Value Chain Coordination Service for Manufacturing and Distribution in the New Normal

The conventional operations of the manufacturing and distribution industries are reaching their limit as the world enters the new normal. The new normal is characterized by greater product diversity and demand for immediate delivery arising from changes in consumer shopping behaviors, along with growing risks of supply chain disruptions caused by factors such as natural disasters and the pandemic. Hitachi has conceived a value chain coordination service that provides value by responding immediately to customization demands while ensuring a good balance between resilience and business efficiency. The concept is being developed through collaborative creation with customers. The service is composed of value chain orchestration that brings together the boundaries between companies and sites for seamless connection and execution, along with value chain matching enabling dynamic switching of component companies. This article presents the overall service concept and the core technologies that make it possible.

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1. Introduction

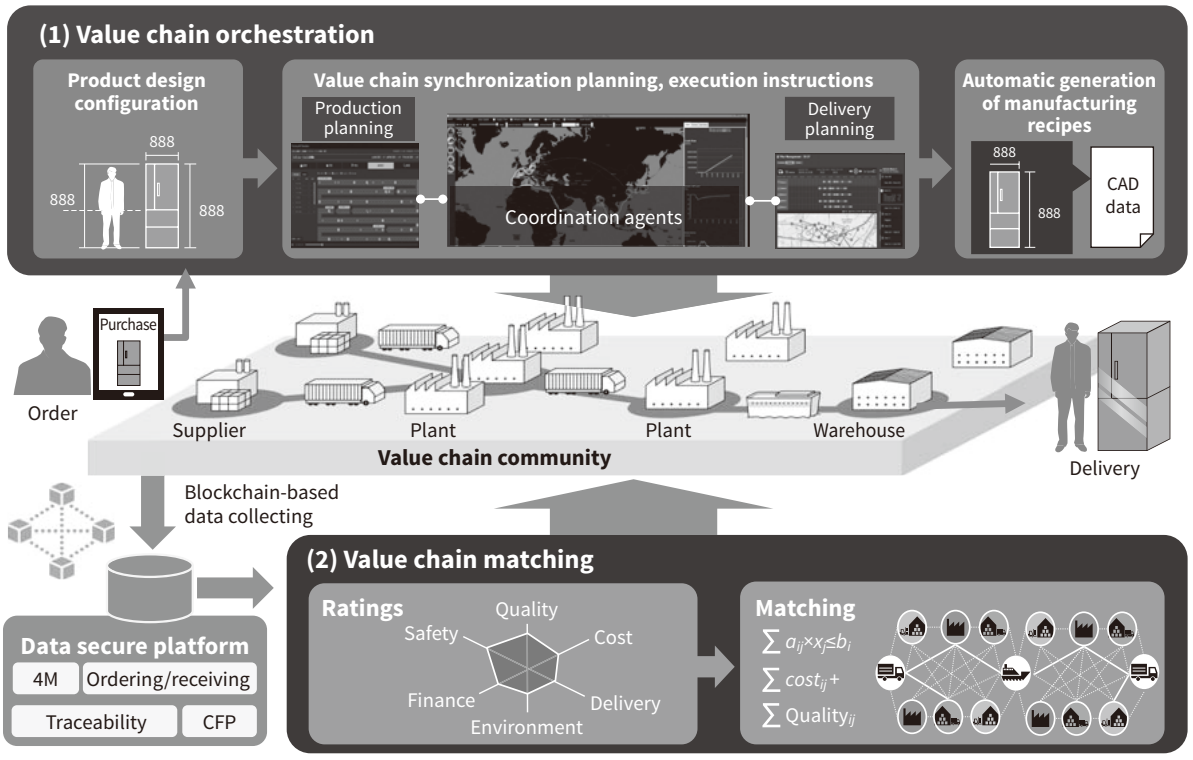
Diversifying consumer preferences and the rise of electronic commerce (e-commerce) are creating a shift toward greater product diversity and demand for immediate delivery in the manufacturing and distribution industries. This shift is creating an urgent need for the creation of consumer-initiated synchronized operation systems by the value chain component companies and sites that handle design, procurement, production, distribution, and sales. Ensuring a good balance between resilience and business efficiency is another important requirement as value chain disruptions become more frequent due to factors such as COVID-19. Hitachi, Ltd. has conceived a value chain coordination service designed to assist the manufacturing and distribution industries in the new normal. It is being developed through collaborative creation (co-creation) with companies in the home appliance, automotive, apparel, and other industries. With the Group's addition of US robotic systems integrator JR Automation, Hitachi is targeting overseas expansion through JR Automation's worldwide customer platform that includes plants producing products such as vehicles, aircraft, and medical equipment, and e-commerce distribution sites[(1)]. This article presents the concept and technologies behind a value chain coordination service that creates consumer-initiated value chain synchronization and ensures a good balance between resilience and business efficiency.

2. Concept of the Value Chain Coordination Service

The value chain coordination service is composed of (1) value chain orchestration that selects the optimum sites for design, procurement, production, and distribution with

Figure 1 — Overview of Value Chain Coordination Service

The value chain coordination service is composed of value chain orchestration that enables customer-initiated optimum site selection and brings together the boundaries of design, procurement, production, and distribution for seamless connection and execution, along with value chain matching enabling dynamic switching of component companies.



CAD: computer-aided design 4M: human, machine, material, and method CFP: carbon footprint

the consumer as the starting point, bringing together the boundaries of these sites for seamless connection and execution, and (2) trust-assuring value chain matching that enables dynamic switching of value chain component companies (see **Figure 1**). Enterprise resource planning (ERP) and supply chain planning (SCP) software packages are standard applications used in business management. These applications are usually designed for optimization of operations within companies and for supply chains with fixed partners. In contrast, Hitachi's value chain coordination service is designed for supply chains that bring together the boundaries between companies. It has two distinctive features. One is that it ensures a good balance between overall supply chain optimization and attaining each company's business goals. The other is that it has been designed for dynamic business partner rearrangement. The details are as follows:

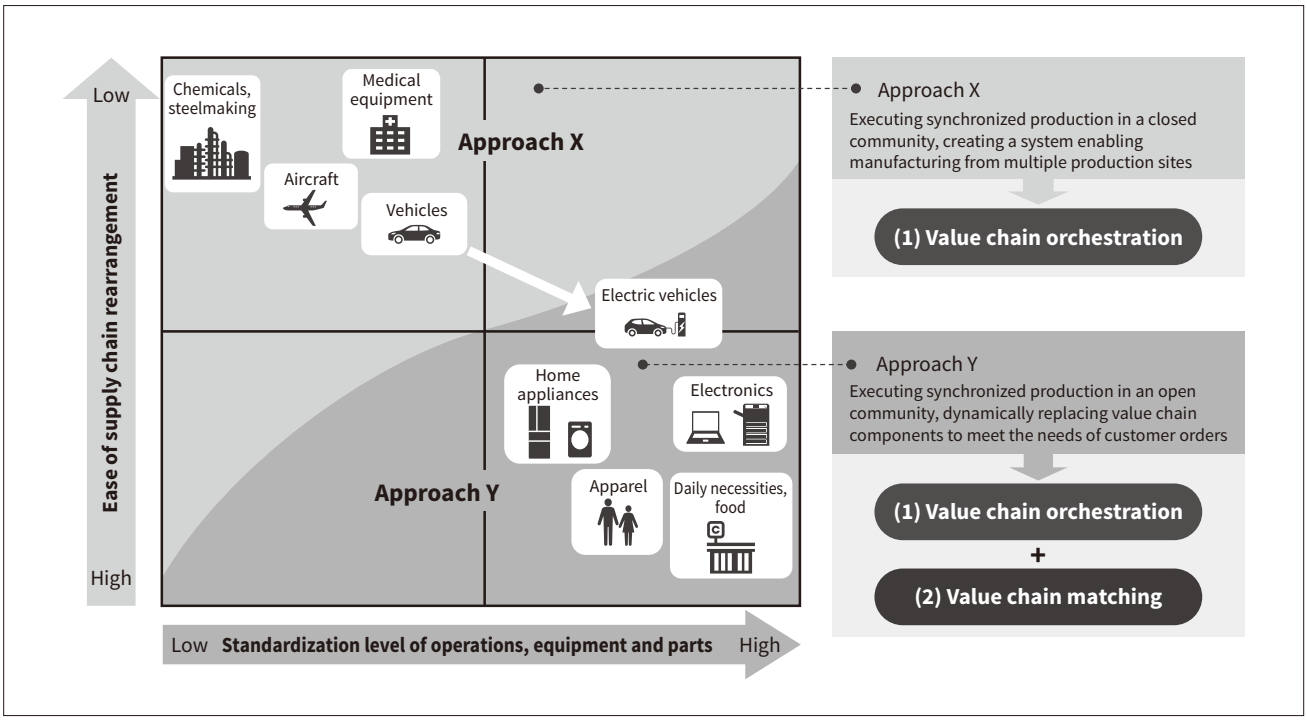
(1) Value chain orchestration is done to configure the product design as specified by the customization request in the consumer's order. The next step is then to draft plans and execution instructions that seamlessly connect the suppliers, assembly plants, and shippers[2), (3)]. Manufacturing recipes tailored to each plant's equipment are then automatically generated and provided[(4)]. These steps enable high-quality products to be provided rapidly even when orders are customized. These functions have already started to provide services.

(2) Value chain matching uses blockchain technology to collect and store performance data in a secure environment. This data includes human-machine-material-method (4M) data from the companies taking part in the community, incoming and outgoing orders, and carbon footprint (CFP) data. The data is then analyzed to rate each company and plant on the basis of both traditional measures such as cost and delivery time, as well as the measures of safety, quality, cost, delivery, environment, and finance (SQCDEF). The results are used to recommend and match optimum value chain component companies and provide an environment that enables simplified contracts and payments using technologies such as smart contracts. This process enables dynamic switching of value chain component companies, while ensuring a good balance between resilience and business efficiency. These functions are in the conceptual phase and under development.

The approach used to enable resilience and business efficiency varies according to industry-specific value chain characteristics (see **Figure 2**). The automotive, aviation, medical equipment and other industries are unsuited to supply chain rearrangement as they have little standardization of operations, equipment, or parts. Since these industries make

Figure 2 — Resilience Tailored to Value Chain Characteristics, Approaches to Business Efficiency

How easily a supply chain can be rearranged depends on whether the products or parts are certified or authorized in quality guarantees, and the difficulty of acquiring this certification or authorization. The level of standardization of operations, equipment, and parts is determined by factors such as the need for specialized work skills or equipment, and whether product architecture is modular.



it difficult to suddenly switch business partners or production plants, Hitachi is handling them by creating synchronized operation systems and providing redundancy that will enable manufacturing by multiple companies or sites within closed communities. Value chain orchestration will help make these synchronized operation systems possible for customers in these industries. In contrast, the electronics, home appliance, electric vehicle (EV), apparel, and other industries are well suited to supply chain rearrangement since they have highly standardized operations, equipment, and parts. Hitachi is handling these industries by creating synchronized operation systems and rearranging value chains dynamically in response to customer orders, in open communities with high levels of horizontal specialization. Value chain matching will also be provided to customers in these industries along with value chain orchestration. Services will be combined in this way to meet the needs of the customer's value chain, helping create a good balance between resilience and business efficiency.

3. Technologies behind the Concept

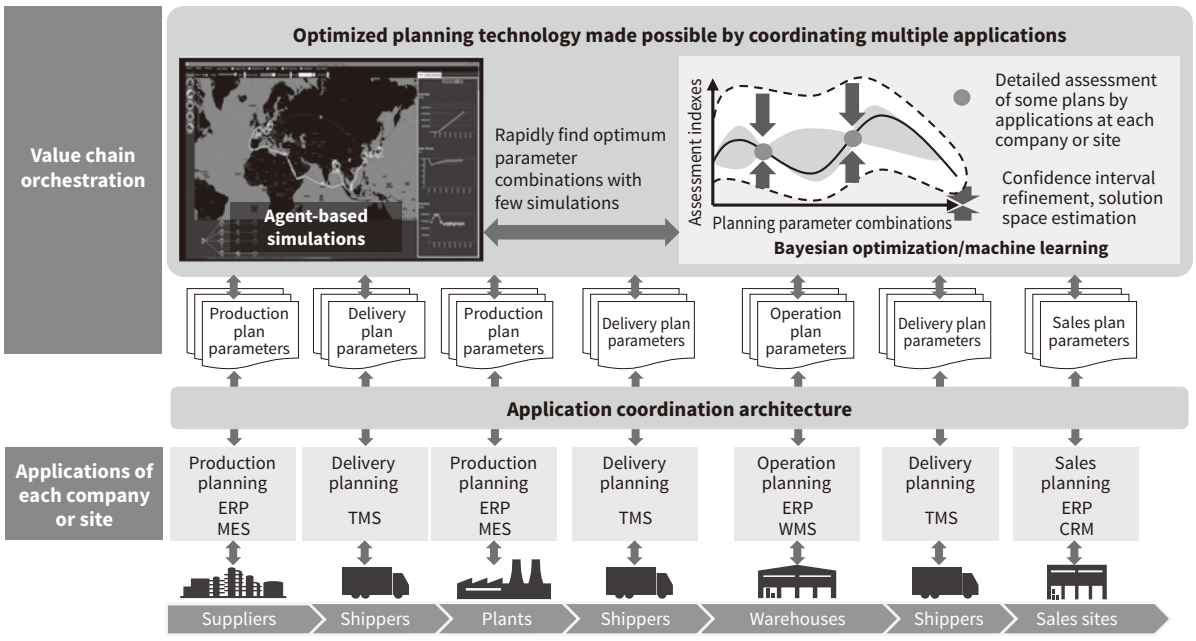
This section presents the optimized planning technology made possible by bringing together the multiple applications that form the core technologies of value chain orchestration. It also looks at the architecture underpinning the value chain coordination service.

3. 1
Optimized Planning Technology Made Possible by Coordinating Multiple Applications

Optimized planning and execution platforms for individual companies or sites have so far been created by installing ERP, manufacturing execution system (MES), warehouse management system (WMS), SCP, customer relationship management (CRM), and other applications. A system integration (SI) service by Hitachi that installs these applications has been provided along with application packages developed by Hitachi for optimizing production plans and delivery plans[(5)]. Shutting down these applications would be impossible since they provide business platforms crucial for the business continuity of the companies or sites that depend on them. Replacing them would also require extensive time and money since complex business restrictions need to be considered for each site. Hitachi has responded by developing a technology that optimizes planning and execution to connect the entire value chain across all the companies and sites (see **Figure 3**). The technology enables the continued use of existing applications under the autonomous decentralized system concept that Hitachi has created by building a portfolio of rail transport, power, and other infrastructure systems. The technology rapidly derives the optimum combinations of application parameters for each company or site so that the entire value chain's key performance indicators (KPIs) are optimized and each company or site's target KPI values are satisfied. Each company or

Figure 3 — Overview of Optimized Planning Technology Created from Multiple Applications

The technology derives optimum plans that synchronize the entire value chain. It is provided as a wrapper on top of the previously installed applications of each company or site.



ERP: enterprise resource planning MES: manufacturing execution system TMS: transportation management system WMS: warehouse management system CRM: customer relationship management

site then uses the calculated optimum parameters with the installed applications to propose and execute procurement, production, shipping, or sales plans. This process enables operations that synchronize the entire value chain.

The technology is composed of two elements: (1) agent-based simulations that predict value chain behavior, and (2) Bayesian optimization/machine learning[6] that maximizes KPIs with few simulations. Agent-based simulations model the applications of each company or site as agents. For each combination of application parameters, the actual plans, and executed operations for a given demand case hypothesis are simulated in chronological order, and KPI values are calculated for the entire value chain and for each company or site. Each of these calculations will be time-consuming if the value chain contains a lot of component companies or sites, the products are very diverse, or the applications work with very complex operation restrictions. The number of parameter combinations will also increase enormously. Bayesian optimization/machine learning is used to handle these issues. Several parameter combinations and demand cases calculated from agent-based simulations are used as input information along with the associated KPI values. The calculated parameter combinations are refined to enable rapid calculation of optimum parameter combinations.

Since value chains are composed of multiple components, gaining the consent and understanding of the companies and sites involved is an important requirement when plans proposed by this technology are being applied to actual operations. Hitachi is now stepping up the pace of development on functions that explain the reasons that calculated parameter combinations are optimum. These functions are designed to enable understanding among the operations staff making the final decisions at companies and sites.

3. 2
Architecture Underpinning the Value Chain Coordination Service

One of the issues involved in creating the value chain coordination service is to coordinate the applications while adapting to three types of diversity—diversity among the planning applications themselves at each value chain component company, diversity among planning application execution locations, and diversity of trust. Hitachi is working on this issue by developing the architecture and associated technologies that offer the following benefits:

Diversity among the planning applications themselves could mean that a production plan is handled using a different application at each company, for example. Some companies might use vendor packages, while others use systems developed in-house. The value chain coordination service defines data models conforming to open standards to coordinate data among a wide range of different applications from company to company.

Diversity of planning application execution locations means that factors such as company security policies result in different locations being favored for execution (such as

on-premises or public cloud execution). Therefore, the key lies in how data is coordinated with on-premises applications while still focusing on using the cloud to coordinate applications to enable easy connection of companies. The service is implemented by using a cloud-based workflow engine for synchronous/asynchronous execution control and coordination of data with on-premises applications. Users who want to move their current on-premises applications to the cloud can also do so with the help of Hitachi's cloud handling technology[7), 8)].

Diversity of trust means different levels of trust as rated by the SQCDEF measures for products or individual orders. The key here lies in how trust levels are assessed from collected data, optimum value chain component companies are matched on the basis of the results, and applications are coordinated. The service collects and analyzes performance data from each company without misrepresentation, assesses trust levels, and uses the results to dynamically generate the optimum value chain in workflow format. These processes are implemented by controlling the coordination and execution.

4. Conclusions

This article has presented a service concept and core technologies designed to assist the manufacturing and distribution industries in the new normal. As they work on providing immediate responses to demands for customization while ensuring a good balance between resilience and business efficiency, the manufacturing and distribution industries are increasingly shifting toward new operations and business models that seamlessly connect companies with sites, and the field with management. Hitachi's Research & Development Group is assisting this shift by drawing on capabilities rooted in products, operational technology (OT), and IT acquired from internal and external manufacturing sites.

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