Hitachi AI Technology/Planning Optimization Service

Achieving DX of Planning Operations with Integration of Digital Technology and Design-based Approaches

Driven by the labor shortages of recent years caused by a shrinking working-age population, companies are finding it increasingly necessary to adopt highly efficient working practices based on advanced digital technologies. Planning work, meanwhile, combines tacit knowledge derived from know-how and intuition with large numbers of complex constraints in order to devise optimal plans. As a result, it suffers from an over-reliance on specific individuals, with only a small number of experienced staff able to produce such plans, and also from the difficult nature of the work that makes it hard to computerize using conventional techniques. In response, Hitachi is seeking to resolve these problems using Hitachi AI Technology/Planning Optimization Service, a proprietary AI that combines machine learning with mathematical optimization.

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1. Introduction

The aging of experienced staff has accelerated in recent years who have supported our society on the manufacturing frontline. The skills and expertise possessed by these people are often difficult to pass on, being in the form of tacit knowledge. As well as having an aging industrial workforce, Japan in particular is also concerned about a severe shortage of younger workers able to take their place. Planning work is no exception to this trend. As planning involves deciding how companies can make the best use of finite resources (people, material, and money), work that by its nature is highly reliant on the individuals who do it, the shortage of experienced staff in this role is becoming an ever more serious problem. Meanwhile, there is a growing need for digital transformation (DX), meaning the use of digital technologies to transform companies and their business practices in ways that will sustain and improve key performance indicators (KPIs) such as the productivity and profitability of their operations.

This article presents an overview of Hitachi AI Technology/Planning Optimization Service, an optimization solution for the DX of planning work that uses a design-based approach together with proprietary artificial intelligence (AI).

2. Hitachi's Work on Planning Optimization and the Associated Challenges

Planning generally refers to making advance preparations for some activity. It is about deciding how to make the best use of the finite resources (people, material, and money) available in a company's production, distribution, or sales

operations to achieve objectives such as targets for production or sales volumes. This makes planning optimization crucial, meaning getting the right arrangements in place beforehand. Being a generic concept that does not belong to any particular industry or field, the optimization of planning is something that is required across a wide range of corporate activities (see **Table 1**).

As the scope of a company's operations grows, so too does the scale and complexity of its deployment of those finite resources. As such, planning optimization will only become more necessary and more important in the future.

Work on the DX of planning existed even before terms like big data and AI came to prominence. The aim was to reduce the workload of planners by automating their work while also to deliver plans that were able to achieve their objectives at a high level. The main techniques used to achieve this came under the general category of mathematical optimization. That is, decision-making based on a plan's constraints (things like process times in the case of production planning) and its targets (such as monthly production) can be modeled as an optimization problem for which a solution can be obtained mathematically. As many such methods are available, mathematical optimization can automatically compute a plan with a high index value while still satisfying the constraints.

Unfortunately, there are a number of obstacles in the way of adopting planning optimization systems or services. The greatest of these is the issue of how to leverage the expertise of experienced planners. It is not easy to identify all of the factors that such expert planners consider when formulating their plans, nor to express these in a model, whether as constraints or in other forms. Therefore, even if systems may succeed in automating planning, the resulting plans will be out of step with actual conditions and not able to be used in practice. And this has been the reason why many planning optimization projects have run into difficulties. The root of the problem lies in the knowledge acquisition paradox[(1)], whereby the greater someone's expertise in a particular field, the less able they are to articulate the knowledge they use to solve problems in that field. This is a significant obstacle to progress on planning optimization.

In response, Hitachi supplies Hitachi AI Technology/Planning Optimization Service as a means of achieving planning optimization in ways that are of genuine use in companies' activities and operations. The next section describes this service.

3. Hitachi AI Technology/Planning Optimization Service

The Hitachi AI Technology/Planning Optimization Service enables the optimization and DX of planning work, using a "digital and design" approach to solving the problem of how to incorporate the expertise of experienced planners mentioned above[(2)]. Here, "digital" refers to Hitachi AI Technology/Machine Learning Constraint Programming

Table 1 — Expanding Scope of Application of Planning Optimization

There is a need to optimize plans to make the most of the available resources (people, material, and money). Given that it spans so many different areas of corporate activity, the ability to do this will only become more important and sought after in the future.

Field		Transportation	Industry	Distribution, retail, services	Infrastructure and energy	Finance	Telecommunications	Healthcare
Potential applications		• Traffic management (cars, buses, trains, aircraft) • Equipment and materials handling • Booking, ticketing	• Production management (MES, ERP) • Quality management	• Distribution management • Warehouse management • Promotion and marketing • Sales	• Control and management of electricity and water networks • Equipment operation	• Accounting • Customer channels (over-the-counter, ATM, net banking) • Sales • Investment decisions	• Control and management of communication networks • Equipment operation	• Medical care and diagnosis • Nursing
What to optimize?	People	Optimal staffing, work rotation (regular, daily, irregular)						
	Materials and tasks	• Eliminating congestion • Efficient operation • Energy efficiency • Rapid recovery from problems • Maintenance cost reduction	• Efficient production • Optimal operation and control of production lines • Maintenance cost reduction • Procurement cost reduction	• Efficient delivery • Inventory minimization	• Efficient electricity and water distribution • Optimal operation and control of equipment • Rapid recovery from problems • Maintenance cost reduction	• More efficient cash replenishment (ATMs)	• Efficient location of telecommunications equipment • Maintenance cost reduction	• Optimal operation and control of diagnostic equipment
	Money	• Freight optimization		• Dynamic pricing (hotels, etc.)		• Portfolio optimization	• Billing system design	

MES: manufacturing execution system ERP: enterprise resources planning ATM: automated teller machine

(MLCP), Hitachi's proprietary planning engine that combines AI machine learning with mathematical optimization. The service provides more than just the use of mathematical optimization to devise a plan that satisfies the constraints, and it also provides further optimized plans by applying machine learning to historic planning data to determine how experienced planners deliberately relax certain constraints[3]. One example of this relaxation of constraints relates to the knapsack problem, which seeks to determine the most valuable mix of objects that can be placed in a knapsack without exceeding its weight and space constraints. By definition of the optimization problem, weight is a constraint that must be satisfied no matter what, whereas in practice it is not as if a knapsack will fall apart the moment its maximum carrying weight is exceeded. Assuming there are situations where relaxing the weight limit by just 1 kg will allow the addition of another item of value, and if there are instances of experienced planners having done this in the past, it is possible to produce plans with more value in which the weight limit is relaxed by 1 kg, even though this is not something that is safe to do on a regular basis.

The "design" side of "digital and design" refers to how the team of specialists uses a design-based approach to understanding the customer's business processes[4]. It involves the team of data scientists and other specialists leveraging their skills in interviewing and ethnography to dig into how the customer performs the work in question, including the extraction of undocumented constraints, and at the same time the analysis of historic data extracts and models the planning practices. Combining these approaches, the service enables the formulation of optimal plans by extracting practices of which the experienced planning staff are not consciously aware as well as constraints that in the past have been overlooked and incorporating these findings into the planning engine. Moreover, once it becomes part of the customer's planning operations, the planning engine is able to adapt to changes in the business as it is continually updated through the feedback of actual planning performance (see **Figure 1**).

Hitachi AI Technology/MLCP is a core component of this service and the following is a review of its functions and features (see **Figure 2**). In broad terms, Hitachi AI Technology/MLCP is made up of a mathematical optimization engine and a machine learning system. The mathematical optimization engine in turn features a constraint programming function for generating plans that satisfy a variety of different constraints while also considering other relevant issues, and an optimization engine for generating plans that maximize specific performance indicators. Machine learning, meanwhile, generates flexible plans by learning the practices of experienced planners, such as the practice described above of relaxing particular constraints. Because the data layouts for the inputs and outputs of these functions are defined to suit how the customer goes about planning, and because attention is paid during system implementation to how this data relates to the various constraints, use of Hitachi AI Technology/MLCP is not restricted to particular types of planning or customer industries.

One of the product features is the ability to handle a number of different types of optimization problem. In practice, the planning done by companies often involves a number of different optimization problems, which in some cases need to be solved in combination, rather than a single optimization problem. Planning the optimal mix of goods to transport and then the optimal route by which to transport them, for example, requires two separate optimizations in the form of a knapsack problem and a travelling salesman problem respectively. Existing systems and optimization packages are often ill-suited to such applications because they are designed for use on one particular type of planning or optimization only. Hitachi, in contrast, is able to offer optimal planning even for such complex applications thanks to ongoing functional enhancements that have expanded the range of optimization problems able to be handled.

Figure 1 — Digital and Design Approach

A design-based approach is used to obtain a comprehensive understanding of the customer's operations and extract undocumented constraints, and this is combined with the analysis of historic customer data to identify their planning practices. Incorporating these findings into the planning engine enables the formulation of optimal plans.

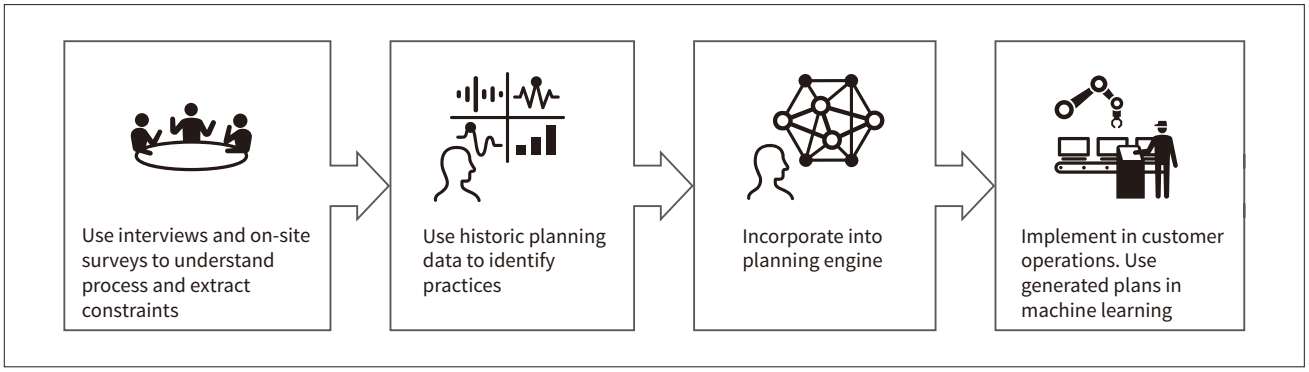
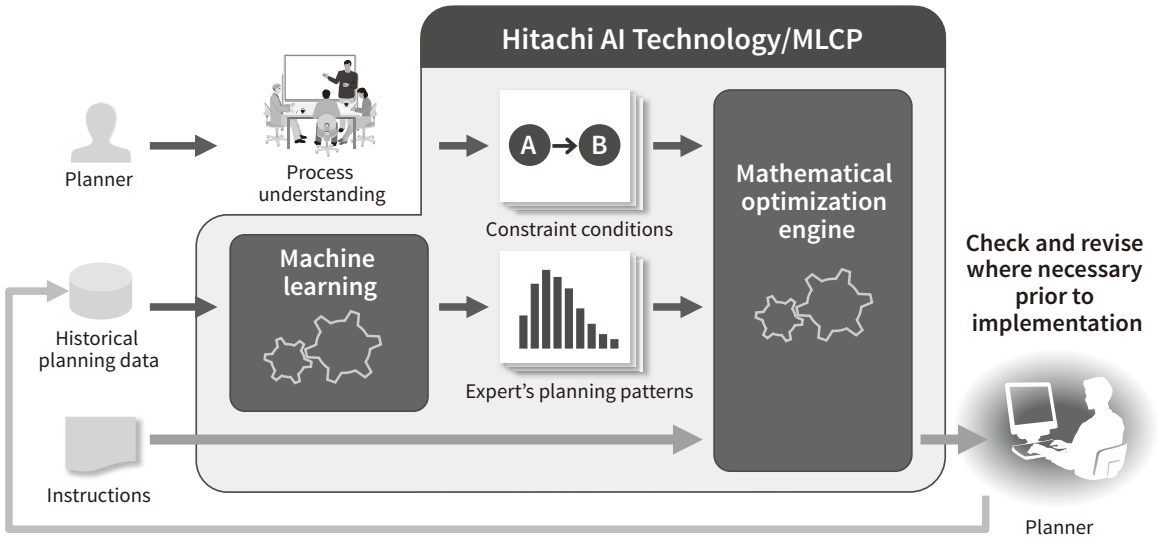


Figure 2 — Overview of Hitachi AI Technology/MLCP

Hitachi AI Technology/MLCP is a proprietary Hitachi technique for constraint programming that integrates AI with mathematical optimization to generate optimal plans from past planning data and through an understanding of the process.



AI: artificial intelligence MLCP: machine learning constraint programming

4. Application Example for Industrial Field

This section describes the use of Hitachi AI Technology/Planning Optimization Service in a collaborative creation project with Kao Corporation to automate the planning of store support visits[5].

Kao Corporation has approximately 2,000 sales staff who travel around retailers in Japan to help improve in-store operations, including advising on merchandising, assisting with store upgrades, and displaying goods in new stores. The existing practice was for the company's planning staff to schedule these store visits for each of the roughly 60 different sales areas by means of a time-consuming manual process that drew on their past experience and took a variety of different constraints into account. These included the retailer's date and other preferences, staff working hours and work plans, skills and aptitudes, and the travel times between the traveler's home and the stores to be visited.

In response, a project set about using the Hitachi AI Technology/Planning Optimization Service to automate planning with the aims of reducing the time and cost of planning while also smoothing the workload and improving the efficiency of retailer support work (see **Figure 3**).

Through an analysis of historic planning data and by utilizing the design-based approach to interviewing planners, the project visualized the sequence of steps involved in preparing visit schedules and extracted the relevant constraints and performance indicators. The visualized data was then used as a basis for determining the intentions of planners and which factors they consider important so as to document the tacit rules involved and to incorporate this knowledge into the constraints and performance indicators. In prioritizing and balancing these different factors, the project took account of a mix of considerations, encompassing the views of experienced planners, the KPIs that Kao Corporation wanted to focus on in the future, and the planning practices found in historic data. Moreover, the application of machine learning to past plans meant that the plans produced by the system also made use of tacit knowledge, such as which sales staff are best suited to visiting particular stores.

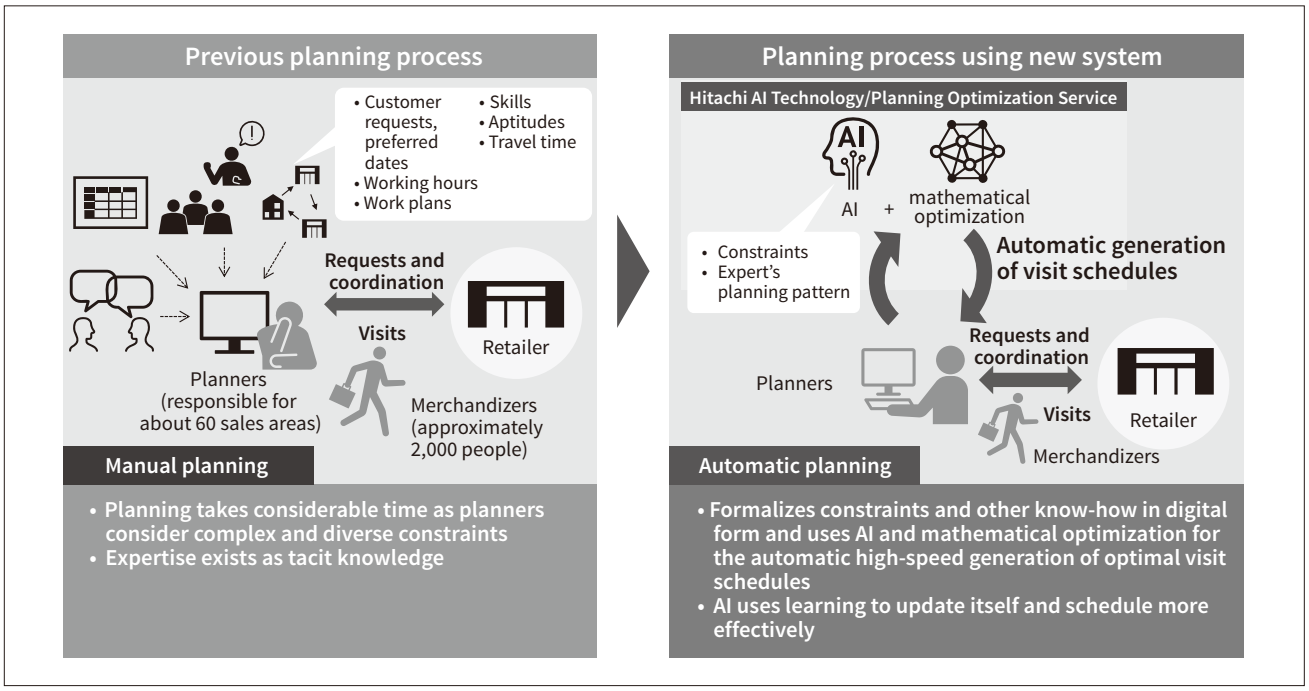
It is anticipated that this project will halve the tens of thousands of hours that are spent each year on scheduling and that it will free up planners who are also skilled sales staff to do more creative work. Benefits are also expected from the smoothing of workloads across different sales areas as the ability of the mathematical optimization engine to consider a wider geographical area than was the practice when using human planners means it can schedule visits across adjacent sales areas.

5. Conclusions

This article has reviewed work on planning optimization and the challenges that have arisen, describing the Hitachi AI Technology/Planning Optimization Service that Hitachi supplies to address these challenges together with an example of its use in industry fields.

Figure 3 — Collaborative Creation Project with Kao Corporation to Plan Store Support Visits

The existing practice involved a time-consuming manual process in which company planning staff drew on their experience to schedule store visits. In its place, the project set out to automate this scheduling process using Hitachi AI Technology/Planning Optimization Service.



By leveraging capabilities that combine IT, operational technology (OT), and products, Hitachi uses Lumada to supply total seamless solutions that deliver systemwide optimization by linking workplaces together with management and supply chains. The service described in this article is one such example.

In the future, Hitachi intends to enhance social, environmental, and economic value by deploying this service, which has already proved itself in fields such as retailing and manufacturing, to a wider range of industries in support of customer digital transformation.

References

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