Ubiquitous Provision of Context-Aware Web Services

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ABSTRACT

Providing context-aware Web services refers to an adaptive process of delivering contextually matched Web services to meet service requesters' needs at the moment. This article presents an ontology-based context model that enables formal description and acquisition of contextual information pertaining to both service requesters and services. The context model is supported by context query and phased acquisition techniques. We also report two context-aware Web services built on top of our context model to demonstrate how the model can be used to facilitate Web services discovery and Web content adaptation. Implementation details of the context elicitation system and the evaluation results of context-aware services provision are also reported.

Keywords: context-aware; OWL-S; portable devices; service oriented architecture; ubiquitous; Web services

INTRODUCTION

Context in the field of Web services refers to users’ situated environment or surrounding information, which may impact service execution, from the perspective of either service requesters or services. Typical contextual information includes computational devices, communication network, lighting, noise level, location, activity, and time (Dey & Abowd, 1999; Schilit, Adams, & Want, 1994). In our view, context not only emphasizes people’s mobility and physical location, but also people’s abstract situations (e.g., whether they are in a meeting). Although context can be interpreted differently from various perspectives, in this research, we will address context from the aspect of mobile and pervasive computing.

Each Web service typically requires its most suitable context (e.g., platforms and devices) for the best execution performance. For example, a Web service may be developed oriented to desktop browsers instead of Personal Digital Assistant (PDA) browsers. Meanwhile, as people are constantly on the move in heterogeneous working environments, their available resources (e.g., computational devices and communication network coverage) are more frequently prone to change due to physical location changes. Therefore, in the process of a service consumption, a service may have to
smoothly adjust its content delivery according to the ever-changing environment (i.e., context), especially when a gross mismatch between resource requirements and supplies occurs (Satyanarayanan, 2004). For example, if a service requester moves into a dark area, it will be proper for the corresponding service to switch from video content delivery to audio content delivery.

One might argue that there is no need to perform content adaptation such as turning the video off while a person is driving. The concept behind this adaptation is that removing unnecessary medium can save transmission time and improve transmission performance, especially when transmitting rich media over a wireless network. In addition, not every device can play all types of media. Hence, content adaptation will save unnecessary network bandwidth by removing such media if it is unplayable on certain devices. Nevertheless, there is always a tradeoff between quality and performance, and this is one of the motivations why we need a dynamic content adaptation.

Providing context-aware Web services thus refers to an adaptive process of delivering contextually matched Web services to service requesters. It aims to provide personalized and adaptive services based on service requesters’ varying characteristics and situated environments. We envision that providing context-aware Web services is the first step toward ubiquitous Web services by finding the right services in the right place at the right time.

Here we summarize the characteristics of context-aware Web services and their requirements in the following eight aspects: mobility, location awareness, interoperability, seamlessness, situation awareness, social awareness, adaptability, and pervasiveness.

1. **Mobility**: The capability of continuous computing while moving from one position to another. Requirements include mobile computing on portable devices with embedded software.
2. **Location awareness**: The capability of detecting and identifying the locations of persons and devices. Requirements include outdoor positioning and indoor positioning.
3. **Interoperability**: The capability of interacting between various standards of resource exchange and services composition and integration. Requirements include standards of content, services, and communication protocols.
4. **Seamlessness**: The capability of providing an everlasting service session under any connection with any device. Requirements include state transition of network roaming and service migration.
5. **Situation awareness**: The capability of detecting and identifying person-situated scenarios. Requirements include knowing what a person is doing with whom at what time and where.
6. **Social awareness**: The capability of knowing socially related entities, their knowledge, and their activities at one moment. Requirements include discovering social partners’ knowledge competence and social familiarity.
7. **Adaptability**: The capability of dynamically adjusting services and contents depending on users’ needs. Requirements include discovering people’s accessibility and preferences.
8. **Pervasiveness**: The capability of providing an intuitive and transparent way of service and content access. Requirements include predicting users’ needs before their explicit expressions.

These characteristics pose significant challenges to services delivery and provision. Beyond others, such characteristics and constraints should be formalized with requirements specification so that they can be precisely defined and captured to satisfy the demands of a service requester in a ubiquitous environment.

For ease in explaining why contextual information is necessary for proper services provision and ease in explaining our solution, let us consider an example scenario that will be used throughout this article. Steve is a manager
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