancement of Hybrid Cloud

The reconsideration of virtual machine(VM) environment and the surge in graphics processing unit(GPU) demand for generative artificial intelligence(AI) are dominant trends in IT systems. Two key challenges are becoming increasingly urgent for customers: 1. There is growing pressure to modernize existing VMware environments by migrating to newer virtualization technologies. However, these migrations are often hindered by complex and time-consuming processes. 2. The rising demand for computationally intensive applications, such as generative AI, is significantly increasing energy consumption in data centers, impacting both operational costs and sustainability goals.

We offer two innovative solutions to address these challenges: 1. Provide advanced VM migration technology that enables seamless migration from the existing VM platform to modern virtualization platforms, utilizing efficient storage-based copy techniques to simplify and accelerate the process. 2. Provide carbon emission estimation at the workload level and carbon footprint visualization through a single-pane-of-glass dashboard, empowering data centers to monitor and optimize energy consumption for improved sustainability.

[01] Efficient IT Modernization and Sustainability Enhancement of Hybrid Cloud



SaaS: software as a service
CNT: container

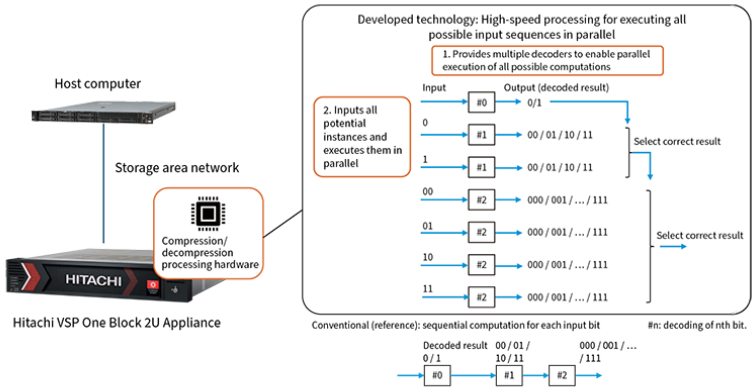
2. High-speed Technologies for High-compression LZMA Algorithm for Data Storage

With the advancement of enterprise digital transformation (DX), the amount of data handled by data centers is increasing so that reducing data retention costs is becoming an issue.

In response, Hitachi has developed a data compression technology that balances high compression ratios with high performance. Lempel-Ziv-Markov Chain Algorithm (LZMA) was considered as a candidate compression algorithm due to its high compression ratio. However, the algorithm processes input bits sequentially so it is difficult to speed up using parallel processing. To solve this problem, Hitachi developed its own proprietary high-speed processing technology that enables parallel execution by all possible computations for multiple input bit sequences and selects the correct result. This technology was implemented as compression and decompression processing hardware. This acceleration method enabled the application of LZMA to data storage.

This technology has been adopted in the Hitachi Virtual Storage Platform 2U Block Appliance mid-range storage system.

［02］LZMA Compression Algorithm Parallel Processing Hardware for Storage Products

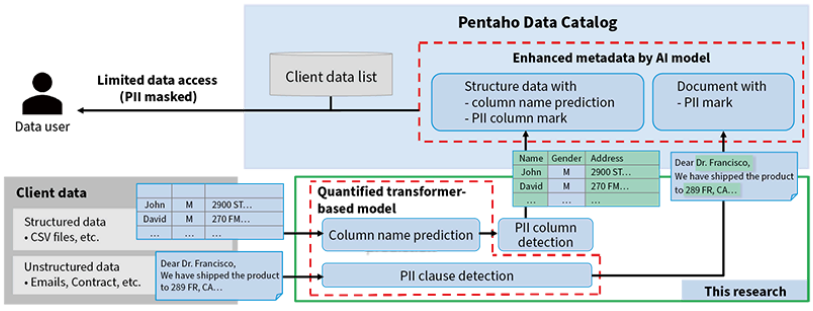


3. High-precision and Lightweight Personal Identifiable Information Detection for Pentaho Data Catalog

Pentaho Data Catalog (PDC) helps customers discover, catalog, and govern their data to prepare it for use in business decisions via traditional and AI based analytics. When governing and determining what data could be used for training AI, it is imperative to detect personal identifiable information (PII) presence in data, both structured and unstructured data. With conventional technology, regular expressions, the accuracy of detecting various types of PII was not sufficient. Large language models were not practical for PDC due to the increased computational cost.

To achieve both high accuracy and computational efficiency, a quantized transformer-based model as the PII detection machine learning model was introduced. Hitachi showed that it is possible to detect a wide variety of complex PII with high accuracy at a moderate computational cost. The address detection success ratio in unstructured documents has improved by 89% compared to traditional methods. For Japanese and Korean structured data, the accuracy of identifying column names exceeds 90%. This technology has been employed from PDC version 10.2.

［03］Personal Identifiable Information Detection in Pentaho Data Catalog Using Transformer-based Machine Learning Model



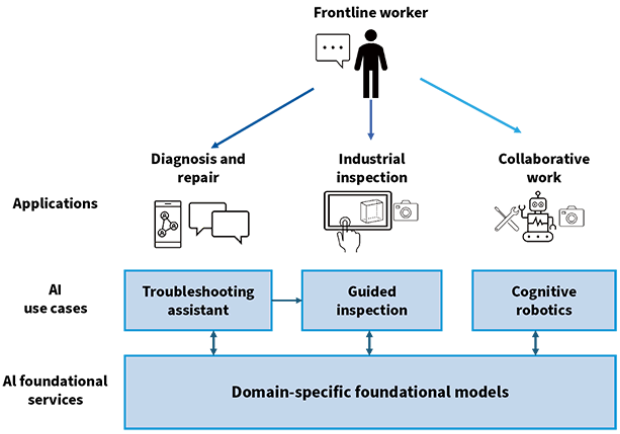
CSV: comma separated values

4. Empowerment of Frontline Workers Using Generative and Industrial AI

Frontline workers are the backbone of industrial operations, and by combining Industrial AI with generative AI, Hitachi aims to empower them and improve their well-being as well as the operational efficiency of operations. In this effort, it has built several solutions: 1. For helping workers make decisions on which repairs to undertake, they learn fault trees from equipment manuals, reducing the time of fault tree creation from weeks to hours. After workers build the fault tree, generative AI provides them with step-by-step guidance during diagnosis and repair. 2. Hitachi built an interface using generative AI to convert natural language instructions to a set of instructions robots can understand, so that humans and robots can work collaboratively in the field. 3. In another solution, Hitachi built a

tool using AI to help humans do better inspections of industrial equipment and processes through AR guidance. These solutions show how AI can augment the thinking and decision-making abilities of frontline workers and help Hitachi be a leader in this space.

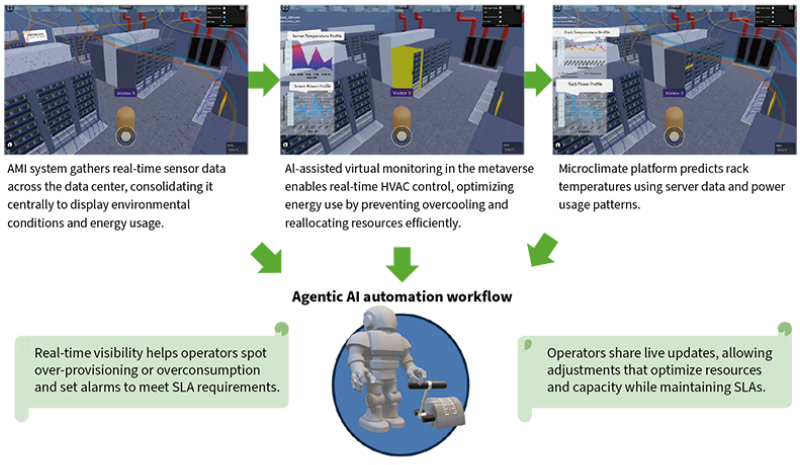
[04] Empowerment of Frontline Workers Using Generative and Industrial AI



5. Enablement of Data Center Infrastructure and OT Systems for Capacity Elasticity

The exponential growth in data center markets has driven significant advancements in IT systems, enabling dynamic resource scaling and optimization. While cloud providers and digital platforms have mastered IT elasticity to handle millions of concurrent users efficiently, OT systems in data centers face unique challenges in achieving similar flexibility. Traditional OT systems, designed with fixed capacity and redundancy requirements (e.g., power N+1 or 2N configurations) must now evolve to support rapid scaling, particularly in multi-tenant environments. This disparity between IT and OT capabilities creates a critical challenge: how to transform rigid physical infrastructure into adaptable systems that can scale efficiently while maintaining reliability. The challenge lies in optimizing OT resources to handle elastic capacity efficiently, minimizing stranded capacity, and avoiding overconsumption, all while ensuring continuous availability during scaling events. Part of Hitachi's research focuses on creating adaptive ecosystem solutions that enable data centers to optimize resource utilization and enhance scalability. Its facility virtualization platform offers collaborative monitoring with permissioned views in multi-tenant environments, while AI-based alarm management and microclimate platforms provide modularized allocation of cooling and power, ensuring flexible and efficient infrastructure for modern data center demands.

[05] Adaptive Data Center Ecosystem



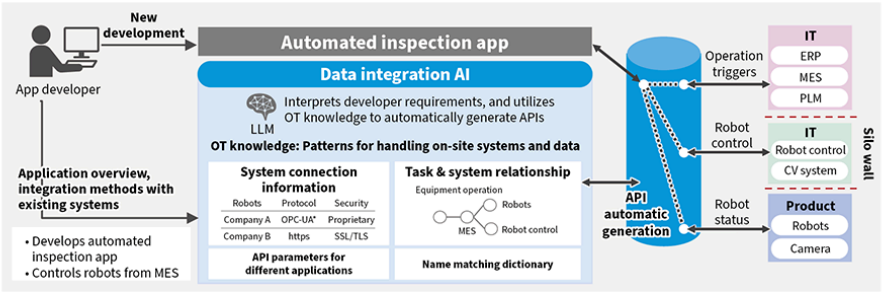
AMI: advances metering infrastructure, HVAC: heating, ventilation, and air conditioning, SLA: service level agreement

6. Data Integration AI for Rapid Development and Introduction of Apps

In many industries such as railways, power, and manufacturing, systems are siloed by business, making difficult cross-system operational reforms and efficiency improvements. For example, in the manufacturing industry, IT systems such as enterprise resource planning (ERP), product lifecycle management (PLM), and manufacturing execution system (MES), as well as OT systems such as robot control systems and computer vision systems are each operated independently. This makes it difficult to develop and deploy new applications to quickly address issues arising at production sites.

To solve such an issue, Hitachi has developed data integration AI that interprets developers' requirements, and uses generative AI to unearth information from past OT knowledge including system connections, data locations, and protocols. This then automatically generates application programming interfaces (APIs) to connect on-site systems and data. This technology enables seamless integration between siloed systems, allowing for the rapid deployment of applications that link systems together. The effectiveness of this technology is currently being evaluated at a factory in North America.

[06] Development of Cross-system Integration Applications Using Data Integration AI



LLM: large language models
CV: computer vision
OPC-UA: OPC unified architecture
SSL: secure sockets layer
TLS: transport layer security

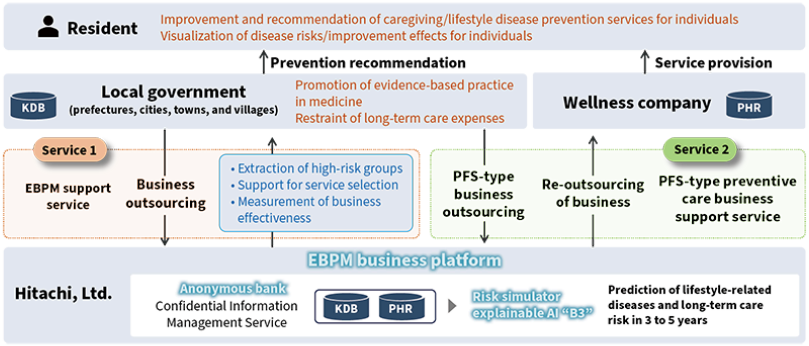
* See the list of "Trademarks.

7. Development of the EBPM Business Platform to Support Pay for Success Type Projects of Local Governments

The government estimates that implementing preventive care can reduce annual long-term care benefits by 3.2 trillion yen. High-quality preventive services are significant for improving quality of life and fiscal sustainability. Private companies' contribution is expected for widespread service provision. However, the lack of understanding of prevention's cost-effectiveness hinders private service adoption and fair market pricing. Urgently needed is a new mechanism like pay for success (PFS) to accelerate service dissemination, where prevention beneficiaries share outcomes.

In the "Tokyo Next-Generation Wellness Solution Construction Support Project," Hitachi verified the evidence-based policy making (EBPM) business platform concept. It utilized secure personal data infrastructure and big data AI analysis in care, health, and medicine. From the Reiwa 5th fiscal year, it clarified that preventive service effects can be quantified through big data AI and statistical inference with local governments. Hitachi aims to promote evidence-based PFS-type preventive care, contributing to citizens' improved quality of life.

［07］Overview of EBPM Business Platform



KDB: Kokuho Database
PHR: personal health record
PFS: pay for success

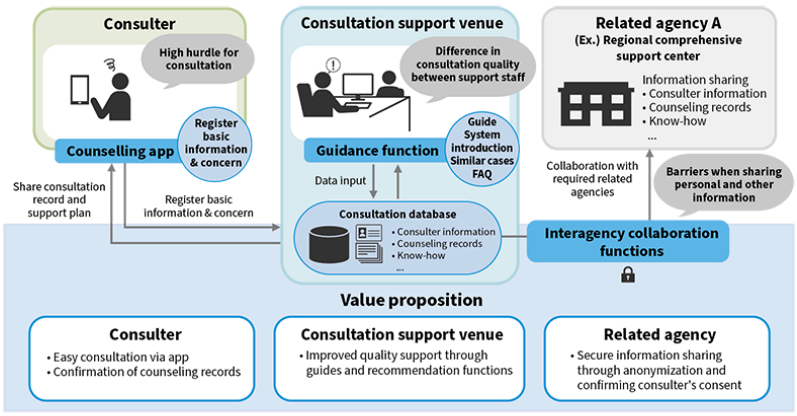
8. Consultation and Support Solutions Contributing to Reducing the Burden of Welfare Consultation and Support Work

In recent years, demands for support in social welfare have become increasingly complex. Cases that are difficult to cover under existing systems such as social isolation and young carers, as well as cases in which households or individuals face multiple challenges such as double care, have come to light. As a result, issues such as the increased workloads in welfare consultation and for support staff, along with the transfer of experience and skills have become concerns.

To contribute to sustainable welfare through the use of digital technology, Hitachi is working on the development and societal implementation of a “Consultation Support Solution” that aims to improve both the work efficiency and quality of work performed by consultation and support staff. By creating and utilizing consultation record data, this solution supports assessment at the time of consultation, as well as recommending available system information and similar records. In fiscal 2024, Hitachi is advancing the development of prototypes in collaboration with multiple local governments. By leveraging not only digital technology but also NEXPERIENCE*, the company aims to achieve the digital transformation (DX) of welfare consultation and support services, both of which are centered on interpersonal communication and tacit knowledge.

* Hitachi's collaborative creation methodology that uses collaboration with partners to create new businesses and services.

［08］Consultation Support Solutions Concept



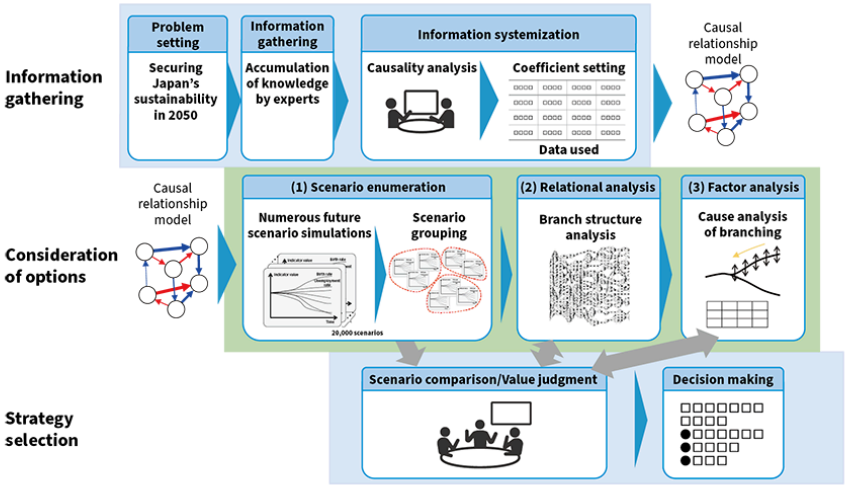
FAQ: frequently asked questions

9. Future Scenario Simulation Technology to Support Roadmap Development and Decision-making

Both public and private sectors are expected to make decisions based on future social issues. However, it is difficult to comprehensively consider and make decisions based-on the various scenarios regarding society. There are two challenges. One is that there are countless scenarios, making it difficult to consider them all. The other is that it is difficult to have discussions about specific measures such as when and what to do.

In future scenario simulations, two approaches are taken to address these challenges. First, a causal relationship model is created based on discussions from workshops and data, describing the relationships between indicators necessary for decision-making. By using this model, many future scenarios can be generated and grouped automatically, making it easier to consider countless possible scenarios. Furthermore, by selecting the branching points that determine the group of each scenario and conducting sensitivity analysis of each indicator at those points, it is possible to visualize which indicators influence the scenarios. This enables discussions on specific measures by understanding the impact of each indicator.

[09] Future Scenario Simulation Overview



10. Proof of Concept for Social Prescriptions and Development of Causal Inference Technology to Evaluate Prescription Effects

In order to realize a 'social prescription' that would resolve the increased burden on local medical and long-term care facilities due to the declining birthrate and ageing population, a new analytical technology was developed, and its effectiveness was demonstrated in Tokamachi City, Niigata Prefecture.

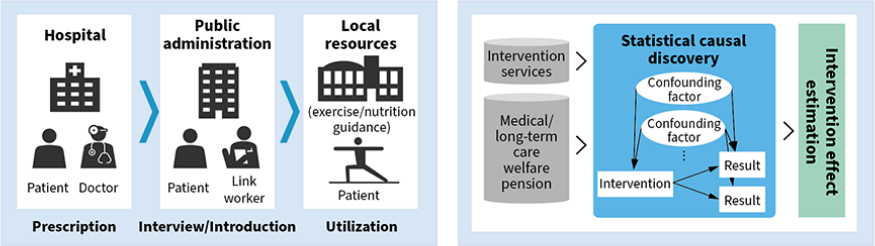
In collaboration with Niigata University and Tokamachi City, the 'Tokamachi Kenko no Shohousen' initiative was launched, in which link workers introduce local nutritional and exercise guidance to diabetes patients who are undergoing outpatient treatment. As a first step, a small-scale demonstration intervention was conducted for about three months, and a significant improvement in HbA1c* was confirmed.

In addition, the presence of confounding factors that produce pseudo-correlations with regional characteristics, etc., is an issue in accurately evaluating the effects of 'social prescriptions'. Therefore, a causal inference technique has been developed, which repeatedly searches for causal graphs of intervention variables, candidate confounding factors, and outcome variables using Linear Non-Gaussian Acyclic Models (LiNGAM) . Using this method, confounding factors were identified with an accuracy of over 90% based on items such as attributes and test values.

The aim is to develop social prescription solutions that promote these initiatives and achieve sustainable social security. Part of this research was supported by JST, RISTEX, and JPMJRS22I1.

* The value of hemoglobin bound to sugar in the blood expressed as a percentage (%).

［10］Social Prescription and Causal Inference Technology

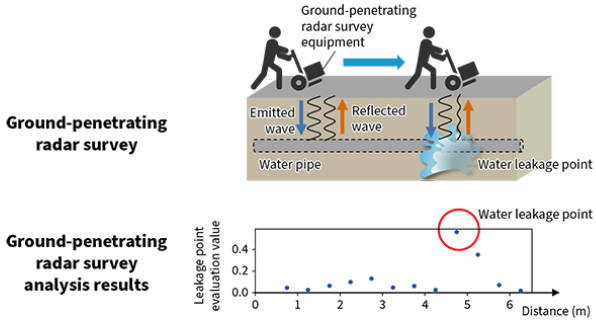


11. Water Leakage Point Detection Technology

Traditionally, investigations into water pipe leaks have used a method called acoustic leak detection, in which inspectors use a listening stick to identify the sound of the leak. However, conducting routine inspections across an entire water supply area is time-consuming and highly dependent on the skills and experience of individual inspectors, leading to challenges in detection accuracy. Hitachi provides a leak monitoring service using ultra-high sensitivity vibration sensors, capable of detecting even small underground leaks. However, once the leaks are detected, inspectors still need to conduct on-site investigations to localize their exact location.

Instead of relying on the acoustic leak detection techniques, Hitachi has developed a new leak detection technology using ground-penetrating radar for detecting the location of leakages, and that does not require these skills and experience. This technology analyzes radar images captured from the vicinity of suspected leakages using a proprietary algorithm to accurately identify leakage characteristics. Combining this new detection technology with Hitachi's leak monitoring service means that leaks can be located without depending on inspector skill and expertise, thereby enabling more efficient maintenance and management of aging water pipes. By utilizing digital technology, Hitachi supports improvements to the productivity of frontline workers responsible for the operation and maintenance of urban infrastructure, thereby contributing to the realization of safe, secure, and resilient cities.

［11］Overview of Leakage Detection Technology Using Ground-penetrating Radar Survey Equipment



12. Confidential Information Processing Technology Utilizing Trusted Execution Environment

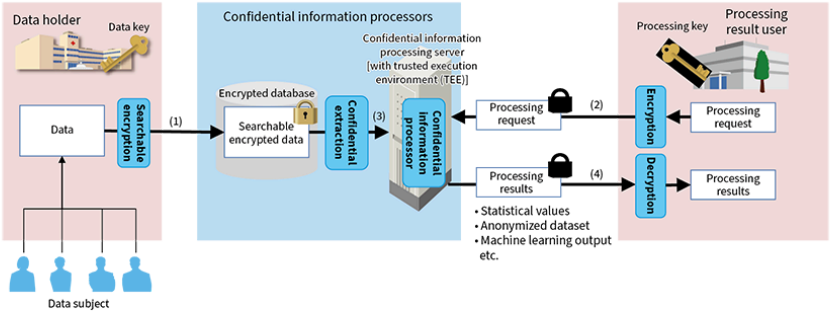
While there is a growing trend toward creating added value from sensitive information, incidents of data breaches continue to occur worldwide, leading to stricter regulations on data protection. In utilizing sensitive information, there is often a trade-off between security and convenience, but reconciling these can generate hitherto unseen customer value.

Hitachi has developed a technology that enables confidential information processors to efficiently handle sensitive data using a trusted execution environment (TEE), while at the same time keeping both the data holders' sensitive information and the processing requests of the result users confidential. TEE allows data decryption and arbitrary computation within a secure trusted area, even if root privileges are compromised; however the issue exists in that importing data into TEE and performing decryption processing introduces overhead. To address this, searchable encryption is used to extract only the necessary encrypted data

while maintaining its confidentiality before importing it into TEE. This approach reduces data import and decryption time, thereby shortening response times for processing results.

This technology is expected to contribute to secure and convenient information utilization for customers in the expanded infrastructure of “Tokumei Bank,” which utilizes TEE.

[12] Confidential Information Processing Technology Utilizing Trusted Execution Environment



DB: database

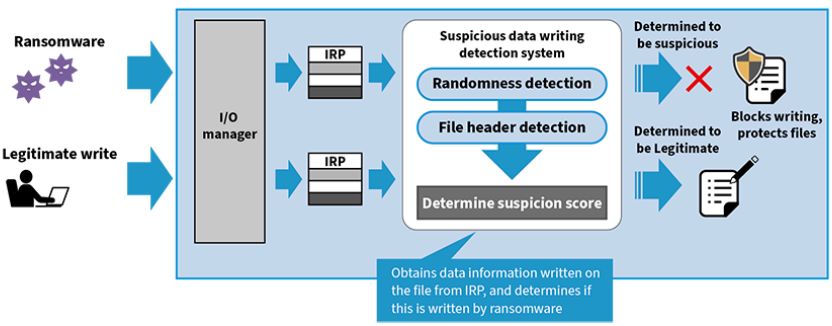
13. File-less Ransomware Detection Technology

Recent years have seen the emergence of variance of ransomware that leave no trace on storage devices such as hard disks. This is referred to as fileless malware. Traditional detection methods, which inspect file characteristics, struggle to identify such threats, whereas detection methods based on process behavior face issues such as several files being compromised before detection occurs, or difficulties in detecting attacks that inject malicious code into legitimate processes.

To address these issues, this research developed a new technology to minimize damage by extracting byte sequences sent to storage devices using I/O request packet (IRP) analysis, evaluating randomness in the data from the perspective of information entropy, combining entropy analysis with file header characteristics to calculate a suspicion score, and detecting and blocking ransomware-specific file write patterns.

This technology is utilized in Hitachi Solutions' information leakage prevention solution “Hibun” and “Data Recovery Solutions,” and will contribute to the protection of critical assets in customer IT environments.

[13] File-less Ransomware Detection Technology



I/O: input/output

14. Cloud-based, High-reliability Platform for Creating New Value in Information Control Systems

Hitachi is conducting research and development on high-reliability cloud platforms for social infrastructure systems such as railways and power networks in response to changes in social needs. In the past, control systems have ensured reliability through dedicated operating system/hardware (OS/HW) and communication channels, however moving forward, utilizing new IT technologies such as cloud computing will be essential in enhancing maintainability and scalability.

To this end, Hitachi has developed the following three methods and mechanisms to consolidate multiple control functions, to maintain the same level of reliability and real-time performance as conventional systems, and to provide remote and efficient monitoring, control, and inspection, as well as flexible system adaptation in response to societal changes.

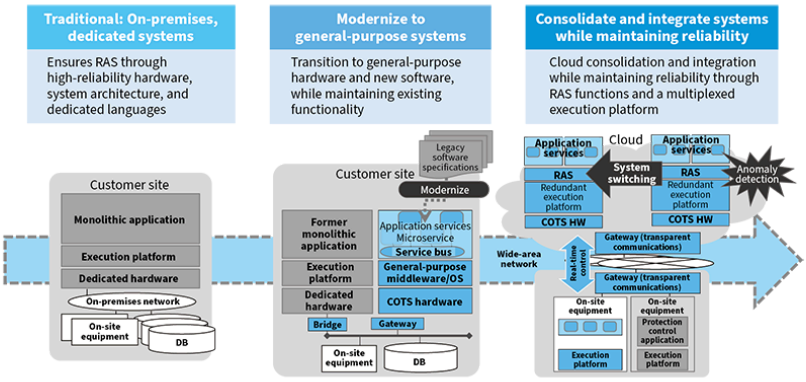
(1) A method for detecting critical failure signs based on communication and I/O status, rather than relying on dedicated detection functions.

(2) A redundancy mechanism on a general-purpose platform that allows rapid switchover to a standby system in case of failure detection.

(3) A modernization method to transition to a new software architecture, while preserving the functions and performance of legacy software.

Moving forward, by coordinating multiple infrastructure systems, Hitachi aims to bring about integrated cloud services for information and control systems that will contribute to solving societal challenges such as reducing environmental impact and addressing labor shortages.

[14] Migration to Cloud Control



COTS: commercial off the shelf

RAS: reliability, availability, serviceability

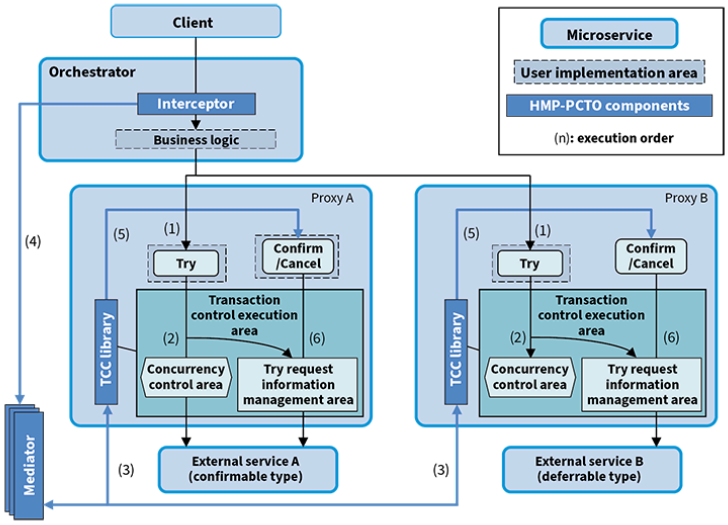
15. Strong Consistency Assurance for Microservice Distributed Transactions

In modernization projects that distribute the functions of legacy systems across multiple microservices, flexibility in integrating with external services outside the system allows for system expansion. However, it also requires distributed transaction control to maintain consistency across the entire distributed system.

To this end, Hitachi has launched the Hitachi Microservices Platform-Paxos Commit Transaction Orchestrator (HMP-PCTO), a distributed microservice operation platform. This supports atomicity, consistency, isolation, durability (ACID) features, making it applicable even for mission-critical systems. This platform product supports distributed transactions across a variety of data resources including relational database management systems (RDBMS), as well as supporting the development of new services in line with the standard try-confirm/cancel (TCC) design type.

In this research, with the aim of enabling external services not designed to conform to TCC to be linked, Hitachi defined a classification of external services based on their ability to restore state, along with transaction control methods for each service class, thus achieving an architecture that can execute the control via a proxy between HMP-PCTO and external services. This confirmed the feasibility of modernizing mission-critical operations such as financial services that link to a variety of services.

［15］ Architecture that can Execute Control via a Proxy between HMP-PCTO and External Services



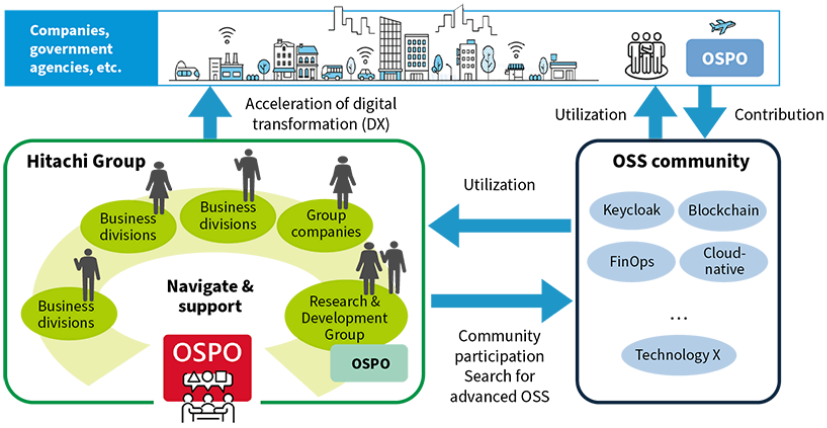
16. OSS Community Activities Supporting Co-creation with Customers

With 97% of organizations in Japan planning to modernize their technology stack, there is still room for growth in the Japanese market for open-source software (OSS), which is core to new technologies. The Research & Development Group has been leading the way in cutting-edge technologies in the OSS community as well as working with customers to expand the Japanese market. These efforts include serving as an ambassador for the Cloud Native Computing Foundation, hosting workshops with the OpenSSF which handles OSS supply chain security, and developing the distributed trust platform, Hyperledger Fabric*, as a maintainer. Building on these achievements, Hitachi has established an open source program office (OSPO) to further strengthen its OSS activities.

Moving forward, the Hitachi Group as a whole will promote OSS initiatives globally, aiming for further growth through collaboration not only in the IT sector but also with the OT sector.

* See the list of “Trademarks.

［16］ Role of Hitachi Group OSPO



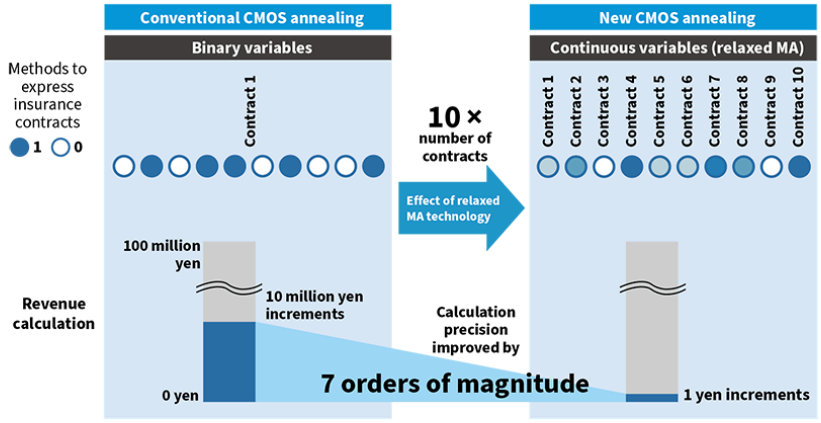
17. CMOS Annealing with Continuous Variable Support for Solving Customer Challenges

Hitachi is developing complementary metal oxide semiconductor (CMOS) annealing as a key technology for solving large-scale, complex societal challenges. With this, Hitachi has developed a new CMOS annealing technology called "relaxed MA" enabling optimization calculations using continuous variables (any decimal value between 0 and 1), in addition to optimizing traditionally used binary variables (1 or 0). Since a single continuous variable can replace multiple binary variables, this allows for high-precision solution of even larger combinatorial optimization problems.

To verify its effectiveness, we applied this technology to the optimization of a reinsurance portfolio. In this, insurance companies diversify multiple risks through reinsurance contracts, thereby constructing a balanced risk portfolio. As a result, we confirmed that the expected revenue amount could be calculated with fine precision down to 1 yen increments, even for a number of insurance contracts an order of magnitude larger than what was possible with conventional methods.

Moving forward, in addition to reinsurance portfolio design, we will apply this technology to optimizing power grid operations by balancing supply and demand, enhancing sales promotion strategies in electronic commerce (EC), and improving logistics planning efficiency, thereby contributing to solving various challenges for both customers and society.

[17] Effectiveness in Reinsurance Portfolio Optimization



Hitachi Review

Hitachi Review is a technical medium that reports on Hitachi's use of innovation to address the challenges facing society.

The *Hitachi Review* website contains technical papers written by Hitachi engineers and researchers, special articles such as discussions or interviews, and back numbers.

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