

Platforms to Realize Nippon Steel's DX

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Abstract

Along with the major evolution of ICT in recent years, many types of cloud services, network options, and security services have emerged. In addition, there are many platform options for handling large amounts of data nowadays. To promote DX, we redesigned our enterprise architecture and developed it as a DX platform.

1. Introduction

The steel industry is based on made-to-order manufacturing and produces a large number of products through multiple processes by using large-scale manufacturing facilities. We have applied many of the latest system technologies of the era, including order management, quality control in the manufacturing processes, and production planning that groups and schedules products to maximize production capacity while considering delivery dates and product quality. We have also conducted research and development and constructed systems.¹⁾ One of the characteristics is that many plants in the steel industry operate continuously 24 hours a day and 365 days a year, excluding time for repairs. A system infrastructure must be available to meet the continuous production requirements or must be capable of supporting continuous operation. Additionally, an enormous amount of information is produced in the production process. In this paper, we introduce the system infrastructure of Nippon Steel Corporation with these characteristics, starting with its history, issues, and measures, and then introduce data utilization platforms, analysis and AI platforms, etc.

2. Changes in Nippon Steel's System Infrastructure: Conventional System Development

In 1968, Nippon Steel was the first company in the world to build an online system at the Kimitsu Works plate mill of the then Yawata Iron & Steel Co., Ltd. The online system operated 24 hours a day and 365 days a year and consisted of four IBM360-M40 computers (Fig. 1) (CPU: 0.3 MIPS, disk capacity: 300 MB, memory: 32 KB). This marked a significant shift from the previous paper-based manufacturing information instructions and manufacturing performance information collection to system-based online instructions and online performance data collection. At that time, Japan was experiencing high economic growth, and building factories with thorough labor savings and high productivity was a top priority. Automation of production equipment and online production manage-

ment systems were required. It was essential to introduce the latest computer technology to meet these requirements. Specifically, to support 24-hour plant operation, Nippon Steel developed a transaction management system for processing multiple performance information sent from multiple processes accurately and without confusion. We also developed a queue management system for storing the information sent or attempting to be sent from the production processes in a mainframe (MF) computer without losing any information, even when the MF computer went down. Application software and middleware software with such functions were also developed.

At the time the systems were constructed, there were no online system middleware software products with the functions described above. Therefore, we developed middleware software in-house and implemented it on the aforementioned computers. We also promoted the development of individual business applications. By using the middleware mentioned above, we built a system to respond to real-time requests. This is how we were able to create the world's first online system to support our 24-hour operation. Since 1960, the ideas of "making what we don't have" and "creating our systems



Fig. 1 Appearance of IBM360-M40

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ourselves (in-house principle)” have been passed down from generation to generation. To date, our steelworks scattered throughout Japan have independently produced a variety of system infrastructures, such as MF infrastructure and distributed system infrastructure, as well as middleware and applications, in their on-premises (in-house) environments.

In steel production sites where production continues 24 hours a day and 365 days a year, it is essential to establish system stability, availability, and responsiveness to transmit and process actual result values immediately. The idea of “developing systems in-house” was highly compatible with Nippon Steel, as it enabled system development to be tailored to the requirements of each plant. Additionally, Nippon Steel can handle system failures and repairs itself and has achieved great results in terms of stability, availability, and responsiveness as a system that supports production sites. Because Nippon Steel is self-sufficient, we are able to create consistent medium- to long-term training plans for training engineers and accumulating expertise, which has great advantages in addition to stability, availability, and responsiveness. Nippon Steel has achieved various results, including securing its technological capabilities and accumulating expertise.

However, with the recent dramatic improvements in the performance of computers and communication equipment and the recent development of virtualization technology in cloud environments and external services, many system infrastructures can be maintained by others. It is also true that at that time, there was no such environment or service, and we were forced to do it ourselves whether we liked it or not. Since the late 1960s, we have been creating in-house systems on the mainframe. In the 1990s, we rode the trend of decentralization. We introduced server equipment and software for each business into an on-premises environment, creating distributed systems and enjoying the benefits of such systems. However, problems associated with in-house development have gradually become apparent.

3. Changes in Nippon Steel’s System Infrastructure: Challenges in Conventional System Development

3.1 Increased time cost when applying new technology

In system development at Nippon Steel, no matter which manufacturing base it is located at or whether it is developed on an MF platform or a distributed system platform, development is based on the “waterfall type” (from now on referred to as the WF type). A series of development methods in which system specifications are finalized, elaborated, tested, and released are the most used development methods for releasing high-quality systems. We still use them in many system developments. On the other hand, because they are cumulative methods, once the specifications are fixed (frozen), they cannot be changed, or the development period may have to be revised and restarted from a certain phase (redoing production, redoing tests, etc.). This methodology also causes rework and is not suitable for system development projects where it is difficult to define system specifications or where trial and error is desired. We have been carrying out large-scale development using the WF type for many years. As a result, once a system is constructed, although small improvements may be made, its basic structure remains unchanged for a long period. We tended to continue using it. Nippon Steel has approximately 800 million programs based on the number of active lines. Of these programs, 70% have been in operation for more than 16 years. Approximately half, or 47%, of the programs

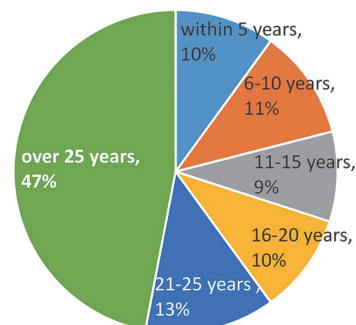


Fig. 2 Number of years since system operation started

have lasted more than 25 years (Fig. 2).

Once a system was built, we continued to use it without renewing its basic structure. When somebody said about an existing system, “I want to apply the latest technology immediately, or I want to rebuild this function with the latest technology,” it was rarely possible to apply the new technology to the existing system or recreate some functions using the latest technology. In most cases, it becomes necessary to make large-scale renovations and updates to infrastructures and programs that have been used for many years. As a result, it becomes necessary to carry out work that is burdensome in terms of time and cost, and a suitable reason for carrying out such work and the agreement of the parties involved are required. Considering the current situation where various surrounding environments are rapidly changing, we must keep up with the changes. Not being able to keep up with such changes for lack of time or speed would be fatal.

3.2 Fixation of development and maintenance personnel/turning expertise into a black box (personnel development problem)

Of the 800 million lines of programs mentioned above, the COBOL language accounts for a considerable number of programs for both the MF platform and the distributed system platform. A certain amount of the programs are written in the PL/I and Assembler languages. Engineers who can use these languages are getting older each year, and the challenges of securing engineers who can are becoming more apparent as time passes. For the middleware and tools produced in-house, only a few specific engineers can understand them (or these software programs are black-boxed). Because it is impossible to know what is inside, a situation has arisen in which even if you try to train personnel, you can’t. As the remaining experts are getting older, we must use the limited time we have left to deal with both “migrating to standard mechanisms” and “passing on the expertise of the current systems.”

4. Challenges and Responses in the 2000s: Integration of Communication Tools and Business Systems

Originally, system budgets were managed separately at each steelworks, and system personnel were also part of the organization within each steelworks. It was rare to introduce unified company-wide systems. However, as part of the solutions to the issues mentioned above, Nippon Steel has been working since the 2000s to integrate, centralize, and efficiently revamp common business functions such as communication tools and general management systems at their head office and all steelworks.

4.1 Integration of communication tools

Regarding communication tools, the email and schedule management software that had previously been installed individually at each steelworks has now been implemented as the same software for the entire company, and the subdomains owned by each steelworks have been unified as one company domain. Address books have also been unified. By unifying previously individual products, we were able to streamline maintenance and operation methods. We were also able to obtain volume discounts for purchasing software licenses by allowing all employees to use them. Additionally, in addition to being able to centrally check the schedules of members at each steelworks across the country, it also eliminates the hassle of having to look up the email addresses of members at other sites in Excel before creating an email, allowing for smoother communication.

4.2 Construction of NS-eSYS

General management systems often have functions that employees commonly use. Previously, each steelworks had a separate system with the same functions, resulting in a highly inefficient situation, including production and maintenance management. In order to improve this situation, we launched a new integrated business system platform (named the Nippon Steel e-business system and abbreviated as NS-eSYS) in 2003. The NS-eSYS was not just a platform integration project but an unprecedented and groundbreaking attempt. Some of our distinctive initiatives are described in the following sections.

4.3 Formulation of “NS-eSYS Charter”

When constructing the NS-eSYS, we not only simply aggregated the servers existing at each steelworks, but also “standardized the application structure” and consolidated it onto a large-scale server, thereby achieving “efficient use of server resources” and “improvement in the ease of adding applications.” Prior to this, we first formulated a “charter” (approximately 60 pages of A4 paper) to serve as a basis for developers and users. We documented the purpose of the construction, basic policy, and concept of each function. This made it possible for anyone to go back to basics and revise and unify their way of thinking, no matter what development phase they are in. The existence of the Charter was extremely significant as the NS-eSYS was a large-scale standardization and integration server construction project that had never been seen before. When the NS-eSYS was first launched in 2003, the number of running applications was around 100, but after three hardware updates, the number of applications has now increased to 582. By rebuilding the systems that had been built individually at each steelworks into a system that all employees could commonly use, significant results were achieved in terms of operational and cost savings. Additionally, we learned through this project that the existence of a “charter” is extremely meaningful when making large-scale changes to ideas and architecture.

5. Challenges for Realizing DX

The NS-eSYS, which was launched in 2003, has steadily increased the number of applications implemented while solving problems that arise from time to time. However, although the NS-eSYS is still in operation, new challenges emerged in the 2010s.

5.1 Company integration and environmental changes in the Asian region

As mentioned above, Nippon Steel has repeatedly merged with

various companies to this day. In particular, since the birth of Nippon Steel & Sumitomo Metal Corporation in the 2010s (former Nippon Steel and former Sumitomo Metal Industries), we consolidated production facilities when we grew to a group of six large steelworks in 2019. Nippon Steel was born from 2019 to 2020 (the trade name was changed to Nippon Steel, and Nippon Steel was integrated with Nisshin Steel). In the systems department, with the aim of further improving efficiency and strengthening governance, information system personnel who previously belonged to the head office information systems department and each steelworks were unified into a single organization as head office information systems department members. Outside the company, several new cutting-edge mills of Nippon Steel Group companies have started operations in East Asia. The competition on quality and price with overseas competitors is becoming fiercer. These mills were in a situation where they could only survive if they strengthened their competitiveness without degrading the quality of their products. In such an environment, it was extremely important to realize “quick decision-making that can respond to changes” and “a system structure that can quickly respond to changes in the business environment.”

As mentioned above, since the 2000s, we have been promoting a company-wide common infrastructure by unifying communication tools and building the NS-eSYS. Although we achieved some results, we were forced to take even more in-depth measures to achieve “further operational efficiency” and “business shift to keep up with the speed of change in the industry” in parallel with the solution to the problems mentioned above. In other words, the conventional system construction method (construction of an integrated infrastructure into an in-house on-premises environment) had its limits in keeping up with the speed of change. We decided that we had to take measures involving a bolder and more in-depth change in our mindset.

6. Formulation of “Information System Charter”

Recognizing these challenges, we decided that we should also formulate a charter in our problem-solving efforts similar to the “charter” formulated when the NS-eSYS was constructed. When the NS-eSYS was constructed, the Charter was strictly concerned with the NS-eSYS alone. This time, we decided to expand the scope and prepare an “Information System Charter” as a “guidepost covering all areas of Nippon Steel’s systems.” This was because we believed that it would take more work to build a consistent architecture that can keep up with changes while following a charter that covers only a specific infrastructure or domain.

In this “Information Systems Charter,” we clearly declared that we would move away from the in-house principle. Based on this, we have turned to building a system that maximizes the use of services and clouds (minimizes the in-house areas) and have just begun to utilize various cloud environments and vendor-provided service environments.¹⁾

6.1 Formulation of “Cloud Service Utilization Guideline”

As mentioned above, Nippon Steel formulated an “Information System Charter” and clearly declared its intention to do away with the in-house principle in the Charter. However, the mindset (culture) of in-house production based on the “in-house principle” that had been passed down from the 1960s could not be easily dispelled. When we were suddenly told to “make full use of the cloud environment,” even the members who participated in the formulation of the Charter were confused. Therefore, we formulated a “Cloud Service

Utilization Guideline” as a subordinate document of the “Information Systems Charter” to make it easier to understand the content and ideas described in the Charter. A reading book was produced to help the employees use the cloud services proactively and correctly. We believe that these efforts have deepened employees’ understanding of the cloud environment and consequently have contributed to the construction of a system infrastructure that can keep up with extremely rapid changes in the environment. The Cloud Service Utilization Guideline is designed for ease of reading and understanding and has almost the same volume (about 60 A4 pages) as the Information System Charter.

7. Utilization and Construction of New Systems Based on “Information System Charter”

As of April 2022, Nippon Steel uses cloud environments in 44 systems. In addition to the cloud environments, service environments provided by various vendors are also used. We plan to expand their use further in the future. Among these, the NS-eSYS platform (NS-eSYS2019), a core business system, is scheduled to reach the end of its service life (EOSL) in 2025. The next platform (NS-eSYS2025) is scheduled to be built at that time. The NS-eSYS2025 will reflect the Information System Charter and achieve a system platform that can quickly respond to changes in the management environment (Figs. 3 and 4).

8. Data Collection and Storage Platforms

Next, we introduce data utilization. As shown in Fig. 5,²⁾ at Nippon Steel, platforms are established and maintained for data collection, data linkage, data analysis, and AI implementation.

As shown in Fig. 6, there are various types of internal data, such as data from company-wide sales and finance management systems

and the setting data and actual result data from production management systems, operation systems, control computers, control devices, sensors, equipment, and devices, etc., at the respective steelworks. These data are stored by considering the collection cycle and accumulation period according to the respective requirements.

The steelworks cover very large site areas, and their power supply systems and networks cost much to maintain. Even at present, more data must be collected and stored. Nippon Steel is currently working to further expand its data, such as various types of sensor information, by utilizing new technologies, such as the integrated platform for facility monitoring (NS-IoT™).³⁾

The storage locations are distributed across the company’s centralized platform (including clouds) and the platform at each steelworks by considering factors such as the main usage locations and the network load due to the amount of data.

9. Integrated Data Management Platform NS-Lib™

Up until now, we have accumulated a large amount of data within the company and used it for operation management and analysis. The data is used in a variety of ways, with each department promoting data-based operations such as management, operational improvement, and problem analysis.

Data utilization tools include BI tools (Business Intelligence tools) such as Tableau and data analysis tools such as DataRobot. Dashboards are used for the sharing of information and the advanced analysis of data.

In 2020, we assessed the degree of data governance maturity and identified areas that needed to be strengthened to increase the asset

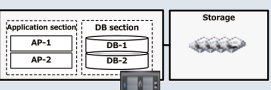

	Old NS-eSYS (2003~2019)	Current NS-eSYS platform
Aim	<ul style="list-style-type: none"> Aimed at improving the efficient use of server resources and ease of application addition by standardising application structures and consolidating them in a large integrated server. Start : 2003 The number of server aging updates : 3 (p690→p550→p770→UCS/EXData) The number of applications in 2010 : 173 	<ul style="list-style-type: none"> No operating hardware constraints are set in order to be able to follow various forms of resource provision in anticipation of future migration to the cloud. Development period <ul style="list-style-type: none"> Planning : 14 months Development : 9 months Transition : 33 months The number of applications : 582
Configuration	<ul style="list-style-type: none"> Large-scale servers from IBM are used. 	<ul style="list-style-type: none"> Separation of AP server and DB server computers, with AP server configured for scale-out (easy capacity expansion) to increase portability to cloud environments. 

Fig. 3 Comparison of Old and New NS-eSYS

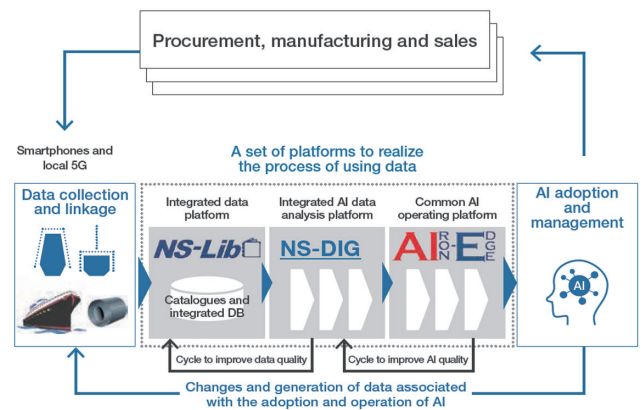


Fig. 5 Overview of NS Data Utilization Platform²⁾

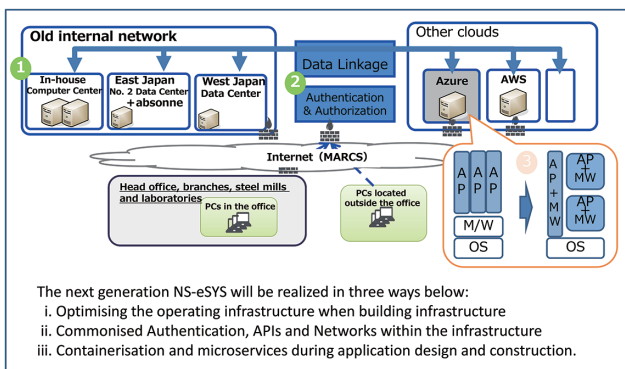


Fig. 4 Overview of New NS-eSYS

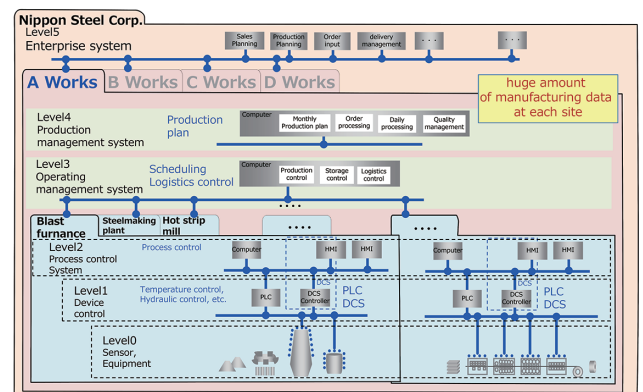


Fig. 6 System hierarchy structure of Nippon Steel

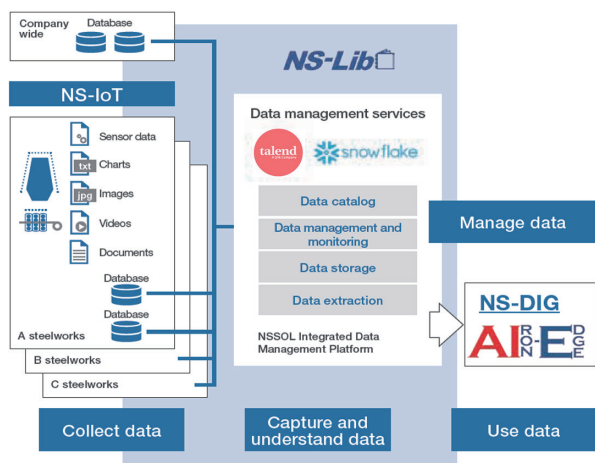


Fig. 7 Concept of NS-Lib²⁾

value of data and promote the utilization of data. The assessment revealed that we needed “cross-sectional data utilization systems,” “metadata management systems,” and “strengthen data governance systems” to achieve this goal.

Until now, data utilization within the company was limited to people who knew the system and data, such as owners and users of the system in question. When people from other departments used data, item definition confirmation and data transfer had to be done manually. The assessment pointed out that this situation was due to the lack of a “metadata management system” for company-wide databases, which resulted in only a limited number of members who knew the data being able to utilize the data freely. Additionally, due to the lack of the function of efficiently implementing the access control necessary for “cross-sectional data utilization,” the data could not be easily disclosed to other departments and had to be manually transferred to other departments. This issue was also pointed out in the assessment. Lastly, to further promote data utilization, we believe that it is necessary to “strengthen the data governance system, etc.” in addition to the development of the platform mentioned above. We are promoting the strengthening of data governance. This initiative is reported in the technical paper No. 131–20 in issue 131 of the Nippon Steel Technical Report (NSTR).

Based on the situation mentioned above, we constructed the integrated data management platform NS-LibTM.⁴⁾

The NS-LibTM has the following two main functions. Both functions aim to achieve more efficient data utilization and more data utilization across a wider range of departments within the company.

- ① Metadata management function (catalog management function)
- ② Company-wide access control function

We have built the metadata management function by using Talend, which supports both cloud and on-premises databases. Additionally, we are efficiently constructing the access control function by utilizing functions such as Snowflake and the virtual database Denodo (Fig. 7²⁾).

10. Integrated Data Analysis Platform

We are working diligently to provide customers with the high-quality steel products they need in a stable and timely manner by proactively introducing advanced IT, including AI and IoT, into our supply chain and engineering chain by creating competitive manufacturing sites through support for safety and operation and work style reform, and by promoting stable production through preventive

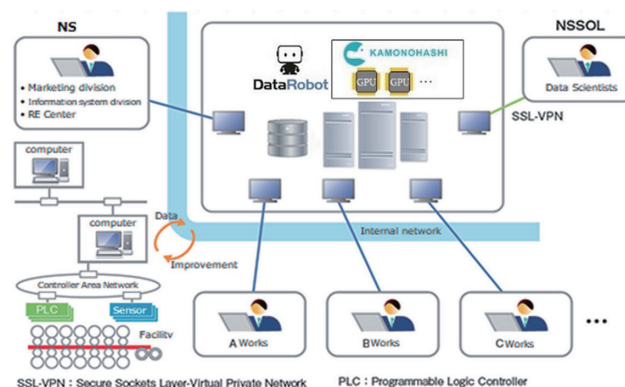


Fig. 8 Outline of NS-DIG

maintenance, and quality improvement and intelligentization (operational sophistication). The introduction of advanced IT requires high-speed and advanced analysis of large amounts of data or so-called big data. We have developed a platform called “NS-DIGTM.” The NS-DIGTM has high computing power capable of performing advanced image analysis and deep learning so that all staff members across the company who promote the development and application of advanced IT can analyze the big data quickly at any time. As tools for AI development, we have incorporated the AI automation tool DataRobot, which has already been introduced, and the image analysis and deep learning tool KAMONOHASHI from NS Solutions Corporation. Implemented as a through-process platform from data preparation and analysis through AI development to evaluation, the NS-DIGTM made it possible to develop more efficient and larger AI systems.⁵⁾ Our data scientists and other staff working on advanced data analysis and AI development have been using the NS-DIGTM to promote the intelligentization of the steelworks (Fig. 8).

11. Common AI Operating Platform

Along with the development of the integrated data analysis platform NS-DIGTM, we have investigated and verified the application of AI models. In parallel, we have worked to standardize the environments where AI models are executed. To smoothly deploy the AI models to the respective steelworks and improve the agility of platform construction, we have defined the usage requirements and standard platform configuration of the AI execution environment. Based on these efforts, the edge computing platform AIRON-EDGETM is being deployed at each steelworks (Fig. 9).

12. Company-Wide Network and Security Enhancement

The present company-wide network NALSYS (Network ALI SYSTEM) provides secure and stable communications by contracting multiple dedicated lines and making full use of communication bandwidth control and priority control functions to protect important communications (redundant configuration, etc.).

As we cope with the recent increase in the communication volume (increase in cloud communication volume, increase in image data, and increase in data utilization), there is concern about the sharp increase in the communication cost associated with the securing of communication bandwidths. To counter this concern, we are developing a new wide-area network (WAN) called the MARCS (Multi Access Route Communication System) by utilizing the SD-WAN (Software Defined-Wide Area Network) technology as a measure to “prevent a further increase in the communication

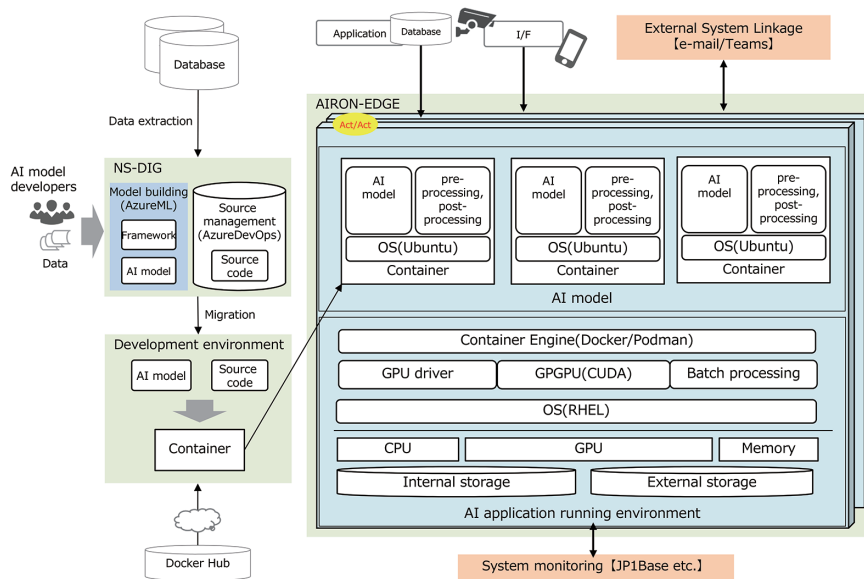


Fig. 9 Outline of AIRON-EDGE

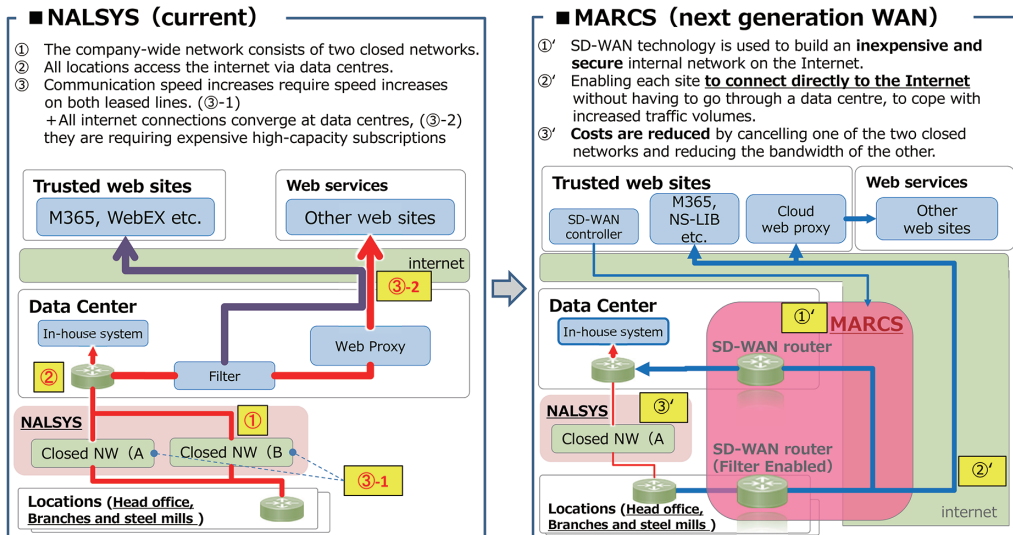


Fig. 10 Outline of new corporate network for Nippon Steel

cost” while “stabilizing large-capacity data communications (securing the bandwidth)” (Fig. 10).

13. Conclusions

Concerning the platforms to realize Nippon Steel’s DX, we have described the future policy and current state of system development. In the future, we intend to continue our activities to drive the DX expansion while incorporating the ever-evolving ICT as appropriate.

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