Task Model and Task Ontology based on Mobile Users' Generic Activities for Task-Oriented Tourist Information Service

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Abstract

With the recent advances in mobile platform technologies, a variety of studies on context-aware information services for the tourist information domain have been undertaken. Many studies on ontological approaches to tourist information services, moreover, have been conducted. However, most studies have focused on upper-level or domain ontologies; comparatively, few have proceeded from the perspective of task ontology based on mobile users' generic tasks. Thus, we considered the construction of a task model and task ontology based on mobile users' generic activities for a task-oriented tourist information service. In this paper, we introduce 1) a generic task model based on travelers' needs and generic activities before and during trips, which model accounts for generic tasks and task processes; 2) a task ontology based on the generic task model, and 3) a task-ontology-based Task-Oriented Tourist Information Service (TOTIS). Using the generic task model and the task ontology, task-oriented menu can be constructed automatically by means simply users' selections and context-awareness. Additionally, compared with the existing domain-oriented services, the TOTIS can facilitate more flexible searching of tourist information and make real-time determinations with context-awareness.

Keywords: *Task Model, Task Ontology, Tourist Information Service, Mobile Tour Service, Task-Oriented Service.*

1. Introduction

With the recent advances in mobile and sensory technologies, a variety of applications (apps) that functions on the basis of users' context-awareness have been introduced into the tourist information service domain. Today's Smartphones typically include high-resolution touch-screens, GPS navigation units, high resolution digital cameras, high-speed 3G/4G mobile communication, and various embedded/external sensors/devices for each vendor. As such, travelers can easily search/plan information/schedules during a tour, can quickly obtain tourist information, and can determine their preferences in real time according to their context-awareness (location, time, movement, trace, *etc.*), without the need of additional devices or system software.

Many studies on ontological approaches to tourist information services, moreover, have been introduced, and to various ends. Ontology, in the present context, is a term that originally suggested in 1992 by Tom Gruber who defined it as "a specification of a conceptualization." The word tends to generate controversy in discussions on artificial intelligence (AI) [6]. Top-level ontology describes general concepts and provides a correspondingly high-level model of the world using constructs provided by meta-ontology. Domain ontology refers to the vocabulary related to a generic domain. Task ontology relates to a generic task or activity, such as the process of booking a package tour, including perhaps flight, rental car arrangements. Application ontology is a combination of domain and task ontologies [4, 5, 14].

Tourist information services with ontologies typically involve a virtual travel agent system for M-Tourism, a mobile tourist information system with identifying zones, the agent-based tour-guiding system iJADE FreeWalker, a ubiquitous infrastructure for the tour-guiding system, a traveler/service matching system for group package tours, and the ubiquitous tourist assistant system (UTAS), among still other modalities [1, 2, 3, 5, 7, 8]. As for ontological approaches that incorporate users' context-awareness, there are location-aware mobile tourist guides with the Tour Building Block (TBB) and Dynamic Tour Guide (DTG), and ontology-based situation-awareness mobile services [15, 16, 17]. However, most of the studies on these travel utilities have focused on upper-level or domain ontologies for tourist attractions travel agents, package tours or tour recommendations; contrastingly, there have been relatively only a few studies treating task ontology based on travelers' tasks.

Task ontology describes reasoning concepts and their relationships within given tasks for a specific domain, for example, diagnosis, monitoring, scheduling, or designing. Mizoguchi *et al.*, (1995) proposed task ontology for the reuse of problem-solving knowledge that consists of four kinds of concepts, and applied them to a scheduling task in MULTIS [14]. Ikeda *et al.*, (1998) presented Conceptual LEvel Programming Environment (CLEPE) as an implemented system based on Task ontology [19]. Fang (2007) proposed a graphical model that shows activities, inputs, outputs, controls and mechanisms for representing task ontologies: the TTIPP framework [18]. Martins *et al.*, (2008) introduced task knowledge that involves sub-task decomposition and the knowledge roles that are involved in task fulfillment in task ontology [14]. As regards studies on task ontologies for tourist information service domains, there are Wayfinding with multiple transportation modes in an urban area based on travelers' perspectives and public transportation systems (Timpf 2002), Task models and task ontology in map-based mobile guides (Hunolstein *et al.*, 2003), Tourist information for realization of adaptive Mobile GI Services in the pedestrian navigation domain (Zipf *et al.*, 2006), and a task-oriented menu system based on a task ontology for mobile users using the Ontology-based Obstacle, Prevention and Solution (OOPS) (Sasajima *et al.*, 2007) [10, 11, 12, 13].

However, those studies have focused on certain restricted activities and spatial situations of travelers rather than generic traveler-perspective-based tasks. It is somewhat problematic to construct generic tasks based on users' generic activities, because this can involve unpredictable sub-tasks and their processes, not to mention complicated relations among tasks. In this paper, we considered on a task model that can support mobile travelers' general needs and activities, and task ontology based on the task model with their context-awareness for improved tourist information services.

Thus, we treat 1) travelers' needs, activities and their objects before and during trips, 2) users' general activity flow and construction of sub-tasks for relevant generic tasks, 3) generic task model with the generic tasks and the construction processes, 4) task ontology based on the generic task model, and 5) a task-ontology-based Task-Oriented Tourist Information Service (TOTIS) for mobile users. In Section 2, we discuss a generic task model based on mobile travelers' general activity flow and the sub-tasks using their needs and activities, which model includes generic tasks and their task processes; in Section 3, we introduce a task ontology that incorporates that task model and users' context-awareness, and in Section 4, present the task-ontology-based TOTIS. In Section 5, we draw conclusions.

2. Generic Task Model

Task ontology for reuse of problem-solving knowledge is constructed of four kinds of concepts: 1) generic nouns, 2) generic verbs, 3) generic adjectives, and 4) others. Generic nouns represent the roles and generic verbs represent the activities in the problem solving process, and generic adjectives modify the objects. Task decomposition concerns division of a task into sub-tasks, setting goals for each sub-task, and describing the control-flows among those sub-tasks. The knowledge roles facet specifies the concepts and relations pertinent to given task [14, 17, 18, 19]. In the present study, we considered the construction of a task model of travelers' perspectives on the tourist information service domain. Figure 1 maps the procedure for construction of a generic task model. First, we analyzed travelers' needs, activities and their objects both before and during trip. Second, we constructed domain ontology for tourist information domain to represent the objects. Third, we defined generic activity flow using all possible users' activities (verbs) and objects (nouns) with domain ontology for tourist information. Last, we introduced the tasks and their processes based on the users' specific behaviors, objects and parameters.

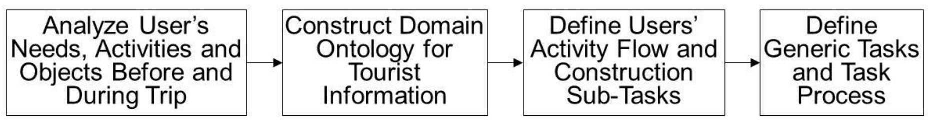

Figure 1. Procedure for construction of generic task model

2.1. Travelers' Needs, Activities and Objects Before and During Trip

We investigated travelers' needs and activities in various cases, based on travelers' viewpoints both before and during trips. Before a trip, generally, travelers want the following tourist information: "How can I get transportation to the destination?", "What's the most affordable hotel near that place?", "How much will the traveling expenses be?", "What are the attractions near the hotel?", "How's the weather there?", "How's the weather there?", among others. They want information on the destinations, transportation schedules, accommodations, costs, etcetera, as well as to compare prices, schedules, locations, recommendations, and other things. Then, they want to plan the schedules and reserve transportation and accommodations, etcetera.

During a trip, travelers want to know/do real-time information/activities, and thus ask the following questions: "Where is the most famous restaurant near here?", "What is the attraction famous for?", "How can I get to the hotel from here?", "What's the price of one ticket to the opera?", "How do I confirm the reservation?", "I'd like to confirm the reservation", and etcetera. Relatedly, they want to search information on movement, ticketing, food, and shopping, to compare them in real time, and do immediately: determine where to go, reconfirm a schedule, or recommend/have/see something. Sometimes, they make notes of where they go, visit, stay, etcetera. Table 1 lists the generic activities (verbs) and objects (nouns) for travelers' tasks before and during trip.

For example, if a businessman in Hong Kong has a plan to visit Boca Raton, Florida in USA for five days and four nights for a meeting at a convention center in Boca Raton, he will search for a round-trip plane ticket from Hong Kong to Boca Raton and a nearby hotel, reserve them, and search transportations from the airport to the hotel and the convention center. When he arrives at the airport in Boca Raton, he wants to get information to move the best way and transportations to the hotel. During the trip, he wants to know/do a variety of information/actions for attractions/foods /restaurants/shops/events in the city, will take transportation, make reservations, go shopping, tour the sites, have a food, and so on. Thus, more specific information and activities are required.

Table 1. Generic activities and objects for travelers' tasks before and during trip

Activities	Objects
Search	Transportation, Accommodation, Shop, Food, Attraction, Weather, History/Culture, Event, Location, Map, Nearby Somewhere, etc.
Compare	Transportation, Accommodation, Food, Weather, Shop, Attraction, Price of Something, etc.
Plan	Schedule, Transportation, Accommodation, etc.
Reserve	Transportation, Accommodation, Package Tour, Restaurant, etc
Pay	Transportation, Accommodation, Shop, Food, Admission of Attraction/Event, etc.
Move	Accommodation, Restaurant, Shop, Attraction, Somewhere, etc.
Have/Get	Accommodation, Goods, Transportation, Food, etc.

For the objects of the activities, we constructed a domain ontology for a tourist information domain, using the ontological concepts and their instances to represent the objects. The ontology, as shown in Figure 2, consists of 10 main classes of tourist information based on a Metropolitan City [9, 20, 21]. For all of the sub-classes of each main class, there are "is-a" relationships. Those sub-classes have instances, properties, restrictions and relations among classes or their instances. The instances of the Location class have relationships with those of the Food, Shopping, Accommodation, Attractions, Entertainment, Festival/Event, Shopping, Food, Transportation and History/Culture sub-classes. By means of these, we can easily offer context-aware information services.

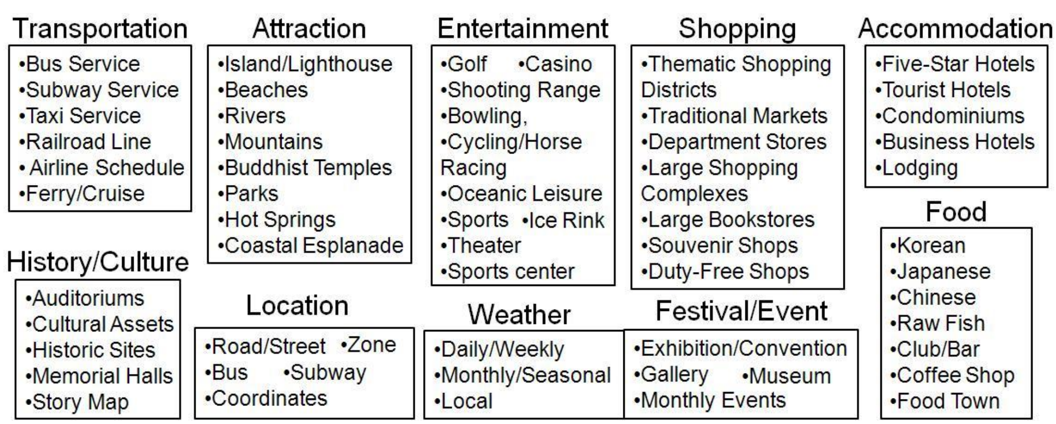

Figure 2. Ten main classes and subclasses of domain ontology for tourist information domain

2.2. Users' General Activity Flow and Construction of Sub-Tasks

To construct the generic tasks, we 1) analyzed users' general activity flow with input and output parameters according to their general behaviours, and 2) decomposed the sub-tasks with the activities (verbs) and their objects: the concepts/instances of the domain ontology, according to the construction procedure. The structures of the tasks are represented by the relations among them. However, a task decomposition process that involves only verbs and objects entails some difficulty, because it can be constructed of all possible sub-tasks combined; thus, it was decomposed by domain experts generally. Also difficulty is the definition of hierarchical structures of tasks, because there are a variety of users' behaviours that fulfill them. We adopted six verbs as activities in this study, that is, Search, Compare, Reserve, Move, Have and Pay, to analyze users' general tasks.

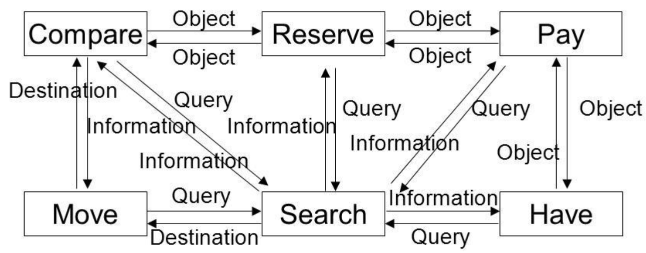

Figure 3. Users' general activity flow and properties

Figure 3 depicts users' general activities flow with the verbs and their properties (input/output): first, users search something, after which they compare results, reserve something, move somewhere or pay/have something. Accordingly, he/she fulfills the tasks recursively with feedback until the desired results are obtained. For the objects and information in the flow, we used the concepts of the domain ontology and their instances, as defined in Figure 2. Thus, we could construct the sub-tasks by combining the six verbs and all possible concepts or their instances in the ontology.

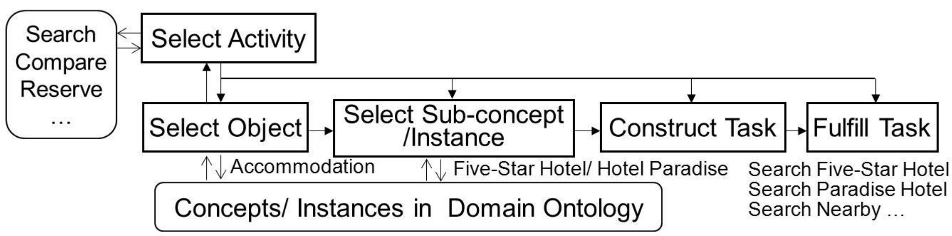

Figure 4. Procedure for construction of generic sub-tasks with activities and objects

Figure 4 depicts the procedure for construction and fulfilment of sub-tasks with users' activities and objects. First, users select an activity from among the six verbs, and secondly, select an object from the main concepts in the domain ontology. Third, if sub-concepts/instances of them exist, are selected, as an object. Fourth, a sub-task is constructed with the activity and the object selected, and it is fulfilled. All sub-tasks are constructed and fulfilled, recursively, through this procedure. For example, first, an activity, "Search" is selected, and second, concepts, "Accommodation", "Five-Star Hotel", or an instance, "Hotel Paradise" is selected. Third, sub-tasks "Search Accommodation", "Search Five-Star Hotel" or "Search Hotel Paradise" are constructed, which are then fulfilled. Additionally, we can construct the sub-tasks with context-aware terms for users' situations or movements: 'Nearby', 'Here', 'Hotel Paradise (recently visited)', etcetera. Those tasks are generated in real time automatically, and recursively, through users' selection of verbs and relevant objects.

2.3. Generic Tasks and Task Processes

According to the flow of users' generic activities (six verbs) and the procedure of sub-task construction, we can construct generic tasks and the processes among them. The notations for construction of generic tasks are as follows: Task: T={t_1, t_2, ..., t_n}, a set of generic tasks that consists of verbs and nouns. Activity: V={v_1, v_2, ..., v_m}, a set of activities that consists of generic verbs. Object: O={o_1, o_2, ..., o_k}, a set of objects that consist of concepts or instances. Concept: C={c_1, c_2, ..., c_l}, a set of concepts of domain ontology. Instance: I={i_1, i_2, ..., i_s}, a set of instances for a concept. Relation: R={r_1, r_2, ..., r_s}, a set of relations among generic tasks. Parameter: P={p_1, p_2, ..., p_x}, a set of parameters for a task.

Basically, using the general activities flow (Figure 3) and the procedure for construction of generic sub-tasks (Figure 4), various generic tasks can be constructed automatically by users' selection. For construction of generic tasks, there are five methods and their parameters, as follows.

Select Activity. $\forall v \in V$ *select_activity(v)* $\rightarrow$ *a verb v*. Select a verb among Search, Compare, Reserve, Move, Have and Pay, as activities. Each activity (verb) has semantic links with the relevant concepts of the domain ontology and their instances.

Select Concept/Sub-concept. $\exists v \in V, \forall o \in O, \forall c \in C$ *select_concept(v, o)* $\rightarrow$ *concept* c_k. Select a concept c_k among concepts, that can combine with the activity *v*, from the domain ontology, as objects. If the concept c_k has sub-concepts and a user wants to select a sub-concept among them, this is fulfilled recursively until the lowest-level sub-concept is selected.

Select Instance of Concept. $\exists v \in V, \exists c_k \in C, \forall i \in I$ *select_instance(v,* c_k*)* $\rightarrow$ *instance i*. Select an instance *i* among instances of the concept c_k from the ontology.

Construct Task. $\exists v \in V, \exists c_k \in C, \exists i \in C_k, \exists p \in P, \forall t \in T$ *construct_task(v, i, p) or construct_task(v,* c_k*, p)* $\rightarrow$ *task t*, Construct a generic task *t* with the verb *v*, instance *i* (or concept c_k), and parameter *p*.

Fulfill Task. $\exists v \in V, \exists c_k \in C, \exists i \in C_k, \exists p \in P, \forall t \in T$ *fulfill_task(v, i, p) or fulfill_task(v,* c_k*, p)* $\rightarrow$ *results*. Fulfill a task that consists of verb *v*, instance *i* (or concept c_k), and parameter *p*. It has different parameters for each verb. Those processes are fulfilled recursively to obtain relevant information for users.

Thus, we can obtain tasks with parameters, as follows: Search 'Object' with 'Parameter', Compare 'Objects' with 'Parameter', Reserve 'Object' with 'Parameter', Pay 'Object' with 'Parameter', Move from 'Parameter 1' to 'Parameter 2' by 'Object3', and Have 'Object' with 'Parameter'. Further, there are some context-aware terms for users' situations or movements, for example, 'Nearby', 'Here', 'Hotel Paradise (recently visited)', 'Recommended', and others. Thus, the tasks and their parameters are generated and fulfilled through users' selection; they are not system defined.

Figure 5 shows examples of generic tasks for hotel reservation and dining according to generic task processes and their parameters.

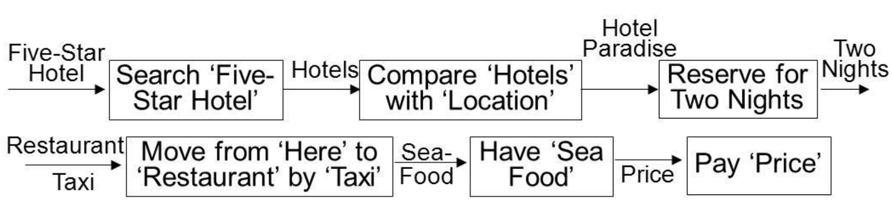

Figure 5. Generic tasks and their processes for hotel reservation and dining

3. Task Ontology based on Generic Task Model

Using those generic tasks with the parameters and the activity flow, we can construct a task ontology for a tourist information service domain. First, with the six verbs and the ten main concepts of the domain ontology, we can construct 29 main concepts: Search(S)_Transportation, S_Accommodation, S_Shop, S_Food, S_History/Culture, S_Attraction, S_Weather, S_Event, Reserve(R)_Accommodation, R_Transportation, R_Attraction, R_Event, R_Food, Compare(C)_Transportation, C_Food, C_Shop, C_Attraction, Pay(P)_Transportations, P_Accommodations, P_Shop, P_Food, P_Attraction/Event, Move(M)_Restaurant, M_Accommodations, M_Shop, M_Event, M_Attraction, and Have _Food. Each concept has sub-concepts automatically according to the methods defined in Section 2.3, and the procedure for construction of generic sub-tasks shown the Figures 4 and 5. The properties can be obtained from instances of concepts of the domain ontology by selection of a user's or users' context-aware terms (nearby, here, etc). The relationships among the concepts are defined with the terms combined with a verb 'has' and the concepts/instances of the domain ontology, automatically.

Figure 6 shows the concepts 'MoveTo_Accommodation', 'Search_Accommodation', "Reserve_Accommodation', and the sub-concepts of 'Search Accommodation': 'Search_ Nearby', 'Search_ Five-StarHotel', 'Search_Hotel-paradise', etc., the relationships, between the concepts 'Moveto_Accommodation' and 'Reserve_Accommodation'.

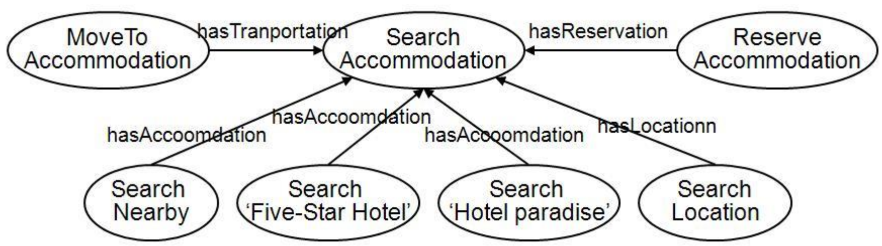

Figure 6. Task 'Search Accommodation', their sub-tasks, properties, and relational tasks

Figure 7 shows the relationship between sub-concepts and instances of task ontology and those of the domain ontology. The child concepts of the task ontology have their object and parameters that are linked with those of the domain ontology or users' context-aware terms. For "MoveTo_Accommodation" concept, it has sub-concepts "MoveTo_Hotel-Paradise" and "MoveBy_Parameter". The instances of the former "Source" and "Destination", and those of the latter are "Taxi", "Bus", "Subway", *etc.*, are obtained from the domain ontology, or the users' context-aware terms. Therefore, we can generate the concepts, their sub-concepts, relationships and parameters of the task ontology of tourist information service domain by using users' generic task model and the domain ontology, and then we can construct task-oriented menu services based on users' context-awareness.

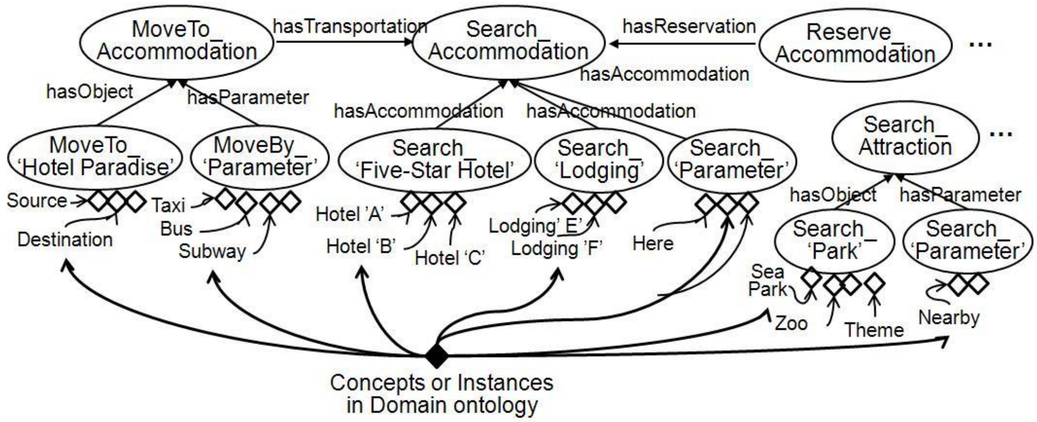

Figure 7. Sub-concepts and instances linked those of the domain ontology with relationships

4. Task-Oriented Tourist Information Service

Using the generic task model, the domain ontology and the task ontology, we can provide for a Task-Oriented Tourist Information Service. A task-oriented menu, significantly, enables users to search for services based on “what they want to do” rather than by “name of category”. Construction of such a task-oriented menu is based on task ontology, the generic tasks that support the description of user activity such as task execution and the solving of problems encountered during the task [10]. Thus, using the task ontology and domain ontology, we introduce a design for the TOTIS that consists of the Task-Oriented Menu Service (TMS) and the Tourist Contents Service (TCS).

Figure 8 depicts the TOTIS system architecture with the ontologies, database, and the roles of each service. The TCS system maintains tourist content in the domain ontology and the database: it reads/writes instances of tourist content from (to) the domain ontology, and reads/inserts/updates the records of tourist content database. The TMS system provides various task-oriented user interfaces for contents. With the generic task model and the task ontology, we can, as shown Figure 4, construct a task-oriented menu for specific tasks based on users’ context-awareness.

We introduced the task model for tourist information services based on travelers’ needs and activities, and we presented the task ontology using 29 main concepts, their sub-concepts and parameters obtained from users’ activities (verbs) and instances (or sub-concepts) of the domain ontology, and users’ context-awareness, and relationships among them, as shown Figures 4 and 5. Thus, we can construct a task-oriented menu using them for various users’ context-awareness. To construct a task-oriented menu for specific tasks based on travelers’ needs and activities, first, the menu shows the upper menu with six main activities: Search, Compare, Move, Reserve, Have and Pay. Second, if a user selects an item among them, the child menu is generated using sub-concepts and their instances in the task model and ontologies. Three kinds of menu can be generated: 1) using only sub-concepts of task ontology, 2) using instances of objects and parameters of concept in task ontology, and 3) with only instances of domain ontology or users’ context-awareness.

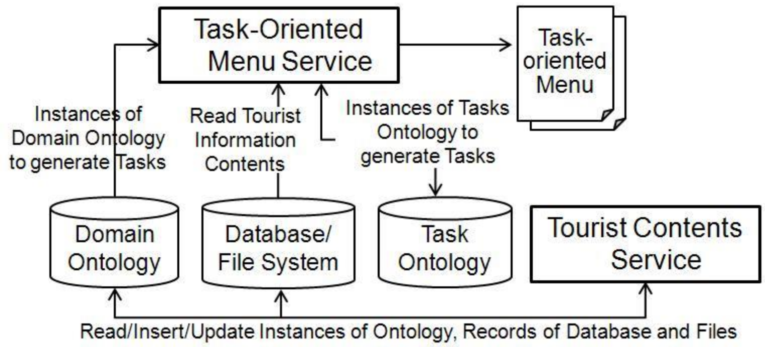

Figure 8. TOTIS system architecture with ontologies, database, and roles of each service

Figure 9 shows task-oriented menus for the "Accommodation" concept using concepts of the task ontology and their instances based on the task model. For example, if a user searches a hotel nearby and move to there, the menu (a) shows the main activities and the menus (b) and (c) are generated from sub-concepts of 'Accommodation' in the task ontology. The menu (d) is constructed using instances of the lower sub-concept "Search Five-Star Hotel" of the "Search Accommodation" concept. He/she want to move to there, the menu (e) shows the activities to do something, and the menu (f) is for "MoveTo Hotel Paradise". The domain-oriented menus are constructed by the sequences of hierarchical structures for the concepts, sub-concepts, and instances of the domain ontology. Therefore, the task-oriented menu can efficiently facilitate tourist information services for various travelers' needs based on their perspectives, which are constructed using the concepts, instances, relations of the task and domain ontologies, and users' context-awareness.

Figure 9. Task-oriented menus using concepts of task ontology and their instances

However, if it is constructed with a domain-oriented menu and a traveler wants to search for an accommodation, it first shows menus by category of "Accommodation" of domain ontology: Five-Star Hotel, Tourist Hotel, Business Hotel, Condominium, Lodging, *etc.*, and he selects a class of accommodation and options in that category. Then, he selects menus of other categories (concepts) to obtain more specific information for that selected accommodation or for transportation, foods, attractions, *etc*. Figure 10 shows domain-oriented menus for each main concept, constructed by the sequences of hierarchical structures for the concepts (or instances) of domain ontology. Therefore, the task-oriented menu can provide efficient tourist information services for various travelers' needs based on travelers' perspectives, which are constructed using concepts, instances, relations of task ontology and domain ontology, as well as records from various databases, as compared with a domain-oriented menu of them.

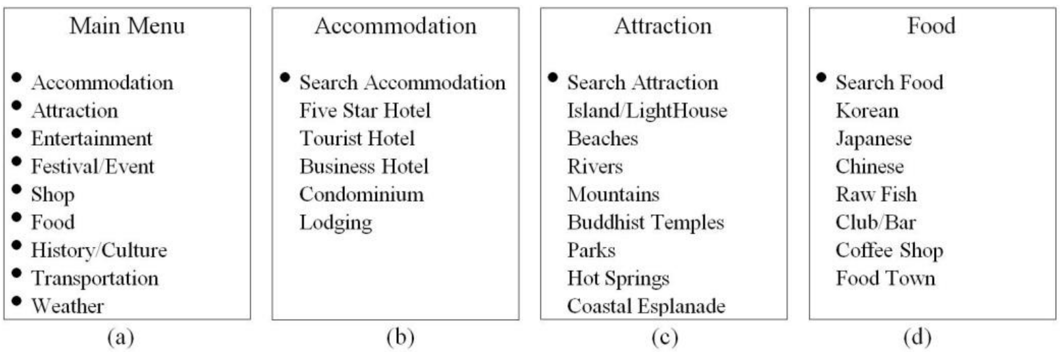

Figure 10. Domain-oriented menus using concepts and their instances of domain ontology

5. Conclusion

We proposed a task-ontology-based generic task model that can support travelers' general needs and activities in a mobile tourist information services domain. First, we introduced travelers' needs and activities and objects before and during trips, along with the domain ontology for a tourist information domain. Second, we presented users' general activity flow by means of six verbs, as well as a procedure for construction of sub-tasks. Thereby, we can construct sub-tasks automatically by users' selections. Third, we defined notations, methods, and parameters for construction of generic tasks based on travelers' general behaviors in a tourist information service domain. According to the generic tasks, their flow and the procedure, we could construct a task ontology that linked to the domain ontology. We also propose a task-ontology-based Task-Oriented Tourist Information System (TOTIS) for various travelers' activities and viewpoints. The TOTIS can provide a task-oriented menu for intelligent tourist information services using the concepts, instances, properties and relations of task ontology according to various travelers' needs and activities. On the contrary, the domain-oriented menu using domain ontology is constructed by the system's perspective. The TOTIS provides for a more intelligent tourist information service than the existing ones. All in all, TOTIS can be said to be a novel ontology-based intelligent tourist information service model centered on travelers' needs. With the model, travelers can easily plan, and enjoy, interactive tour services in ubiquitous environments.

Acknowledgements

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