

# Decision Intelligence

The future of decision-making through  
effective data utilization



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## CHAPTER.1

### Introduction

With the recent evolution of artificial intelligence (AI)/machine learning (ML) technologies, there is a growing need to apply AI/ML not only to the classification and prediction of single events, which has been the central role of AI/ML but also to decision making, where the selection of the next action to be taken is mechanized.

The framework and activities that systematize the concepts and methods for best decision making are called Decision Intelligence, and Decision Intelligence has the potential to change the way decisions are made and data is used in companies and organizations in the future.

In this paper, we will explain what Decision Intelligence is, its definition, growth forecasts, domestic and international trends, challenges to be

solved and their effects, as well as the concept of application areas. We will also consider the future of decision making brought about by Decision Intelligence, with a particular focus on automation through the application of AI, and the impact of the expanded scope of AI application on business operations.

Decision Intelligence is originally an engineering field that reinforces data science with various scientific theories. However, this paper focuses on the application of Decision Intelligence in business and describes it mainly as a framework for solving problems in decision making and data utilization in companies and organizations. This paper focuses on the business applications of Decision Intelligence.



## CHAPTER.2

### Challenges in Decision Making in Companies and Organizations

The nature of decision making in companies and organizations has long been a subject of debate.

Dr. Herbert Simon, who was awarded the Nobel Prize in Economics in 1978, stated that "management is decision-making" [1]. Although decision-making should be the most important management issue in business, today's decision-making often fails to adequately capture and explain "behavior" in the business scene. In other words, there is no transparency regarding "who is

involved in the decision-making process and what mechanism was used to make the decision" [2].

For example, in many management decisions, the management staff prepares data on the status of the business each time a decision is needed, and the manager attempts to make a decision based on this data, but in the end, the decision is based on the intuition, experience, and courage of the individual manager, or on the results of adding up KPIs from each department.

## CHAPTER.3

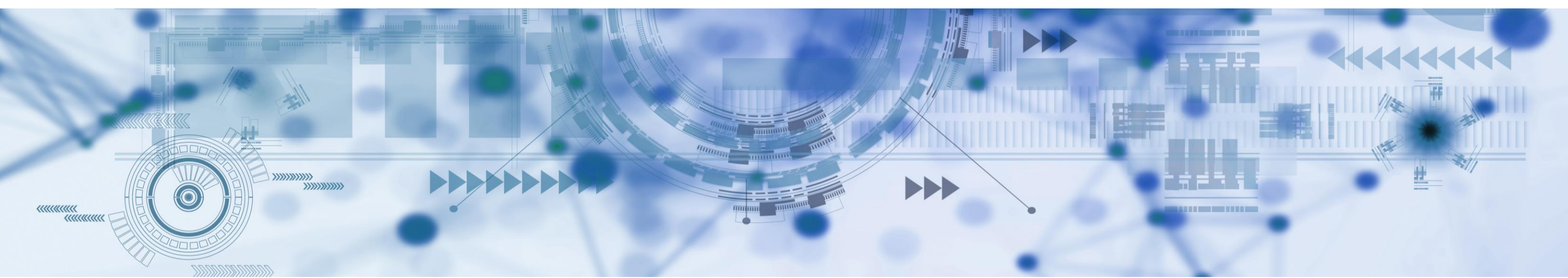
### Challenges in Utilizing Data in Organizations

It is said that there are disputes regarding how data should be utilized in an organization.

Many companies are repeatedly aggregating Big Data at high cost and conducting ad hoc analysis without determining which data is to be used for which decision-making. It is also said that Big Data is not being used for decision-making that truly improves business value [3]. Furthermore, data scientists at many companies have been faced with the

problem that data analysis itself, such as making predictions and hypotheses, has become the objective, and they are not able to conduct analysis that contributes to decision-making and creates managerial value [3] [4].

Decision Intelligence is the key to solving these decision-making problems and data utilization issues. Starting with the next chapter, we will explain what Decision Intelligence is from various perspectives.



# What is Decision Intelligence?

### Decision-making and Decision Intelligence

Decision-making (Decision) is a human cognitive behavior in which a person or organization tries to find the best solution from multiple options for a certain situation to achieve a specific goal.

(Decision-making can describe the act of choosing among multiple possible alternatives or the chosen alternative [5], but this paper uses the former definition.)

Decision-making is a natural act for humans, and humans routinely make repeated decisions to seek the best solution. Decision-making takes place in all situations and has been emphasized in a wide range of academic disciplines, including cognitive

science, psychology, economics, systems science, and operations research.

Intelligence is also the knowledge gained from analyzing and analyzing information for decision making and the mechanisms for obtaining that knowledge [6]. In other words, it refers to factual information that can be used for decision-making and the activities and organizations for obtaining it.

Artificial Intelligence (AI), on the other hand, is an evolving technology that uses computers and machines to mimic human problem-solving and decision-making abilities.

Decision Intelligence is a concept proposed by Dr.Lorien Pratt.

Decision Intelligence is an engineering discipline that augments data science with social science, decision theory, management science, etc. Gartner has ranked it as one of the top strategic technology trends for 2022 [7]. Decision Intelligence also includes its application as a framework for implementing best decisions and best-practice activities.

In other words, Decision Intelligence is an engineering discipline for making the best decisions through the analysis of information, including the use of artificial intelligence (AI). AI is an advanced technology for utilizing data, and its applications include:

frameworks and activities consisting of various AI technologies, modeling and design methods, and processes. Decision Intelligence is also a thought process that leads to action and is expected to be an appropriate "building block" for solving many complex decision-making problems and integrating humans and technology in a wide range of areas from product recommendation to sustainable management. It is expected to be an appropriate "building block" for integrating humans and technology, solving many complex problematic decisions in areas ranging from product recommendation to sustainable management [3].





As shown in Figure 1, people act and obtain results through a thought a decision-making thought process that involves recognizing things and their situations, identifying options, comparing options with goals. After further defining the options, some action is taken and the outcome is obtained. Decision Intelligence defines this sequence of processes as connecting humans, data, and AI/ML [3] to get the best options and then a person or machine (such as an AI or system) makes a decision.

Until now, academic disciplines such as cognitive science, psychology, economics, and management science have treated decision making as a discipline but have not covered the engineering perspective or automated decision making. Likewise, data science, which developed based on statistics, does not necessarily address the issue of "how humans make decisions".

Therefore, to integrate the knowledge of disciplines that have dealt

with decision making with the latest technologies in data science, it is necessary to design the decision-making process and assemble the data into a way to gain insight and effectively make choices.

AI and machine learning(advanced data science technologies) are components that produce excellent predictive results, but component-by-component predictive results alone are about complex, intertwined events insufficient to inform decisions.

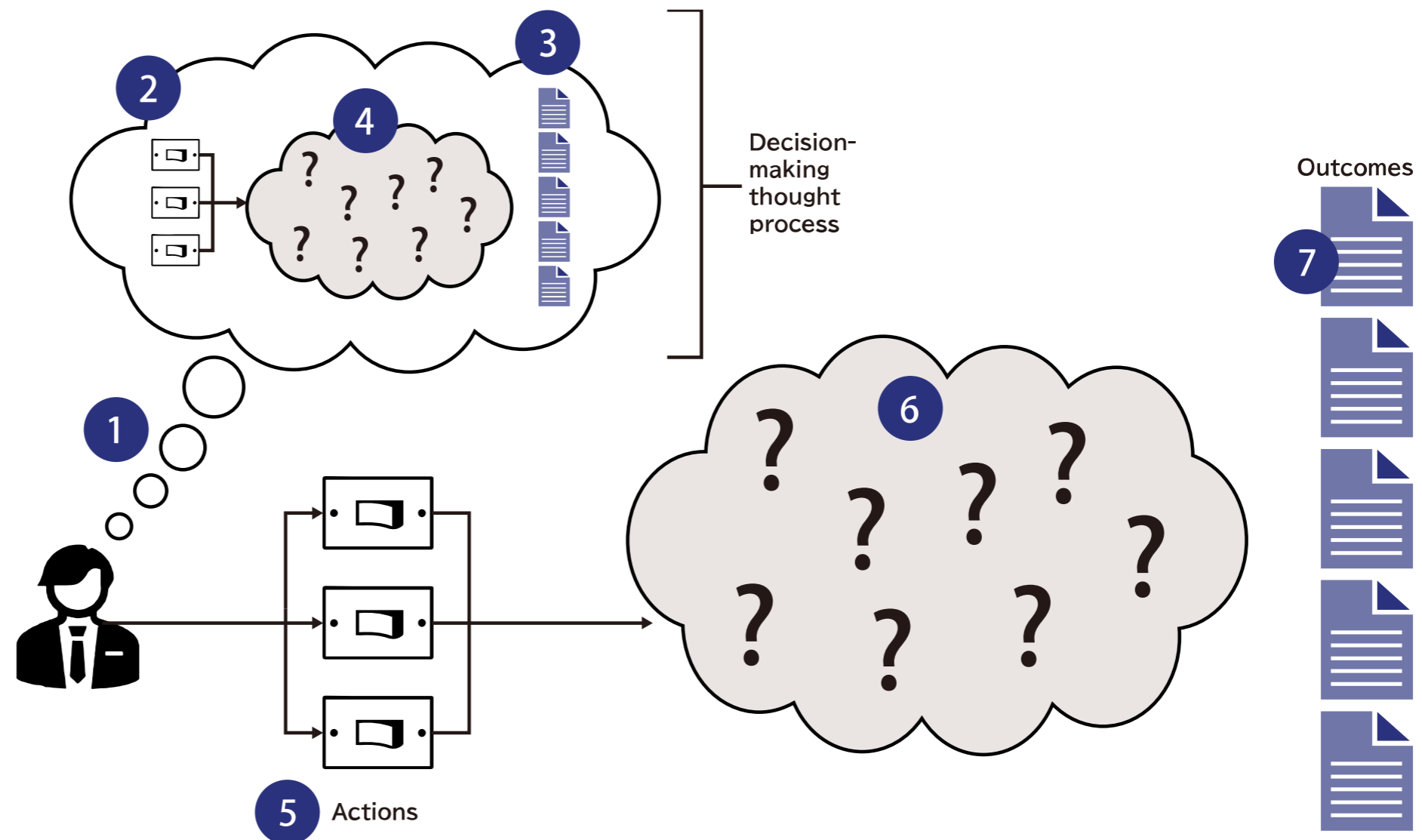


Fig. 1: An image of the human decision-making mechanism. Source: [3]

To make the best decisions, it is important to identify the interactions among a series of components involved in decision making, such as AI, machine learning, people, and systems, and based on causal relationships, to seek alternatives and decide which one to choose. Decision Intelligence is a series of activities to make this decision-making process transparent using an engineering framework, and to automate it using AI and ML models for optimal processing.

The basic principle behind Decision Intelligence is that decision making is based on understanding how actions lead to outcomes; Decision Intelligence is also a discipline for analyzing this chain of cause and effect, and Decision Modeling is a visualization technique for representing this chain.

In the case of computer-automated decision making, the act of determining an output value (the chosen alternative) from the input values of

one or more sources of information, as shown in Figure 2, uses logic that defines how to determine the output value from the input values. This decision logic uses business rules (industry common sense and customs) based on one or more business knowledge, and analytical models based on AI/ML. It is said that by using this basic structure, decision making can be modeled [7].

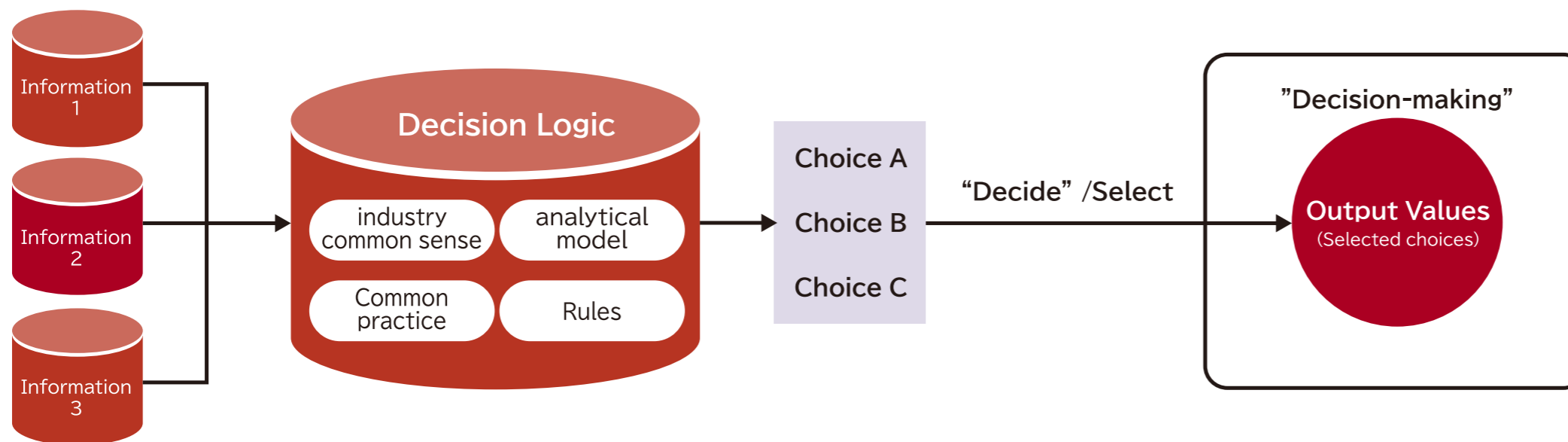
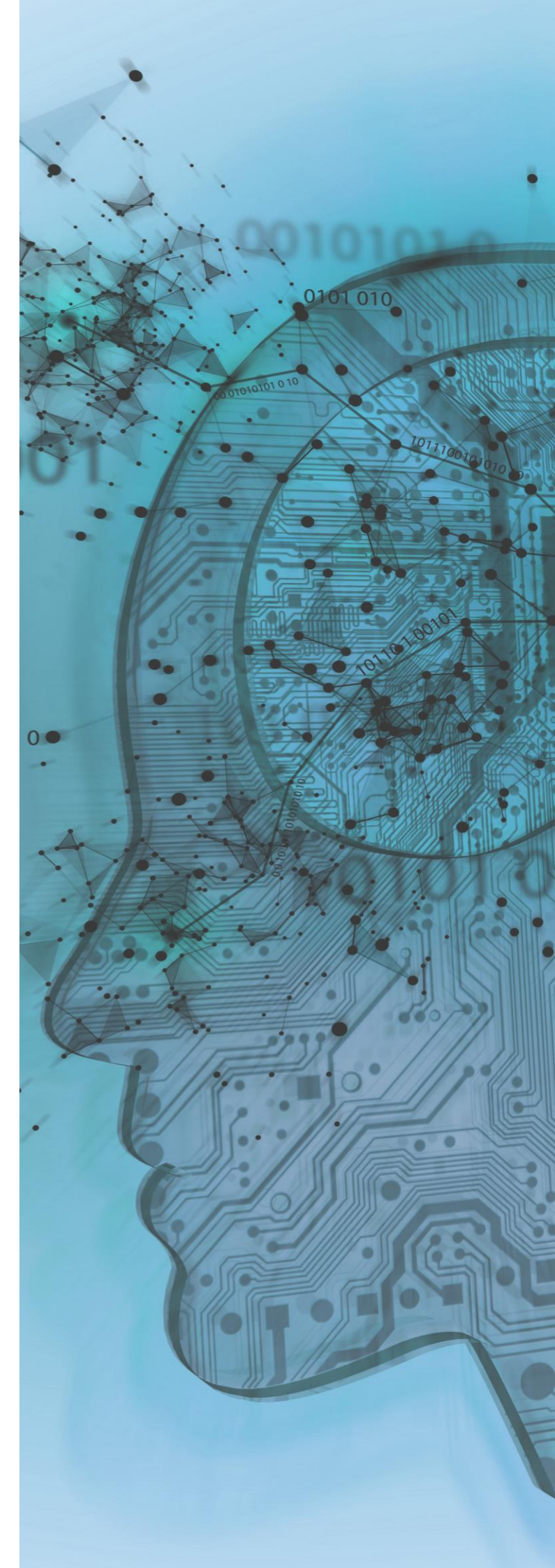


Figure 2: Logic options for automated decision making



# Decision Intelligence Market Forecast

Decision Intelligence is one of Gartner's top strategic technology trends for 2022.

Gartner predicts that "in the next two years, one-third of large companies will use Decision Intelligence, including decision modeling, to enhance their competitive advantage." [8]

This is because Decision Intelligence is predicted to become a "practical discipline" that improves decision making by establishing a clear understanding of how decisions are made, how results are evaluated, how they are managed, and how they can be improved through

feedback.

It also predicts that by 2023, more than 33% of large companies will have analysts who practice Decision Intelligence, as "Decision Intelligence is the shape of decision making in the near future." [9]

In addition, Gartner advocates that Decision Intelligence be a process modeling and organizational activity with a Gartner Decision Intelligence Model (GDI Model), consisting of three layers, with a specific focus on business management decision making. It also recommends the use of Composite AI, which is "the combi-

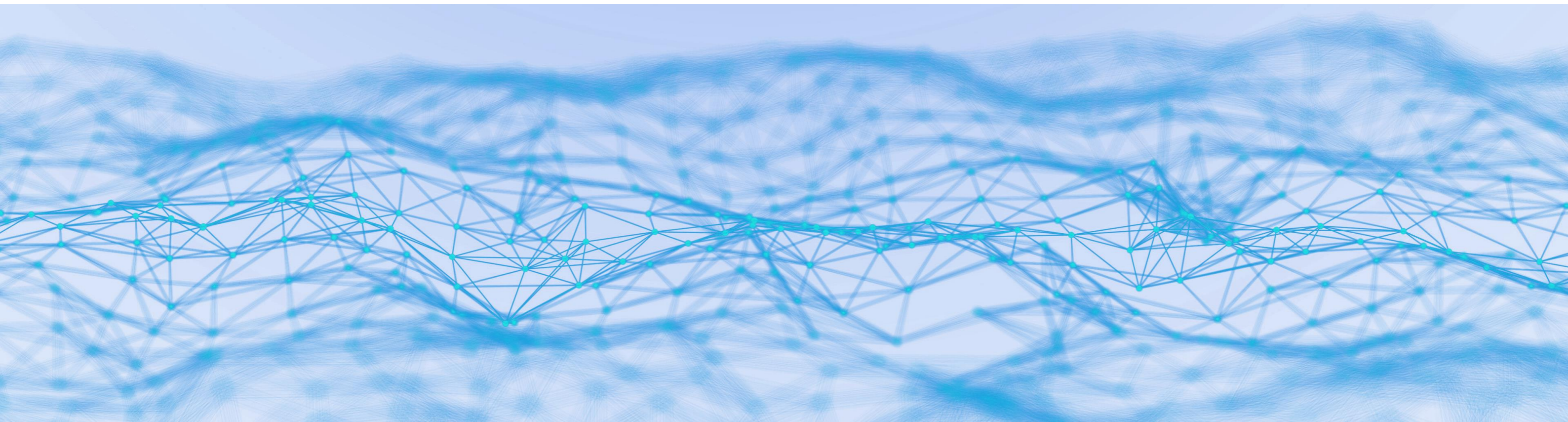
nation of different AI techniques to achieve the best result," as a suitable component for Decision Intelligence.

In a recent market analysis report by Emergen Research [10], the global Decision Intelligence market size reached US\$10.3 billion in 2020. It further predicted that the sales CAGR (Compound Annual Growth Rate) would record 13.7% by 2030.

This is due to the increasing need to detect decision problems and achieve flawless decisions by understanding human-machine interactions.

Decision Intelligence is a framework that enables decision-making proce-

sses to combine components from AI, machine learning, people, and systems. The combination of these components can be broadly classified into human-based (human-driven), hybrid-based (human-machine interaction), and machine-based (fully mechanized) [11]. Of these, the growth of hybrid-based is expected to be particularly significant in the future [10]. It can be inferred that the motivation to promote mechanization as much as possible while maintaining accountability in decision making is influencing the growth of the hybrid base.







## CHAPTER.6

# Domestic and International Trends in Decision Intelligence

### ■ Overseas Trends

#### ① Lorien Pratt's proposal and CDD

Lorien Pratt, an advocate of the Decision Intelligence field who wrote "Link," one of the earliest publications on Decision Intelligence, is a co-founder of Quantellia, Inc. in Silicon Valley. She is not only the co-founder but also a chief scientist and thought leader in the Decision Intelligence field.

She believes that the ideal form of

Decision Intelligence is to solve social issues such as the SDGs (Sustainable Development Goals) by modeling the general human way of thinking and maximizing the value of various decision-making processes through a scientific approach.

To this end, we propose to integrate many theories and technologies related to decision making, such as causal reasoning, transfer learning, complexity theory, systems thinking, dynamics, simulation, game theory,

operations research, analytic hierarchy process, design thinking, and knowledge management, to design decision making itself as decision engineering

Pratt proposes Causal Decision Diagram (CDD) [3] as a solution to "link" human decision making with AI, ML, etc. In the CDD framework, the decision-making itself is designed by modeling, based on the external requirements considering the goals and outcomes. Based on this design,

AI is used to infer cause-and-effect relationships, and data science is used to index the basis of the decision to make the best decision. In addition, many decisions involve intangible factors that cannot be captured by traditional quantitative or financial models, such as employee morale, intellectual capital, brand recognition, etc. CDD also analyzes the chain of factors that make up these intangible factors so that they can be structured.

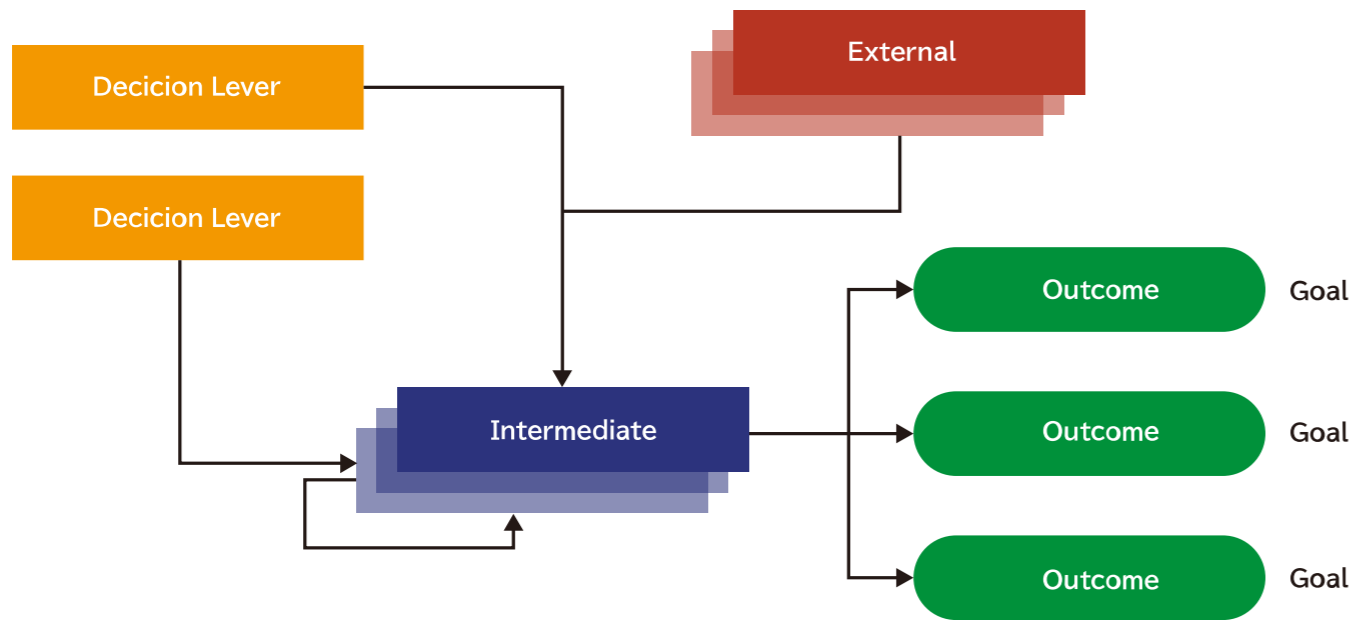


Figure 3: Causal Decision Diagram (CDD) template Source: [3]

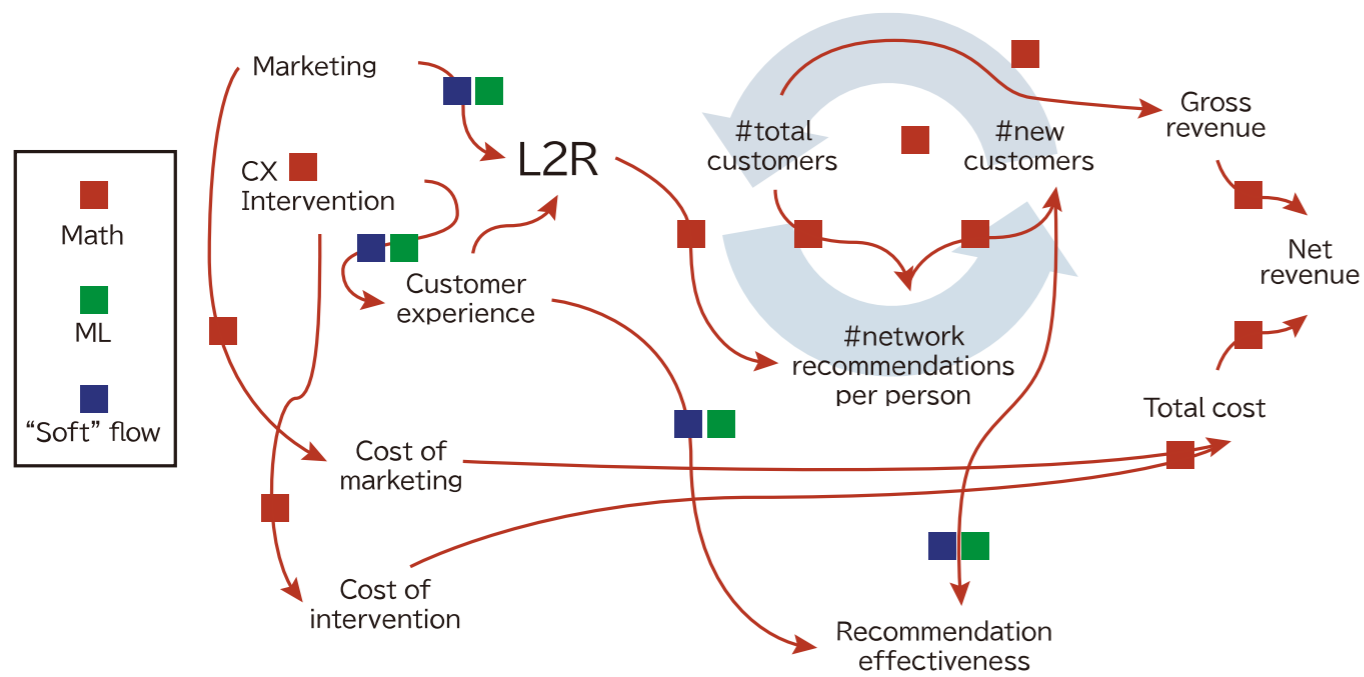
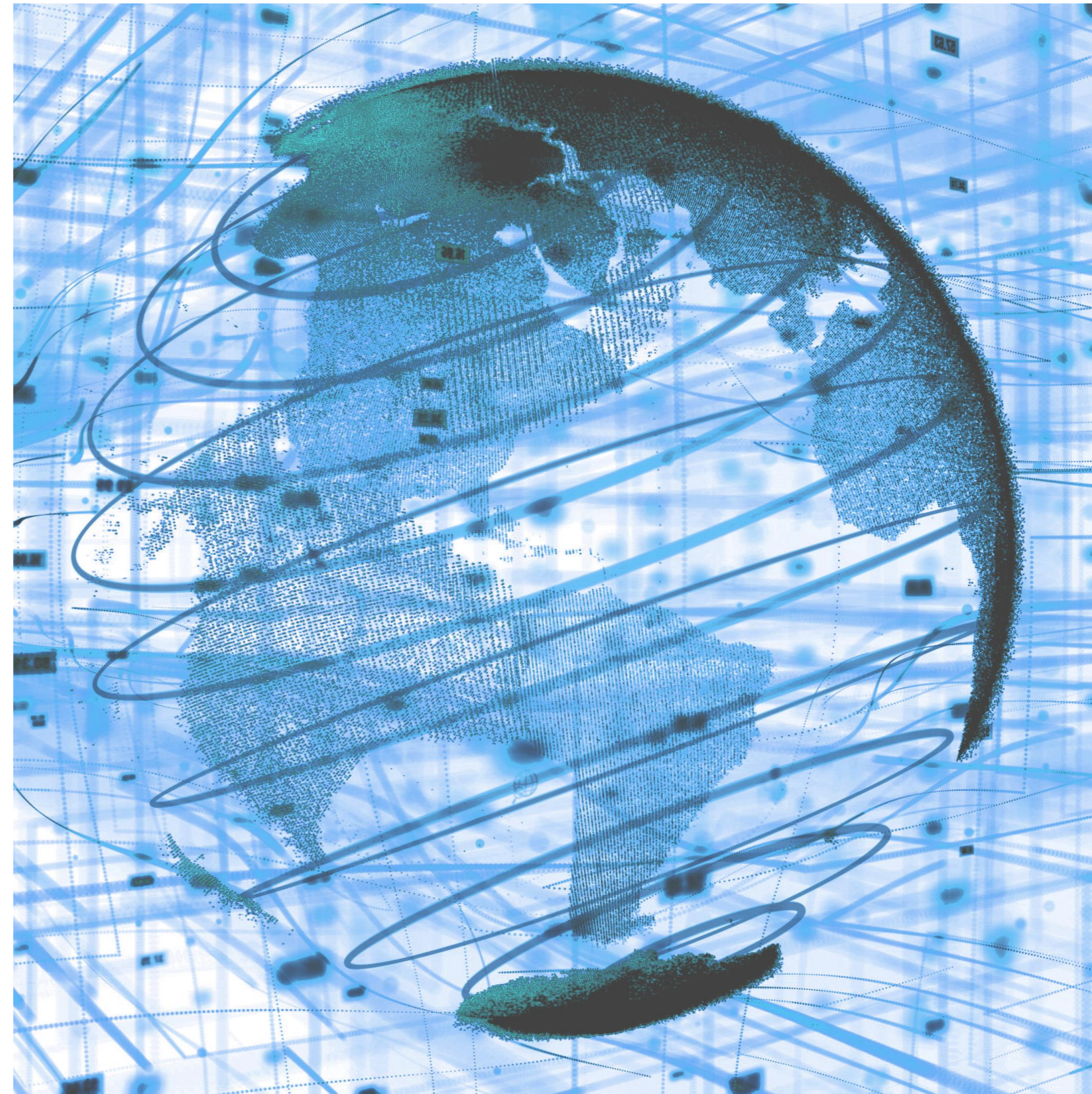


Figure 4: Causal links in decision making (example) Source: [3]

CDD is unique in that it can be used not only for invisible "soft" factors such as corporate profit, brand value, and inspiration, but also for complex, high-value strategic decisions such as sustainable management and providing

solutions to social problems. For example, in Figure 4, mathematics (corporate profit), "soft" factors, and machine learning (AI) are connected to decision making.



## ② Digital Decisioning and DMN

Digital Decisioning [7] is the idea of automating decision making through machine processing and became a technical trend around 2018. As shown in Figure 5, OMG (a non-profit technical standards consortium) has standardized Decision Model and Notation (DMN) as a modeling language and notation for accurately describing business decisions and business rules, which is used for process management (DMN is proposed to be used in conjunction with tools compliant with standards for process management (BPMN™) and case management (CMMN™) [5].

James Taylor, founder and CEO of Decision Management Solutions, the company developing this DMN-based solution and a leading expert on the DMN standard, recommends that

fixed rule decision making be advanced by replacing it with AI scoring and expanding the scope of automation.[7]. He also states that AI here includes rule engines, optimization algorithms, and probabilistic algorithms, in addition to machine learning.

By using DMN to model organizational decision making, it is said that all stakeholders can automate complex decision-making processes with readable diagrams and an understanding of the process. Companies such as Redhat and CAMUNDA are working on this DMN-based development.

Digital Decisioning is considered to be an element that automates decision making. And based on the above, Decision Intelligence is a higher level concept of Digital Decisioning.

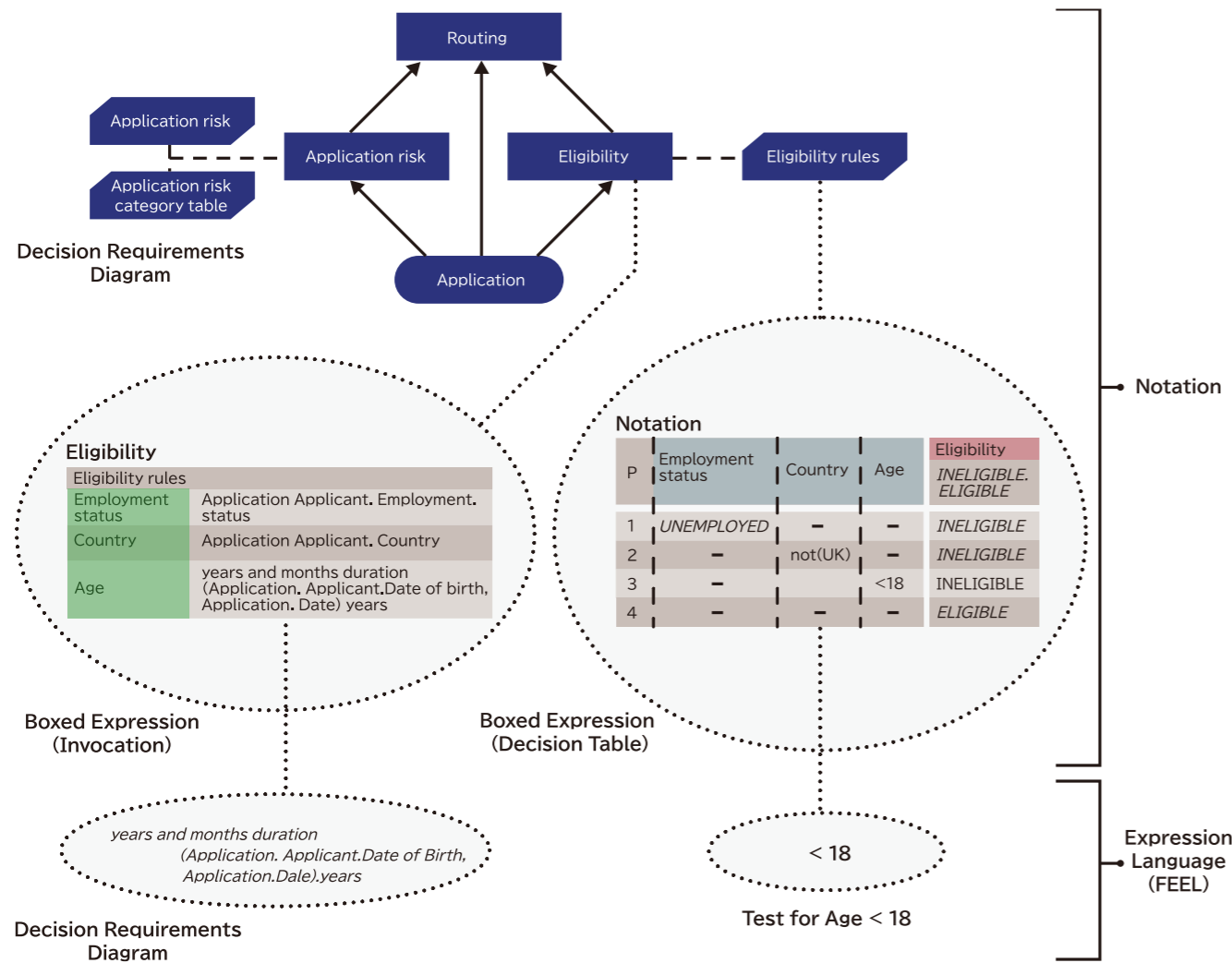
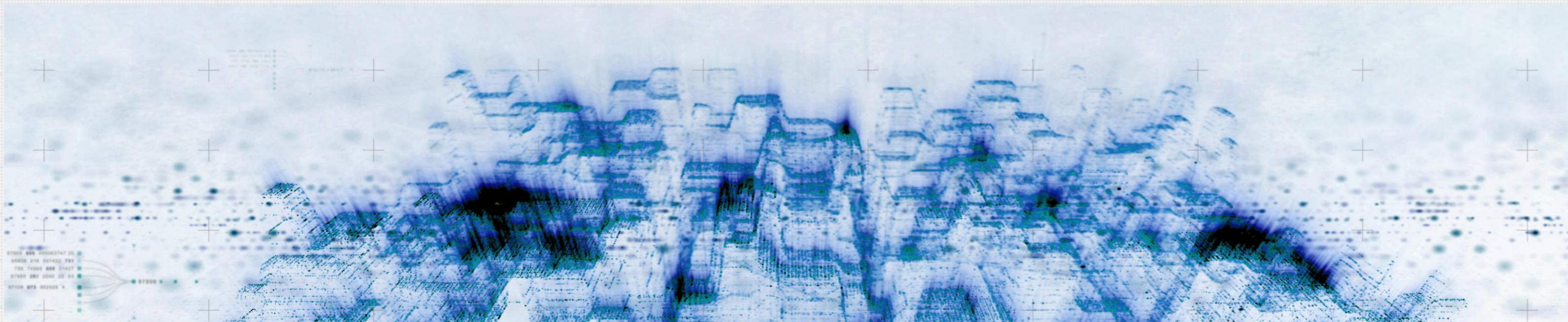


Figure 5: Structure of DMN Source: [ 5 ]





### ③Other Companies' Trends

Google has adopted Decision Intelligence as a decision-making framework that enables individual humans, groups of humans, and machines to make wise decisions. Decision Intelligence plays a central role in the application of Google Data Science to action and decision making [12]. Cassie Kozyrkov, the

company's thought leader in Decision Intelligence, has trained 17,000 Google employees to enhance data science with psychology, neuroscience, economics, and management science to help them make better decisions [13].

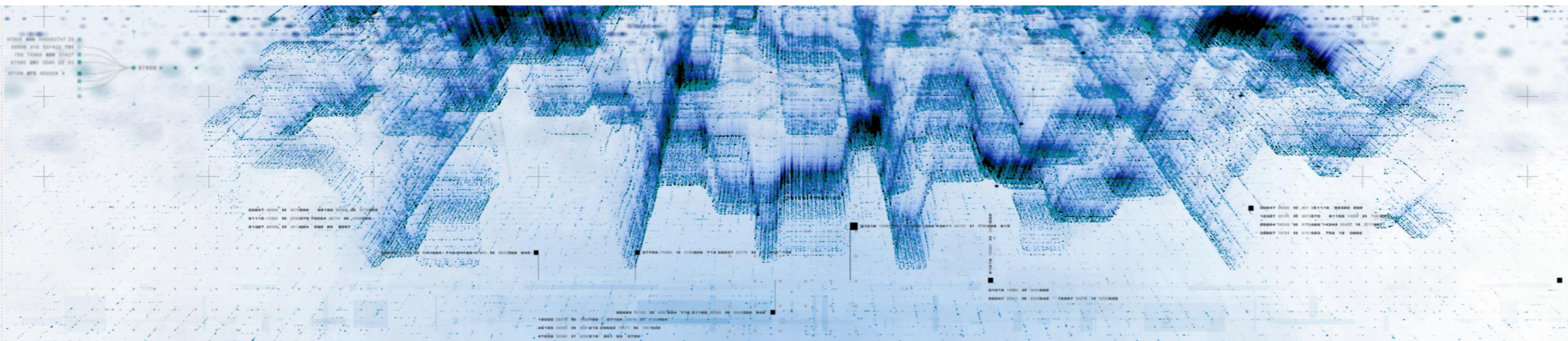
NASA also used Decision Intelligence to deflect an approaching asteroid. Elsewhere, Alibaba, the world's largest retailer, also operates a

Decision Intelligence laboratory [3].

Other recent surveys of major companies promoting Decision Intelligence include Baidu, Inc, Advanced Micro Devices, Inc, Arm Limited, H2O.ai, Inc, AiCure LLC, Clarifai, Inc. Enlitic, Inc, Ayasdi AI LLC, HyperVerge, Inc, and Iris.ai AS, among others [1].

IBM proposed Prescriptive Analytics, which takes both structured and

unstructured data and combines advanced analytic techniques and disciplines to predict, prescribe, and adapt. Prescriptive Analytics is similar to "decision optimization" and Prescriptive Analytics can be viewed as a concept similar to "decision optimization" [14].





## ■ Trends in Japan

### Kawamoto of Shiga University raised this issue.

Based on his experience of leading data scientists in companies for many years, Professor Kaoru Kawamoto of Shiga University states that improving the decision-making process is the key to logically linking the business world and the world of data analysis, as shown in Figure 6.

Problem solving through data and AI means "changing the decision-making production method that relies on intuition and experience to a rational decision-making production method that also uses data and AI," and it is necessary to view data science from a business perspective [4].

Here, as shown in Figure 6, Kawamoto advocates data-driven thinking, recognizing as problematic that conventional data scientists often start by "solving with data and AI" and fail to set and solve business

problems.

Data-driven thinking process is defined as (1) Establish the business problem. (2) Drill down to the issues in the decision-making process. (3)

Design a data-driven decision-making process. Therefore, the flow starting from "solving with data and AI" is the opposite direction of data-driven thinking and does not contribute to

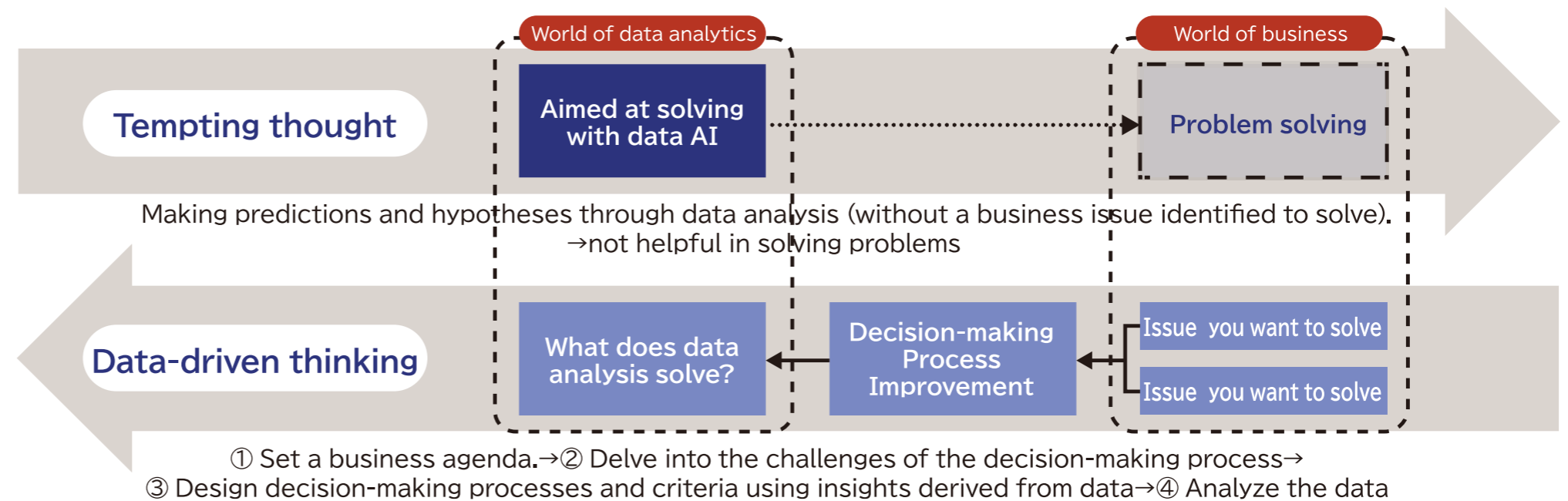
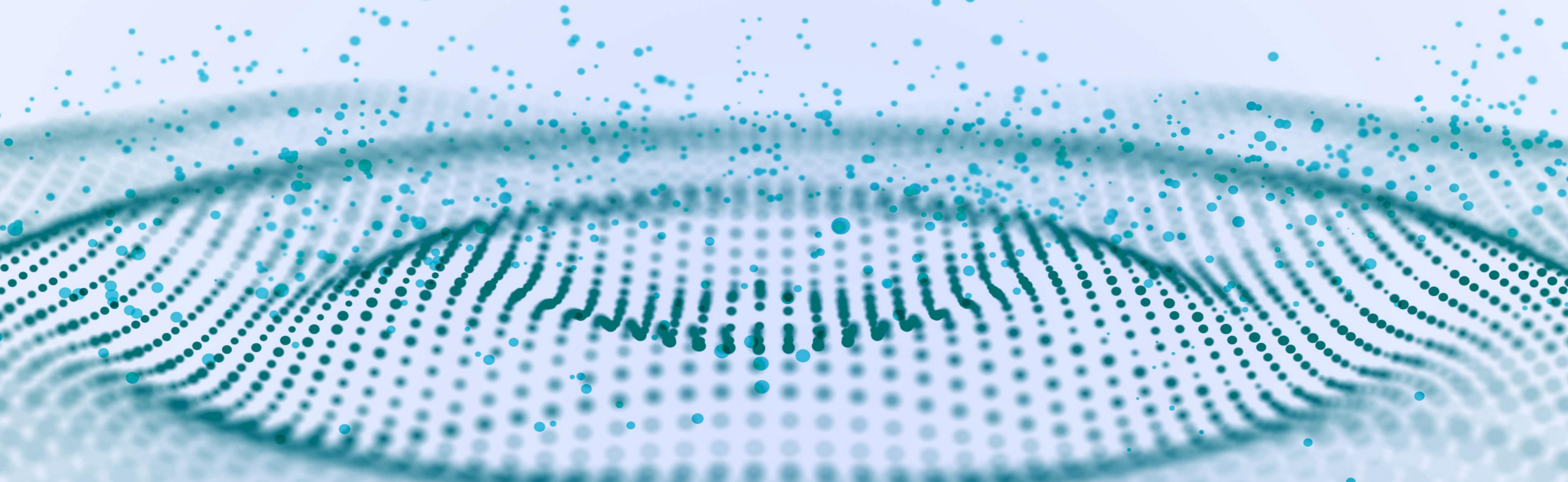


Figure 6: Thinking flow and data-driven thinking Source: [4]



problem solving.

Kawamoto also states that decision making can be classified into patterns such as iterative selection type and management judgment type (Table 1). These patterns range from the business processing level handled by individual data scientists to the level requiring middle-level management judgment and managerial decision making, with varying degrees of difficulty (Table 1). The decision-making process reform by the person in charge is limited to on-site business improvement, but middle-level personnel can be involved in cross-organizational business impro-

vement, and top-level personnel can reform the business model. By dividing responsibilities by level of difficulty, we can transform ourselves into a truly data-driven company.

The table below shows the decision-making typology and the results of the process.

Kawamoto suggests that by redefining business issues as decision-making process issues and making

the decision-making process responsible, Japanese companies, which are considered weak at change, can overcome this weakness and should also develop the ability to design KPIs that lead to overall optimization.

Types of Decision	Making Example	Role of Data Analysis
A. Iterative Selection Type	Targeted Sales Preventive maintenance	Predicting the consequences of using a choice branch
B. System selection type	Vehicle allocation Location of store openings	Decision-making material for making rational choices
C. Cause Identification Type	Resolving an Increase in Non-Delivery Solution to decrease in sale	Relation between candidate causes and results
D. Planning type	Distribution route Shift schedule	Finding the optimal plan
E. Hypothesis trial type	Sales promotion measures Release of new service	Discovery and verification of hypothesis for purchasing customers
F. Management decision type	New business entry Policy formulation	Reduction of management thinking bias

The table below shows the decision-making typology and the results of the process.  
Source: [4]

## Classification of Decision-Making and the Future of Decision Intelligence

### ■ Relationship between decision-making level, technologies used, and application categories

What kinds of decisions are involved in organizational activities? Which technologies should be used for which decisions?

As shown in Figure 7, decisions in corporate activities can be broadly classified into strategic, tactical, and operational decisions [7] [11]. Strategic decisions are made by management and have high business value because of the large impact that a single decision has on corporate management and the future of the company.

However, they are not suitable for automation by AI because they are

not repeatable [7]. On the other hand, operational decisions do not have high stand-alone business value, but they can generate high business value if the volume of work is high. They are also highly repetitive, making them suitable for automation by machines. Tactical decision-making combines elements of both.

Decisions can be made by machines, people, or a hybrid of the two. In contrast to this classification, there are three categories of AI application to decision making: automation, augmentation, and support. "Automation" refers to a situation in

which a machine is making decisions autonomously, while "augmentation" refers to a situation in which a machine recommends decision options and humans confirm their validity and investigate them. "Support" refers to a situation in which the decision-making body is human, but a machine supports visualization, search, and alerting.

To optimize these decisions, it is important to utilize Decision Intelligence according to the decision-making level and business value of the target outcome.

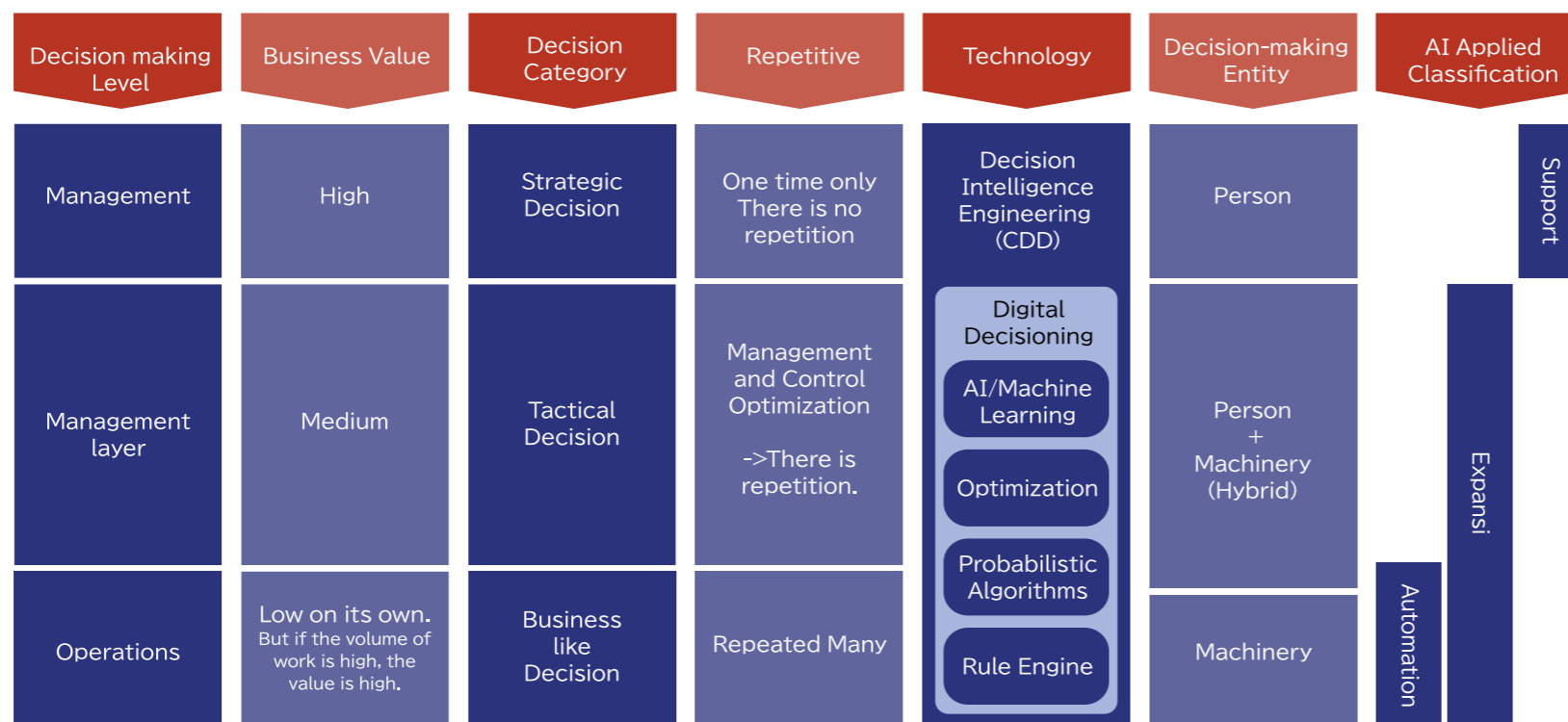
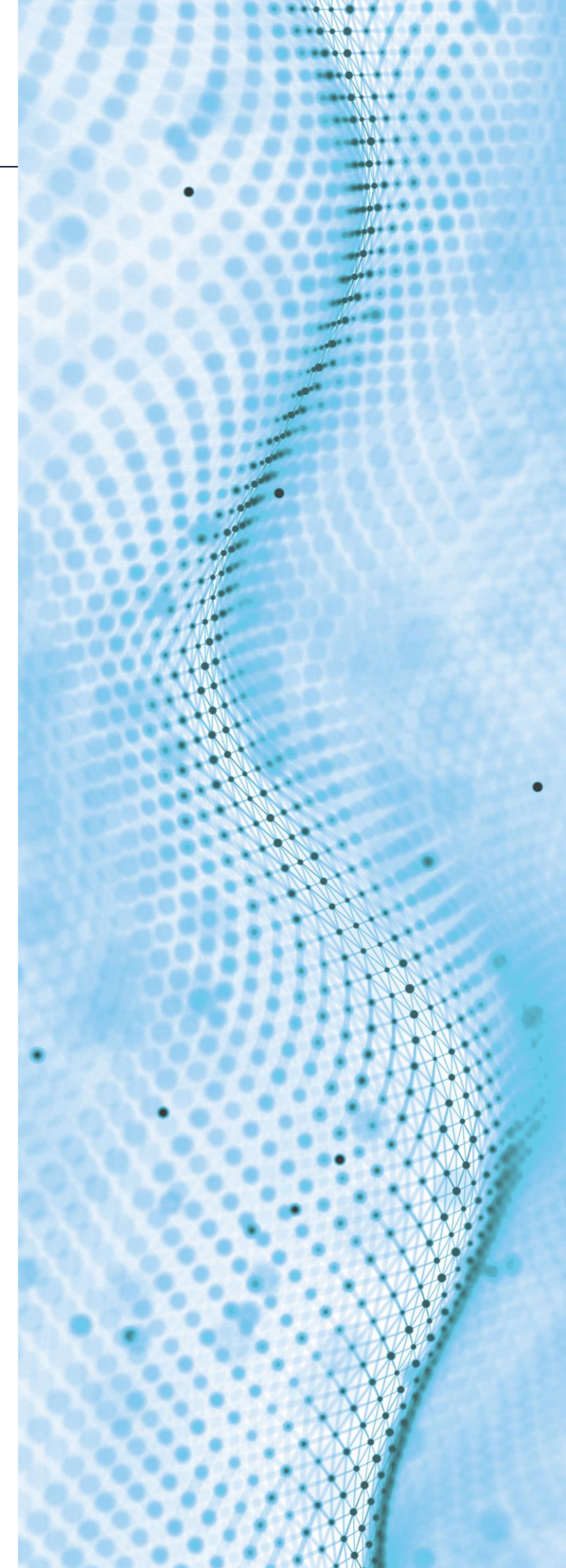


Figure 7 Differences by decision-making level



## Selection of target business and determination of AI application categories

When identifying operations to be targeted by Decision Intelligence, it is important to introduce data-driven thinking and to clearly aim to solve business problems and issues, so as not to make AI-based forecasting and hypothesis generation an end. To maximize the outcomes from AI as much as possible, we identify situations that require repeated decision making. In addition to operations where decisions are made at the discretion of the operations staff, situations where decisions must be made among multiple options to improve efficiency and sophistication of operations would be appropriate.

Then, how will the categories of "automation," "support," and

"expansion" of AI application in the target operations be determined? As shown in Figure 8, it is easy to classify decision-making means and evaluate the possibility of automation by evaluating operations requiring decision-making on the two axes of "time required for decision-making" and "complexity of the problem" [11].

The time aspect varies from microseconds for product recommendations to months or even years in some cases for strategic M&A. The complexity aspect varies in level from "simple" to "difficult," "complex," and "chaotic,".

When mapping the operations on

the two axes, if the target task can be automated only by AI, proceed with automation. If the target task cannot be automated by AI alone, clarify the reasons and constraints, model the relationship between AI output and human judgment, and clarify whether "expansion" or "support" is appropriate.

Note that in the future, as AI is expected to be able to handle more complex problems, the scope of AI application to Decision Intelligence is expected to develop from the current simple and difficult systems to complex and chaotic systems.

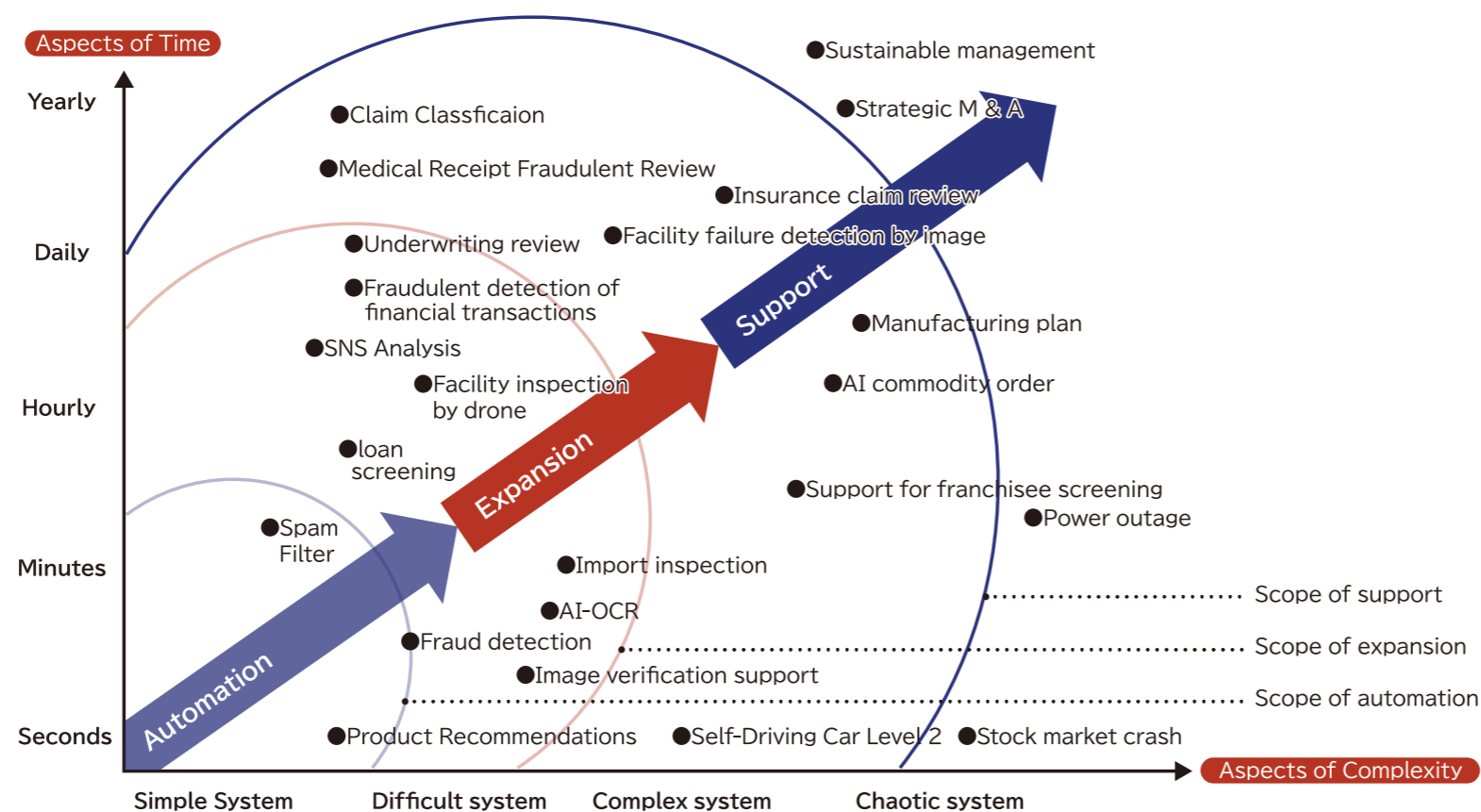


Figure 8: Classification of Application and Target Tasks by Time and Complexity Source; Gartner@2021 Gartner, Inc. All right reserved. partially modified



## **Decision Intelligence will solve decision-making problems and its effects.**

As mentioned above, decision making in companies and organizations has the issue of lack of transparency regarding "who is involved in the decision making and by what mechanism the decision was made". Decision Intelligence is expected to improve on current organizational decision-making methods that use spreadsheets, text, verbal discussions, etc.

Decision Intelligence ensures transparency by using a framework to

design decisions considering goals and outcomes and capturing external requirements. Based on that design, we utilize the output of AI to make the best decisions.

In today's rapidly changing business environment, the use of Decision Intelligence improves the accuracy and throughput of individual decisions, thereby increasing agility in the face of changes in the business environment.

## **Decision Intelligence can solve the problems and improve the effectiveness of data utilization.**

Decision Intelligence eliminates the need to collect useless data that will not be used because it selects only data that will contribute to decision-making. Eliminating the collection of useless data, leads to a significant improvement in the cost performance of data utilization.

At this time, data-driven thinking will enable even higher value-added analytical activities by implementing data utilization that contributes to

solving business issues and will also lead to the development of human resources capable of realizing improved decision-making.

In this way, Decision Intelligence enables both management and front-line staff to make the best decisions for their respective operations, then the company can achieve the desired or better results, reduce costs, and develop human resources in line with its goals.



## Conclusion

In this paper, we have discussed what Decision Intelligence is, which solves the problems of decision making and data utilization in companies and organizations. We also considered domestic and international trends and the form of decision making that Decision Intelligence will bring about.

As a form of decision making that solves business issues, it is predicted that "machine" decision making will

increase in the future, but in particular, "hybrid decision making by humans + machines" will develop rapidly [1]. In the future, we should aim to become a truly data-driven company by utilizing Decision Intelligence, establishing decision design and improvement processes that unite various personnel in the company, and implementing activities to promote the expansion of AI application.

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