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A Knowledge-based Service Creation and Execution Framework for the Adaptation of Composite Wireless 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 access technologies, terminal types & 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.

Key-Words: - Composite Wireless Services, Knowledge Engineering, Ontologies.

1 Introduction

Mobile service providers have already begun to offer composite wireless services as vehicular route assistance & 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, transmission of a file, acquire user position, etc) [1]. However, presently there is no direct or indirect way for the user to personalise 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 (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 capture and autonomously exploit knowledge of user 'wants' for the synthesis, deployment, and persistent adaptation of highly personalised composite wireless 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 & automated mobile services creation, deployment and early validation. For this purpose, the paper proposes and defines a knowledge-based, ontology-driven approach for wireless composite services conceptualisation and synthesis, and introduces a modular and scalable architecture & accompanying tools serving the creation and deployment of adaptive composite wireless services.

Our paper is organized as follows: In Section 2 a state of the art introduction is taking place, section 3 describes the proposed Architecture and finally, section 4 concludes the paper.

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. Presently, 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 & '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.

The paper makes use of novel approaches emerging in the field of wireless services specification and creation: a composite wireless service consists of a combination of component wireless services. A component wireless service can be: a fundamental wireless service that cannot be partitioned into separately identifiable services, a utility service that carries out a function within a particular composite service sequence and acts as the binding between fundamental wireless services, or another composite wireless service.

The ontologies provide the means for the valid description and specification of composite wireless services. 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 [3].

In technical terms ontologies can be defined using the standardised W3C Web Ontology Language (OWL) [4]. OWL makes use of the XML syntax and is part of the growing stack of W3C recommendations related to the Semantic Web.

3 The Proposed Architecture

3.1 Overview of the architecture

The proposed generic architecture is depicted in Figure 1.

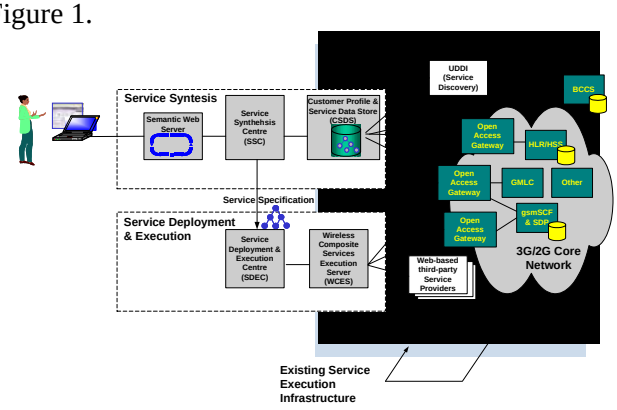

Fig.1: The proposed generic architecture

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 constitutes an iterative procedure for progressively collecting user 'wants' 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 'wants').

The ontological models provide the means for the valid conceptualisation, and specification (instantiation) of composite wireless services. Further these ontological models provide the means for the communication among the Service Synthesis entities. Specifically:

1. Customer & Business Domain ontological models can be used to effectively represent knowledge pertaining to what the customer wants and can have as a subscriber.
2. Implementation Domain ontological models can be used to effectively represent knowledge pertaining to the capabilities, functionality, and behaviour of existing wireless service execution platforms.

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 & 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 & 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 & Services Data Store (CSDS) provides to the SSC a single harmonised interface for accessing data required for the production of valid service specifications.

Service deployment involves the Service Deployment & 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 & 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.

Service execution involves 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.

3.2 Service synthesis procedure

Figure 2 depicts the proposed service synthesis infrastructure. Service synthesis is performed at the Service Synthesis Centre (SSC), which cooperates with a Semantic Web Server for handling interactions with the user and capturing user-perspective service descriptions (user 'wants'). Further, the Customer Profile & Services Data Store (CSDS) provides to the SSC a single harmonised interface for accessing data required for the production of valid service specifications.

The ontological (data) models provide the means for the communications between the entities of the Service Synthesis infrastructure. Service synthesis constitutes an iterative procedure for progressively collecting user requirements and building valid service specifications.

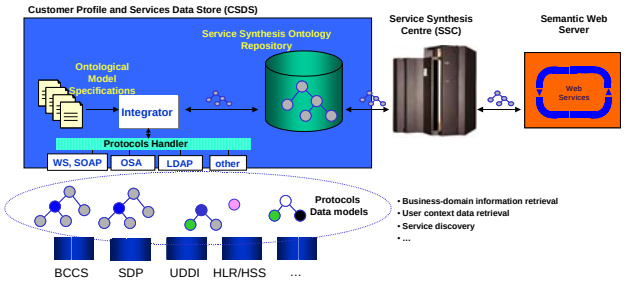

Fig.2: The Service infrastructure

A service synthesis iteration process involves the following main steps:

1. A query is built for requesting description of user 'wants'. This query can be constructed on service triggering (initial query) or at an intermediate stage after determining that further information on the user 'wants' is required from the user side.
2. The SSC formulates and deploys, using a Web-Service, the objects that will serve the specific interaction with the user.
3. The user provides the requested input and the instantiations of the relevant ontological models are updated accordingly.
4. 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.
5. 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 Composite wireless service example

The architectural approach presented in this paper 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 [5]. A component wireless service can be:

1. 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.
2. A utility service that carries out 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.
3. Another composite wireless service.

The Service Deployment & Execution Centre (SDEC) hosts intelligent functions, including:

1. Creation of the adaptive SW agents that may be installed at the Wireless Composite Services Execution Servers and user terminals.
2. Monitoring of the performance of a composite service during execution through interactions with the adaptive SW agents.
3. Tracing out SW agents not performing according to the user requirements.
4. Retrieval of information from the CPS to be used for charging the users.
5. Submission of new service composition requests towards the Service Synthesis Centre.

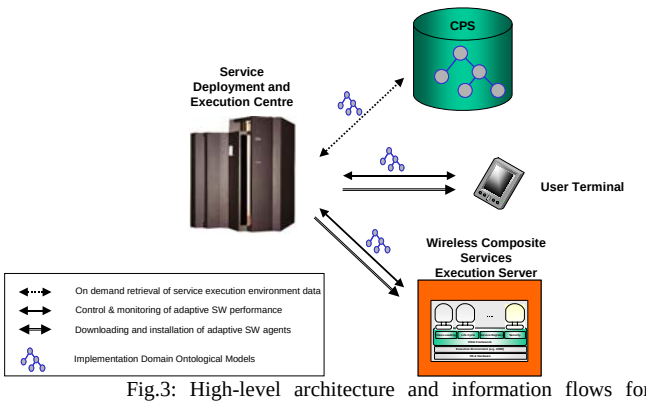

Fig.3: High-level architecture and information flows for service deployment infrastructure

To demonstrate the utility of composite wireless services, we can take the paradigm of a wireless composite navigation service. Consider having a severe time constraint for driving a vehicle between two geographic points. Three fundamental wireless services can be employed to achieve this vehicular route assistance:

1. Location service – determines the present location of a user's wireless terminal in the vehicle.
2. Travel route computation – computes the least time-consuming drive between the current wireless terminal location and a designated destination.
3. Traffic information retrieval – interrogates traffic information systems available from state, police and other providers for travel route regions.

The composite wireless service consists of continual iterations of these three services, in the following sequence, until the destination is reached:

1. Determine 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.
2. Compute 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.
3. Retrieve 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 2 with the updated delay information; otherwise, proceed to step 1.

The logic of the composite service is executed at an application server (Wireless Composite Services Execution Server - WCES).

4 Conclusion

This paper proposed a generic approach and architecture addressing the realisation of novel, user-centric service creation 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 'wants', 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, are comprising the proposed architecture, namely the Service Synthesis Centre (SSC), Service Deployment and Execution Centre (SDEC), Customer Profile & Services Data Store (CSDS) and Wireless Composite Services Execution Server (WCES), ensuring at the same time their interoperability.

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