

# TASK ONTOLOGY-BASED MODELING FRAMEWORK FOR NAVIGATION OF MOBILE INTERNET SERVICES

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## ABSTRACT

For the improvement of usability of mobile internet services for mobile handsets based on the semantic web technology, one of promising ways is to realize task-oriented menu system which enables users search for mobile internet services by "what they want to do", not by "name of the category". To realize such task-oriented menu system, this paper proposes a task ontology-based modeling method which supports the description of users' activity and related knowledge such as how to solve problems that occurs on the users, prevention method for accidents, and so on. Models described by our method contribute to checking, designing and improving mobile internet services for mobile handsets.

## KEY WORDS

Web and Internet Systems and Tools, Knowledge-based Systems, Task Ontology, Modelling Mobile Users

## 1. Introduction

According to an annual report by NTT DoCoMo [1], Japan's premier mobile communications company which manages mobile internet services and occupies about 58% of the market, we have more than 96,000 service sites today. While we can enjoy many kinds of mobile services via mobile handsets, such a large number of services cause difficulties in searching, finding and selecting suitable services for consumer's needs.

Current menu system of mobile internet services is organized from the viewpoint of domain, which we call domain-oriented menu. In the menu system, each category of the menu is named for the domain such as "Traffic report", "Shopping" and "Hobby", but the services inside the category sometimes does not meet users' intuition. When a user faces "problem", such as "I have to get on a bus bound for an airport" or "I want to transfer some money from my account", she/he have to consider which category has the proper internet service to solve the problem first. In the case of the "bus problem", she/he has to find out that information about bus is served in the domain of the "Traffic" among many categories. Then she/he have to search in the menu hierarchy like

"Traffic > Public transportation > Bus > XYZ Bus line". The user is forced to consider by two steps before she/he reaches the mobile service. This example may be seen as an easy one, but as I mentioned above, today we have too many services with many domains in Japan. Each layer of the menu hierarchy has several candidates to be selected. At the top level, for example, "Traffic", "Local information" and "Latest information" are contained and all of them seem to have bus information service inside.

To solve the problem, the authors proposed another type of menu system for mobile services which we call "task-oriented menu" that works on mobile handsets. By task, we mean users' problem solving activity in the real world. In the task oriented menu, the users seek for mobile internet services by the name of the directory which represents a task they are involved in rather than the name of category which might be unfamiliar to them. Users select a menu that is most resemble to what they want to do; "Move to station X", "draw cash to buy a ticket", "get on the next bus", for example. Value of information depends on how well the information fits to the needs of the users. The necessity of information lies in a task, not in a domain. You seek for information when you face a trouble, which is difficult to get over with knowledge at hand, on your way of achieving a task. Such a situation is the context and origin of the necessity for the information. Furthermore, task-oriented menu has potential of providing useful information for mobile service users quicker than that of a domain-oriented menu today. Naganuma [3] evaluated a prototype of task-oriented menu and showed that even novice users can reach his/her necessary mobile services faster than current domain-oriented menu system or keyword search.

Task-oriented menu evaluated by Naganuma [3], however, is an ad hoc one because they designed it based on an ad hoc model of users. Since there are neither effective supports nor guidelines to model mobile users, we have to design them. Firstly we need to list up task models of users as many as possible. Referring to the models, providers of mobile service look for chances to support users and design mobile services. For better design, vocabulary for the model should be carefully defined and systematized, thus ontology for the users' activity is needed. Since mobile services are useful when users face troubles, the ontology should contain such situations.

Furthermore, to realize coherent mobile services from the top level (e.g. entrance menu of the mobile service) to the concrete service level (e.g. model of mobile banking service at “bank X”), we have to modify all of them. Since we have more than 96,000 service sites to be modified, effective supports for transfer of the technology is essential. In other words, we have to design new task modeling method and ontology to support it.

With backgrounds discussed above, this article proposes a task-oriented mobile service navigation system with task-ontology-based modelling framework. The research project is conducted by experts of ontology design in cooperation with experts of mobile services. Although it is difficult to separate this research project with a clear boundary, this paper mainly focuses on how to analyze users’ activities, how to build models of them and how to build necessary ontologies. Practical use of the developed knowledge and its application framework for mobile services are described in [3]. Designer of ontology provides necessary ontologies for analyzing and building user models. For building and providing ontologies, we use “Hozo” [6-8], an ontology editor with GUI, which can export developed ontologies in OWL, RDF, XML, and so on. On the basis of the theory of task ontology [2] and experiences in the field of engineering domain [5][10,11][18], we propose a methodology for modeling user activities and necessary ontologies with their design guidelines. The approach based on task ontology enables us to describe task models in terms of generic task vocabulary which are detached from domain model. A model of the task “move”, for example, can be applied to model movement in several domains like travel, commute, and so on. Based on the task ontology, our modeling method contributes to designing and describing users’ activity models that are referred when designing mobile services by service providers. Furthermore, specification of the modeling process based on categorization of users’ activity provides the knowledge authors with guidelines.

At the same time, the authors conducted several experiments to evaluate the proposed framework. This paper reports preliminary experimental results in terms of (1) supports for generation of ideas about mobile services (2) effect of our guidelines for modeling users.

This paper is structured as follows: Chap.2 describes our mobile internet service application with task oriented menu. Chap.3 describes several issues about modeling framework. In Chap.4 we propose a new modeling framework. Chap.5 explains about ontologies we developed and Chap.6 shows experimental results. Chap.7 discusses issues about related works and Chap.8 concludes with future research topics.

## 2. Task Oriented Menu for Mobile Service Navigation

Fig.1 shows a process of service selection by task-oriented menu on the prototype system [3]. First, the most abstract task candidates are shown on the mobile phone

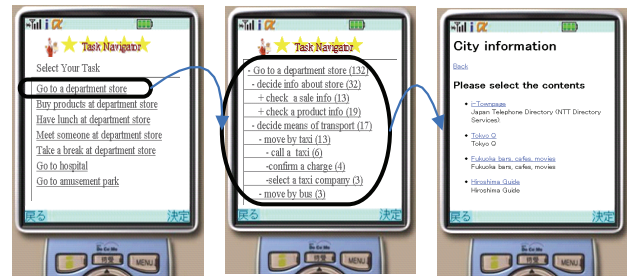


Fig.1 Task oriented menu system (prototype)

(Fig.1 left). A user selects one of them (e.g. “Go to a department store”) to solve his/her current problem (e.g. “need to buy cloths”). Then services associated with each task are displayed on the right side of the task nodes (Fig.1 center). Finally, services associated with the task selected by the user are shown, and each of them leads to access to the actual service (Fig.1 right).

As shown on this example, task-oriented menu is easy for novice users of mobile internet services. Just selecting “what the user want to do in the real world” from the menu, he/she will be lead to the service for solving current problem. Knowledge about the hierarchy of the domain-oriented menu is not necessary.

In this research, we do not deal with problem about planning. Our service navigation system just provides necessary information to solve problems on the spot.

## 3. Issues about Modeling Framework

As described in Chap.1, to realize a task-oriented menu system, we need to analyze users’ activities first. The more activities are modeled, the more needs for mobile services will be revealed. Ideally all tasks users want to do with mobile handset must be listed and organized as a task-oriented menu. Of course, it is impossible to list every possible task by limited research members. To achieve better results, we need a strategy and a framework to make our plan feasible.

Firstly, the method to model users’ activity should have enough scalability and generality. Since there are so many mobile services and activities, the framework should have enough scalability for both task and domain.

To cope with this issue, the authors carefully designed task and domain ontologies with guidelines as describe in Chap.5. To enhance generality, we exploit an abstraction hierarchy in task organization. “Move”, for example, can be a general task of “go to restaurant”, “go to a coffee shop”, “travel”, etc. At the same time, quality of the ontologies and modeling framework is evaluated by experts of mobile service providers. Especially NTT DoCoMo is a top service provider in Japan whose mobile service is subscribed by 46 million users. Many other service providers watch NTT DoCoMo’s behavior and they are ready to follow it.

Secondly, the framework and modeling technology should be easy to transfer. Applying our framework, we aim at supporting reorganization of the mobile service from an abstract level like "move" to a concrete level like "get on train to go from Osaka to Tokyo". As is mentioned above, there are so many services that limited project members cannot cover them all.

To cope with this issue, designer of ontology provides with not only a framework, ontologies and models but also their design principles and guidelines for usage. Transferring our technology, we plan to let the service providers modify their mobile services by themselves. Mobile service providers, users of our framework, are neither experts of modeling nor experts of ontology engineering. We assume they do not concern about design of ontologies. They utilize already designed ontologies and give feedback to the contents of ontology. Furthermore, to reveal difficulties in transferring our technology, we conduct several experiments. The results are described in Chap.7.

Thirdly, the framework should output models that represent obstacles for users' activity. In many cases users seek for information when they come across some troubles on their way to achieve goals of tasks, as we mentioned in Chap.1. Mobile internet services are especially useful when users face some troubles.

For this requirement, our framework explicitly includes models with such obstacles to be prevented or solved by mobile services. Since such troublesome situations are the target of the mobile service, support for modeling them helps generation of new ideas about mobile services.

#### 4. Framework for Modeling

Fig.2 depicts the framework of our system where rectangles represent knowledge, rectangles with round corners represent modules and circles represent people. "Designer of mobile service" in Fig.2 designs users' activity models and mobile internet services through the interface module. Its output is the menu of the mobile internet services for the "User of the mobile services".

Although the service providers usually have implicit

business models about their own mobile services, they do not have generic task models for representing users' activities. Generic models and task/domain ontologies which are designed by "Designer of Ontology" are referred to by the service providers to obtain concrete models by instantiating the generic models.

"Designer of Ontology", an important role of the authors, designs and maintains ontologies. The authors are specialists for building task ontologies [2], and have experiences of its application to the real world problem solving [10]. Although there are huge numbers of "tasks" in the real world, those have to be solved by mobile handset users are not very large, since they are limited to daily-life tasks done out side home. Furthermore, to organize task concepts is easier than that of domain concepts, because it is independent of domain, is able to be decomposed into subtasks and has a generality in the abstract space. For example, a task concept "buy a ticket for a movie" consists of two task concepts, "buy something" and "receive service (Including model of queuing)". Both concepts can be applied to modeling similar tasks in various domains. Task concept thus has a generality in its nature and hence we can organize its structure at a high level of abstraction.

The authors are investigating reorganization of the mobile services from the viewpoint of task. The approach based on task ontology enables service providers to describe users' activity models in terms of generic task vocabulary which are detached from the domain model. Furthermore, specification of the modeling process based on categorization of users' activity provides them with guidelines. Based on the task ontology, our method contributes to building homogeneous and generic models. Fig.3 shows a model description process with an example. Our framework has been designed intended to support four kinds of user model. (1) Usual activity based on the decomposition of task model (2) Obstacles that disturb achievement of the activity (3) How to prevent occurrence of troubles and (4) How to solve troubles occurred.

#### 4.1 Description of Basic Activity Models

The modeling method proposed in this paper is inspired by an ontology-based modeling framework for functionality of artifacts [5] [10]. It has been successfully deployed for engineering knowledge management in a manufacturing company [11]. It is summarized as follows: We define a function of a device as a result of teleological interpretation of its behavior with a goal to achieve. One of the key ideas of the modeling framework is function decomposition with the way of function achievement. The function of the whole system can be decomposed into sub-functions of sub-systems or components. The sub-functions are further decomposed into finer-grained sub-

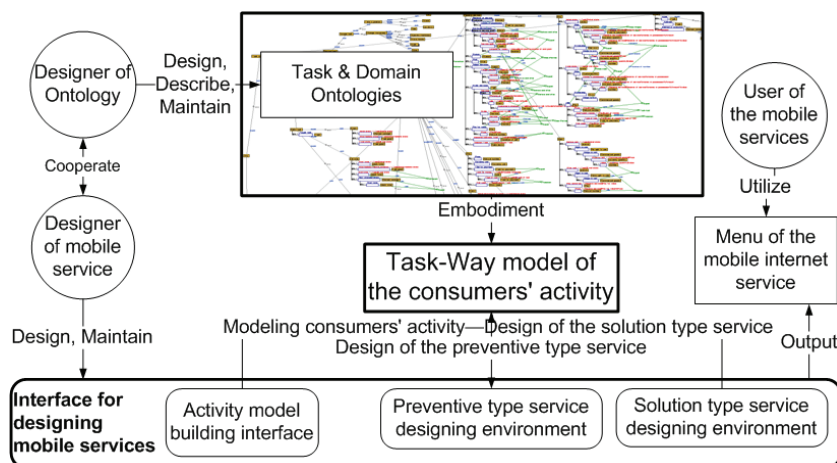


Fig.2 Framework for modeling

functions. Such functional structure represents how the components achieve the goal-function of the whole system (i.e., how things work). We introduce the concept of way of function achievement as conceptualization of background knowledge of functional decomposition such as physical principles as the basis of the achievement. For example, a cooling-function for a CPU can be achieved by the sub-functions; “to provide air”, “to transfer heat”, and “to move air”. It can be conceptualized as “heat conduction to moving-air” way for cooling functions. In general, there are other possible ways to achieve the same goal-function, in this example, say, “heat conduction to water coolant”. The conceptualization of way of achievement helps us detach “how to achieve” (way) from “what is intended to achieve” (function). We call this model “function-achieved-by-ways model”.

The method is applicable to modeling users' activity. Since users' activity can be modeled at various size of granularity, we can decompose activities with larger granularity into smaller ones. Each and every activity has a goal, and several ways to achieve it. As we call such activity as "task", we can build "task-achieved-by-ways model" by applying modeling method for "function-achieved-by-ways model".

Fig.3 represents a process of building a Task-Way model. A dotted rectangle with number (1) in Fig.3 corresponds to the basic model of users' activity. It is described by instantiating generic models and/or ontology. Description starts from the task at the level of large granularity.

Next, ways to achieve the task are linked, and each of the

ways is decomposed into a sequence of sub-tasks. Our “way” is similar to “method of CommonKADS [4] and "how to bundle" of the Business Process Handbook [12].

Following this process task of the large granularity is decomposed into sub-tasks via ways. The area with number (1) in Fig.3 represents that a task “Move to a theme park” is achieved by three ways. Among them, the way “Move by driving my own car” is decomposed to three sub-tasks such as "Go to the parking lot", "Drive from one’s home" and "Park the car at the parking lot".

An important guideline in this framework is that the model of activities is described based on the observation of physical activity on the spot. Cognitive activities such as “plan to move more efficiently” or “Get traffic information beforehand” are not described. This guideline and modeling process based on decomposition of the task contribute to making modeling process easier and output models more objective. As described in Chap 1, to realize a coherent task oriented menu structure, transfer of the technology is important. If we allow modeling non-observable activities, quality of output models differs according to the skill of each model builder. The less knowledge about the task and/or domain he/she has, the worse output models will become. In such a case, process of modeling becomes implicit and the transferability of the method decreases.

On the contrary, our guideline allows modeling of physical activities only. Modeling process is simple; just observe physical activities and model them referring to the ontologies. The model does not contain cognitive

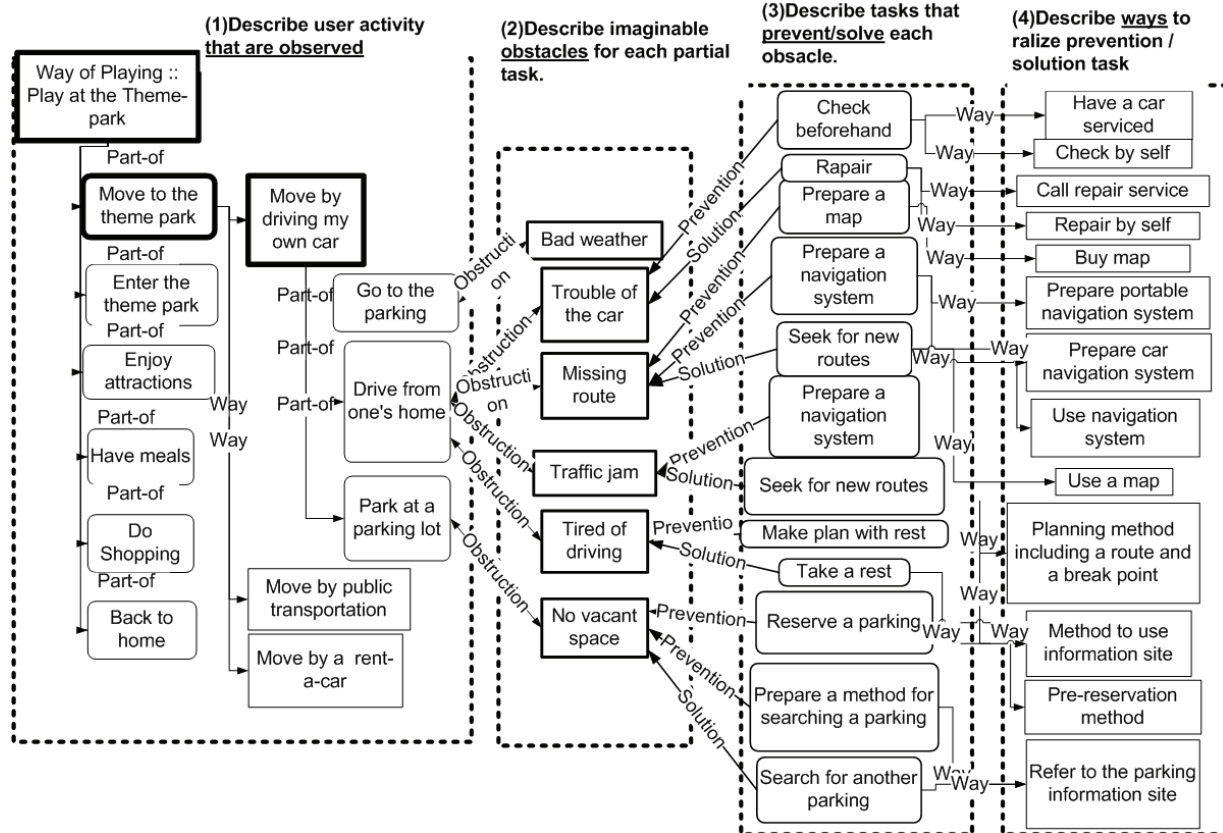


Fig.3 Process of building Task-Way models

activities such as "planning", thus objective. The simplicity and objectiveness contributes to the transfer of our technology.

#### **4.2 Description of Obstacles**

Models of how to prevent/solve problems are described in three steps. Firstly, the designer describes plausible obstacles for each partial task. For example, the task "Drive from one's home" has four obstacles: "Trouble of the car", "Missing route", "Traffic jam" and "Fatigue of driving"(Fig.3).

Building models of possible troubles is a unique feature compared to previous researches like [2][3][18]. Since the most valuable mobile service is to provide information to solve such problems, our modeling method contributes to coping with obstacles that occur on the spot.

As mentioned in section 4.1, basic model of the users' activity is described by decomposition of the task. To foresee obstacles about the task with small granularity is easier than that with large granularity. With our example in Fig.3, to enumerate plausible obstacles about the task "Drive from one's home" is easier than about the task "Go to the theme park". Since we have more experiences of driving than going to the theme park, we can enumerate more obstacles which might occur while driving. This characteristic meets our requirement that the framework should support generation of new ideas. As described in Chapter 5, result of our preliminary experiment also supports this point.

#### **4.3 Description of Prevention/Solution Tasks**

When we go out for holiday, we make a plan and anticipate possible troubles beforehand. Then we prepare to prevent occurrence of the troubles. In the example in Fig.3 (3), one of the tasks "Drive from one's home" may be obstructed by "Trouble of the car". We can prevent occurrence of the obstacle by the task "Inspect the car beforehand", for example. As described in Fig.3(3), model of an obstacle and its preventive tasks are linked by "Prevention" links.

One of the most useful mobile services is a one that provides solutions for troubles that occur outside of the home. To deal with models that users come across troubles and solve them, our method supports modeling of solution tasks as well as preventive task models. In Fig.3 (3), those tasks linked to the obstacles with a "solution" link are task models of the solution. We can solve an obstacle "Trouble of the car" by the task "Repair", for example.

Since models of obstacles are described for the task with small granularity, we expect that one can imagine more tasks for their prevention and/or solution than conventional modeling methods. In Fig.3, for example, to generate preventive ideas for obstacles about the task "move to theme park" is more difficult than that for the "Park at the parking lot in the theme park", because the former task is abstract and contains many obstacles

according to its interpretation. Based on the decomposition of the task models, our method helps generation of new preventive and/or solution ideas.

#### **4.4 Description of Ways to Achieve Prevention/Solution Tasks**

The most important goal of mobile internet services is to provide ways to prevent or solve problems for the users. After modeling the prevention/solution tasks, our method supports description of ways to achieve the tasks. Examples are shown in Fig.2 (4). The prevention task, "Check beforehand", can be achieved by two ways, "Have a car serviced" and "Check the car by oneself" way. In Section 4.1 to 4.3, we explained modeling method based on decomposition of task models. A guideline for "To what extent we should decompose a task?" is that we should stop it when an existing (or designing) mobile service becomes just same as the task or the way model.

An advantage of our method is that it has a potential capability to allow designers to come up with new mobile services. Referring to the model of prevention and solution, designers of the mobile internet service can check whether the current mobile service is enough or not. If there's no way or no internet service for a plausible obstacle, it means another service is needed to solve it for users now. If a new mobile service is invented here, the service has a possibility to be a new business. In Fig.2, for example, there's no way to solve "bad weather" today. In that sense, we expect that the model output from our framework works as a finder of the new business opportunity. We plan to evaluate this issue in future.

### **5. Ontologies for the Consumers' Activity Model**

For building "Task-Way" models of mobile service users, ontologies that are referred to for describing the model should be scalable and general. It makes Task-Way modeling framework scalable and general, too.

As mentioned in Chap.3, designers of mobile services refer to the user models based on the ontology, so the ontology should contain enough number of concepts with their explicit definition. Some designers may require precise user models, so the definition should be precise to some extent. Ideally, all of the requirement should be satisfied, it is difficult to build such ontologies at an early stage of the research without enough experience of mobile services. So we build ontologies concerning about mobile users' activities within limited situations first. Then we expand target domain and task. We exploit an abstraction hierarchy in task ontology and reuse it when we expand target task and domain. "Receive service", for example, can be a general action of buy a book, have a meal at a restaurant, etc.

In the process of building ontology, experts of mobile services supervised it. Designer of ontology designed from the top level with about 200 concepts, and the

experts supplemented about 200 concepts by the bottom up analysis. For building ontologies, we use Hozo [6][7] as a tool. The latest version is available at [8]. We built ontologies that consist of 400 basic concepts and 14 relational concepts assuming mobile users' activities related to playing at a theme park. Our ontologies consist of Task ontology, Domain ontology and Generic Task-Ways. This chapter describes them with design principles.

### 5.1 Task Ontology

Task ontology is a system of concepts/terms for explaining problem solving structure domain independently [2]. In building task ontology, we describe each task as a sequence of states. When a user of the mobile handsets does a task, states around the user change. Fig.4 is a graphical representation of "task" which is at the top level of the task ontology to be inherited by other task concepts (e.g. move, receive service, etc). Rectangles linked to task concepts with right-angled link in Fig.3 represent slots for attributes (denoted by a/o) or parts (denoted by p/o) of the tasks. Value of each slot is constrained to be an instance of the class which is described in a rectangle on the right of the slot. A short text above each rectangle represents a role concept [9].

The first three slots in Fig.4 represent changes of states along with doing the task. The values of each slot are constrained to be an instance of "stative" class which is at an upper level of concepts about states of things in the target domain. The fourth slot represents possible obstacles which correspond to "obstacles" in Task-Way models (cf. Section 4.3). This slot represents that a domain concept plays a role of "Possible Obstacle" (e.g. "rain" obstructs "playing at theme park").

The fifth (sixth) slot represents prevention (solution) tasks for the obstacles. It corresponds to "Prevention task" ("Solution task") in Task-Way models. Although there are three kinds of tasks in our Task-Way models, we build an ontology of "Task", and we do not build that of

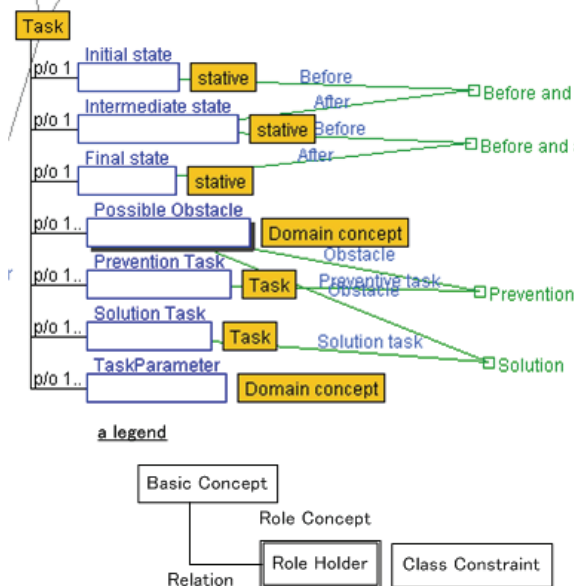


Fig.4 Definition of "Task" (Screen shot of Hozo)

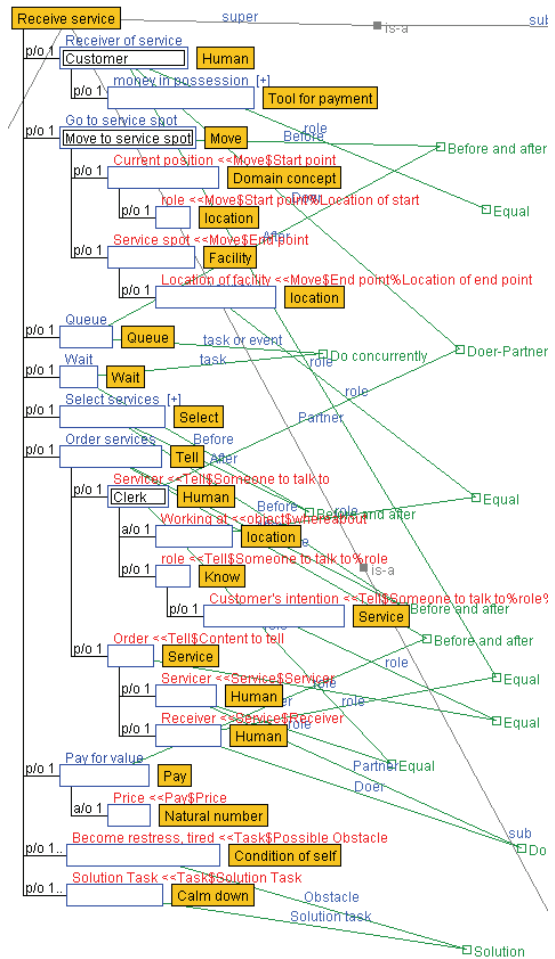


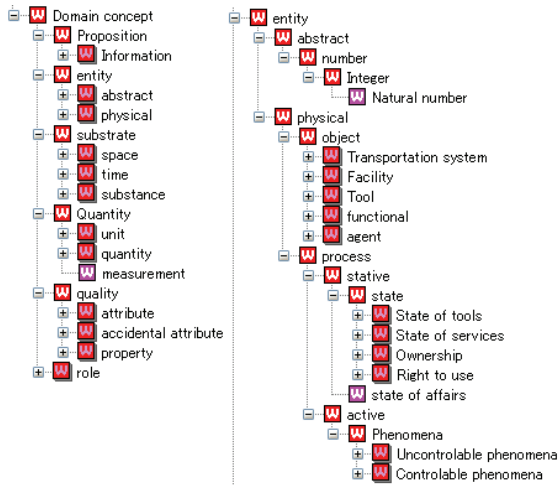
Fig.5 Task concept "Receive service"

"Prevention task" nor "Solution task" because they are "Task role". A task concept "Draw cash" for example, prevents occurrence of a bad state "short of cash" beforehand. It also solves a bad state "short of cash" occurring now. As this example shows, any task can play a role of "prevention" or "solution". Ontology of normal "task" is enough and we model "Prevention" and "Solution" tasks as a role of normal task (cf. Fig.4).

Fig.5 represents an example of a task concept "Receive service". It consists of a sequence of several sub tasks. As the first slot indicates, a human play a role of "Customer", and the customer goes to service spot first. After that, he/she queues, wait for a service, select a service, ask for a clerk and pay for value. Domain concept, "condition of self", plays a role of obstacle for those people waiting for services. The obstacle is solved by the task "calm down". The task concept of "Receive Service" is inherited by other task concepts such as "Buy", "have meals", etc.

### 5.2 Domain ontology

As described in the beginning of this chapter, domain concept contains tremendous number of concepts and we cannot cover them all. To cope with this point, we adopt "Activity First Method (AFM)" [18], a methodology of building task ontology with necessary domain ontology



**Fig.6 (left) Top level of the domain concept (right) hierarchy of a domain concept “entity”**

from the task-specific point of view. Firstly, we limit target task and domain (e.g. activity in a theme park). Within the limited situation, we analyze activity first to develop task ontology. Along with the development of task ontology, we develop domain ontology which contains at least necessary concepts for defining each task concept. Next, we expand the target task and domain (e.g. activity in daily life). AFM thus provides us with task-specific guidelines for articulating and organizing domain concepts.

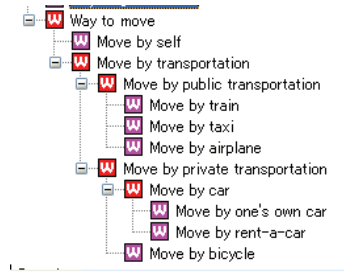
Referring to the domain concepts, we define task models like Fig.5. As the example in Fig.5 shows, meaning of a domain concept depends on the task concept which refers to it. To make domain ontology general and scalable, we separate interpretation result from the domain ontology. A kind of weather “rain”, for example, is a bad weather for the people playing at a theme park outside. On the other hand, the weather is good for a farmer waiting for water supply for his/her field. So we define “rain” or “sunny” in our domain ontology, but we do not define “bad weather” nor “good weather for driving” which contains task-dependent interpretation of the result, which would make the domain modeling less general.

Furthermore, even if we build domain ontology assuming only limited situations of mobile service users’ activities, there are still many ways of defining domain concepts. To make domain ontology coherent, we apply “top-level ontology” to the upper level of our domain ontology for its organization. The left part of Fig.6 represents our top-level ontology. Domain concept consists of “Proposition”, “entity”, “substrate”, “Quantity”, “quality”, and “role”. Since all these concepts are defined explicitly, designers of ontology can search or add domain concepts to define task concepts as they want. If a designer wants to refer to the domain concept “weather”, for example, he/she can look into the concept “entity” which contains concepts about “Uncontrollable phenomena” including weather.(cf. the right part of Fig.6).

### 5.3 Generic Way Concepts

Although concept of way is a key for building our Task-Ways models, it strongly depends on task and domain concepts. Thus its explicit separation is important to keep generality of task and domain ontologies.

For describing our Task-Way models which represent various methods to achieve task goals, we developed hierarchy of generic way concept separately from task and domain ontology. For a task concept “move”, for example, we have several ways such as “move by train”, “move by rent-a-car”, etc. to achieve its goal (Fig.7).



**Fig.7 Part of conceptual hierarchy of generic way “Way to move”**

### 6. Evaluation of Modeling Method

We conducted several experiments with 25 subjects whose ages are from twenties to forties. All subjects had no experience of “modeling” and “ontology”. With experiments, we interviewed them to see actual voices.

#### 6.1 Understandability of Task-Way Models

For two groups of subjects, we conducted an experiment to examine understandability of our Task-Way models. In this experiment, we gave both groups (G1 and G2, 5 subjects each) a list of existing 100 mobile services with their titles and their brief explanations such as “JR Travel Navigator” and “Using the latest timetable, you can seek for connection among the different transportation systems.” With the list, we gave a task to each of the subjects to list up possible usage scenarios of the mobile services at the given situations. Situations are (a) At a theme park (b) At a station. We also asked for the subjects not to describe the usage scenarios with the same meaning to the “brief explanation” itself, but interpretation results. As for the case of “JR Travel Navigator”, we assumed that “Seek for the last train from the theme park bound for Tokyo” is a valid answer, but “Seek for connection among the different transportation systems” is not valid.

For each subject in G2, we gave right Task-Way models (cf. Fig.2) for the two situations described by the authors, and for those who belong to G1, we gave nothing. We gave one hour for each group including times for instructions, and after the experiment, we counted answers

**Table1. Total number of the valid usage scenarios described by subjects**

Situation	G1(No reference)	G2(With reference)
Theme park	159	177
Station	67	100

described by subjects.

Table1 shows result of the number of the valid answers. Since we selected the list of 100 service sites at random, it included several sites which has no relation to the situations given like “Information about driver’s license school”. As the table.1 shows, with reference to the Task-Way models, subjects described more usage scenarios. Subjects of G2 also gave rather positive comments on this point such as “The task-way model was useful to find the boundary of given situation” and “The model was useful to some extent when I was stuck for new ideas of usage.” The results show that the Task-Way model supports imagination of usage scenario of the mobile services.

### 6.2 Support for Modeling Users’ Tasks

For two groups of subjects, we examined whether our framework supports modeling users’ tasks or not. In this experiment, we gave both groups (G3 and G4, 5 subjects each) a task to imagine and describe mobile service users’ activities related to the shopping in a department store as much as possible. For one group (G3), we gave no instruction and the subjects described activities by natural language like “Search for the information about the department store.” For another group (G4), we gave instruction manuals about our modeling method, modeling tool, libraries based on ontologies for modeling, and some examples. Subjects of G4 described a graphical model for the given task. After the experiment, we counted number of the tasks described by subjects.

Table2 shows the result. The second line of the table shows average numbers of tasks imagined by subjects. Compared to G3, subjects of G4 with our modeling framework imagined about twice the number of tasks. Furthermore, even the minimum number of the tasks described by one of the subjects in G4 exceeds maximum number of the G3.

Analyzing the data, we found that subjects of the G4 describe many preventive tasks or solution tasks for obstacles in our modeling framework. For the comparison, we counted the number of the tasks of G4 excluding prevention or solution tasks connected to nodes of obstacles (G4’ in table2). Now average number of task models in G4’ is about 54% of G4. Comparing tasks contained in G3 and G4’, both of them mainly consist of normal activities like “buy a ticket”, and only a few numbers of prevention tasks or solution tasks are included. This shows description of obstacles revealed alternative situations for subjects and stimulated new ideas.

**Table2 Number of task models described by subjects**

Number of tasks described by subjects	G3 (No instruction)	G4 (With instruction)	G4’(G4 without obstacles)
Average	24.6	56.2	30.4
Minimum	18	39	19
Maximum	34	72	37

### 6.3 Similarity of the Described Models and Summary

The authors evaluated the similarity of the task models described by subjects from the viewpoint of structure in comparison with right examples described by authors. The result shows that similarity of task models described by 5 subjects with ontologies is 2.5 times higher than those models without ontologies.

As described in section5.1 and 5.2, our modeling framework with ontologies supports generation of many ideas about users’ activities. Furthermore, experimental result supports similarity of the described models. As described in Chap.3, we have to transfer the modeling technology to service providers to realize a coherent task-oriented mobile service consists of more than 96000 mobile service sites. The experimental results show that our method is promising for support of better analysis about users’ activities as well as description of homogeneous models, regardless of the difference of skills and/or knowledge of the modellers.

## 7. Related Work

In the field of semantic web research, there are several mainstreams aiming at achieving high quality of web services for consumers. Although the goal of research is the same, our framework centers description of users’ activities while many other researches focus on description of web services. For example, OWL-S [13], SWSO/FLOWS [14] and WSMO [15] describe model of web services first, and define ontologies necessary for describing the services. Lastly they translate the service models into executable form referring to the ontologies. They have proposed standardization of their method to W3C, and released several guidelines or tools.

These research projects mainly focus on how to utilize existing web resources, not how to build or improve quality of the resources or ontologies. Researches related to WSMO, a main stream in Europe, have been releasing several tools for designing and developing semantic web services including WSMX [16]. WSMX supports from finding services, mediation of the services and execution of the composed services.

Masuoka proposed Task Computing framework and built a ubiquitous environment which provides more than 100 web services [17]. Web services are described by OWL-S, and the environment changes dynamically. The ubiquitous environment is unique because it deals with dynamic changes such as appearance/disappearance of clients/services, and gained much knowledge.

To satisfy users’ needs many researches today focus on "better composition of existing mobile services". Our modeling method which focuses on "better analysis of users’ needs" is able to strengthen the researches explained in this chapter.

MIT’s Process Handbook Project [12] deals with knowledge models about business. It focuses on modeling business activities and has taxonomy of basic business activity. However, the method for building the model is

implicit and confusion of task concept with way concept occurs with some models. One of the models, "buy in a store", consists of a task concept "buy" and a way concept "in a store" for example. Such confusion lowers generality of the model, and does not meet our requirements.

## 8. Conclusion and Future work

For the improvement of mobile services based on the semantic web technology, this paper proposed "task-oriented menu" for mobile service navigation and a new framework for analyzing and building models of users' activities based on task-ontology.

Designing the framework, we focused on three important issues: generality and scalability of the framework, easiness of the transfer of the technology, and modeling obstacles under the mobile environment for generation of new ideas. To enhance generality and scalability, the authors carefully designed task and domain ontologies with guidelines. At the same time the ontology is supervised by domain expert and supported by bottom up analysis of the actual services.

For designing task ontology, we adopted "Activity First Method [18]" and separated task concepts from domain concepts to keep domain ontology general and scalable.

Defining each task concept, we applied our theory of role concepts [9] to keep basic task concepts general.

For designing domain ontology, we excluded interpretation result such as effect of natural phenomena to keep generality of ontology. Furthermore, we adopted top-level ontology for its organization to make it coherent. Lastly, our modeling framework explicitly represents obstacles, and our experimental result showed description of obstacles enhances task models.

Our modeling framework and ontologies aimed to support description of homogeneous models regardless of difference of modellers which in turn supports transfer of our technology. Experimental results in Chap.6 showed potential of proposed framework on this point. As described in Chap.1, we conduct this research in corporation with NTT DoCoMo whose behavior is watched by many other service providers thus we can expect feedbacks from both of them. Since proposed framework satisfies these specifications and works well within limited tasks and domains, the authors aim at the next goal. To realize task oriented mobile services, our next step is expansion of the target domain. Currently our target is focused on activities in a theme park. Next target will be activities in other domains like town, streets, and so on. We expect that we can reuse task concepts already built for expansion of the target domain, since task concept is common regardless of differences among various domains as described in Chap.3. Of course, further effort must be devoted for it, and we are going to repeat a cycle, building ontologies and their review by specialists, for realization of task-oriented menu in future.

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