基于情境感知的服务系统①

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Services in Context

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Abstract: The paper gives an overview of a recently started research project addressing the question: Can context be exploited to add value to IT-services? Beyond today's way-finding services based on GPS and maps, we believe there is a new class of context-aware pervasive services making good use of a broad range of context information (e.g. identity, time of day, temperature, history as well as relative location of friends and belongings). Last but not least we believe one can find ways of adding value to IT-services by using disembodied conversational agents based on voice, sounds and visual signals integrated into the environment, instead of being guided by explicit directions shown on a display. The project aims at giving both new fundamental insight about the theory behind IT-services, their architecture and user interfaces and at building a number of prototypes demonstrating innovative context-aware pervasive IT-services.

Key words: IT-services; context-awareness; service-oriented architecture; context representation and innovative user interfaces

1 Introduction

The context of an IT-service could be physical information about location, time, environment of users and or key components delivering the service; it could also be information about the identity and social context where the service is currently used, or it could be information about use patterns. An example would be a GPS system where current location, speed, driving habits and time of day,mode of transportation (walking, cycling, driving), is used to select exactly which map scale, position and routes to suggest. In this example, context information (speed, location, user-id., driving habits and time) adds value by filtering the information given to the user; for example, a small map with only relevant information reflecting the habits of the user who likes to get extra exercise in the morning by taking a longer route. A central hypothesis of this project is that a general, yet well-founded notion of context can provide

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additional value such as usability, efficiency, entertainment, reliability, security and flexibility of IT-services.

The challenges of context-aware services range from technical such as improved sensing of context informa- tion, over foundational and software architectural issues, to user involvement and ethical issues related to tracking and surveillance. Beyond today's way finding services based on GPS and maps, we believe there is a new class of context-aware pervasive services making good use of a broad range of context information that will give users added value by using disembodied conversational agents based on voice, sounds and visual signals integrated into the environment, instead of being guided by explicit directions shown on a display. Another key innovative point is to unobtrusively and systematically gather user feedback, interpreting it as context of the service and influencing future decisions on service selection and composition. Services in Context has four main points of focus:

• Developing a novel context-aware user interaction form based on disembodied conversational agents and ser feedback

• Context-aware service quality assurance, based on verification and automatic test case generation

• Ontology-based representation of context for flexible and effective service selection and composition

• Context-aware service choreography, integrating explicit specification of context in services and automatic service composition.

We are deliberately using the term service some what ambiguously. In the above, service is used as a general term for an entity that a user perceives as valuable and which is not a physical product. When the service is based on IT, it is called an IT-service. However, service is also used in a somewhat different meaning to characterize a particular architecture of the underlying IT-technology (service oriented architecture). The two meanings are orthogonal, for example, one can certainly implement an IT-service without using a service oriented architecture (and vice versa). In our project, we are attempting to combine the two, which is investigating IT-services implemented by service oriented architectures.

2 Related Work

The research on context-awareness was initiated by Mark Weiser in his paper on ubiquitous computing[1] from 1991. He suggests integrating computers seamlessly into the world in order to make human focus on the real task rather than information system. This demands that the computing devices vanish into the background and pervasively adapt operation and information as "context" of the computing environment.

Dey et.al. use physical properties to describe context, including location, time, emotional state and focus of users[2-5]. In the paper[6], Dey gives a definition of context: any information that can be used to characterize the situation of entities (i.e., whether a person, place or object) that are considered relevant to the interaction between a user and an application. Context can be classified as physical and logic context[7]. Yau et al.[8] suggest distinguishing between context and situation. The former is context explicitly fetched from the real world through sensors or some other equipment (i.e. location, time, temperature, and object status) whereas the latter refers to information abstracted from the user's requirements or computing demands. Fig.1 illustrates a hierarchical framework inspired by the conceptual framework presented in Ref.[5]. The framework consists of seven layers (sometimes overlapping). The seven layers are:

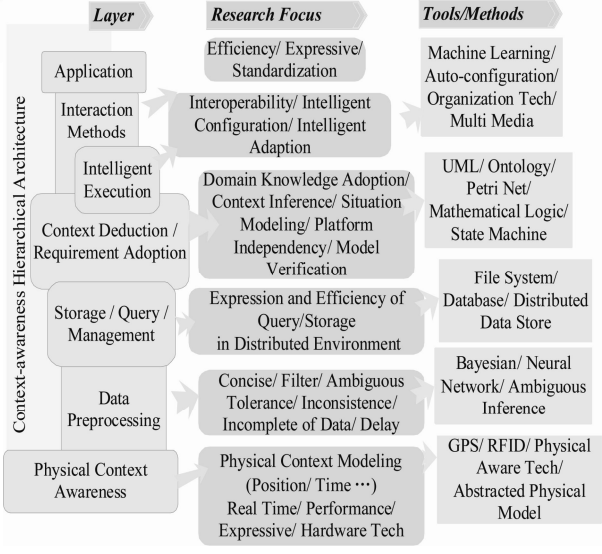

Fig.1　Context awareness framework

(1) body Physical Context Awareness: most research on this focuses on physical context modeling, performance of the real-time system, and the hardware techniques of information detection (e.g., GPS, RFID)

(2) Data Pre-processing: Information from detector or sensor is always incomplete, blurred and unreliable Data filtering techniques are used to provide consistent, effective date for higher levels

(3) Storage/Query/Management: Most of the contextawareness systems are real time systems; therefore, efficient storage and query methods are required, especially in distributed environments and with large data sets. Fewer researches seem to focus on this level than on the other levels[9].

(4) Context Deduction/Requirement Adoption: This layer provides context information exploiting domain knowledge. Modeling methods include ontology, Petri nets and UML. Platform independence and model verification are focus areas[10,11].

(5) Intelligent Execution: This field focuses on smart configuration. Convention learning and preference configuration are expected[12].

(6) Interaction Methods: This layer is concerned with the interaction between the context-providing system and the context-requirement application, which are required to be expressive and unambiguous. Standards are expected to provide global interoperability.

(7) Applications: One can develop a variety of applica- tions based on the context-awareness. However, there are few reports describing the full applications based on context-awareness techniques. In our project we will exploit the ideas first proposed in Ref.[13], suggesting the paradigm of disembodied conversational agents, some- times just called ghosts.

3 Example: the Lost-and-Found-Service

The lost-and-found service is used in this paper to illustrate our project. It can be explained with the following illustrative story: Mr. Con Fused is at the market buying groceries. One of the bags with dried fruits has the dietary information written in very small letters, so he must replace his sunglasses by the reading glasses in his pocket. While reading, he places the sunglasses on the shelve and is interrupted by his good friend Mr. Nice that he has not talked to for a while. They quickly get absorbed in bringing each other up-to-date and start walking towards the cash register of the market. They continue talking while paying for their goods. To get his wallet Mr. Con Fused has to take out his mobile phone which he places on the cash-register while paying. The two friends leave the market together, leaving both sunglasses and mobile phone behind. However, stepping out the market Mr. Con Fused's personal "lost-and-found-service" gives an alarm telling him that he is about to walk away from some of his personal belongings.

The "lost-and-found-service" is an example of a disembodied service ensuring that a number of personal items stay within a short distance. It could be realized by a short-range wireless communication technology such as Bluetooth embodied in simple IT-devices running the "lost-and-found-service". This service has functions such as: 1) registering a personal item (mobile phone, camera, mp3 player, umbrella etc.), 2) continually ensuring that a registered item is within a certain distance of other registered items, and 3) giving an alarm when registered items get away from each other.

The simple "lost-and-found-service" illustrates several of the ideas we would like to exploit in our project. First and foremost, the focus is on using IT-technology to add value to products that are already useful by themselves; in the example the sunglasses and the mobile phone. The lost and found service could also add value to many other personal items that we tend to forget such as umbrellas, gloves, pens, books and gadgets such as games and mp3 players.

Another important aspect illustrated by the lost-and-foundservice is finding an appropriate architecture that allows for dynamic discovery (e.g. when a new item comes within range), specification of service quality (e.g. selecting the device that currently has the best sound for giving the alarm) and reliability (one can imagine that with a lost-and-found-service users quickly become more sloppy because they rely on the service).

4 Research Focus Points

The four focal points of Services in Context are seen

as crucial aspects required for a framework for ubiquitous context-aware services, providing flexibility and reliability in service selection and composition. In the following, we give a brief description of each of the focal points.

4.1 Disembodied conversational agents

Among the research foci are the efficiency of ambient and primarily non-visual interfaces, the minimal requirements for conversation mediated assistance and combining assistance with a narrative universe inhabited by artificial agents (ghost) pursuing their own goals. The project is motivated by the hypothesis that it is possible to achieve high quality agent based assistance without demanding visualizations. We believe that audio is a somewhat neglected but efficient modality for interfaces when compared to the information processing and bandwidth capacities needed and variability of attention demand. A sound based user interface, as compared to traditional graphical user interface, can be better suited for use in-situ interaction. They may also be operated from minimal display units, solely through keystrokes, microphones and loudspeakers in mobile units. Interaction may become hands-free and thus operated by a minimum of visual attention. We use ghosts as a metaphor for the service added by such disembodied conversational agents. The lost-and-found example is a good illustration of a ghost that warns one against moving away from personal items.

The notion of ghosts has been chosen because of traditional characteristics of ghosts found in the popular literature and in folk tales. It is our experience that this metaphor is a very rich and fruitful source of ideas for designing innovative user interfaces:

• Ghosts are disembodied, often location bounded creatures, with motives and powers to engage with humans

• Ghosts owe their twilight status to unfinished business and they are therefore active and striving

• Ghosts reveal themselves unexpectedly or if called upon by the use of a spell or a specific artifact, but only at certain times and/or places.

The quality of the service-measures is provided as implicit and explicit feedback from users. They are important for the creation of a dynamic, self-adjusting system with load-balancing and easy service delivery as an inherent property of the system. Implicit feedback may be obtained from the number of interactions and the length of interactions that a user population has with a given service. Explicit feedback can also be given as keystroke or via simple commands. In the lost-andfound example, users may often want to leave behind their sunglasses-in their car, for example. So it should be possible to disable and give simple feedback to a lost-and-found-ghost with a spoken command. Negative feedback will teach the service not to respond when sunglasses are left in the car (context information). The?training paradigm is operating through?such positive and negative reinforcements.

4.2 Context-aware quality assurance

A service providing value in a certain context may have different service levels. For example, the lost-and-found-service may be able to sound simple alarms in the form of beeps or it may use HiFi ear-plugs; or it may have both a high- precision positioning system based on WiFi available to it or a crude RFID based system. To guarantee the quality of such systems, we build a quality assurance infrastructure to verify and control the service behavior and collaboration as shown in Fig.2.

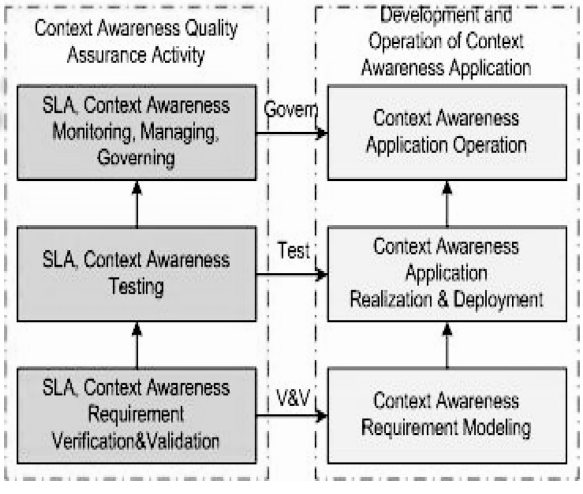

Fig.2　Context-awareness quality assurance infrastructure

The right hand of the figure shows the development process and operation of context-awareness applications, and the left hand depicts the activities of context awareness quality assurance.

• *Verification and validation of the context awareness requirements*: Verify the consistency and completeness of the requirements which incorporate context awareness elicitation and analysis; verify the testability of the requirements to meet controllability and observability of context-aware services; and verify the modeling of service level of agreements in context (SLAIC). The metrics to measure context awareness in such systems are categorized into three aspects: awareness, reflection and action.

• *Testing context awareness applications*: The testing activity focuses on dynamic service composition and service workflow. We define test coverage according to the verified requirement model, build test case generators to automatically test cases using model-driven approach, and create a test framework which verify and control service applications in context.

• *Governing and monitoring context awareness applications*: According to the defined SLAIC, quality assurance activity at this stage monitors application operation, the enforcement of context- awareness, and user satisfaction of services in context. The monitoring results are used to update a context rules database to achieve better user experience.

4.3 Ontology-based service composition

A context-aware service platform will be developed in this project. The service platform, with the context-aware functions, can identify the context of the user and hence provide certain services accordingly. With the disembodied conversational agents the application platform for services in context can interact with the end users. The agents can be regarded as the front-end of the platform. The back-end of the platform provides the services for the users. These services can be existing services or non-existing services, which can be obtained via ontology-based service composition.

In order to leverage the large amount of services deployed both on the internet and intranet, the project is expected to contribute to the theoretical foundations and engineering of ontology-based service repositories. The basic ideas of service repositories, ontology-based service discovery and service composition are depicted in Fig.3. More specifically:

• *Ontology-based context Model*: Ontology based modeling method is currently viewed as a good way of describing the context [14]. In this project we will build a context for a specified domain with the ontology based method, for example using the Web Ontology Language (OWL)[15].

• *Service repository*: We propose to develop formalizations of services allowing for an explicit notion of context. The repository provides the functions such as service registration, publishing, discovery, matching, versioning, and monitoring. OWL-S will be used to depict the service profile, service model and service groundings[16]. Although there are some ontology based discovery algorithms available[17,18], some more advanced algorithm are still required to find desired services more efficiently. Furthermore, a tool set for service registration and ontology-based service discovery will be developed.

Context-aware service composition: We need to define the methods for automatic context-aware service composition. The Business Process Execution Language (BPEL) and OWL-S will be used to depict the process when conducting service composition. There are two ways of service composition, one is the static method that combines the services when developing the context-aware application system, the other is the more flexible dynamic method that discover and combine services for some new situation while the application is running.

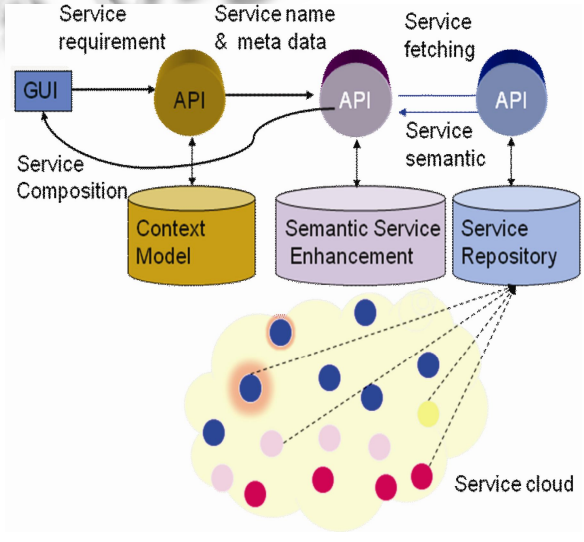

Fig.3 Ontology-based service repository and service composition

4.4 Service oriented architecture of the system

Service oriented architectures make it possible to encapsulate distributed applications as services and to assemble services dynamically. It enables more flexible system integration and improves the software reusability. Service oriented architectures is adopted not only as the basic architecture for service components like service repository, service adapter, service composition engine and service, but also for context-aware components such as context searching and filtering. The individual services defined by WSDL. The next generation of context-aware services, based on the theoretical foundations developed in the research project, is expected to allow internalize-tion of context-awareness rules used for selecting and composing services. It makes it possible to remove the present-day tight coupling between the service level decision and the available services. We also we envisage extensions to BPEL and WSDL founded on concurrency and type theory allowing us to describe relevance and ability of adaptiveness of a web service to a particular context. The result is a loosely coupled architecture in which a service level decision need not know the individual services beforehand. The service execution language features for dynamic adaption of services to specific contexts will be developed, including handling of feedback from partner services and users. The architecture is shown in Fig.4.

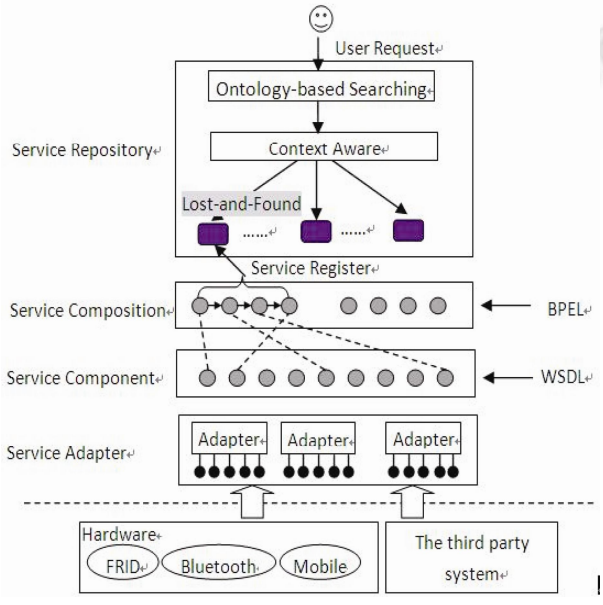

Fig. 4　Architecture of a lost-and-found service

Let us describe the system architecture using the lost-and found example, as shown in Fig.4. From bottom up, some basic functions are encapsulated as service components. They can be composed using the service choreography language. For example, the lost-and-found-service is composed of service components such as item registration, location enquiry and alarm. Then lost-and- found is registered in service repository that customers can use. From top down, users requirement, which is described as "help to find the item", will be first identified by ontology - based searching and filtering so that it can link to the standardized context definition. Then context the context- awareness component is used to link users' requirement to the lost-and-found service and guide the user to go through the registration.

5　Conclusion

Services in Context is an ambitious research project aimed at paving the way for flexible, reliable context-aware services. We hope that the envisioned framework will demonstrate the value of actively and dynamically utilizing valued user feedback, in service quality assurance and testing, in ontology-based context-aware services, and in context-aware service choreography, finally integrating services and context.

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