An OWL-Based Knowledge Model for Combined-Process-and-Location Aware Service

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Abstract. This paper presents a knowledge model for spatiotemporal context awareness. The knowledge model is designed to understand user goals and to guide users who perform complicated tasks involving several routes, such as tasks at a hospital. An information system should be able to consider both the location and process context to provide relevant guidance regarding tasks, their location, and their process, as location and process information are collaboratively associated. A service that is both process- and- location-aware is considered, and a knowledge model that represents the semantics of the proposed process- and-location-aware service is given.

Keywords: spatiotemporal context, process, location, knowledge model, OWL (Web Ontology Language).

1 Introduction

Context-aware computing has been drawing much attention with the development of u-computing environments. A context-aware system can help users concentrate on their tasks with reduced complexity and can provide users relevant guidance when performing their tasks. Context awareness or situation awareness can be defined as the answer to “what is going on?” [1]. For instance, in a case in which a user is watching a football game without any background knowledge, it would be difficult to infer what is going on. In short, situation awareness is the inference of a situation using background knowledge.

Recently, a number of applications have been developed to provide context-aware services, and various context models have also been designed to support these applications. Baldauf et al. [2] present architectures of context-aware systems as well as approaches for context models. Among them, the ontology-based approach has been used widely due to its formal expressive and reasoning techniques. Krummenacher and Strang [3] defined contexts for a context-aware service and suggested criteria for context and ontology modeling.

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In addition, research has centered on a context-aware system with a knowledge model. Ongenae et al. [4] suggested an ontology-based system for context-aware hospital nurse call optimization. The context-aware call system has a context model that includes the status of the nurse, the characteristics of the nurse (gender, language, etc), and the location of the patient and the nurse. With the model, patients can walk around freely, select their preferred nurse (gender, language, etc), and nurses can identify whether calls are urgent or normal. An ontology-based personalized path-finding system using deviation detection for individuals with cognitive impairment [5] was suggested by Chang et al. They suggested a system and developed a knowledge model for guiding cognitively impaired people to their work places, by showing pictures at crucial places and times. The system considered the leaving time and the expected time of arrival to an area when alerting the system of a problem, using the person's ID for personalization. Niu and Kay present Pervasive Personalization of Location Information: Personalized Context Ontology (PECO) [6]. The purpose of this system is to provide personalized information to a user using an ontology model with seven parts: *location sensors, building plans, technical building data, staff directories, internal email aliases, direct user input.* However, these knowledge models of the systems are designed only to focus on location-awareness or limited situations. To provide users guidance with accomplishing complicated tasks, it is necessary to understand the current process and location context together, as the process and the location context are collaboratively associated.

This paper presents the design of the knowledge model for a spatiotemporal context-aware service and presents a knowledge model which enables systems to recognize and adapt to changing situations. To validate the proposed knowledge model, scenarios in general hospitals are presented and instances of the knowledge model are developed for the scenarios.

2 System and Considerations

A process and location-aware information service system [7] that helps users to handle tasks with complicated procedures was designed. The system provides information via a mobile device such as a PDA or a smart phone regarding what to do, how to do it, and where to go while performing complicated tasks in unfamiliar public places such as hospitals. To give a user relevant guidance, the system first should recognize the time and location from the process data of a local information system and the location data of sensor networks, and must then infer the tasks and location with which the users should proceed.

To understand users' situation and provide relevant information, the system should be able to consider both the process and location context because process and location are collaboratively associated. Moreover, the system should be able to adapt to changes in time and space situations, as processes and locations can change frequently as a task is being completed. Thus, a knowledge model of a context-aware information guide system should be able to reflect the following two features: interrelation between the process and the location, and adaptation to changes of the spatiotemporal context.

2.1 Interrelation between Process and Location

The relationships between the process and location should be expressed collaboratively in the knowledge model because process and location information can be helpful to interpret each context. The location information of a user can be grounds for inferring a user's task or processes. Additionally, a system should be able to infer the location of the user from process information and provide relevant information services; the meaning of a particular location can be interpreted differently according to a user's goals and processes.

Figure 1 shows the difference between a location-based and the proposed-process-and- location-based knowledge structure. In the location-based service, the system provides information only related to the user's current location. It is difficult to guide the user in terms of his or her next location and process. Moreover, if there are several possible tasks or services at one place, this system cannot easily decide which of these is necessary within the current user's situation. In comparison, the proposed system can provide information regarding the next service and location as well as the most relevant information among possible candidates related the current location based on recognition of user's spatiotemporal situation.

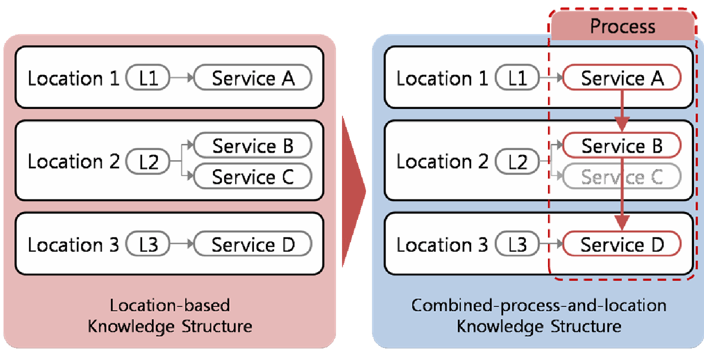

Fig. 1. Comparison between the location-based and the combined- process- and- location-based knowledge structure

2.2 Adapting to a Change of the Spatiotemporal Context

The system should have a flexible knowledge structure to adapt to changes of the spatiotemporal context, as process and location procedures can vary according to ongoing results or to changes of the user's intentions. At a hospital, for instance, the patient's procedure can be modified by the result of a doctor's examination. In addition, if a patient would like to rest or use the toilet before going to the doctor's office, the route information should be modified. Figure 2 shows an example of a process adaptation. The initial service sequence (a)->(b)->(c) becomes (a)->(b)->(d)->(e)->(c) due to the result of (b). According to the modified process, the guide information about what to do, how to do it, where to go, and how to go there also changes.

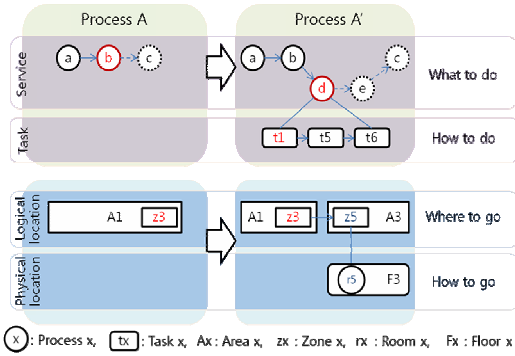

Fig. 2. Adaptation to a context change

3 Knowledge Model

A knowledge model for a context-aware information guide service that requires consideration of both process and location situations was designed. The knowledge model expresses the relationships between the process and location and has a flexible structure for changes of the spatiotemporal context.

The knowledge model includes three main parts: the process, the location, and the user. The process part represents the Process, Service, and Task classes. They are linked to the user and the location classes where they are performed. In the location part, classes are classified into two layers: a physical layer and a logical layer. The classes included in the physical layer represent real-world entities such as rooms. On the other hand, the classes of the logical layer are defined by their use, such as waiting

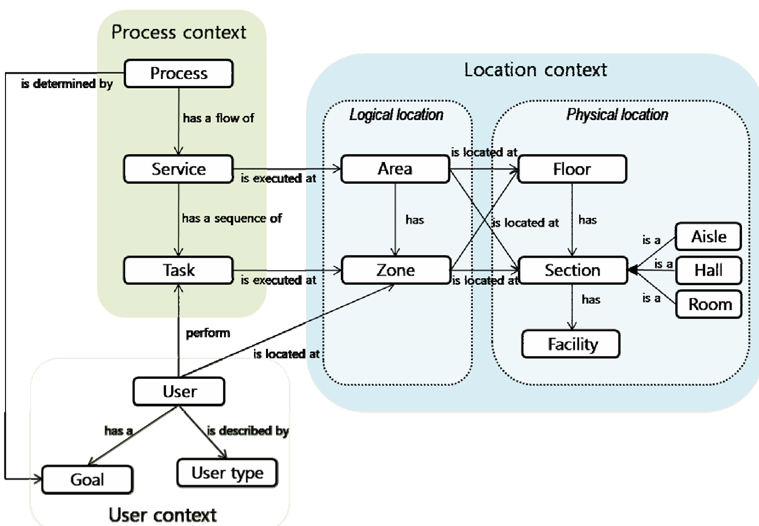

Fig. 3. Classes and relations

Table 1. Definition of classes of the knowledge model

Primary Class		Sub Class	Definition
User		Goal	A final aim of a user
Process Context		Process	A flow of Services for accomplishing user`s goal
		Service	A unit operation such as examination, inspection
		Task	An activity that user to do for the Service
Location Context	Logic-al	Area	A place where the Services are executed
		Zone	A place where the Task is executed
	Physical	Floor	A level on inside a building
		Section	An abstract physical space including Room, Aisle, and Hall
		Room	A space within a building enclosed by a ceiling, and walls
		Aisle	A passage between rows of rooms
		Hall	An opened space linked to rooms and aisles

places, dental departments, etc. Lastly, the User, Goal, and User type classes are defined in the user part. The overall structure of the knowledge model is illustrated in Figure 3, and the definitions of each class are described in Table 1.

Figure 3 also represents the relationships between the classes. In particular, the logical location classes play the important role of inferring the relationships between the process classes and the physical location classes. The Area class is defined to match the Service class; the Area denotes the places where the Services occur. In addition, the Zone class is defined on the same level of the Task class, which represents the detailed activities of the user as they pertain to services. At a hospital, for example, a dental examination can be an instance of the Service class, and the dental department can be defined as an instance of the Area class, which is related to the Service of the dental examination. The dental department instance also contains the Floor and Section information so that the guide system can provide location information to patients who are set to receive a dental examination.

3.1 Process Context Model

A Process Context model was designed to provide users with guidance regarding what to do and how to do it according to the users' goal. Figure 4 presents the process model. This model has three classes: Process, Service, and Task. The Process consists of a flow of the Services they are needed for the goal. These Services in the Process can be swapped with other Services depending on ongoing results. Each Service can also have a sequence of the Tasks that users should carry out for the Service. With the Process Context, the system can recognize whether or not users are doing well with the process and can provide users with relevant guidance when they have problems. If a user is waiting for his/her turn in a waiting area without the task 'take a number',

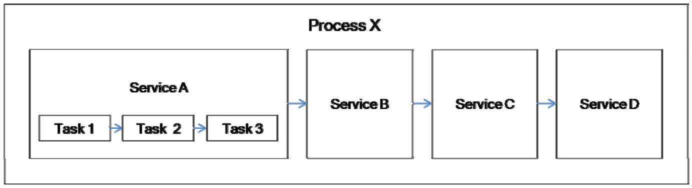

Fig. 4. Process Context model

the guide system can inform the user that he/she should take a number for his/her service. It also tells the user how to do this.

3.2 Location Context Model

The Location Context model was designed to recognize a user's current position in addition to his or her next destination with the process context. From the location context, the system can provide users with route guidance. Figure 5 describes the Location Context model classified into the Logical Location and Physical Location. The Logical location has Area and Zone classes, and Zones are linked to other Zones so that the path of the user can be expressed as a sequence of Zones. Additionally, the Physical Location includes the Floor and Section classes. The Section class has three subclasses: Room, Aisle, and Hall classes.

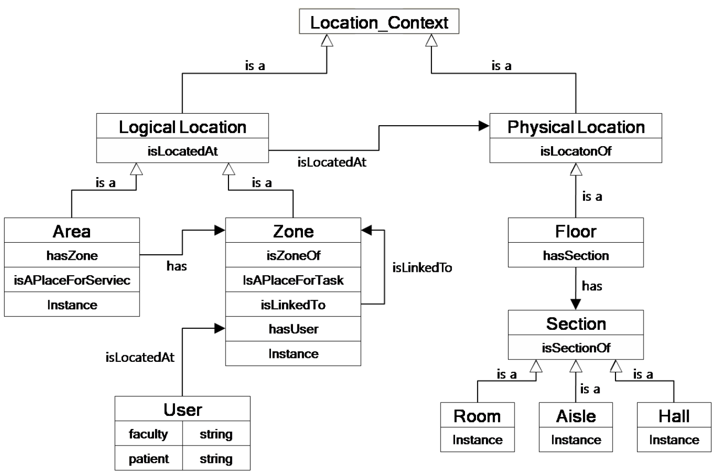

Fig. 5. Location Context model

4 An Example of a Knowledge Model

4.1 Hospital Scenarios

In order to design a more practical model, a general hospital was chosen as the domain for this research. The services of hospitals and users' tasks were analyzed before the knowledge model was designed.

It was assumed that a patient was visiting the hospital to resolve a toothache. During the first step, the process of the patient is set up as a sequence of basic services that include Reception, Examination and Payment. The remaining processes are modified after the completion of each step. After the Examination (Step 2), the doctor requests an X-ray, and the remaining process, Payment, is changed by adding the X-ray inspection. During the last step, the remaining process is only Payment. The scenario shows how the proposed knowledge model reflects the process changes after Step 2. Figure 6 shows the context information at each step.

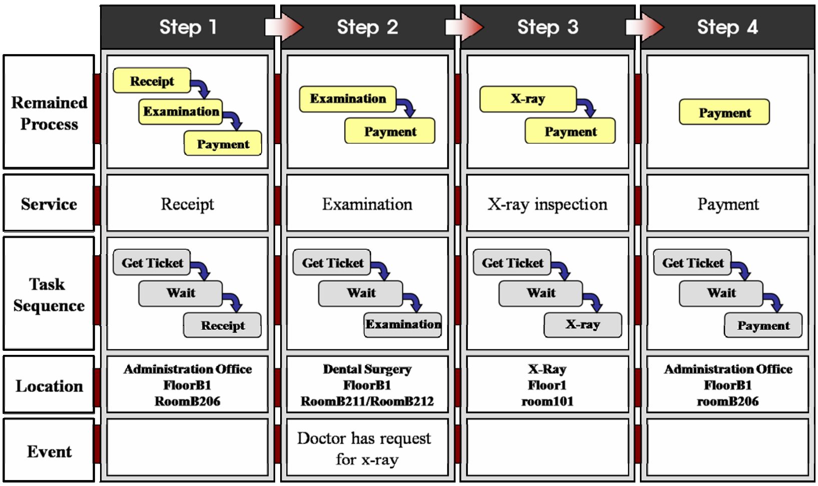

Fig. 6. Hospital scenarios

4.2 Implementation

The knowledge model was built with the OWL language and a scenario-based prototype system to validate the developed knowledge model. The knowledge model was built using a protégé. Figure 7 describes an example how ontology is written in OWL/XML. The Sequence represents the flow of the Tasks, and the flow of the Service is represented as shown below.

```
<Process rdf:ID="Process1">
    <flow_step2 rdf:resource="#serviceDentalExam"/>
    <flow_step1 rdf:resource="#serviceReceipt"/>
    <flow_step3 rdf:resource="#servicePayment"/>
```

Figure 7 also represents the relationships between the Logical and the Physical Locations as well as the relationships between the Services and Tasks. Here, the current location is Dental Surgery Doctor Kim's room with room number B211. It is a Zone of the Dental surgery Area and provides dental services. The Task of the zone is the dental examination. With these relationships, the reasoning engine RacerPro can infer the

```
<isAt rdf:resource="#zoneDentalSurgeryDoctorKim"/>
                  </Faculty>
                    </hasFaculty>
                    <RelatedTo rdf:resource="#roomB212"/>
                    <isZoneOf rdf:resource="#areaDentalSurgery"/>
                    <isAPlaceForTask rdf:resource="#taskDentalExam"/>
                  </Zone>
                </isExecutedOnZone>
              </Task>
            </isAPlaceForTask>
            <isZoneOf rdf:resource="#areaDentalSurgery"/>
            <RelatedTo rdf:resource="#roomB211"/>
          </Zone>
        </hasZone>
        <RelatedTo rdf:resource="#roomB211"/>
        <RelatedTo rdf:resource="#roomB212"/>
        <hasSection rdf:resource="#roomB212"/>
        <hasSection rdf:resource="#roomB211"/>
        <isAPlaceForService>
          <Service rdf:ID="serviceDentalExam">
            <sequence3 rdf:resource="#taskDentalExam"/>
            <sequence1 rdf:resource="#taskGetTicket"/>
            <sequence2>
              <Task rdf:ID="taskWait">
                <isExecutedOnZone rdf:resource="#zoneAdministrationOfficeWaitingPlace"/>
                <isExecutedOnZone>
                  <Zone rdf:ID="zoneOphthalmologyWaitingPlace">
                    <isAPlaceForTask rdf:resource="#taskWait"/>
                    <isZoneOf>
                      <Area rdf:ID="areaOphthalmology">
```

Fig. 7. An OWL expression for the Zone and its related Tasks

location of the Zone, what Services are executed in the Zone, and other information. The system can then provide the user spatiotemporal-context-aware guidance.

5 Conclusion

In this paper, an OWL-based knowledge model for context-aware system is proposed that considers both the location and the process. The knowledge structure of this model expresses the interrelationships between the process and the location classes as well as adaptations to changes in the spatiotemporal context. With the knowledge model, the system can recognize the combined process- and location-based context of users and can provide users with relevant guidance.

The knowledge model was not designed only for a specific domain; hence, the domain of the knowledge model can be expanded easily to other public places such as schools. The knowledge model and the system will be applied to actual public places in future studies in an effort to validate the overall usefulness of the proposed system.

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References

1. Kokar, M.M., Matheus, C.J., Baclawski, K.: Ontology-based situation awareness. Information fusion (2007)
2. Baldauf, M., Dustdar, S., Rosenberg, F.: A Survey on Context-Aware Systems. International Jounal of Ad Hoc and Ubiquitous Computing (2007)
3. Krummenacher, R., Strang, T.: Ontology-Based Context-Modeling. In: Third Workshop on Context Awareness for Proactive Systems (CAPS 2007) (2007)

4. Ongenae, F., Strobbe, M., Hollez, J., Jans, G.D., Turck, F.D., Dhaene, T., Demeester, P.: Ontology Based and Context-Aware Hospital Nurse Call Optimization. Complex, Intelligent and Software Intensive Systems (2008)
5. Chang, Y., Wang, T., Chuang, Y., Tsai, S.: Ontology-based Personalized Wayfinding System Using Deviation Detecting for Individuals with Cognitive Impairments. In: International Conference on Convergence Information Technology, pp. 1844–1848 (2008)
6. Niu, W.T., Kay, J.: Pervasive Personalisation of Location Information; Personalised Context Ontology. In: Adaptive Hypermedia Conference Website, pp. 143–152 (2008)
7. Han, M., Kim, G., Park, S., Kim, L., Ha, S.: Process and Location-aware Information Service System for the Disabled and the Elderly. In: 13th International Conference on Human-Computer. Springer, Heidelberg (2009)