Decision Support for Management of Agents’ Knowledge and Skills with Job Rotation in Service-oriented Organization

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Abstract

Service-oriented organizations have the properties that their main resources are the knowledge and skills of service agents, and they produce intangible outputs, while those of manufacturing organizations are tangible products. So managers in the service-oriented organizations have taken “seat-of-the-pants” approaches to evaluate their new policies for preventing productivity slump. The purpose of this paper is to model service agents and tasks in a specific service-oriented organization through a field research, and to provide helpful information from the viewpoint of creating multi-skilled agents for the managers, who wish to make an accurate policy relevant to job rotation, through agent-based social simulation (ABSS) with the model.

1. Introduction

"Services" have been defined in many conventional studies. For example, some well-known definitions are as follows:

- A change in condition or state of an economic entity (or thing) caused by another [11]
- An activity or series of activities of a more or less intangible nature that normally, but not necessarily, take place in interactions between the customers and the service providers, which are provided as solutions to customers' problems [10]
- A time-perishable, intangible experience produced for a customer acting in the role of co-producer [6]

As will be noted from the definitions, a service is generated through the interaction between customers and service agents and it consists of combination of customer requirements and tacit knowledge [15] as intangible experience.

From the service characteristics, service-oriented organizations have different properties from those of manufacturing organizations. Here, the manufacturing organizations represent the producing departments which are composed of many workers assembling products. So we regard marketing and distribution departments in the manufacturing organization as the service-oriented organizations. Service agents produce intangible outputs, while those of manufacturing organizations are tangible products [4].

The workers in the manufacturing organizations need to gain the knowledge to assemble products. However, the knowledge for assembling products can be more easily formalized as explicit knowledge (e.g. Preparing an official procedure manual) than the knowledge for offering services for different customers. Product workers require common skill sets for developing the same product, while service agents have to conduct different problem solving for handling different customer demands. So the knowledge required in the service-oriented organization is accumulated in each service agents through their customer contacts. As a result, each operation in the organization will be gradually dependent on the individual knowledge. Consequently, if a service agent with important tacit knowledge for providing a service suddenly leaves the organization, the performance of the organization would be significantly reduced.

Since the 1990s, most countries have developed into service-oriented economies. Nonetheless, there are few studies concerning knowledge management in service-oriented organizations. Hence, it is very important for many organizations to provide a new type of academic findings, instead of the conventional theories of manufacturing systems, based on the properties of service. IBM formed a new research group in 2003, named Almaden Services
Research, to gain a deeper understanding of the problems faced by service-oriented organizations. Then, the group developed a new academic field, which is called “Services Science Management and Engineering (SSME) [12][19][20].” The role of SSME is to create a new approach instead of conventional “seat-of-the-pants” approaches, which have resulted in low productivity in service in many cases. The central concept raised by SSME is S-D logic, which views applied, specialized skills and knowledge as the focus of economic exchange and is one of the fundamental foundations upon which society is built [24]. Therefore, organizations need to have knowledge-workers who can create value with customers and others for achieving high productivity and high quality services.

In this paper, we focus on the problem of knowledge management in service-oriented organizations. Then, we provide a new approach to analyze the effects of policy alternatives in the service-oriented organizations by using a field research method and agent-based social simulation (ABSS) [16][17]. For verifying the effectiveness of our approach, we target a specific service-oriented organization that has the problems relevant to agents' knowledge and skills as we mentioned above. The organization is namely a department in a company providing a customer relation support service, which is one of kind of service business. The managers in the organization want to create and manage various knowledge for preventing productivity decline. However, the managers have encountered difficulties in sharing the knowledge created from a service agent. The main reason is that such knowledge is generated from his/her own experiences of activities satisfying individual customers’ demands. As a result, each individual operation in the organization is dependent on individual know-how, which is largely classified into tacit knowledge. The service agent, who does not have the knowledge to satisfy a customer demand, has to consult with other agents or a supervisor. So the agents or supervisor, who are asked by the agents, necessarily spend the time to teach the agent how to satisfy the demand. As we mentioned above, the problem situation is one of the major concerns when approaching to the service-oriented organization. The managers in the organization do not know how to handle the situation. To support the managers' decision making for handling the situation, we apply our new approach to the organization. As a first step, we focus on "job rotation" as a knowledge management policy to improve the situation in the organization. The main reason is that the job rotation was the main concern of the manager of the organization where we performed the field research.

The job rotation contributes to enabling workers to become multi-skilled and then to run productions smoothly in the case of generating risks [13]. Conventional research relevant to job rotation has mainly targeted manufacturing organizations and focused on the operators' health such as lower back pain [7] and the severity of lifting tasks [23], and the boredom of the operators [2][14]. The latest research concerning job rotation [1] mathematically modeled workers’ skills. The research focused on the effects of some job rotation policies as rotation intervals to the productivity in an organization. If a worker stays too long in one department, he/she might lose many kinds of skills. On the other hand, if the rotation is conducted too frequently, the worker might have to spend much of his/her time adapting to new tasks. Hence, this is a tradeoff problem between the benefits of long and short intervals, which is also our concern in this paper.

In the service-oriented organizations, service agents are required various knowledge to satisfy heterogeneous customer demands. They cannot know when customers’ demands are generated in the organizations. A knowledge acquisition behavior of a service agent for satisfying a demand affects the productivity of other agents or a supervisor. Models for service-oriented organizations should essentially represent such complex interactions of service agents, knowledge and customer demands. This requires to describe in a bottom-up manner a model of micro interactions. Thus in this paper, we use an agent-based social simulation (ABSS) to represent the problem situation. In particular, the ABSS can provide a way to analyze complex behavior of service agents affected by essentially uncertain factors in social complex systems.

The purpose of this paper is to build a service agent model, including knowledge and tasks, and a task model, which represents customer demands, for conducting a simulation to provide helpful information for managers who wish to make an accurate policy relevant to job rotation in a specific target organization. To determine necessary and sufficient model components and variables for describing a specific situation of concern, as the first step of modeling we conduct detailed field research related to the managers’ problems and service agents’ works in the target organization by using ethnographic approach. The approach is effective to analyze a potential problem situation that cannot be revealed by using normal interview method in the organization. After that, we build an agent-based model based on the result of the field research and
conduct a scenario analysis [8], which is one of useful methods in ABSS, to support the manager's decision making.

This paper is a new attempt with a combination of field research and ABSS in the quest for new findings on knowledge management problems in a service-oriented organization. Moreover, practical application of ABSS to the specific organization has never been conducted in the research field of ABSS.

The rest of the paper is organized as follows. Section 2 explains the research process and methods such as the field research and ABSS. Section 3 identifies the problem situation of the target organization and model components and structures by analyzing the results of the field research. Section 4 shows the service agent model and the task model. The models are built based on the analysis results in Section 3. In Section 5, we explain the method of model parameters settings. Section 6 describes the simulation results using some scenarios. The simulation is conducted by using the scenario analysis method. Section 7 verifies the effectiveness of our approach through discussion with managers. Finally, Section 8 concludes the paper.

2. Methods

In this paper, we apply the two kinds of methods, which are “field research” and “ABSS,” for analyzing the job rotation policies in a specific service-oriented organization. The research process is as follows. First, we identify the problem situations of our target organization and managers’ issues about knowledge management through field research methods such as interviews and behavioral observations with regard to managers and some service agents in the organization. Second, based on ABSS methodology, we build a service agent-model and a task model as an organization model, and then estimate the model parameters through an additional interview survey and questionnaire survey. Finally, we analyze the effectiveness of some job rotation policies by using the scenario analysis method, which is one of the useful methods in ABSS.

2.1. Target organization

We selected a department of a computer maintenance company in Japan as our target organization. The reason is because a contract renewal service of the department has the typical features of service business as described in the previous section. The department has 2 or 3 divisions and each division has from 5 to 7 service agents. In the organization, service agents renew contracts based on customers’ requirements. There are very many service profiles to define a contract of services, and they require a volume of knowledge to set a contract appropriately. Some customers request customized services to fit their business environments and new combinations of service profiles are created. Therefore, a great amount of effort is needed to maintain the service knowledge in the department. So each operation in the organization is dependent on individual know-how and the managers cannot think a good way of describing a useful manual. If an agent cannot correspond to a customer demand because of the lack of knowledge, he/she consults with other agents or a supervisor. After that, the agents or the supervisor, who are questioned by the agent, necessarily spend the time to answer the question. In particular, if a high-level agent has many queries from other agents, the productivity in the organization declines. So the increase of an agent's productivity cannot always increase the organizational productivity.

2.2. Field research

In our approach, the field research plays the two important roles. First role is to identify the problem situation in the target organization. Second role is to extract the model components and structures and the parameters to represent the problem situation in the target organization by using ABSS. So we need to analyze the relationship between agents’ knowledge and customer demands, and the knowledge acquisition process in detail. However, conventional agent-based analyses have not described the model of the specific service-oriented organization, because intangible nature such as the knowledge exchange between service agents could not be structured easily.

So we apply the ethnographic approach to extract the model structure, which the approach is one of the promising ways to understand the intangible and tacit nature of service work. Ethnography is originally a study method of anthropology, understanding different cultural from the insiders’ points of view [3][21]. It is not an easy task to clarify a tacit view of culture that people take for granted as everyday usual activities.

Ethnographic study consists of the following three phases. In the first step, research questions and target work are defined. In this research setting, we focused on the knowledge activity of service work, such as how knowledge is created and acquired by service agents and what kinds of knowledge are interchanged among service agents and managers. Secondly, we observe people as they work in their natural settings.
Ethnographic interview [21] is also an effective way to collect a variety of episodes in a short time period of study. Interviewers are encouraged to talk with informants to collect stories of their service scenes. In the final stage, we analyze the collected episodes to discern knowledge flow and tacit problems that are hardly uncovered by closed-ended questions.

Likewise, the ethnographic study contributes to not only the identification of the problems in the target work but also of the structure and parameters of our agent model. So, this field research has the key role to describe the agent-based model in the specific service-oriented organization.

2.3. ABSS methods

Agent-based models are used to analyze the system having following features: 1) autonomous agents make a decision based on their internal model and interact with other agents; 2) macro system behaviors are observed as emergent properties; 3) the micro-macro link is formalized as the process of interaction between agents and their environment. So ABSS has essentially the complexity of interaction among model elements and the uncertainty generated by environment elements. By using the ABSS, we can describe in micro- or individual-level activities and interactions and provide deeper findings in a complex social system.

Conventional mathematical models in job rotation literature are useful for analyzing some policies in manufacturing systems. However, they cannot sufficiently describe the emergent phenomena observed in our target systems, which are service-oriented organizations that have the mechanism of knowledge exchange between service agents and the uncertainty of generation of customer demands as we mentioned above. So we build an agent-based model to analyze our target service-oriented organization.

After building the model, we conduct a simulation to provide useful information for the managers' decision support. The latest ABSS research pointed out that valid ABSS does not predict exactly what will happen in the future, but rather provides a set of potential outcomes to consider [16]. Thus, ABSS helps in making “better-informed” decisions by increasing knowledge about a target system [17].

2.3.1. Agent-based modeling  Agent-based models have been used for many different purposes, including to explain basic social mechanisms and norms, to describe the characteristics of a particular social behavior and to generate a specific behavior in a specific target system. Gilbert [8] classified agent-based models into Abstract Models, Middle Range Models and Facsimile Models. Most agent-based organization models built in conventional studies can be classified as Middle Range Models, ones that can provide common findings and dynamics in various organizations rather than just in a particular organization. Hence, the conventional models cannot sufficiently support managers who wish to assess the effectiveness of some typical policies relevant to job rotation in his/her organization. In this paper, we attempt to model a specific organization through detailed field research as described in Section 2.2.

2.3.2. Scenario Analysis. The ABSS generates different possible behaviors for every run in a simulation experiment due to the uncertainty and complexity in a complex social system. So, it is difficult to analyze the data generated by the simulation. The latest research [22] introduced into ABSS a useful analytical method called “scenario analysis” in which all of the results of every run are described without modification. The scenario analysis consists of two steps. First, the analyst focuses on system changes generated by all scenarios from a macro view point. The useful analysis method in the first step is to draw a landscape of the possible outcomes under the considered uncertainties [9]. This landscape illustrates the possibilities or tendencies of a system’s changes after implementing each policy alternative, but not “an optimal value” or “an exact prediction.” Second, the analyst investigates the system changes in detail from a micro viewpoint by observing the learning processes of agents’ internal models. This analysis method, called “micro dynamics analysis,” can be expected to play an essential role in the deep and, as far as possible, rational understanding of various system behaviors [18]. In this paper, we also analyze simulation results through the two steps, and then support the managers in our target service-oriented organization where it is difficult to predict quantitatively the impact of the policies that the managers consider.

3. Analysis of field research results

Based on the result of our field research, this Section firstly shows the problem situation in our target organization. The situation is also used to determine the conceptual model, which is represented model components and structures. Then, we have to confirm whether our simulation can represent the situation. Second we identify the components and structures of our simulation model which are described in the next section. Most of conventional
agent-based organization models were described by using only a problem situation or conventional theories, because they could not correspond to field research data in a specific organization. Consequently, the conventional models cannot sufficiently support managers in the specific organization.

3.1. Identification of a problem situation

According to the field research method in the previous section, we first identified research questions and target work. The research question is derived from our concern as described in Section 1. Research question: what is the appropriate job rotation policy to enable service agents to become multi-skilled for maintaining a certain level of productivity in the case of a shortage of manpower due to an increase in orders or the opening of the organization? Target work is described in Section 2.1.

Second, we observed the service agents’ behaviors such as service offering, knowledge acquisition and interaction with other agents. Then, we interviewed the managers and the service agents for the identification of a problem situation in the department. Finally, we could find the problem situations in the organization as follows.
1. The existing work manual, which is described basic service offering procedures, is not helpful in satisfying most customer demands, because the interactions between service agents and customers often generate new customized services in the department.
2. Although the managers in the department keep in mind that they should update the existing work manual or newly introduce a database, they tend to postpone the update or introduction because they cannot think of a good way to execute them.
3. The number of customer demands varies at different periods as shown in Fig.1, and in a busy period, the managers bring in some agents from another department for satisfying all demands.
4. There are different levels of skills among service agents, and the entry level agents often have to ask other agents or a supervisor (SV) in the department to satisfy some demands.
5. The agents, who have high skills, tend to spend time teaching the entry level agents how to satisfy customers’ demands.
6. When an agent leaves the department unexpectedly, the knowledge of the agent cannot be inherited to other agents.
7. Although the managers tried to conduct job rotation in the department, the agents transferred to another department could not learn the skills efficiently. As the result, the education costs for re-learning knowledge and skills are generated.

From the problem situation, the managers wish to make an accurate policy relevant to job rotation, which the policy enables agents to become multi-skilled. Through our interview-based surveys to other service-oriented organizations such as a call center and an accounting department, we could observe the similar situation with our target organization in this paper. So we consider that the problem situation is generated commonly in many service-oriented organizations.

![Figure 1. Transition of the number of tasks (customer demands) for a month](image)

3.2. Identification of model components and structures

Next we analyze the field research results to identify components and structures of our simulation model which are described in the next section. Most of agent-based organization models in previous research have been built based on conventional theories and existing qualitative data. Hence they are described mostly at abstract levels in terms of model resolutions. On the other hand, we determined the model components and structures through detailed field work in the actual organization.

First, we analyzed basic service offering procedures to identify the components of tasks and the relationship between the tasks and agents' knowledge. For the analysis, we used existing documents such as work manuals and instructions and the results of interview-style survey. As a result, we created a data flow diagram (DFD) relevant to basic service offering procedures. Figure 2. shows a part of the whole DFD of the procedures. The purpose of using DFD is to determine only basic functions of the procedures involved and the relationships between them for an organization.
model. DFD is therefore selected because it is enough and simple for describing them. This partly validates the way that our organization model is constructed. Other modeling languages that have more descriptive power such as UML or IDEF1 are not necessarily applied here.

![Diagram](image)

**Figure 2. A part of the whole DFD relevant to basic service offering processes**

Next, we asked some questions of service agents and a supervisor in the department. First, we checked with them regarding the correction of the whole service offering procedures and the difficulty level of each function in DFD. Then, we estimate kinds of knowledge required to resolve each function. As a result, we identified 17 basic service procedures, which are called "tasks" in our model. Each task is composed of some functions in DFD, which are called “unit tasks.” For example, unit tasks are "confirmation of record files," and "customer information registration" depicted in figure 2. To resolve unit tasks, service agents are required to have the explicit knowledge which is described in the manual and the tacit knowledge which cannot be described in it. The agents, who do not have the tacit knowledge to resolve an unit task, need to acquire the knowledge from other agents or the supervisor. Second, we asked service agents about their resolution time of some typical tasks at 3, 6, 12 and 24 months after joining the company. As a result, we classified the learning curves of agents into three types.

In addition to the interview, we analyzed the service agents’ behaviors in detail based on the observation survey. As a result, we gained the agents' knowledge acquisition process and agents' other activity flows. By using the result, we determined detailed agent model structures. Finally, we conducted a questionnaire survey for estimating the model parameters.

### 4. Organization Model

We build an organizational model (Fig.3) through the field research in the target organization, as shown in the previous section. The organization has two divisions, and division 1 has six agents who resolve tasks and a supervisor (SV) who provides knowledge for resolving tasks to agents. Our simulation analyzes only agents' skills in division 1, because the managers felt the pinch of the low productivity in division 1 and wanted to improve the productivity by creating multi-skilled agents. So we do not model other divisions in detail and create only one agent who is the target of job rotation in division 2.

$$\text{OrderTask}_k = \{\text{orderTask}_{k1}, \ldots, \text{orderTask}_{k,17}\}$$

![Diagram](image)

**Figure 3. Summary of Organizational Model**

Generated tasks are assigned to agents in division 1 and each agent resolves the tasks. If the agent does not have the knowledge for resolving a task, he/she asks the SV or other agents how to resolve the task so that he/she can acquire the knowledge. After that, they spend time, which is calculated based on his/her skills and the difficulty of the task, for resolving it.

#### 4.1. Task model

A task means a service order, concerning a contract renewal, based on customer demands. The order task $\text{OrderTask}_k$ consists of unit tasks $\text{unitTask}_j$, 

$$\text{OrderTask}_k = \{\text{orderTask}_{k1}, \ldots, \text{orderTask}_{k,17}\}$$

![Diagram](image)
for each order task index $k \in \{0,1,\cdots,17\}$ and each unit task index $j \in \{0,1,\cdots,50\}$. So $\text{OrderTask}_k$ is expressed as a binary vector as follows.

$\text{OrderTask}_k = (\text{orderTask}_{k,1}, \cdots, \text{orderTask}_{k,j}, \cdots, \text{orderTask}_{k,50})$

where $\text{orderTask}_{k,j} =
\begin{cases} 1 & \text{if unit Task}_j \text{ is an element of } \text{OrderTask}_k \\ 0 & \text{otherwise} \end{cases}$

Every order task has different probabilities of its generation. Each unit task has a different difficulty $\text{difficulty}_j \in \mathbb{R}$ which affects agents’ resolution time. The relatively easy tasks, which are associated with higher generation probabilities, are assigned to entry-level agents. Other tasks are assigned to the agents who have intermediate-level or high-level skills.

Based on the analysis in Section 3.2, we can set the model parameters concerning tasks such as the difficulties of tasks and the relationships between order tasks and unit tasks. This shows that various knowledge can be needed to resolve the tasks.

### 4.2. Agent model

The internal model of agent $i \in \{1, \cdots, 6\}$ is defined by $\text{IM}_i = (\text{knowledge}_{i,j}, \text{skill}_{i,j})$, where $\text{knowledge}_{i,j}$ represents whether or not agent $i$ has the knowledge for resolving $\text{unitTask}_j$, and $\text{skill}_{i,j}$ shows the degree of proficiency in resolving $\text{unitTask}_j$ of agent $i$. If agent $i$ has $\text{knowledge}_{i,m} (=1)$, he/she can resolve the $\text{unitTask}_m$. When agent $i$ does not resolve $\text{unitTask}_m$ for a 5-day period, $\text{knowledge}_{i,m}$ that is 1 is set to 0, which means the forgetting of knowledge.

Agent $i$ learns a skill corresponding to a unit task as he/she solves the unit task. The value of $\text{skill}_{i,j}$ is determined based on the value of experience in resolving $\text{unitTask}_j$ as shown in the following learning curves (Fig.4).

![Figure 4. Learning Curves](image)

We determined the learning curves based on the interview with the service agents in the target organization. If agent $i$ solves a unit task, a constant unit value is added to the value of experience in resolving the unit task. Thus, the more agent $i$ resolves a unit task, the more he/she gains the value of experience.

The resolving time of $\text{unitTask}_j$ is calculated based on $\text{difficulty}_j$ and $\text{skill}_{i,j}$ as shown in the following equation.

$$\text{Resolving time} = \frac{\text{difficulty}_j}{0.8(\text{skill}_{i,j} - 0.5) + 1}$$

Since the interview with the managers revealed that agents took about 2 years to improve their skills to high- or professional-level from entry-level, we developed the above equation for representing the interview results.

As with knowledge forgetting, a skill forgetting phenomenon also occurs in our model. We gained data, from the analysis in Section 3.2, that service agents who have high-level skills return to an entry-level skills if they do not resolve tasks for three months. To satisfy the data, we set the number of resolving a unit task of an agent to be reduced if he/she does not resolve the unit task for a constant time. In the case that he/she relearns the skill for resolving a unit task, the corrected unit value increases the current experimental value. This implies that the learning speed of skills increases in the case of relearning.

### 5. Parameters settings

This section estimates model parameters based on the field research results. We made it clear in the interview with the managers that the number of tasks increases at month-end and month-start. However, detailed data on daily task generation was not gained through our field research. One of the methods of estimating model parameters in ABSS is to reproduce the phenomenon accepted by most stakeholders, called “stylized facts” in the target system [5]. So, we calibrate the number of daily tasks through reproducing the following three situations recognized by most members in the division: 1) although an entry-level agent in other divisions is invited to help the division during the busy period such as month-end and month-start, there remain some unresolved tasks; 2) during the slack period, all daily tasks are resolved by agents and agents have idle time; 3) the rates of tasks resolved within 2 days after generating them fluctuate between 70-90%. In the simulation, we set the parameters of number of daily tasks and confirmed the reproduction of the situations. Figure 5. shows that our model using the parameters could reproduce situation 3).
6. Scenario analysis

This section conducts a scenario analysis relevant to the job rotation policies in our target division. In Section 6.1, we define the job rotation policies as scenarios used in the simulation. In Section 6.2, we show possible skills’ changes after implementing some job rotation policy alternatives under the problem situation in the division.

6.1. Job rotation policies

In our research, we define a job rotation policy as the combination of a rotation interval and a target agent transferred. As we mentioned in Section 4, this paper considers only the knowledge and skills relevant to tasks generated in division 1, and there is only one agent in division 2. So, we set a rotation interval and a target agent in division 1 as a job rotation policy. In this paper, we fix the agent who has medium-level skills in division 1 as a target of transfer, because the managers in our target organization said that it would be hard to think that a high-level skill agent would be transferred to another division due to the productivity in division 1 being relatively low compared with other divisions. So, this paper considers only following some rotation intervals as policy scenarios used in the simulation. Policy scenarios (job rotation interval): Scenario 1) 1 month, Scenario 2) 2 months, Scenario 3) 3 months and Scenario 4) 4 months. In the scenario analysis, we add Scenario 5) to the four policy scenarios for comparison, where the managers do not rotate agents in the divisions.

6.2. Scenario analysis for agents' skills

Job rotation contributes to enabling agents to become multi-skilled. So, this paper analyzes the effect of job rotation from the viewpoint of skills. First, we focus on the skills generated by all scenarios from a macro viewpoint. Then, we simulate 100 trials for each scenario, and calculate a sum of the skills’ values of all agents. After that, we describe a landscape of the sum of skills’ values by plotting the results of all 100 trials in each scenario and a dotted line connects the average rates of the 100 trials in each scenario (Fig. 6). Figure 6. shows that the sum of skills’ values in every policy scenario using job rotation is higher than in the scenario where a job rotation policy is not conducted. Hence, the job rotation policies could achieve the creation of multi-skilled agents.

In particular, Scenario 3) shows the highest average value of skills in all scenarios. Next, we investigate the reason for showing the value by focusing on a dynamical change of skills in each agent. We focus on trials that show typical agents’ behaviors in Scenario 1) and Scenario 3), respectively. Figure 7. and 8. show the transitions of skills of the agent who was targeted as transferred in Scenario 1) and Scenario 3), respectively.

In the case of Scenario 1) which is the short interval, the target agent in division 1 is transferred to another division before gaining high-level skills. As a result, he/she is prevented from gaining adequate growth of skills. On the other hand, the agent tends to relearn his/her skills, in the case of Scenario 3), because he/she is transferred to another division after learning high-level skills efficiently. So, he/she maintains the high-level skills despite that he/she is targeted for transfer in the job rotation. However, Scenario 4), which is the longest interval, shows a lower average value of skills than in Scenario 3) in Figure 6. The reason is that other agents, except the agent targeted in the job rotation, lose the opportunity for learning skills, because he/she continues to learn skills in division 1 even though the value of the agent’s skills moves toward the maximum values.
7. Discussion with managers

To evaluate our analysis, we discussed the results of the scenario analysis with the managers. Then, we received all sorts of comments such as, “the simulation plays a part in communication when discussing concrete policies,” “the simulation results lead to new discoveries such as organizational problems and business challenges” and “the simulation provides new findings to think from various perspectives.” The comments indicate that the simulation results, such as possible outcomes and micro dynamics of agents' skills visualized in the scenario analysis, provided managers in service-oriented organizations with the materials for discussions about new policy alternatives.

As an additional discussion with managers, one of the managers said some questions such as “could the division achieve a target of productivity even if we do not have an agent who has high-level skills?” and “could the division whose ratio of entry-level agents and high-level agents is 50:50 achieve the target of productivity?” So we plan to focus the composition of agents in the division as scenarios in the future. Likewise, our approach contributes to not only evaluating policy alternatives but also finding new research questions and scenarios.

8. Conclusion

This paper focused on the job rotation policies that contribute to enabling service agents to become multi-skilled in a service-oriented organization. Although conventional research exists relevant to job rotation policies, it is mainly focused on manufacturing systems, which have different properties from service-oriented organizations. Based on the result of our field research, we found out that the various tacit knowledge in service-oriented organizations can be needed to resolve tasks and informal knowledge propagation between agents can be observed. The findings mean that the service-oriented organization has high complexity derived from the agents' interactions. Then, the managers cannot learn much about the uncertainties of customer demands generations, and agents’ learning level affected by the demands generations. As a result, the managers have to perform uncertainty-based analysis for the complex organization system.

For the analysis, we build an agent-based organization model to consider the complexity and uncertainty. Most of previously developed agent-based models of organizations have been described only based on theoretical findings or a simplified problem situation. The important feature of our approach is to target a specific service-oriented organization and to build a task model and an agent model, which includes knowledge, skills and knowledge flow, based on the detailed field research as shown in Section 3.

The approach can be useful for providing the possible outcomes under the considered organization’s uncertainties. In this paper, the scenario analysis showed the landscape concerning the change of agents’ skills in the organization and investigated the cause of the landscape by focusing on agent’s parameters. Hence, the managers can evaluate their policy alternatives before implementing them. Here we should emphasize that the purpose of our simulation is not to predict a future change in the organization. The biggest contribution of the simulation results is to help the managers in making “better-informed” decisions, as explained in [17]. Then, as we mentioned in the previous section, the managers could find new research questions and scenarios. Thus, we conclude that our approach could support the managers, who
have taken only “seat-of-the-pants” approaches, in service-oriented organizations.

However, the simulation in this paper shows results in only a small portion of considered scenarios, because it is an initial attempt to analyze service-oriented organizations with the new approach. The future direction of this study is to enhance our model for analyzing other problems in service-oriented organizations such as the design of a personnel assessment system and the introduction of a new information system. For example, in the department that we surveyed, a high-level agent has a heavy workload because he/she is often asked how to resolve tasks by other agents who have entry-level skills. As a result, he/she cannot increase the number of resolving tasks. So, one of the solutions for the problem is to introduce a new information system, which can provide information such as “know-how” about how to resolve a task.

9. References