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A human-centric framework for context-aware flowable services in cloud computing environments

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ABSTRACT

Services are expected to be a promising way for people to use information and computing resources in our emerging ubiquitous network society and cloud computing environments. In this study, we propose a metaphoric concept called a flowable service. It is defined as a logical stream that organizes and provides circumjacent services in such a way that they are perceived by individuals to be naturally embedded in their surrounding environments. We present our view on how some of these problems, such as the flexibility, portability and interoperability of services, can be solved using flowable services in order to provide a seamless integration of diverse services in the most intuitive "flowable" way possible, thus achieving maximum satisfaction for both service providers and consumers while decreasing the delivery cost of the services. Recognizing the importance of the awareness of each individual's context for a smooth and accurate provision of services, we further propose a human-centric framework for context-aware flowable services, which harnesses the users' contexts to enable a pro-active support of human activities in a flexible and natural way. Owing to context-awareness, this framework can find and integrate circumjacent services that are considered needed by each individual and can create an ambient service environment that is tailored to his/her specific needs, proclivities and characteristics.

1. Introduction

Since the term "cloud computing" was coined in 2006, there have been many cloud-related controversies that have been of concern [5,33,27,44,14]. We classified them into the following three groups:

1.1. Cloudy concept vs. attractive marketing

A majority of the cloud computing definitions [13,31], including *on-demand*, *pay-by-use model*, *virtualized and dynamically-scalable*, have the characteristics of cloud computing. However, all of the definitions are descriptive and can change on a daily basis. Although *there are no clear examples of successful scientific applications of clouds* [5], business long-term marketing for large profits, cost-effective storage for data sharing, and high-speed computing for system maintenance attract many individuals with good business sense who incorporate these technologies into the field.

1.2. Novel diverse computing types vs. old Internet techniques

Some of practitioners and researchers believe that cloud computing is nothing new because it uses existing Internet techniques for concepts, approaches, and practices. However, in others' opinions, everything that pertains to cloud computing is

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new, because cloud computing applies novel diverse computing types, such as SaaS (Software as a Service), PaaS (Platform as a Service), utility computing, web services in the cloud, MSP (Managed Service Providers), service commerce platforms, and Internet integration. Furthermore, these computing types are based on new payments, new deployments and new updated/maintained mechanisms.

1.3. Single open cloud manifesto vs. multiple business giants

"Open Cloud" (or "Blue Skies")—the third of three types of cloud computing scenarios—is presented in Nelson [33], where open standards, open interfaces, and open-source software are used to enable thousands of different organizations to link their infrastructures into a single, global cloud. The open cloud manifesto mentioned in Worthen [44] seems to not provide fair opportunities for all of the potential business participants. For developing cloud computing, the issues of protocol, security, and openness must be addressed. Commercial competitions also must be considered.

In this study, we propose the Flowable Services Model (FSM) to seamlessly integrate services in order to seek maximum satisfaction from both service providers and consumers while decreasing the delivery cost of services in open cloud environments. This model emphasizes capturing users' needs to best provide required services and to improve their satisfaction by harnessing user contexts. We address the relevant issues, which are described as follows.

1.4. How cloud-related problems are solved with contexts

In [1], researchers provide a widely accepted definition of context: "Context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between the user and application, including the user and applications themselves." In our study, user context information includes three factors: human, nature and culture (details are discussed in Section 4). In a specific situation, these context factors have different weighting. The more context information that can be captured, the more accurate the expected results are.

1.5. How contexts in today's services are captured and applied

RFID tag and sensor technologies are applied to acquire physical information such as information about users moving from one location to another. However, developing methods for acquiring a user's cultural context in real situations is a key problem that has been left unsolved.

The remainder of this paper is organized as follows. Section 2 describes related works that concern the context approach and a variety of related models. Section 3 explains the concept and definition of our proposed FSM and its user-oriented architecture, which uses user-oriented backgrounds and metaphors of human thinking for the FSM. Section 4 provides a classification of contexts and introduces measures for this model. Section 5 introduces system layers and a prototype of an FSM-based system, which includes a design and application scenario. Finally, in Section 6, we summarize this study and discuss future work.

2. Related works

In this section, the main issues about cloud computing and challenges are discussed. We overview and compare context approaches and investigate a variety of context models.

2.1. Issues and challenges

Although this young multidiscipline developed rapidly over recent years, many gaps between theory and practice have been exposed. On the basis of our survey, we summarize the open issues of services computing and classify them into three groups (see Fig. 1).

- Group 1 is related to the services computing process.
- Group 2 describes problems that involve relationships among services.
- Group 3 concerns the whole environment of services computing, such as integration or security.

As shown in Fig. 1, Group 1 is a large set of issues that consider services such as offline availability and resource diversity. We believe that issues that are related to human needs deserve more consideration within a services computing paradigm (therefore, the human is an essential element of the flowable service model that we propose in this study). One of the attempts to reach this goal is in the Human-Provided Services (HPS) framework, which allows people to manage their interactions and to seamlessly integrate their capabilities into Web-scale workflows as services [36]. To study these issues with greater depth, agent-based modeling approaches applied to the study of complex adaptive systems can be considered. Such approaches are used to study social systems, such as how local interactions among agents generate emergent social structures and patterns of behavior that are larger and more global [35].