A Knowledge-based Service Creation and Execution Framework for Adapting Composite Wireless IP Services

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Abstract. Wireless services infrastructures beyond 3G are evolving into highly complex and heterogeneous network environments embracing a multitude of different wireless internet access technologies, terminal types and capabilities, different bearer services, core/access network configurations, along with a wide range of application-related functions. Further to this reality, service operators are confronted with increasingly demanding users, becoming more and more aware of their needs. Thus, the main objective of this research work is to pave the way to novel service creation and execution systems beyond 3G, allowing the mobile user to build her/his own highly personalised composite wireless services.

1 Introduction

Mobile service providers have already begun to offer composite wireless services as vehicular route assistance and navigation services, location-sensitive advertising services, presence services, etc. These services typically consist of a combination of elementary component services (e.g. establishment of a bearer channel, a file transmission, user position acquisition, etc) [1]. However, presently there is no direct or indirect way for the user to personalise the most significant services component such as the service logic, (the logic for selecting the elementary components of a composite wireless service) and mandating the way that these resources (elementary component services) are utilised in a coordinated manner. This paper aims at the definition of novel, user-centric service creation and execution systems able to

identify and autonomously exploit knowledge from the user's needs for the synthesis, deployment, and persistent adaptation of highly personalised composite wireless internet services. The scope is to valorize existing wireless infrastructure investments by radically increasing the value of services in terms of personalisation, and contributing towards the realisation of novel schemes for rapid and automated mobile services creation, deployment and early validation. For this purpose, the paper proposes and defines a knowledge-based, ontology-driven approach for wireless internet composite services conceptualisation and synthesis, and introduces a modular and scalable architecture and accompanying tools serving the creation and deployment of adaptive composite wireless services.

2 State of the Art

As wireless services have started to penetrate into a wide range of everyday-life aspects (work, entertainment, health, safety, etc), wireless service operators need to cope with increasingly divergent user requirements and challenges pertaining to the personalization of the delivered services. Wireless services are still built in an "one-size-fits-all" manner, typically addressing the "specific" requirements of identified broad categories of users, while services personalisation has been limited to simple service-parameterisation. There is no direct or indirect way for the user to cause the adaptation of the most significant services component: the service logic, i.e. the logic for selecting the elementary components of a composite wireless service and mandating the way that these resources are utilised in a coordinated manner. The main problem of current service creation and execution systems [2] is their inability to support different needs of individual users. Hence, there is an evident need for a consolidated approach that will allow the effective capturing of the knowledge pertaining to wireless user requirements and 'wants' and the capabilities of the wireless service-execution infrastructures, and enable the exploitation of this knowledge for the synthesis, and deployment of personalized wireless composite services.

2.1 Objectives

This paper makes use of novel approaches in the field of wireless services specification and creation using the concept of the composite wireless service,which consists of a combination of component wireless services. The proposed generic architecture is consisted of several entities, which their roles and relations are depicted in Figure 1 and described below.

- The Service Synthesis Centre (SSC) hosts the intelligence required for the management of Service Synthesis functions, the identification of the users' needs, and the generation of valid service specifications.
- The Customer Profile and Services Data Store (CSDS) entity provides the means for retrieving data required for service synthesis from the multitude of possible sources (HLR/HSS, SDP, BCCS, etc), and mapping the data onto the

ontological models used for Service Synthesis in order to be accessed in a straightforward manner by the SSC.

Services deployment involves the Service Deployment and Execution Centre (SDEC), which generate on the basis of implementation domain service specifications received from the SSC, the self-adaptive software modules (self-adaptive SW agents that implements the wireless composite service logic, and the installation and integration of the SW into the execution environment of the Wireless Composite Services Execution Server (WCES). During service execution the SDEC is capable of redesigning and reactivating SW agents on the basis of the information provided through interactions with the agents and/or knowledge available within the SDEC.

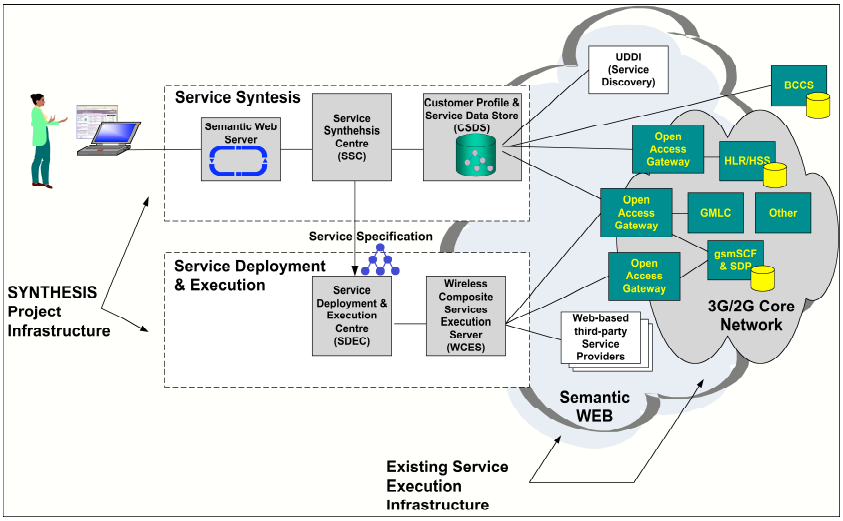

Figure 1: The proposed generic architecture

2.2 Composite Wireless Services Functional Requirements

Our approach makes use of and extend state-of-the-art approaches emerging in the field of wireless services creation and execution: a composite wireless service consists of a combination of component wireless services [4]. A component wireless service can be: a fundamental wireless service that cannot be partitioned into separately identifiable services – for example identify a location, obtain vehicular travel information, transmit/receive a file, etc, a utility service that implements a function within a particular composite service sequence and acts as the binding between fundamental wireless services – for example, invoke a composite service sequence, execute a pause, assign a parameter value, etc, another composite wireless service.

The composite wireless service consists of continual iterations of these three services, in the following sequence, until the destination is reached: a) Determines the present location and provide it to the wireless terminal. If the present location is the same as the destination, inform the user and cease the iteration of services, b)

Computes the least time-consuming route from the present location to the designated destination. If the route has changed, alert the user, of a new route and its directions, c) Retrieves traffic information for the route's regions and determine if traffic delays, such as those due to an accident, would ensue. If traffic delays exist ahead, repeat step (b) with the updated delay information; otherwise, proceed to step (a). The logic of the composite service is executed at an application server, which is called Wireless Composite Services Execution Server (WCES). More specifically service synthesis involves the user and the service synthesis environment interacting for the production of a personalised and valid service specification. This specification should be consistent with the capabilities of the service execution platforms in use, the user profile and subscription status information stored in the multitude of mobile services data infrastructure (HLR/HSS, SDP, BCCS databases, etc), and user context information (e.g. location) retrieved from the network using open access interfaces (OSA). On the other hand, service deployment involves the generation of the self-adaptive software module implementing the wireless composite service logic (self-adaptive SW agent) and its installation and integration into the execution environment of the Wireless Composite Services Execution Server. During composite service logic execution, the Wireless Composite Services Execution Server needs to interact with the mobile user terminal (typically through the use of an OSA gateway or in a proprietary manner using the GPRS service), and also a set of other application servers that belong to external third-party service providers. In this case (navigation service), third party providers include a route estimation (navigation) provider, and a traffic information provider (e.g. state police traffic information server).

3 The Proposed Architecture

Service synthesis is the process resulting into the production of service specifications to be exploited by the advanced service deployment and execution infrastructure. Service synthesis consists of an iterative procedure for progressively collecting user needs and building valid service specifications. The Service Synthesis Centre (SSC) hosts the intelligence required for the management of Service Synthesis functions and the generation of valid service specifications. The SSC cooperates with a Semantic Web Server for handling interactions with the user and capturing user-perspective service descriptions (user needs).

The paper defines adequate ontology models that provide the means for the valid conceptualisation, and specification (instantiation) of composite wireless services. Furthermore, these ontology models provide the means for the communication among the Service Synthesis entities. Additionally, Customer and Business Domain ontological models will be used to effectively represent knowledge pertaining to what the customer wants and can have as a subscriber, while in parallel the Implementation Domain ontological models will be used to effectively represent knowledge pertaining to the capabilities, functionality, and behaviour of existing wireless service execution platforms. On the other hand, service synthesis has to be consistent with static and dynamically changing information pertaining to

capabilities of the underlying service execution platforms, capabilities of available third-party providers, present user context (e.g. location), user profile and subscription status, etc, that should be accessed on demand and/or is stored in the multitude of mobile infrastructure (legacy) databases (HLR/HSS, SDP, BSSC, etc). The Customer Profile and Services Data Store (CSDS) entity provides the means for retrieving this data from the multitude of possible sources, and mapping the data onto the ontological models used for Service Synthesis in order be accessed in a straightforward manner by the SSC. In this sense, the Customer Profile and Services Data Store (CSDS) will be capable of providing a single harmonised interface to the SSC, for accessing data required for the production of valid service specifications.

Service deployment involves the Service Deployment and Execution Centre (SDEC) generating – on the basis of implementation-domain service specifications received from the SSC – the self-adaptive software modules (self-adaptive SW agents) implementing the wireless composite service logic, and the installation and integration of the SW into the execution environment of the Wireless Composite Services Execution Server. Further, the service deployment phase involves the generation of the user-terminal SW to be downloaded and installed on the terminal specifically for this service. Finally, service execution involve the Wireless Composite Services Execution Server cooperating with the mobile user terminal and also a set of other application servers that belong to external third-party service providers.

3.1 The Ontology-driven framework for service synthesis

Ontologies include machine-usable definitions (specifications) of basic concepts (e.g. user, subscription, elementary service, composite service, etc) and the relationships among them. Using ontologies, applications can be "intelligent," in the sense that they can more accurately work at the human conceptual level. These ontologies should be expressed in the standardised W3C Web Ontology Language (OWL) [3], [5]. OWL makes use of the XML syntax and is part of the growing stack of W3C recommendations related to the Semantic Web. The proposed schema develops and utilises two types of ontological models. On the first type the main purposes of the Customer and Business Domain ontological models represent knowledge pertaining to what the customer needs and can have as a subscriber. Conversely, the main purpose of the Implementation Domain ontological models highlight in a generic manner knowledge pertaining to the capabilities, functionality, and behaviour of existing wireless service execution platforms.

3.2 Services Synthesis Infrastructure and Techniques

Service synthesis is the process resulting into the production of service specifications to be exploited by the advanced service deployment and execution infrastructure. Service synthesis is performed at the Service Synthesis Centre (SSC). In the context of the proposed architecture the Service Synthesis Centre cooperates with a Semantic Web Server for handling interactions with the user and identifying user-perspective

service descriptions (user needs). Furthermore, the Customer Profile and Services Data Store (CSDS) provide to the SSC a single harmonised interface for accessing data required for the production of valid service specifications. The ontology models provide the means for the communications between the entities of the Service Synthesis infrastructure, while Service Synthesis consists of an iterative procedure for progressively collecting user requirements and building valid service specifications. A high-level description of the Service Synthesis process is depicted in the Figure 2.

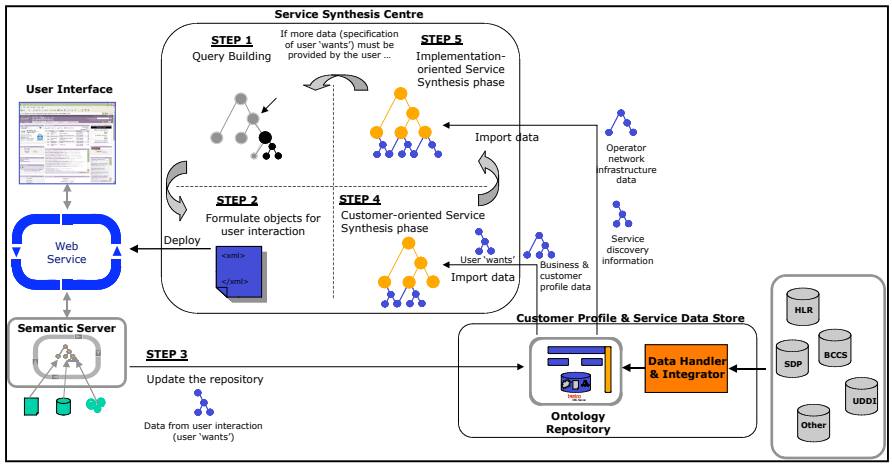

Figure 2: High-level Description of Generic Service-Synthesis Flow

More specifically, a service synthesis iteration process engages the following main steps: i) A query is built for requesting description of user needs. This query can be constructed on service triggering (initial query) or at an intermediate stage after determining that further information on the user needs is required from the user side, ii) The SSC, using a web-service, formulates and deploys the objects that serve the specific interaction with the user, iii) The user provides the requested input and the instantiations of the relevant ontological models are updated accordingly, iv) Customer-oriented Service Synthesis takes place. The SSC captures and validates - at the business and customer level - man-to-machine specifications for a wireless composite service and v) Implementation-oriented Service Synthesis takes place. The SSC maps and validates customer and business domain concepts onto the implementation domain. Data pertaining to user context (location, terminal capabilities, connectivity options, etc), and service discovery (e.g. availability and capabilities of third-party service providers) is imported for this purpose from the Customer Profile and Service Data Store.

3.3 Service deployment and execution techniques

Service deployment involves the Service Deployment and Execution Centre (SDEC) generating the self-adaptive software modules (self-adaptive SW agents) [6] implementing the wireless composite service logic and the installation and

integration of the SW into the execution environment of the Wireless Composite Services Execution Server. Further, the service deployment phase involve the generation of the user-terminal SW to be downloaded and installed on the terminal, specifically for this service. During service execution the SDEC is capable of redesigning and reactivating SW agents on the basis of the information provided through interactions with the agents and/or knowledge available within the SDEC.

In overall, SW adaptation at the wireless composite services execution server and the user terminal is to be performed at three levels. In the first level SW components based on the interactions with their environment (network service execution environment) are self-adapted. The next level re-designs and re-constructs the adaptive SW components (agents) at the Service Deployment and Execution Centre on the basis of the feedback received from the adaptive SW agents. Finally, in the last level, re-design and re-construction of adaptive SW components at the Service Deployment and Execution Centre after a new conceptual service specification has been requested and received from the Service Synthesis Centre, is performed.

Self adaptive software agents are dynamic entities, thus they are capable of discovering a need for change - for additional knowledge and/or functionality on the basis of their analysis of specific situations. The SDEC is capable of redesigning and reactivating agents on the basis of the information provided by agents and/or knowledge available within the SDEC. Specifically, the self-adaptive SW components implementing the logic of composite wireless services will have an explicit model that it will be aware of their sub-components, their external environment and their specifications. In addition, the SW components throughout this model, will be able to monitor and control their sub-components in order to reconfigure their functions at run-time. Finally, SW components will be able to communicate with the SDEC for reporting performance bottlenecks and implementation deficiencies.

3.4 Service creation, deployment and execution tools and infrastructure

The Service Deployment and Execution Centre (SDEC) hosts the intelligence required for constructing the adaptive SW agents installed on the Wireless Composite Services Execution Servers and user terminals, monitoring the performance of service execution, determining whether SW agents are not performing as they should, and therefore proceed in a new implementation design and deployment, retrieving information from the CPS pertaining to the dynamically changing service execution environment, user context, and discovery of alternative service providers and requesting from the Service Synthesis Centre a new service specification. The implementation of the adaptive SW agent execution environment is based on the OSGi service platform [7]. This platform specifies a standard environment which allows multiple, Java-based components, called bundles, to run in a single Java Virtual Machine (JVM) securely. The JAVA environment is selected by the OSGi alliance as the OSGi execution environment. The proposed approach can utilise one of the J2SE and J2ME, execution environments [8]. The service creation SW will be able to exploit the Semantic Web Enabled Web Services

(SWWS) exposed by the Semantic Server, for effectively adapting the service creation interface during the course of service synthesis.

4 Conclusions

This paper proposed a generic approach and architecture addressing the realisation of novel, user-centric service implementation and execution systems able to capture and autonomously exploit knowledge of user requirements for the synthesis, deployment, and persistent adaptation of highly personalised composite wireless services. To target the goals of this approach, a knowledge-based, ontology-driven approach for wireless composite services conceptualisation and synthesis introduced involving the specification of adequate ontological models and of the techniques and algorithms for capturing and exploiting this knowledge pertaining to user needs, business-domain processes, customer profile, and services-implementation-domain concepts. The proposed modular and scalable architecture will effectively interact with existing wireless services execution environments, and data storage infrastructures. The prototypes of the entities introduced, comprising the proposed architecture, namely the Service Synthesis Centre (SSC), Service Deployment and Execution Centre (SDEC), Customer Profile and Services Data Store (CSDS) and Wireless Composite Services Execution Server (WCES), ensuring at the same time their interoperability.

References

1. Z. Maamar, Q. Z. Sheng, and B. Benatallah. On Composite Web Services Provisioning in an Environment of Fixed and Mobile Computing Resources. Information Technology and Management Journal, Special Issue on Workflow and E-Business, Kluwer Academic Publishers, 2003.
2. F. Curbera, M. Duftler, R. Khalaf, W. Nagy, N. Mukhi, and S. Weerawarana. Unraveling the Web Services Web: An Introduction to SOAP, WSDL, and UDDI. IEEE Internet Computing, 6(2), March/April 2002.
3. S. Kouadri Most´efaoui, and B. Hirsbrunner. Towards a Context Based Service Composition Framework. In Proceedings of The First International Conference on Web Services , Las Vegas, Nevada, USA, June, 2003.
4. Benatallah, B. Sheng, Q. Z. Dumas, M., “The Self-Serv Environment for Web Services Composition”, IEEE INTERNET COMPUTING, vol 7, pp 40-48, 2003.
5. Sean Bechhofer. OWL Web Ontology Language: Parsing OWL in RDF/XML. W3C Working Group Note, World Wide Web Consortium, January 2004.
6. Jeff Gray, Raymond Klefstad, Marjan Mernik;“Adaptive and Evolvable Software Systems: Techniques, Tools, and Applications”; Proceedings of the 37th Hawaii International Conference on System Sciences, 2004.
7. Open Service Gateway Initiative, www.osgi.com.
8. Roger Riggs, Antero Taivalsaari, Mark VandenBrink, “Programming Wireless Devices with the JavaTM 2 Platform, Micro Edition”, Addison-Wesley, 2001.