Field-Oriented Service Design: A Multiagent Approach

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Abstract Service has been considered as value co-creation through the cooperation of service providers and customers. This paper, however, focuses on service design in problem fields where complex issues exist among various stakeholders, where identifying service providers and customers is not a simple process. In other words, we focus on a very early stage of service design with huge ambiguities; we call it *field-oriented service design*. A typical case is introducing new services in developing countries. The main issue here is to create new services compatible with existing services through action research that considers a wide variety of regional, national and global stakeholders. It is often difficult to identify the influence of/to the services to be designed due to the differences in culture, language and business customs. As a result, unexpected interdependencies among services together with stakeholders are often revealed during the process of action research. To resolve this ambiguity in the design process, we propose a multiagent approach that couples role playing games with participatory simulations; it is based on our experiences in agricultural support projects in Southeast Asia.

Keywords Service design • Field informatics • Multiagent system • Role playing game • Participatory simulation • Gaming simulation

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1 Introduction

Service has been defined as value co-creation among service providers and customers [1]. However, it is often difficult to identify service providers and customers at the very early stage of service design. To fully reflect the various behaviors and requirements of customers, it is necessary for service designers to identify the individuals or organizations that really are involved [2]. When getting into real fields that are bedeviled by complex issues, service design tends to become a process of trial and error due to the lack of local information.

Let us consider the example of agriculture support projects that are intended to understand agricultural economics, increase productivity, reduce environmental burdens and so on, in developing countries. The process of service design for such projects often adopts a PDCA cycle, with the phases of design, execution, evaluation, and redesign.

In this paper, however, we introduce a vision that goes beyond the usual PDCA cycle: additional services may need to be introduced to satisfy newly recognized requirements, or existing services may need to be redesigned when hidden conflicts among them are revealed. If cross-effects are expanded among related services in both positive and negative ways, how can we grasp the whole picture needed for service design?

We note that the designed service must be sustainable at the final stage of the project [3]. In other words, it is necessary to clarify the cross-effects among new and existing services, reorganize the complex relations among them, and guarantee the sustainability of services as a whole, so as to make it easier to transfer the leadership of the project to local stakeholders.

In the area of service design, some textbooks contain various ideas and methods for customer-centered service design [4]. In this paper, however, we focus on the very early stage of service design. We introduce the concept of *field-oriented service design* based on our field experiences, show how important it is to create a contention-robust design process; we propose a *multiagent approach* for designing sustainable services in real fields.

This paper is also intended to bridge service science (social activities are understood by regarding service as the fundamental basis of exchange [1]), and artificial intelligence (realizing intelligent mechanisms by creating computational models for problem solving). The key idea of connecting the two disciplines is to view service as a social implementation of problem solving. This view can provide a theoretical background for applying problem solving technologies to service design. In particular, technologies of multiagent systems, which model collections of autonomous agents, can be adopted to understand social activities in different fields. In fact, multiagent systems have been used to analyze and simulate different kinds of social activities [5].

The following sections explain the fundamental concepts including field, problem, problem solving, and service design, and then discuss the mapping between problem solving and service design. A multiagent approach including role playing games, participatory simulations, and gaming simulations is explained in detail. Finally, two agricultural support projects in Southeast Asia will be detailed to illustrate how the multiagent approach can contribute to field-oriented service design.

2 Field-Oriented Service Design

This section starts by defining field. We then explain how to understand field-specific problems and to design services that solve those problems.

2.1 What's a Field

You may think field research is a common approach in the service design process, but the term "field" has a wide range of meanings. *Field* here is defined as follows. This definition is given by Osamu Katai [5] and reflects the tradition of cultural anthropology in Kyoto University.

> A spatio-temporal area that is hard to be mastered by any analytical and/or engineering approach due to various individuals and entities being coexistent, which causes the unexpected happening of accidental events thus necessitating our continuing commitment and care.

This definition may confuse researchers or engineers who regard analytical and/or engineering approach as their professions. The definition does not deny the possibility of using analytical and/or engineering approaches to contribute to the solution of problems in the field. However, since problems are layered due to the coexistence and interdependency, problems are spatio-temporally triggered by unexpected events. Therefore, the above definition of field suggests that designers should continue to commit to the problems, since the process of problem solving can never be fully completed. Therefore, fields are troublesome, especially for researchers and engineers, the most functionally divided professionals.

Similar discussions have already appeared in the area of design for a fairly long time. Designers used the term *wicked problem* [6] to describe the difficulties of the design situation that is encumbered with incomplete and changing requirements. Wicked problem means that solving one problem reveals other problems due to the interdependencies among problems.

In the area of artificial intelligence, the term *frame problem* [7] is used to express the difficulties of identifying the effects of actions without representing beliefs that might not be affected. Frame problem is also a philosophical proposition; is it possible to determine the boundary of knowledge and thus fully elucidate the effects of actions.

The definition of field suggests that it is a wicked problem, and the activity of service design in solving it encounters the frame problem. In the following subsections, we first discuss problems and problem solving, and then define field-oriented service design as a process of problem solving and forming problem solving organizations.

2.2 Problem Solving

Field-oriented service design deals with the process of understanding and solving problems in real fields containing complex issues. We define problem, problem solving process and problem solving organization in such situations as follows.

- A *problem* is extracted from complex issues in the field. The expectation is that a problem is always resolvable. That means a problem should be shaped to be solvable.
- A *problem solving process* is literally a process of finding solutions to problems. Since problems are already premised solvable, however, the difficulty of problem solving often lies in the process of shaping problems. In other words, problem solving and problem shaping (sometimes called problem finding) processes are two sides of the same coin.
- A *problem solving organization* is a team of stakeholders tasked with solving problems, or in other words, a team for shaping solvable problems.

As represented in Fig. 1, problems extracted and shaped from the field are often dependent on each other. In such cases, problem solving processes and problem solving organizations turn out to be interdependent. Moreover, the interdependences between problems, problem solving processes and problem solving organizations become clearer but also change as time advances.

In real fields, since problems are networked and layered, it is difficult to fix a description of any problem and to find a permanent solution. Therefore, it is essential to design flexible problem solving processes to deal with continuous problem transfiguration. In other words, problem solving in the field does not aim

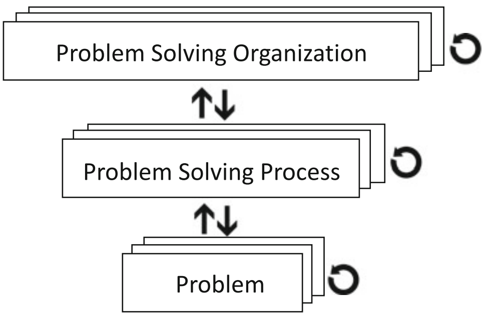


Fig. 1 Interdependency in problem solving

at solving currently known problems but at designing a continuous process for solving problems. Also, it is necessary to maintain a flexible networked organization that can handle the continuous process of problem solving.

2.3 Service Design

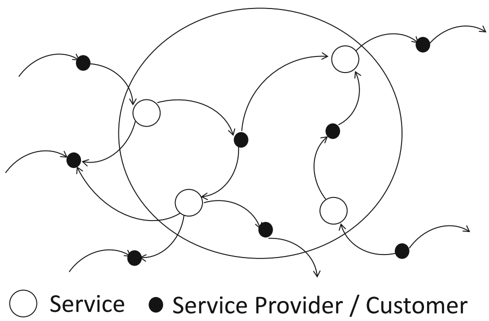
In this paper, we regard *service* as an instance of problem solving in society. Since problems are networked and layered, services to solve those problems are also networked and layered. In Fig. 2, layered white circles represent layered services, black circles represent service providers or customers, and directed arrows represent dependencies between services and providers/customers.

Since problem solving is a continuous process, the crucial issue for service design is to analyze the interdependencies among stakeholders, and establish a continuous process for designing services. In this paper, we use the term *stakeholder*, to mean a customer of some services while possibly providing services to others. Furthermore, stakeholders include not only agents who provide and consume services, but also various individuals and organizations related to the service to be designed such as funding agencies, government offices, community representatives and so on, all of who affect service design both positively and negatively.

When we consider service as the co-creation of value-in-context by service providers and customers [1], it is necessary to have an experimental basis for such value co-creation among stakeholders in the field to develop a continuous process for designing services.

We propose a multiagent approach with the intent of providing a basis for stakeholders to collaboratively conduct experiments. Macro modeling might be applied to service design, if stakeholders and their relations are fixed over time. Unfortunately, in the fields, stakeholders and their interdependencies are often altered over time. Given this, it is effective to model individual stakeholders and their interactions with a micro perspective and to adopt a multiagent approach for service design.

Fig. 2 Networked and layered services



3 Multiagent Approach

This section describes a multiagent approach for field-oriented service design. We first introduce a role playing game, and a participatory simulation that includes humans and software agents. We then propose a gaming simulation, which applies the participatory simulation technology to role playing games.

3.1 Role Playing Game

Role playing games (RPGs) are a well-known multiagent approach, where stakeholders participate in a game and mutually confirm their decision makings on a game board. There are several ways to utilize RPG as follows.

- For consensus building, RPG enables stakeholders to compromise and reach optimal decisions for the community by representing and sharing individual decisions on a game board.
- For system design, team members can learn the requirements and environments of the systems to be designed by simulating the decision processes of various stakeholders.
- For field analysis, a more accurate model of the decision processes of the community can be obtained by observing stakeholder decisions during RPG sessions.

Figure 3 illustrates the modeling process of players' decision making. An initial model is created from relevant literature and surveys. RPG sessions are conducted using a board that represents the players' environment. Decision making process can be understood based on the logs obtained during the game. The reasons behind the decisions made in the RPG are exposed by interviewing the players after the game. Finally, the decision making model is refined by analyzing the RPG log data and the interviews. Running the RPG several times can improve the obtained models.

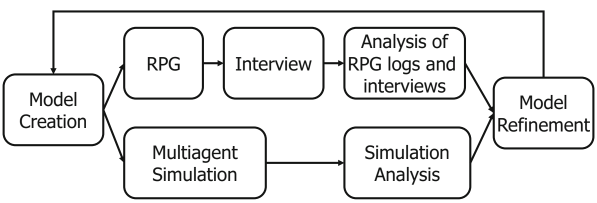


Fig. 3 Modeling farmers' decisions [9]

3.2 Participatory Simulation

Multiagent simulations are getting popular as a method of micro simulation in various research areas. In multiagent simulations, agent behaviors are determined by scenarios, which can either be described by programming languages or scenario description languages with embedded decision-making models. The scenario processor interprets agent scenarios and requests agents in a virtual space to perform sensing and acting functions.

Participatory simulations were invented as an extension of multiagent simulations. We can easily extend multiagent simulations to yield participatory simulations by replacing some of the scenario-guided agents with human-controlled avatars. As in Fig. 4, a participatory simulation consists of (1) *agents* for modeling users, (2) *avatars* to represent human subjects, (3) *scenario*s for modeling interactions, (4) *human subjects* to control avatars, (5) *virtual space* to represent real space, and (6) a *monitor* to visualize simulations underway in the virtual space. In this situation, human subjects and agents can cooperative in performing a simulation. Just as with video games, human subjects can join the simulation by controlling avatars via joy sticks, mice, or other input devices. To analyze simulation results, we monitor the entire process of the simulation by visualizing the virtual space. Recording human behavior is useful for analyzing the simulation results and for improving the agent decision making models.

3.3 Gaming Simulation

Gaming simulation is conducted by fusing participatory simulation with RPG. Although RPG requires all the stakeholders to participate in the game, this is not always practical. Moreover, it might be more efficient for a limited design team to conduct the simulations to understand the nature of problems and services at the early stage of service design.

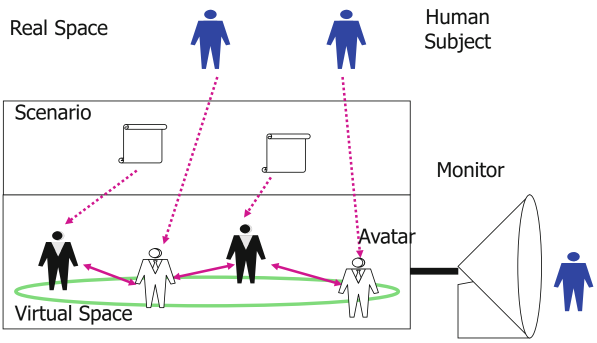


Fig. 4 Participatory simulation [11]

One of the advantages of gaming simulations is that they support seamless design activities: from internal consideration within a service design team to RPG with all stakeholders. Moreover, it is easy to deal with situations where additional services are required or conflicts occur among new and existing services. Those advantages come from the fact that multiagent simulations are a type of micro simulation [8], as is described below in more detail in a comparison with macro simulation.

Macro simulation is intended to reproduce a phenomenon based on a macroscopic viewpoint in that the entire simulation target is represented as a single model and its behavior is defined by governing equations. Macro simulations allow the observation of behaviors or changes in the overall system, but the local properties of individual elements or interactions among elements are not reproduced. For example, system dynamics are often used for macro modeling and macro simulation; they deal with internal feedback loops, stocks and flows that affect the behavior of the entire system.

On the other hand, micro simulations reproduce a complex social phenomenon by accumulating the microscopic behaviors of models of social entities including their interactions. Assuming that human society consists of a lot of decision-making entities, it seems natural to use micro simulations to predict the behavior of society. Micro simulations have manifested their ability to clearly present a variety of individual core behaviors in the reproduction and analysis of complex collective behaviors. The multiagent approach can thus straightforwardly represent the actions of individual people and organizations. It can be applied to social, economic and cultural problems rooted in human decision making and that have been difficult to hold experiments on.

4 Field Experience

The proposed concepts and approaches are based on two agriculture support projects in Southeast Asia that we joined and are active in. In these projects, RPG and gaming simulation were used at the early stage of service design. In this section, we use these two experiences to illustrate that the multiagent approach is promising for field-oriented service design.

4.1 Modeling Agriculture Economics in Thailand

The first case study illustrates how useful it is to introduce the multiagent approach in shaping a problem.

We conducted an RPG to understand farmers' land-use decisions in upper northeast Thailand in a collaboration project with IRRI (International Rice Research Institute). At that time, it was reported that while some farmers used

Fig. 5 Role playing game [9] (**a**) playing the game (**b**) RPG board

their own rice seed, more farmers bought seeds and changed seeds frequently. Since the government's production capacity was low, many organizations and companies joined in the rice seed supply system. Unfortunately, no integrated view of a comprehensive seed management system including market, government, and seed producing companies had been reported.

The first step in improving rice seed production was to investigate the farmers' decision making processes. The last three decades have seen an expansion in upland cash crops through application of the rain-fed lowland rice ecosystem. We thought the reason was that rice prices dropped while sugarcane prices remained high. This project aimed to validate such hypotheses, understand the decision making processes of farmers, and identify how land should be used in the future.

Through the RPG, we achieved the participation of stakeholders and obtained a decision making model that closely approached reality. Figure 5a shows the particulars of the RPG that reproduced the environment surrounding the stakeholder on the board. A board representing farm land was created as Fig. 5b. RPG sessions using the board were organized, and the log data of 25 stakeholders were recorded. The results of the RPG were reflected in the decision making model and then a land use simulation was run. Farmers, who had participated in the RPG, evaluated the validity of the model and the simulation.

RPGs were conducted several times in this project. Since stakeholders have not been clarified, though they are expected to include seed sellers, government institutions and companies, they were replaced by researchers in the project. Through the series of RPGs, we obtained a social network of stakeholders and the farmers' decision making processes that interacted with other stakeholders [9].

The RPG approach is flexible enough to be extended later to include delegates of government and industries to better reflect decision making by farmers. Also, more RPGs were conducted by this project in different types of villages for a comparative evaluation. Again, the multiagent approach is flexible enough to broaden the spatial area to include neighboring villages for investigating mutual impact of economic activities.

4.2 Designing Knowledge Communication in Vietnam

The second case study confirms the difficulty of shaping a problem and why we need the multiagent approach.

We have been participating in an agriculture support project in Vietnam with agriculture experts since 2011. The project aims at designing new services for multi-language knowledge communication via the Internet. The goal is to transfer agriculture knowledge from Japanese experts to Vietnamese farmers in rural areas with low literacy rate, to increase rice productivity and to decrease the environmental burdens caused by excess use of agrichemicals. The motivation of Japanese experts, who work for JICA to support developing countries, in using ICT is they cannot physically travel to all rural areas that need their advice.

There exists a huge gap between Japanese experts and Vietnamese farmers, not only in agricultural knowledge but also language and culture. Furthermore, the farmers have difficulties in using computers and indeed in reading/writing messages. Therefore, as shown in Fig. 6, a youth-mediated communication (YMC) model was proposed and applied to bridge the gap of knowledge, language and cultures [10]. In the YMC model, the children received ICT training at a local telecenter, and then acted as mediators between the Vietnamese farmers (parents) and the Japanese experts. The YMC is a breakthrough idea to bridge the gap, but it introduces another difficulty in communication: the computer literacy and background knowledge of children determine the boundaries of agricultural knowledge communication. To cope with all the problems, we formed a project including a variety of stakeholders: agricultural experts and language processing experts in universities, farmers and their children, NGOs targeting the education of children in developing countries, and Vietnamese national and local ministries.

At the beginning, we designed services for knowledge transfer from Japanese experts to Vietnamese children, where the experts are service providers and the children are customers. Multi-language knowledge communication services were developed and managed by the project. These services have been realized based on different motivations from various stakeholders. The NGO staffs working in the field were motivated to educate the children. Soon after the project started, however, we observed that the experts became more and more motivated by obtaining

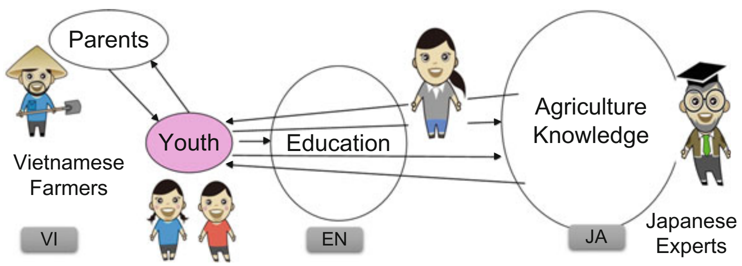


Fig. 6 Youth mediated communication

Fig. 7 Field activities (**a**) collecting field data (**b**) reading expert's advice

field data from the children: a complementary service was added where the children are service providers and the experts are customers. Meanwhile, the local government highly praised the project because they found that it became easier for them to form communities in low literacy areas. Figure 7a shows a child collecting field data, and Fig. 7b shows the local government officers involved in helping the children to read the experts' advice.

The YMC project has been highly recognized and supported by Vietnamese national and regional governments. It has resulted in community formation with local stakeholders and researchers, among which staffs from the local government are in charge of working with the NGOs to train children. During the successful project, however, we recognized the difficulties in understanding the relationships among newly created services and existing services. Here is one episode.

> One of the goals of this project is to reduce the amount of agrichemicals by enhancing knowledge communication among agricultural experts and farmers. Employees of the local government became heavily involved in the project by helping farmers' children to learn ICT. However it was found that local government workers usually work part-time, and they normally have second jobs, such as selling agrochemicals and fertilizers to farmers.

Moreover, it is also difficult to estimate the effects of services. Here is another episode.

> This project aims at increasing the yield of rice. One project member, an agricultural expert, recognized the lack of nitrogen in this particular rice field, and suggested the use of a little more fertilizer. The farmers did not follow this advice, since they believe bugs would gather from neighboring fields, if they increased the amount of fertilizer.

These episodes shows how it is difficult to shape the problem and design services in a single project. Though it is not practical to complete service design in a limited time, the multiagent approach can make it possible to deal with the unexpected interdependency of problems and services by widening the scope of stakeholders and forming a sustainable problem solving organization to continue the process of service design.

5 Conclusion

This paper proposed an approach to service design in the field where complex issues are often faced. At the very early stage of service design, it is necessary to understand the problems in the field, and propose services for solving those problems. However, designing services in a real field is always difficult due to the interdependency between problems and their changes over time. Therefore, developing a continuous problem solving process is more important than solving currently known problems. In other words, the key to service design in the field is to provide a service design process and form a flexible team that can support the process. In this context, we proposed a multiagent approach including role playing games, participatory simulations and gaming simulations as a basis of experiments for designing services with various stakeholders.

The purpose of running gaming simulations is to design sustainable services by understanding the interdependencies of existing services, and to reach agreement on the design of future services. When new services emerge from simulations, stakeholders learn what had been previously overlooked. We have to be careful, however, when interpreting the results of gaming simulations. We should be sensitive to what is important and what is not in the results from simulations. Since simulation results depend on those stakeholders that participate and the results of modeling agents and environments, result validity should be examined both practically and theoretically.

Field-oriented service design does not deal with just the introduction of new services in developing countries. Similar phenomena are observed in general cases, where the service designer cannot completely understand the complex relations and behaviors of stakeholders. Therefore, the lessons learned in our studies can also benefit service design in various situations.

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