

Article

Business Process-Organizational Structure (BP-OS) Performance Measurement Model and Problem-Solving Guidelines for Efficient Organizational Management in an Ontact Work Environment

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Abstract: In the COVID-19 crisis, telecommuting has become one of the most powerful countermeasures against spreading infections. Companies cannot effectively implement telecommuting owing to difficulties predicting organizational performance and future problems and responding to them in advance. Furthermore, even after overcoming the crisis, it is expected that the performance of so-called “ontact” jobs involving telecommuting will increase rapidly in the new typical environment. Nevertheless, there has been no systematic study on a holistic response method considering work interruption time and lead time from work interruption in the ontact work environment. This study predicts organizational performance by modeling the impact of the ontact work environment on organizational performance and presents problem-solving guidelines from three perspectives: business process, organizational structure, and human resource allocation. Additionally, it presents a case study of a simulation model established by extending a previously developed enterprise simulation software. This study presents a scientific model for predicting organizational performance and solving problems in the ontact work environment, which is presently the most significant concern in companies. This facilitates decision-making to minimize damage based on predicting corporate performance in the ontact work environment.

Keywords: ontact; telework; smart work; contactless; enterprise simulation; business process simulation; organizational structure; human resource management; business analytics; process and organization analytics



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1. Introduction

When faced with a new situation, predicting the total effect of changes in a company is challenging. When adapting to such changes, most companies overlook that their productivity may be jeopardized or pose a risk to the employees if the working hours exceed a threshold. For example, the number of accidents in the parcel delivery industry, a representative logistics industry in South Korea, increased by 312% during the Korean holiday season in 2021 [1]. Although the parcel delivery volume increased by 20–30% compared to the previous year, the company could not accurately identify the increased total task cycle time, thereby failing to recruit a sufficient workforce, redeploy the workforce, and streamline the business process. Consequently, industrial accidents have significantly increased beyond a simple proportional relationship with the volume of goods transported. In order for a company to be more competitive and sustainable than other companies, human resource management to secure talent is of paramount importance [2]. In other words, predicting the total working hours of a company in a new situation and securing the appropriate level of human resources is a significant issue directly connected to the survival and development of the company beyond simple problem-solving.

Smart Work is a future-oriented work environment that breaks away from the existing office concept and allows you to work conveniently and efficiently anytime, anywhere [3]. In addition, Smart Work is an innovative work program that takes care of employees through telecommuting, flexible working locations, and inter-worker scheduling [4]. Smart work is essential in the time of the COVID-19 [5], and by using information and communication technology (ICT), workers can perform work through an online network system regardless of time and place [6]. This study focused on non-face-to-face work through online even in Smart Work. In the context of the COVID-19 pandemic, the work environment of companies is rapidly changing from the existing face-to-face environment to a non-face-to-face work environment. Recently, it began to gradually move on to the “ontact” era by combining the terms “on” (representing an online connection) and “untact” (meaning non-face-to-face) [7]. Therefore, in this study, the non-face-to-face work environment through online, not the existing face-to-face work environment, is called the ontact work environment.

Owing to government recommendations or compulsory measures, many companies are adopting the ontact work environment, which is increasingly becoming a necessity rather than an option. However, most institutions and companies can either not adapt to the sudden change in the ongoing work environment, or operate it passively. Although group infections can be effectively prevented in the ontact work environment, companies are passive in adopting it because it is challenging to predict work performance and possible problems in the ontact work environment and to take proactive measures against them. Employers must use performance management practices that can influence all the important determinants of employee performance, such as ability, motivation, and working conditions, to achieve superior performance and lasting competitive advantage [8]. The same applies even in the ontact work environment. Because some jobs require interaction with people, the suitability of telecommuting may differ for each individual [9].

Suppose a rapid increase in the total workload is predicted owing to the influence of the ontact work environment, or the revitalization of the non-face-to-face industry. In that case, it will be possible to respond proactively through staffing, redeployment, or streamlining business processes or organizational structures. However, there has been no study or attempt at a systematic response method considering the work interruption time and lead time due to work interruption. Recently, Google analyzed the impact of telecommuting through a simulation. However, this analysis was on a small scale, considering a specific task, without providing a large-scale analysis of the entire organization or total task cycle time. In other words, analyzing the ontact work environment that supports smart work can be the cornerstone of sustainable human resource management [10,11] from the perspective of employee competency, management, and work-life balance [12]. Sustainable human resource management is very important because the success of an organization is determined within the framework of sustainability by encompassing the economic, social, and environmental aspects of the organization beyond its outputs, production, and profitability [13].

This study evaluates the negative and positive effects of the ontact work environment from a corporate perspective through enterprise simulation. A business process-organizational structure (BP-OS) performance measurement model and problem-solving guidelines to overcome the negative impact of the ontact work environment are proposed. These are intended to encourage organizations or companies to minimize errors or problems in the ontact work environment. The organizational performance measurement model and problem-solving guidelines prevent social problems such as the recent sacrifice of workers in the logistics industry that occurred because of overwork through these preemptive responses.

Although human resource management is very popular in both business and government sectors, conceptual and empirical understanding is limited [8]. While most companies strive to predict organizational performance and solve problems in the ontact work environment, business processes, organizational structures, and human resource allocation

are not considered despite the clear association [14–19]. In the ontask work environment, companies reorganize the organizational structure or human resource allocation at the discretion of the management; however, the stability of the results cannot be guaranteed because reorganization is highly likely to be subjective. It is necessary to find solutions to problems considering the organizational structure and human resource allocation based on the business processes for predicting the impact of organizational performance in the ontask work environment [18–26]. The combination of business processes, organizational structures, and human resource allocation is regarded as challenging in computation. Therefore, this study proposed an alternative search and comparison through simulation as the most effective way to solve this problem. In this study, simulations were performed by extending the previously developed software, BPOA. Four types of data (Business Process Definition, Organizational Definition, Performer Definition, and Manager Definition) that redefine the data used in the previous BPOA were used to reflect the ontask work environment when performing the simulation. Furthermore, in the simulation, the work performance was predicted by reflecting the effect of telecommuting.

The advantage of the problem-solving alternative presented in this paper is that it can be changed to a part or a combination of the business process, organizational structure, and human resource allocation, according to the intention and purpose of the user. In other words, it is an alternative that considers all business processes, organizational structures, and human resource allocation, facilitating their diagnosis or exploration by organically changing each part. It also has advantages in supporting the comparative evaluation and verification of the derived problem-solving methods. Consequently, it enables companies to respond to changes actively and rationally in the ontask work environment.

This study is structured as follows. Section 2 reviews the related studies. Section 3 defines the performance measurement model in the ontask work environment and explains the impact of the ontask work environment. Section 4 performs a simulation using a performance measurement model in the ontask work environment. Section 5 proposes an alternative for problem-solving that changes the business process, organizational structure, and human resource allocation. Finally, Section 6 concludes the study.

2. Related Works

2.1. Factors Affecting Organizational Performance in the Ontask Work Environment and the Need to Consider Them

For effective organizational management, it is necessary to consider the organizational performance factors that change due to the ontask work environment [27,28]. In Smart Work, various advantages and disadvantages have been studied in terms of workers and organizations [4,29,30]. Here, each behavioral/psychological factor added as the work environment has changed until recently should be additionally reflected. They can be summarized from two perspectives. First, factors that affect organizational performance in the ontask work environment, which were not present in the existing work environment, include: changes in concentration and focus caused by factors such as housework and childcare; changes in commuting methods; and psychological factors such as burnout and depression [27,31]. Second, the organizational performance factors that existed in the conventional work environment but have changed owing to the emergence of the ontask work environment include: the work environment; the approval/assignment process; manager absence or negligence; job satisfaction; and the efficiency of meetings and communication [27,28,32]. However, these exist only as individual elements, with a scarcity of studies analyzing the difference in perception between the perspectives of organizations and individuals in the ontask work environment [27]. In other words, the management of an organization is complex through them. Therefore, to perform effective organizational management by reflecting the above factors, it is necessary to develop a new performance measurement method that considers organizational performance factors that change from introducing the ontask work environment [28].

2.2. Evaluation and Redesign Method of Business Process, Organizational Structure, and Human Resource Allocation

Most existing business process re-engineering (BPR) and process innovation (PI) studies mention that it is challenging to expect results if business processes and organizational structures are not designed as mutually compatible. In [33–35], BPR was performed focusing on changes in the business processes; however, only the work variables were considered without considering the organizational structure. Therefore, the business process and organizational structure (BP-OS) should be considered together for a successful BPR study or project. However, the existing BP-OS studies have been conducted without considering human resource allocation [36]. The organizational structure encompasses expressing the structure and considering the human resource allocation. In other words, a successful BPR project should be conducted based on the BP-OS study considering human resource allocation [37]. However, such research is challenging to find. It is unsuitable for effective organizational management in the on-tact work environment as it does not consider the current on-tact work environment that has been in the spotlight. Therefore, it is necessary to BP-OS research for efficient organizational management in the on-tact work environment, which has been introduced to many organizations owing to the recent COVID-19 pandemic.

2.3. The need for Organizational Performance Prediction through Enterprise Simulation and the Limitations of Existing Enterprise Simulations

Suggs and Lewis defined enterprise simulation as applying modeling techniques at an enterprise scale. They have also been explained that enterprise simulations serve two purposes [38]. First, they provide a top-down view of the business enterprise to support the strategic decision-making of the enterprise [39]. Second, to utilize the existing modeling technique, they utilize the related elements within the enterprise. Enterprise modeling is also the abstract representation, description, and definition of the structures, processes, information, and resources of an identifiable business, government agency, or other large enterprises. In other words, enterprise simulation is a model of a company conducting business that organizes any kind of strategic resource possessed by the company through abstraction or quantification. It is the act of deriving valuable results through simulation with these strategic resources. Before the term “enterprise simulation” was first coined, the term “enterprise modeling” was used to refer to enterprise simulation. Enterprise modeling focused on organizing resources with an integrated meaning rather than deriving meaningful results. However, it is common to adopt enterprise simulation to improve enterprises because the enterprise environment is constantly changing [40]. In other words, it seems to be an excellent approach to apply enterprise simulation to organizational management research that comprehensively considers three aspects: the business process, organizational structure, and human resource arrangement.

Most enterprise simulation studies use generic or unique performance indicators to measure and compare their performance. The cycle time is often used in studies based on business processes to prove their effectiveness [41]. Several attempts have been made to overcome the limitations of existing studies. Among them, Business Process and Organizational Analytics (BPOA) is an enterprise simulator developed to predict the impact of changes in the business process, organizational structure, and human resource allocation through simulation based on genetic algorithms [42]. However, this enterprise simulator does not reflect factors related to the on-tact work environment, such as telecommuting, which needs to be developed to indirectly reflect the influence on the on-tact work environment by changing the parameters. Furthermore, it is necessary to verify the effectiveness of the problem-solving alternatives regarding the task cycle time.

Moreover, [43] discussed the impact of considering organizational resources in business process modeling. Reference [14] addressed the theoretical gap between BPR and organizational change (OR). It proposed a “process re-engineering-oriented organizational change exploratory simulation system” (PROCESS) to facilitate the organizational changes in BPR and OR. However, only partial views of organizational structures such as organiza-

tional resources and departments were considered. Reference [23] proposed an approach to evaluate the suitability between business processes and organizational structures in terms of the overheads incurred in the organizational structure to transfer the work from the business process. However, this approach only considered the concept of business transfer and did not represent an integrated evaluation methodology for the business process and organizational structure. Reference [44] proposed a business process simulation model that considers the transfer-of-task that occur during business process execution. Neither study considered the characteristics of human resources, such as resource availability and work capacity. Moreover, they did not consider redesigning processes or organizational structures. Most studies have used simulation techniques to predict the effects of process redesign more effectively, and business analysts have simulated the redesigned process to validate the process and identify possible solutions. However, the existing methodology does not comprehensively consider the business process, organizational structure, and human resource allocation to redesign the problems [14,40,45–47] caused by process changes.

More information on the execution of business processes is recorded in information systems such as ERP, CRM, and BPMS in the form of “event logs” [48–51]. In the past, many process mining studies attempted to derive meaningful results through business processes. However, only limited organizational information could be derived because the process log and data models for deriving sufficient organizational information were not designed to simultaneously support the integrated analysis of business processes and organizational structures [15,16,52]. Most existing approaches do not simultaneously consider data models to analyze business processes and organizational structures [18]. A comprehensive organizational analysis requires a fully designed data model incorporating other organizational information such as resource availability and work capacity. Moreover, even traditional business process simulation approaches do not consider the organizational structure [14,40,43,45,53–55]. Additionally, information on the organizational structure is limited due to the process log [56–58]. An integrated organizational ontology expressing various relationships between organizational units was proposed to compensate for this limitation. However, it did not define the types of organizational units or quantitatively evaluate the impact of various organizational unit relationships on the business process performance [59–63]. Therefore, it is necessary to define a comprehensive data model for business process simulation that incorporates the impact of the organizational structure and human resource allocation to evaluate and redesign the business process, organizational structure comprehensively, and human resource allocation.

3. Performance Measurement Model in the Ontact Work Environment

3.1. BP-OS Performance Measurement Model in General Work Environment through Total Task Cycle Time

This paper presents a mathematical model based on the total task cycle time (TTCT) by reflecting the actual business processes of companies and organizations for measuring performance in terms of the business processes and organizational structures.

Definition 1. The total task cycle time and unit task cycle time are defined as follows:

$$TTCT = \sum_p \sum_t \sum_i UTCT_{pti} = \sum_p \sum_t \sum_i \left(E_{pti} + \sum_o (A_{ptio} + N_{ptio}) \right) \quad (1)$$

P denotes the process set, T denotes the task set, I denotes the instance set, and O denotes the organization set. When $p \in P$, T_i denotes the task set included in process p . When $p \in P$ and $t \in T_p$, O_{ij} denotes all departments constituting the path connecting the t -th task of process p , $task_t$, with the $t + 1$ -th task (follow-up task), $task_{t+1}$. When $p \in P$, $t \in T_p$, I_{pt} denotes all instances of the t -th task of the process.

The unit task cycle time consists of the execution time (E), approval/assignment time (A), and negligence time (N). The execution time refers to the time the performer uses

only to complete the task. The approval/assignment time refers to the time it takes for all managers with authority to formalize the end of the task to review and approve/assign the task. Here, the term “all managers” has two meanings. First, specific organizational structures may have more than one manager (e.g., network organizational structure). Second, it may consist of an immediate supervisor of one performer and an immediate supervisor of the supervisor. Negligence time refers to the additional time required because of the absence or negligence of the managers in charge of approval and assignment under personal or organizational circumstances. The approval/assignment time and negligence time can be collectively referred to as the time required for the transfer of the task. The time required for the transfer of the task refers to the time it takes after one task is completed before the next task starts, which is all the time excluding the execution time from the total task cycle time.

When $p \in P$, $t \in T_p$, $i \in I_{pt}$, and $o \in O_{pt}$, E_{pti} denotes the time required to execute instance i of task t of process p ; A_{ptio} denotes the time required by the managers in department o in charge of approving instance i of task t of process p or assigning follow-up tasks, and N_{ptio} denotes the additional time required owing to the negligence of the managers in department o in charge of approving instance i of task t of process p or assigning follow-up tasks.

The total task cycle time is the sum of the unit task cycle time (UTCT) for all process instances, which can be expressed as $\sum_p \sum_t \sum_i UTCT_{pti}$. $\sum_t \sum_i$ indicates that all tasks and instances included in the p -th process are considered, whereas $\sum_i$ indicates that all instances of task t of the p -th process are considered. In other words, $\sum_t \sum_i UTCT_{pti}$ can be defined as the sum of the time it takes when the number of instances of all activities of process p is executed.

This study determines the time required for moving from a task to the follow-up task in a specific process in two ways: approval and assignment. For the sake of explanation, $task_t$ (t -th task) to $task_{t+1}$ (the follow-up task of t -th task) are defined. After the performer completes $task_t$, the review time for approval by all managers, including the top manager, will be required. Afterward, assigning the performer to perform $task_{t+1}$ from the top manager takes assignment time. Additionally, A_{ptio} and N_{ptio} are estimated only by the average time taken for approval and assignment.

Figure 1 shows an example of the transfer from Task A to the follow-up task, Task G, in the organizational structure. In the example in Figure 1, the performer who performed “Task A” first proceeds with the approval to report to manager M3, which takes time to transfer the work for approval from M1 to T1, the top manager. Subsequently, T1 transfers the task to M2 to allocate a performer to perform Task G, a follow-up task that assigns a performer to Task G through M6.

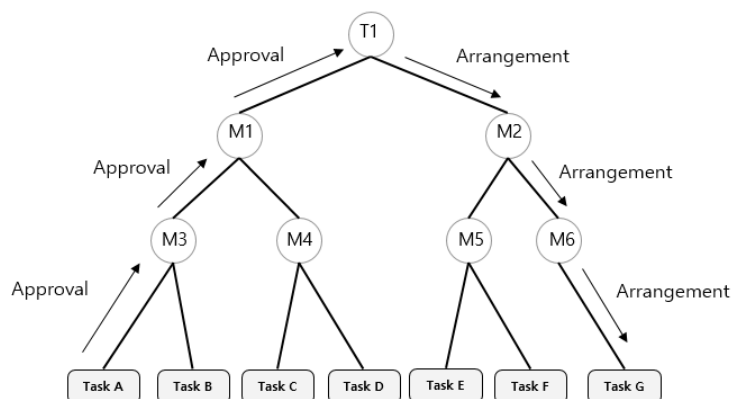


Figure 1. Example of transfer-of-task from Task A to Task G.

3.2. BP-OS Performance Measurement Model in the Ontact Work Environment

This study extends the total task cycle time defined in Section 3.1 by reflecting the factors that affect the organization in the ontact work environment. The BP-OS performance measurement model in the ontact work environment is defined as follows.

Definition 2. $TTPT_{Ontact}$ denotes the total task cycle time applied in the ontact work environment. The total task cycle time in the ontact work environment is defined as follows. Six delaying factors (α , β , γ , δ , ε , and θ) are reflected in the total task cycle time. γ and δ are the weights that affect the total task cycle time. Therefore, the value does not directly represent the time but is an adjusted value according to the organizational situation.

$$TTPT_{Ontact} = \omega * \sum_p \sum_t \sum_i [(E_{pti} + \alpha_{pti}) + \sum_o \{ (A_{ptio} + \beta_{ptio}) + (N_{ptio} + \gamma_{ptio}) \}] + \varepsilon$$

$$\omega = \frac{\theta}{\delta}$$

$$\delta > 0, \theta > 0$$

A description of the delaying factors used in the above equation follows.

1. Delay in pure execution time (α)

The delay in the execution time is the sum of the factors that affect the execution time. The lead time occurs when resuming a single task after an interruption of the task. This lead time may be caused by obstructive factors (e.g., household problems such as childcare) in the ontact work environment when performers perform a single task. The lag time due to the work environment refers to the lag time caused by the difference between the existing face-to-face work environment and the ontact work environment. In the ontact work environment, environmental factors such as hardware, software, and communication speed, may differ from the existing work environment, causing a delay in the execution time. The lag time due to decreased concentration or consciousness of supervision is delayed because the performer does not face the manager offline. In the ontact work environment, the performers are not in a space where they can be supervised when performing a single task. Therefore, performers can avoid direct and indirect pressure from their supervisors, which will likely decrease their sense of responsibility and integrity. Delays in the execution of performers due to the absence of managers may occur for more extended periods and more frequently in the ontact work environment.

2. Delay in approval/assignment time (β)

The delay in the approval/assignment time is the sum of the factors affecting the approval/assignment time for the managers. The lead time refers to the lead time from the managers' perspective. The approval/assignment time can be considered as part of the work performed by the managers. Just as the work of the performers is interrupted by obstructive factors in the ontact work environment, approval/assignment may also be suspended for the same reasons, followed by the lead time. The lag time is due to the difference in the manager's approval/assignment work environment. For the managers to approve or assign tasks in the ontact work environment, environmental factors such as hardware, software, and communication speed, may differ from the existing face-to-face work environment, causing delays in the approval/assignment time.

3. Delay in negligence time (γ)

The delay in negligence time is the sum of all additional factors that may occur due to all the performers under the changed circumstances in the ontact work environment. Unlike the face-to-face work environment, additional delays may occur in the ontact work environment, such as being more negligent at work or the managers in charge of approval being unable to perform effectively because of household duties such as childcare.

Moreover, in the ontact work environment, the method of delivering documents or data and the time required to deliver documents or data changes from that in a face-to-face work environment.

4. Factors increasing total task cycle time (δ)

Factors increasing the total task cycle time include negative factors in the ontact work environment. These include all factors directly delaying the total task cycle time without affecting the unit task cycle time. One of the factors that directly delays the total task cycle time in the ontact work environment is the decreased meeting efficiency due to remote communication. Because the performers and managers accustomed to the existing face-to-face work environment and meetings are not accustomed to remote communication, such as teleconferences, the communication time required to transfer the same amount of information may increase. In addition to communication difficulties, the total work performance/approval time may also increase owing to psychological factors of the performers and managers. Because individuals cannot gather in one space to exchange opinions or take a break as in the existing face-to-face work environment, they have fewer means of relieving stress. They are likely to be less motivated to work. This causes burnout or depression from isolation, which may lead to a decrease in work performance.

5. Factors decreasing total task cycle time (θ)

Factors decreasing the total task cycle time include positive factors in the ontact work environment. These include directly reducing the total task cycle time without affecting the unit task cycle time.

The first factor decreasing the total task cycle time is the increased communication flexibility in the organization. When a manager approves or assigns tasks or results, or when a performer processes work, online or offline communication is essential within the organization. Here, communication refers to individual communication such as direct instructions or confirmation of results by the supervisors. Such communication occurs regularly and irregularly, reminding the individuals of their roles and encouraging the organization to achieve the process goals. In the ontact work environment, such communication does not necessarily proceed face-to-face, and the communication has a longer time window. Consequently, space or time no longer becomes a significant constraint in communication, and tasks or approvals that could not be performed because of time or space constraints can be performed quickly. The increase in communication flexibility within an organization varies depending on the work flexibility of the organization's members and organizational policies.

The second factor increasing work efficiency is the reduced mental burden from non-face-to-face communication and self-directed work performance. Non-face-to-face communication does not require the performers to face their immediate supervisors in person, which reduces stress. Additionally, job satisfaction increases through self-directed work performance and the resulting work-life balance and the reduced workload and stress of employees with responsibilities such as childcare and nursing. Consequently, it reduces the total task cycle time, which is proportional to the total task cycle time.

The last factor that decreases the total task cycle time is the reduced physical burden from reduced mandatory commuting to and from work. Without the need to go to and from a specific place to perform, review, or approve tasks, the performers and managers can use the time for additional preparation or planning for the tasks and conserve stamina for more efficient work performance.

6. Factors independently affecting total task cycle time in the ontact work environment (ε)

The factors that are independently affecting the total task cycle time in the ontact work environment involve newly added or removed tasks, that affect the total task cycle time in the ontact work environment regardless of the unit task or business process in the face-to-face work environment. One of the factors that independently affects the total

task cycle time in the ontact work environment is the additional meetings to overcome the difficulties associated with working non-face-to-face. When working non-face-to-face, additional online meetings are required for communication and collaboration between departments. These meetings require additional presentations by department heads and practitioners. In the case of Netflix, because of the implementation of telecommuting, a meeting process in which corporate managers and business executives participate is to share and report tasks and results. Not only Netflix, but also companies that implement telecommuting, may require different processes (or tasks) for sharing or reporting tasks or results as in the existing face-to-face work. Unlike the decrease in meeting efficiency due to remote communication, which is a factor with an effect proportional to the total task cycle time, the number of fixed meetings increases. Therefore, a fixed value, instead of a proportional value, was added to the equation according to the organizational situation.

4. BP-OS Simulation Modeling in the Ontact Work Environment

4.1. Enterprise Simulation Architecture in the Ontact Work Environment

Figure 2 proposes an enterprise simulation architecture in the ontact work environment. The enterprise simulation can be broadly divided into four parts. The four parts represent business processes, organizational structures, performers, and managers. This is consistent with the data model required for enterprise simulation, described in Section 4.1.1.

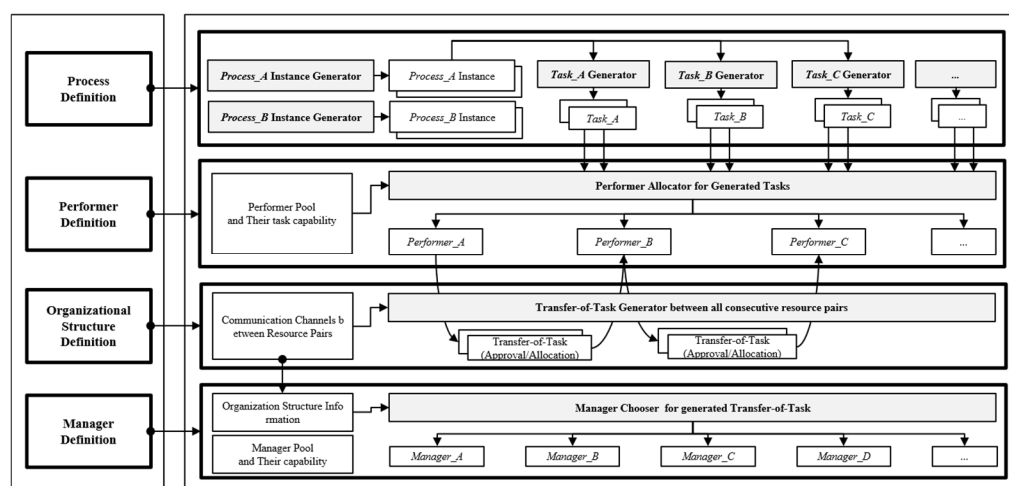


Figure 2. Enterprise simulation architecture in the ontact work environment.

The Business Process Instance Generator produces a specific process instance, and each process instance generates a specific task included in the process through the Task Generator. A performer is assigned through the Performer Allocator to perform the generated task. After the managers' approval and assignment, the performer who completes the task must deliver it to the assigned performer for the follow-up task. This process is referred to as transfer-of-task. There is no allocator for the managers related to the transfer-of-task; all managers in the route for transferring tasks from one performer to the next through organizational structure information are included.

4.1.1. Defining Data Used in Enterprise Simulations

In this study, four data models were defined for the enterprise simulation.

Business Process Definition

A business process is divided into two categories: "task" and "gateway." If a business process consists of only "tasks" without a "gateway," it is executed in the order of "tasks." "Gateway" is added when an intermediate option occurs in the business process and is expressed as "XOR_gateway," "AND_gateway," etc. For "XOR_gateway," where options

are created, the value of ‘probabilities’ is combined, and the probability of proceeding to each option is notified.

Organizational Structure Definition

The organizational structure consists of resource types that distinguish managers and performers and resource relationships that describe the relationship between each resource. “Resource type” is divided into “manager” or “performer,” with each having the characteristics of “performer definition” or “manager definition” according to this type. Among managers, the manager at the top of the organizational structure is the CEO, also called the ‘top manager,’ who has the same characteristics as other managers. In this case, the CEO is named “T,” the manager “M,” and the performer “P”; in addition to the resource type, numbers are assigned to distinguish each entity (e.g., “P4” means the fourth performer). To explain the relationship between resources, “superior_resource_id” is included in the information of each entity (e.g., ‘superior_resource_id’: ‘M4’). Superior_resource_id represents the c, which can have the supervisor’s id or null value. If superior_resource_id is null, the manager is the top manager (CEO). Multiple managers or performers can have the same superior_resource_id value.

Performer Definition

Performer definition includes the unit tasks that each task performer can perform and the time required to perform the relevant unit tasks. Therefore, resource_id to identify the object (e.g., ‘resource_id’: ‘P1’), and task_name, which is a task that the performer can perform (e.g., ‘task_name’: ‘TASK_C’), are included. Finally, the time required to complete the task is represented by a triangular distribution (e.g., ‘execution time’: {‘left’: 5, ‘mode’: 7, ‘right’: 8}). The reason for expressing the task performance time of a performer in a triangular distribution is to observe human task performance more realistically. The meaning of the triangular distribution in the time required to perform unit tasks is as follows.

- Left: Fast, execution time due to excellent concentration, good working environment, etc.
- Mode: Most common execution time. The value of the execution time that can be expected from the performer in the absence of exceptional circumstances.
- Right: Slow execution time due to poor concentration, poor working environment, etc.

Manager Definition: Availability

Manager definition defines the time it takes for the managers to approve the tasks performed by the performers. Managers, similar to performers, are responsible for the approval, assignment, and transfer of tasks, which are expressed as “approval/assignment time” (‘task approval/assignment time’: {‘left’: 1, ‘mode’: 3, ‘right’: 3}). The meaning of the triangular distribution in the time required for unit task approval/assignment is as follows.

- Left: Fast approval/assignment time with excellent concentration and smooth communication with performers.
- Mode: Common approval/assignment time expected from managers with no special situations.
- Right: Slow approval/assignment time with reduced concentration and difficult communication with performers.

One of the differences between the managers and performers is that the managers are not always in a state where they can perform their work, such as while attending a board meeting. Therefore, in an environment where the administrator cannot transfer and approve tasks by adding a state of “available/unavailable,” a delay in the process may occur. To manage such situations, “unavailable_rate” and “unavailable_time” are defined. The “unavailable_rate” refers to the probability that a manager cannot perform their work due to other circumstances within the company. If the manager is “unavailable,” the time is delayed by “unavailable_time.” Conversely, if the manager is in the “available” state, the approval and transfer occur after the “approval/assignment time” (e.g., ‘unavailable_rate’:

0.3, 'approval/assignment time': {'left': 1, 'mode': 3, 'right': 4}, 'unavailable_time': {'left': 5, 'mode': 7, 'right': 8}). Because the "unavailable_rate" and "available_rate" are based on their values in probability, they have the following conditions:

$$0 \leq \text{unavailable rate} < 1$$

$$0 < \text{available rate} \leq 1$$

$$\text{unavailable rate} + \text{available rate} = 1$$

4.1.2. Prerequisites for Enterprise Simulation

The prerequisites of the enterprise simulation are as follows. This should be observed when the organization has hierarchical and tree structure types. These prerequisites must be observed in all enterprise simulations, regardless of the ontact work environment. First, each resource is guided by one manager (however, the company's top manager (e.g., the CEO) is excluded). Second, the direct transfer of tasks between performers is impossible. Third, all performers are located in the bottom layer. Through these conditions, managers and performers have their intrinsic meaning, enabling the meaningful application of enterprise simulation.

For the ontact work environment, the above four additional conditions are required to perform realistic and meaningful simulations.

First, the total task cycle time model has two adjustment values (ω , ε) in the ontact work environment. ω is a value that affects the total task cycle time as weight because it represents the negative and positive factors in the ontact work environment that affect the total task cycle time of the organization. ε is a value-added to the total task cycle time because it represents the factors in the ontact work environment that independently affect the total task cycle time. ω and ε may vary significantly depending on the circumstances and organizational culture of the company. These values are determined by considering subjective aspects such as the corporate composition or management judgment in addition to the objective indicators. These values change when the company adapts to the ontact work environment. Therefore, when the simulation was performed, the ω value was set to 1, and the ε value was fixed to 0. In contrast, the simulation was conducted for a stable analysis of the results. In other words, in the ontact work environment, no effect increases or decreases in proportion to the total task cycle time, with no additional independent effect on the total task cycle time.

Second, all task cycle time follows a triangular distribution. Therefore, the task cycle time of all workers is expressed as A/B/C. In the task cycle time of A/B/C, A is the left value of the triangular distribution (indicating the best work performance), B is the mode value (indicating the common work performance), and C is the correct value (indicating the worst work performance). For example, the task cycle time of 2/4/8 indicates that it takes 2 h with the best work performance, 4 h with common work performance, and 8 h with the worst work performance.

Third, grouping is carried out according to the abilities of the performers and managers. Not all performers or managers have the same delay rate in the non-face-to-face work environment. Therefore, in this simulation, workers in the ontact work environment were divided into three groups, and different delay rates were applied. Each group consisted of 30% who adapt well to non-face-to-face work, 40% in the typical case, and 30% who do not adapt well to non-face-to-face work. Therefore, in all non-face-to-face work cases, the delay rate is expressed as X%/Y%/Z%. The delay rate of X%/Y%/Z% means that a delay rate of X% is applied to 30% of the total workforce, Y% to 40%, and Z% to the rest 30%. For example, 15%/25%/35% means a delay rate of 15% is applied to 30% of the total workforce, 25% to 40%, and 35% to the rest 30%.

Finally, there is unavailable probability and unavailable time. One of the differences between the managers and performers is that the managers are not always in a state where they can perform their work, such as while attending a board meeting. Therefore, in an

environment where the administrator cannot transfer and approve tasks by adding a state of “available/unavailable,” a delay in the process may occur. Unavailable probability and time are defined to manage this situation. Unavailable probability refers to the probability that the immediate supervisor (manager) cannot make a payment immediately owing to other circumstances within the company when the performer completes the task and enters the reporting stage for approval. If the manager cannot approve it right away, it is delayed by the unavailable time, and after that time, the manager’s status is judged again. Additionally, the state where the manager cannot perform approval may occur continuously depending on the company’s circumstances. Unavailable probability is based on probability.

4.2. Enterprise Simulation in the Ontact Work Environment: Case Study

Simulations were performed in three cases through the organizational performance measurement model in the ontact work environment for evaluating the effect of delay factors that may occur in the ontact work environment on the organization. The data used for the enterprise simulation in this study was set based on standard working hours (maximum 8 h) in accordance with the Labor Standards Act of South Korea. Working in the ontact work environment was simulated based on the total task cycle hours that occurred in the face-to-face work environment before the COVID-19 pandemic by applying three types of delay rates (15%/25%/35%, 25%/35%/45%, and 35%/45%/55%) to the execution time and approval/assignment time depending on the amount of delay and applying a fixed delay value for the negligence time. The total task cycle time in the face-to-face work environment is later used as a control group for the simulation results according to the delay rate in the ontact work environment. Based on the above assumptions, the execution time, approval/approval time, and negligence time are shown in the Table 1.

Table 1. Unit execution time for each delay rate (Unit: time).

	Execution Time ($A + \alpha$)	Approval/Assignment Time ($B + \beta$)	Negligence Time ($C + \gamma$)
No Delay	2/4/8	1/2/4	Fixed value according to Case
15%/25%/35% delay rate applied	2.3/4.6/9.2	1.15/2.3/4.6	Fixed value according to Case
	2.5/5/10	1.25/2.5/5	
	2.7/5.4/10.8	1.35/2.7/5.4	
25%/35%/45% delay rate applied	2.5/5/10	1.25/2.5/5	Fixed value according to Case
	2.7/5.4/10.8	1.35/2.7/5.4	
	2.9/5.8/11.6	1.45/2.9/5.8	
35%/45%/55% delay rate applied	2.7/5.4/10.8	1.35/2.7/5.4	Fixed value according to Case
	2.9/5.8/11.6	1.45/2.9/5.8	
	3.1/6.2/12.4	1.55/3.1/6.2	

Based on the delay values in the table above, three non-face-to-face work cases were simulated. The description and characteristics of each case are as follows.

Case I. The values of 2/4/8 for the execution time and 1/2/4 for the approval/approval time are entered, and the value is fixed at 1/3/8 for the negligence time. The unavailable probability is 50%, and the unavailable time value is 1/2/4.

Case II. The values of 2/4/8 for the execution time and 1/2/4 for the approval/approval time are entered, and the value is fixed at 2/4/10 for the negligence time. The unavailable probability is 50%, and the unavailable time value is 1/2/4.

Case III. A value of 2/4/8 for the execution time and 1/2/4 for the approval/approval time are entered, and the value is fixed at 1/3/8 for the negligence time. The unavailable probability is 30%, and the unavailable time value is 1/2/4.

For each case, a simulation was conducted, assuming the business process was performed in a realistic organizational structure. For the business process used in the sim-

ulation, four types of processes were used to reflect the actual process of the company. For each of the four processes, one simulation was performed based on 10 instances to minimize the effect of random error. Seven simulations were performed for each delay rate, and the sum of these values was used as the final result.

4.3. Enterprise Simulation Results in the Ontact Work Environment

The results for each case are summarized in the table below. It is possible to determine how much the total task cycle time increased in a non-face-to-face work environment (Cases I, II, and III) compared to the face-to-face work environment of the company. Enterprise simulation results for each case are shown in Table 2.

Table 2. Enterprise simulation results for each case (Unit: time).

	Case I	Case II	Case III
No Delay	145,884	164,077	173,672
15%/25%/35% Delay rate applied	178,433 (27.9% delay)	218,148 (32.9% delay)	217,264 (25.1% delay)
25%/35%/45% Delay rate applied	196,077 (38.4% delay)	236,119 (43.9% delay)	241,056 (38.8% delay)
35%/45%/55% Delay rate applied	210,392 (50.0% delay)	254,522 (55.0% delay)	265,544 (52.9% delay)

Based on the average total task cycle time, the graph of the delay rate in a non-face-to-face work environment for each case is as follows.

Where, Best, Mode, and Worst mean the triangular distribution's left, mode, and correct values for each case, respectively. In all cases, the simulation results in the non-face-to-face work environment were more significant than the average delay rate (mode in Figure 3). Additionally, as the average delay rate increased in all cases, the simulation result appeared to converge from Mode to Worst.

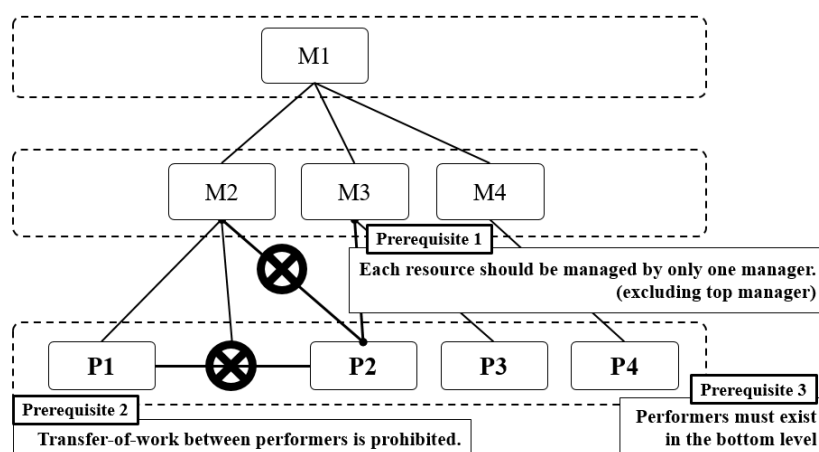


Figure 3. Enterprise simulation prerequisites.

4.4. Analysis of Enterprise Simulation Results in the Ontact Work Environment

In all cases, the simulation results in the non-face-to-face work environment were more extensive than the delay (modes in Figures 3–5) considered by the organization. Therefore, the effects of the non-face-to-face work environment caused a more significant delay than the average delay caused by performers or managers. The organization must be aware of this and prepare countermeasures accordingly. With a more significant average delay rate expressed as the mode value in the triangular distribution, the delay caused by non-face-to-face work increases more than the average delay rate. In other words, the greater the average delay rate,

the greater the negative effect on the organization. Moreover, the greater the average delay rate during simulation, the greater the variance of the triangular distribution. A considerable variance value means that the first start time of the next task is significantly delayed following a significant delay in the performance or transfer of the previous task.

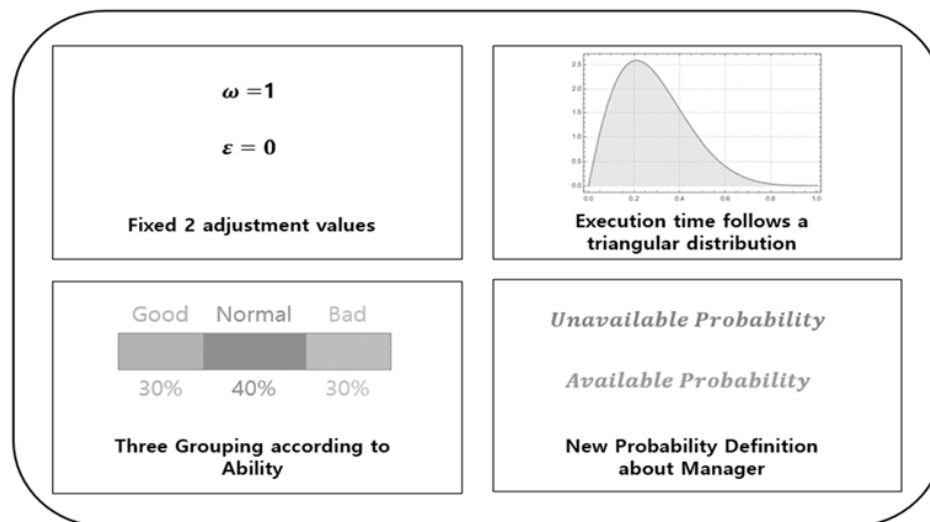


Figure 4. Prerequisites for enterprise simulation in the ontact work environment.

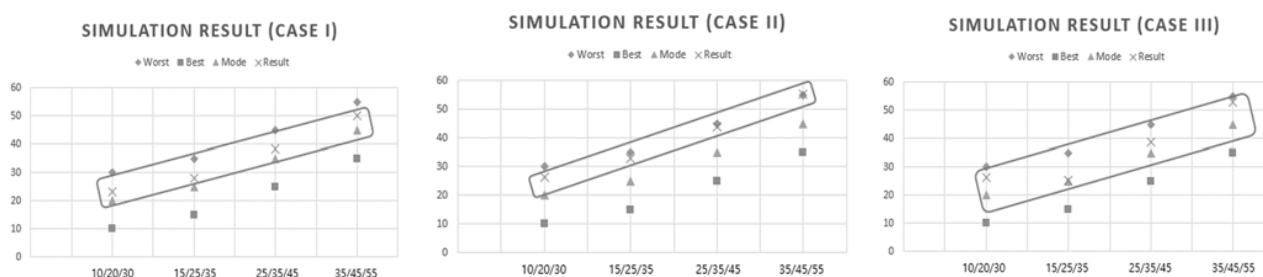


Figure 5. Enterprise simulation results for each case.

Case II is the same as Case I, except for the increase in the negligence time. The simulation result of Case I showed a delay that slightly exceeded the Mode value, but the result of Case II showed a result that converged to the Worst value. This suggests that the delay due to the circumstances of the managers is considerably greater than that in the execution time of the performers in the ontact work environment, considering an organization operating in the hierarchical organizational structure as assumed in this simulation.

Case II is the same as Case I, except for the decrease in the unavailable probability. The simulation result of Case III showed a steeper delay according to the delay rate compared to Case I. Compared with the results, Case III showed a lower delay than Case I at the delay rate of 15/25/35, but Case III had a more considerable delay than Case I at the delay rate of 35/45/55. In other words, a small unavailable probability value leads to a more relaxed delay at a low delay rate and a more extensive delay at a high delay rate. This shows that even with less manager negligence, a more significant delay occurs at a high rate. Furthermore, it can be observed that the delay due to the circumstances of the managers plays a significant role in the hierarchical organizational structure.

5. Problem-solving Guidelines in the Ontact Work Environment

5.1. Streamlining of Organizational Structure and Reporting System

In companies where business reporting and approval are unavoidable during the process, streamlining the organizational structure is one of the most intuitive and effective problem-solving methods. After confident performers have completed their tasks, it is

necessary to receive approval and instructions from several managers to transfer the tasks to those in charge of the follow-up tasks. Therefore, much more efficient work processing can be achieved by streamlining unnecessary organizational structures in the ontask work environment. Furthermore, in the non-face-to-face work environment, unlike in the face-to-face work environment, organic and immediate reporting and instructions are complicated, and delegating some of the authority of a superior to a direct subordinate is likely to contribute to effective work processing. In addition, simplifying unnecessary reporting systems is one of the measures for successful reorganization.

Therefore, in this study, two data modifications were established to proceed with the simulation, assuming the streamlining of the organizational structure (Figure 6). First, during the transfer of work, the reporting system was changed to skip the manager layer located at the bottom of the organizational structure. A skip of the lowest-level managers does not mean the removal of organizational members, but rather unnecessary changes to the reporting system in the organizational structure. Second, the work approval/assignment time between the manager at the top of the organizational structure and the manager right below was reduced by half. The more senior managers are, the more tasks they are likely to approve or assign. However, it is impossible to review even non-important tasks in detail. Therefore, the delegation of authority from the top manager to a direct subordinate was reflected by reducing the approval/assignment time between them. The simulation results with only the two conditions above changed while maintaining the rest of the conditions as shown in Figure 7.

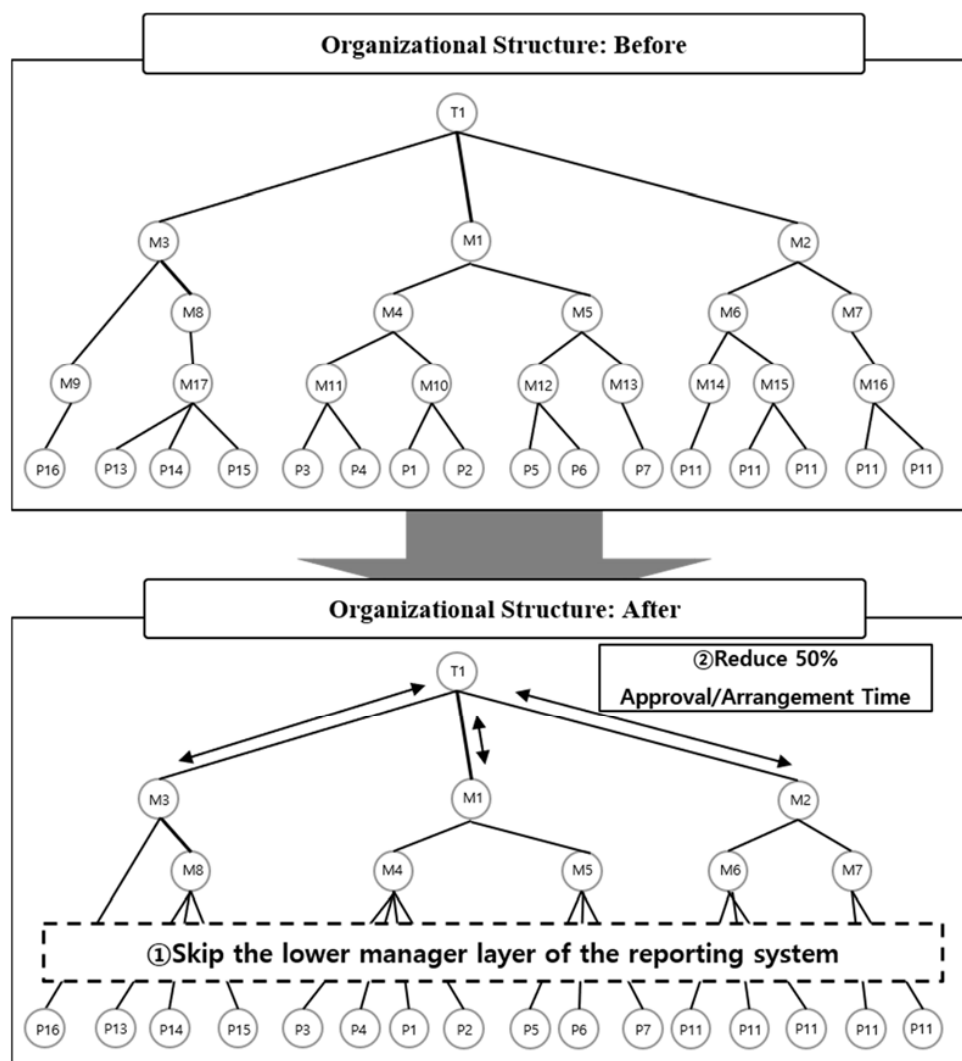


Figure 6. Base and streamlined organizational structures.

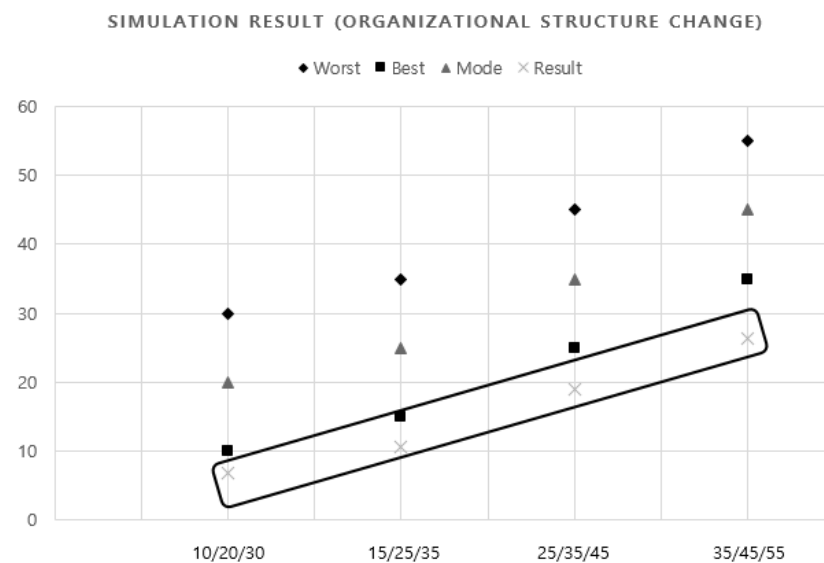


Figure 7. Simulation results (simplification of organizational structure).

The streamlining of the organizational structure was found to significantly reduce the delay rate than that in the Mode value. This suggests eliminating unnecessary approval/assignment processes and delegation of authority for efficient business processing.

5.2. Streamlining Business Process

As one of the causes of the increase in the total task cycle time, the delay due to the unavailability of approval in the ontact work environment was introduced in this study. Here, there were various tasks that were necessary to proceed offline such as selecting a location for a meeting, copying meeting documents, and setting up a meeting room. In fact, they are not directly related to the work performance. In other words, this is one of the parts that can be simplified in terms of ideal ontact corporate operation. Therefore, enterprise simulation can be performed by shortening the execution time of a process (or task) that can be simplified in the ontact work environment. This reduces the total task cycle time delay in the ontact work environment.

Therefore, in this study, data were modified before proceeding with the simulation to streamline the business process (Figure 8). The execution time of Task B common to all business processes (except Process C) used in the simulation was reduced by half.

Task B is included in most business processes in the existing work environment, and at the same time represents offline tasks that can be simplified in the ontact work environment. The rest of the conditions were the same, and the simulation results after changing the above two conditions were as shown in Figure 9.

After streamlining the business process, the delay rate was significantly reduced compared to the Mode value. This indicates the importance of eliminating unnecessary tasks or streamlining the business process for efficient business processing.

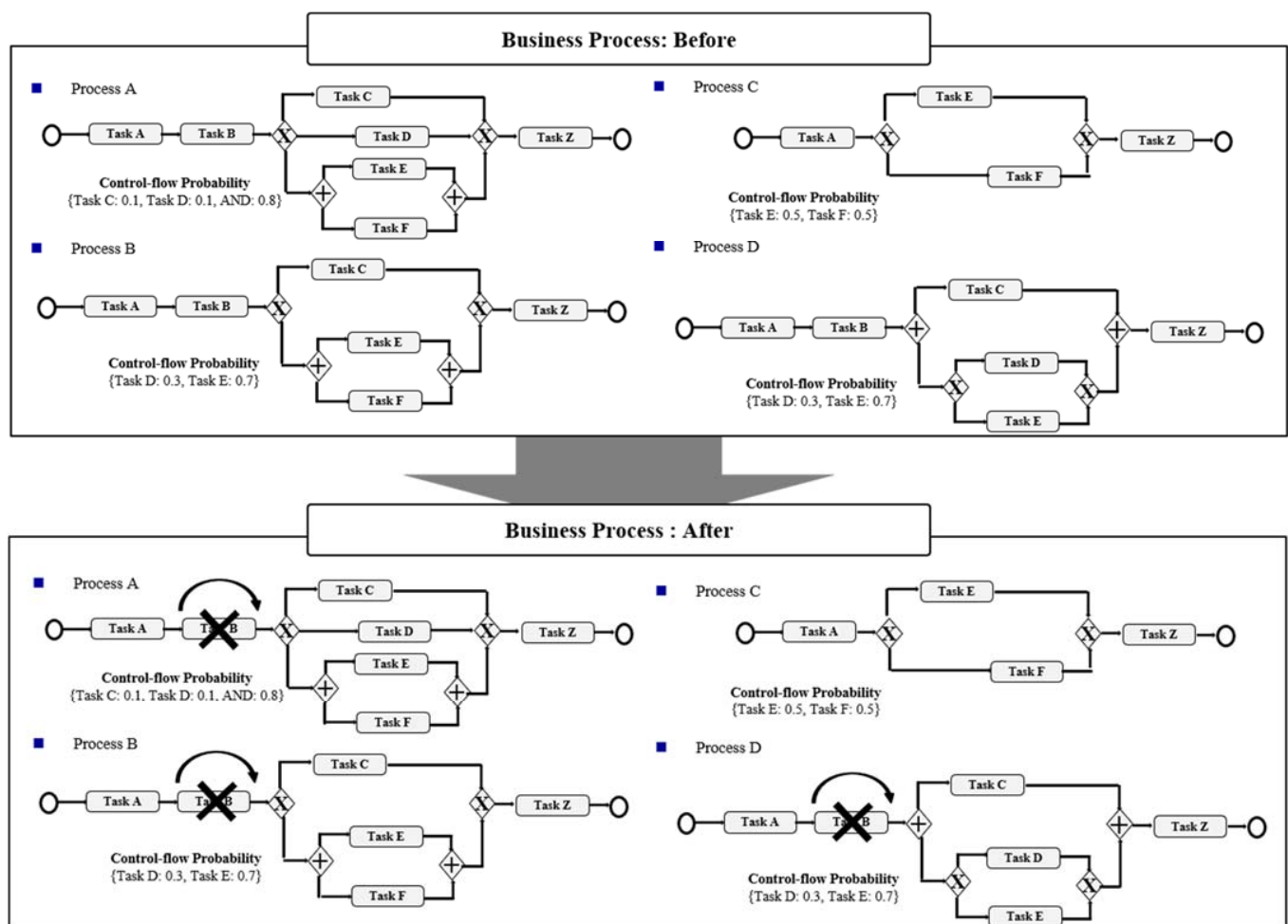


Figure 8. Base and streamlined business processes.

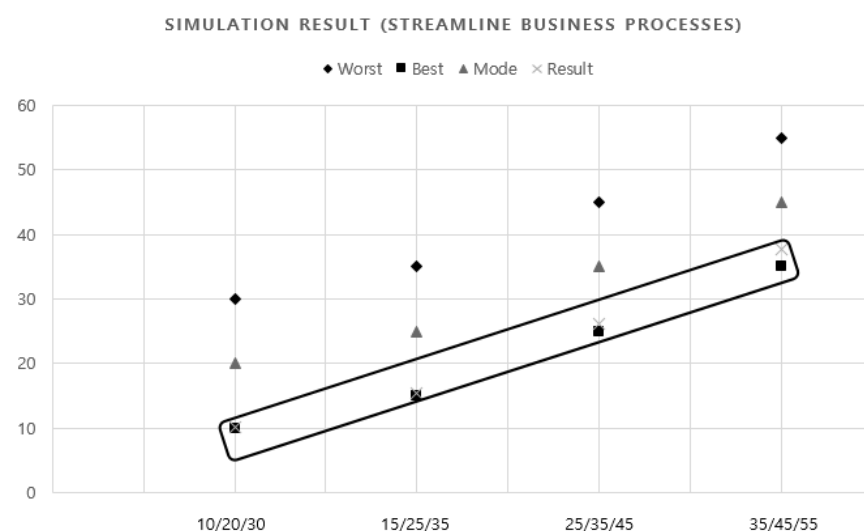


Figure 9. Simulation results (streamlining of a business process).

5.3. Efficient Human Resource Allocation for Non-Face-to-Face Business Operation

Human resource reallocation is one of the primary measures companies can develop for efficient business operations. The key to the alternative suggested in this study is that the optimal human resource allocation may differ between face-to-face and non-face-to-face tasks. Therefore, a simulation was conducted by re-allocating human resources to achieve

the highest efficiency when performing non-face-to-face tasks, which may not necessarily be the optimal human resource allocation for face-to-face tasks.

The data modification was made to reflect efficient human resource relocation in the simulation (Figure 10). First, considering the grouping according to the performer's ability in the non-face-to-face work environment, specific tasks were reassigned to the most efficient performers. A new performer was assigned to replace Performer 1, which had poor work performance in a non-face-to-face work environment, and human resources were reallocated in consideration of the task pool possessed by each performer to perform each task most efficiently. The rest of the conditions were the same, and the simulation results after changing the above two conditions were as shown in Figure 11.

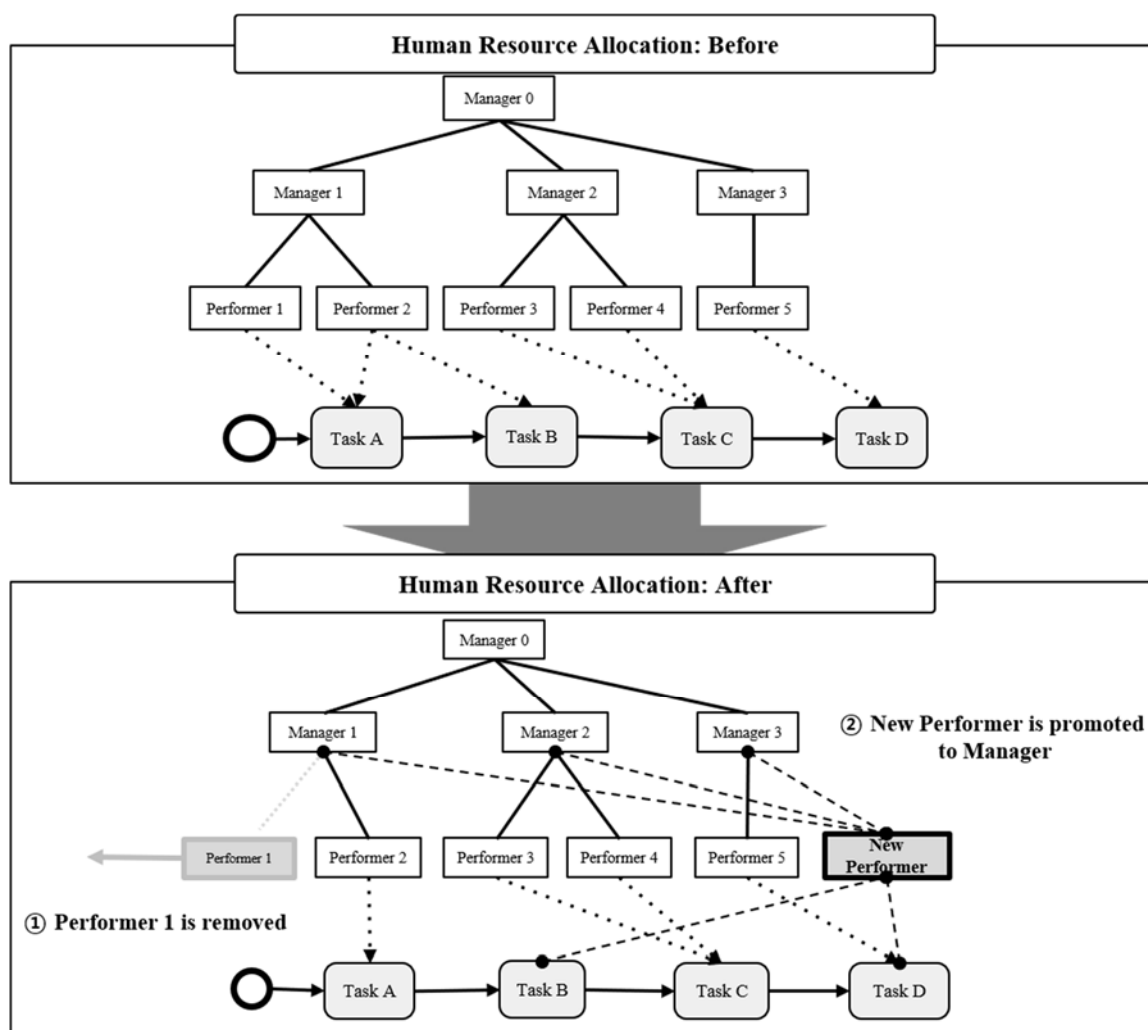


Figure 10. Base and reallocated human resources.

After reallocating human resources, the delay rate was significantly reduced compared to the Mode value. This suggests that reallocating human resources that have changed in the existing face-to-face work environment to a non-face-to-face work environment significantly affects efficient work processing.

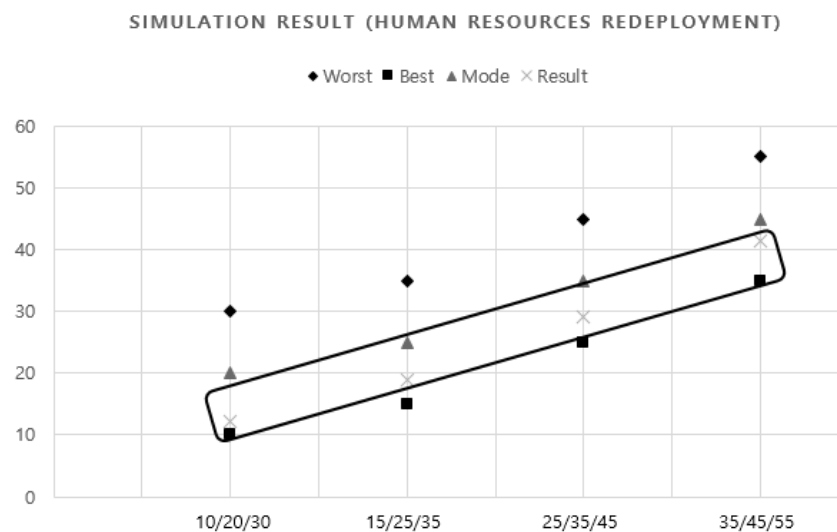


Figure 11. Simulation results (reallocation of human resources).

6. Conclusions

This study predicted the impact of the ontask work environment through enterprise simulation, presented guidelines for overcoming possible problems, and verified the effectiveness of alternatives. A performance measurement model in the ontask work environment was presented to quantitatively predict the impact of the ontask work environment on the organization. The total task cycle time was divided into execution time, approval/assignment time, and negligence time.

In this study, three cases were assumed for enterprise simulation to demonstrate the effectiveness of the approach of analyzing the impact of the ontask work environment. The presented enterprise simulation used the proposed performance measurement model to consider the impact of the ontask work environment. Consequently, delays that exceeded the average delay rate assumed by the company occurred in all cases. Therefore, the effects of the ontask work environment cause a more significant delay than the average delay caused by performers or managers. The organization must be aware of this and prepare countermeasures accordingly.

This study proposed problem-solving guidelines in three aspects (business process, organizational structure, and human resource allocation) that can be applied when the ontask work environment is predicted to negatively impact. Mainly, this can significantly mitigate the negative impact of telecommuting by improving business processes, organizational structure, and human resource allocation. Companies can efficiently make informed decisions by comparing several problem-solving guidelines.

In this paper, it is suggested that simulation result values exceeding the average delay set by us were derived in the case of the ontask work environment. This study has a limitation in that real data cannot be used for enterprise simulation. However, the data used for the enterprise simulation in this study was set based on standard working hours (maximum 8 h) in accordance with the Labor Standards Act of South Korea. This is not as much as real data, but it is set enough to verify the feasibility of the model presented in this study. Our research team is collecting survey data from IT startups and large enterprises that have rapidly transitioned to the ontask work environment. Therefore, it is expected that future studies will be able to more clearly verify the presented BP-OS model using real data. Furthermore, based on the simulation results, the delay relationship between the input parameters included in the BP-OS model will be investigated using SEM (Structural Equation Modeling). It is expected that an advanced BP-OS model can be established through the delay relationship between the factors.

Through the BP-OS performance measurement model and enterprise simulation results that can be applied to the ontask work environment, companies can actively and

rationally respond to changes when adopting the onctact work environment. It enables the company's smooth operation, such as replenishing the workforce in advance based on predicting a workforce shortage. It also prevents social problems such as industrial accidents due to failure to predict changes in the onctact work environment. This study is expected to become a cornerstone of research necessary for corporate human resource management in the era of non-face-to-face work, with COVID-19 and post-COVID-19, by modeling the influence of companies in the onctact work environment.

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