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CATS-CAE Reflective Middleware Framework for Adapting Context-Aware Transactional Services:
Using a Hybrid Policy-Based Approach

Widad Ettazi, IMS Team, ADMIR Laboratory, ENSIAS, Rabat IT Center, Mohammed V University, Rabat, Morocco
Mahmoud Nassar, IMS Team, ADMIR Laboratory, ENSIAS, Rabat IT Center, Mohammed V University, Rabat, Morocco
Hatim Hafiddi, SEEDS Team, STRS Laboratory, INPT, Rabat, Morocco

ABSTRACT

Pervasive environments are characterized by limited computing resources and wireless connectivity. In parallel, current application domains have variable transactional requirements that do not fit the traditional ACID model. As a result, the pervasive environment characteristics are compelling and cannot be supported by conventional solutions that are typically dedicated to a specific application domain and support a limited set of context parameters. This article aims at providing a complete solution that addresses the challenges of the adaptability of context-aware transactional services "CATS" in pervasive environments. Thus, a new framework CATS-CAE was designed, which offers a comprehensive structure of multiple component chains. The adaptation strategy in CATS-CAE is based on a hybrid approach combining the use of adaptation policies, alternative strategy and behavioral adaptation of composite services through the "Profiled Task Class" concept. A probabilistic model is also presented to support the efficiency of the proposed approach.

KEYWORDS

ACID Properties, Alternative Strategy, Behavioral Adaptation, Context-Awareness, Pervasive Environment, Transactional Service

INTRODUCTION

Advances in wireless communication combined with the proliferation of mobile units (cell phones, smart cards, laptops, etc.) have allowed users to access data and perform transactions anywhere, anytime and from any terminal via so-called pervasive applications.

The proposed techniques in mobile transactions have limited support for so-called pervasive environments (Schafer, Dolog, & Nejdl, 2008; Lakhal, Kobayashi, & Toyota, 2009). Indeed, the specification of the transactional model is carried out even before a transaction can be executed. However, this approach is only valid when all transactional and execution requirements can be predicted in advance. Furthermore, even if these techniques can satisfy specific features such as disconnections, they do not provide a suitable platform for making necessary adjustments and modifications at runtime. These adjustments are essential for two main reasons. On the one hand, the pervasive environment is extremely dynamic and subject to rapid and unpredictable changes. On the other hand, the characteristics of current applications require that their transactional needs

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vary. Indeed, the transactional requirements may differ from one application to another or within the same application. Identical requirements may change over the lifecycle of a transaction and are never specified at the design time.

Therefore, the authors consider that the adaptability of a system depends on several parameters. These settings can be set by the application designer. For instance, a payment transaction must require strict atomicity in spite of the transaction execution cost. On the other hand, a reservation transaction of a hotel room can tolerate a relaxed atomicity for a lower execution cost. In the field of Web Services, these applications are structured around services that have transactional properties. These services are generally associated with resources handling, namely, the booking of hotel rooms, event places, etc. An application of such example can be illustrated by an E-Tourism scenario which consists of the purchase of an airline ticket with some specific preferences on (airline company, flight time, price), a hotel room reservation (distance from the conference venue, price) and a restaurant table reservation (near the hotel). These tasks can be structured with three transactional services, where one will be associated with the flight booking, the second with the hotel reservation, and the third with the restaurant reservation. Each of these services can use alternatives; for instance, the choice between several airline companies and prices. However, managing the transactional aspects of a service presents several challenges: (i) Web Services domain is extremely dynamic and unpredictable; where services are constantly modified, (ii) Web Services are loosely coupled, and have heterogeneous transactional properties and (iii) A composite service has variable transactional properties that can be altered throughout the execution of the composition.

The above scenario underscores the importance of taking into account context-awareness aspects in transactional systems development for pervasive environments. Nevertheless, without providing a satisfactory response to users, these systems lose a lot of interest. Hence, the motivation of this research aims to establish a solution which select, compose and adapt, on the fly, services available in pervasive environments and capable of fulfilling users' tasks while meeting their context and transactional requirements.

This paper is organized as follows. The following section will be devoted to review related works. Then, an overview of the hybrid policy-based adaptation approach is given. Next section introduces the CATS-CAE reflective framework for managing CATS and highlights the interactions between the different CATS-CAE components. Finally, a probabilistic study of the impact of the adaptation strategy is illustrated with a succinct alternative tests scenario. Last section will be devoted to present some conclusions and future works.

LITERATURE REVIEW

The research works presented in this section exhibit existing approaches for reliable execution of context-aware composite services, particularly composite services with transactional properties.

Lakhal et al. (2009) introduced a transactional framework called FENECIA that includes backward recovery by compensation, forward recovery by replacing and retrying services, and the concept of vital and non-vital services. Compared to the authors' approach, FENECIA doesn't (i) propose a formal modeling of context-aware transactional services, (ii) support the behavioral adaptation as a proactive strategy and the context-awareness capabilities. Liu et al. (2010) proposed another framework called FACTS to ensure the adaptability of composite services. This is a hybrid approach that combines exception handling and transactional properties. The transactional model and recovery mechanisms are based on FENECIA. Ying et al. (2009) developed a framework for reliable replacement in the context of QoS-driven transactional services composition. The framework considers the QoS parameters of the re-selection service, the transactional risk and the compensation cost during the replacement process. An experimental evaluation is processed under a simulated environment, which shows the scalability of the approach. Compared to the authors' approach, the work of (Ying, Zhang, Zhang, & Zhao, 2009) is QoS-aware, focuses solely on the compensation cost, and offers limited options regarding adaptation