An Agent Based System for Business-driven Service Provisioning

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Abstract

In the 3G mobile networks, utilization of multimedia applications on mobile/wireless devices allows users to be present and communicate with other users, anywhere and anytime. Novel service provisioning models are taking into account user's behaviour, terminal equipment capabilities and the content providers. Thus, service charging schemes must be adapted to prevent the burdening of users with calculation of revenue for all the parties involved in the service provisioning process. We are proposing a system for automated business-driven service provisioning. Proof-of-concept implementation is deployed into 3G mobile network. Based on the operator's business strategies, availability of new software/content components, user's location, equipment capabilities and the amount of money on the user's account, operators can automatically create a list of potential users for the new service.

1. Introduction

It is expected that the worldwide globalization process of mobile communication is going to be completed with the third generation (3G) of mobile networks [Lindemann, Lohmann, and Thümmler 2003]. In the second generation (2G) of mobile networks service development is performed by network operators and/or equipment vendors while the access to the services is limited to the subscribers of a particular operator [Houssos et al. 2003]. Meanwhile, in the forthcoming era of 3G mobile networks, provisioning of advanced services becomes a challenge for the service providers. Besides the network operators, content providers and the equipment vendors, service providers are now also third-party software vendors that couple different applications and content to provide users with various multimedia services. Service providers design personalized and context-aware services for users. Network operators purchase those services and perform innovative service configuration according to their infrastructure capabilities.

In order to facilitate the development, deployment and maintenance of those services, network operators, as well as independent service providers, use Operation Support System (OSS) [Sherif, and Ho 2000]. OSS is based on database applications and its data architecture includes data stores, platforms, systems and access methods that support daily service operations [Papavassiliou, and Pace 2000]. At first the OSS was centralized in the network operator's core network together with the rest of the knowledge for network management. Increased development of advanced services, constraints of user equipment, network capabilities, arising business requirements and customer demands tend to push the OSSs towards the edge of the network to reduce the service provisioning time.

Some of the important aspects in service provisioning environment are service adaptability to user-related constraints (such as equipment capabilities and operating context - location awareness and localization) [Fouial, Fadel, and Demeure 2002]. Hardware and software characteristics of the current generation of user equipment are heterogeneous so only the services supported by their equipment should be offered to the users. Location awareness is an important condition for service provisioning and the personalization of the service. The services can be divided into services that are provided to users only on certain locations and the services provided to users regardless of the user location.

This paper is organised as follows. Section 2 gives a brief overview of the telecommunication environment. In section 3 intelligent software agents are presented. Section 4 describes automation of business-driven service provisioning process. Section 5 illustrates a multi-agent automated process for selecting targeted users. Section 6 gives the directions for future work and concludes the paper.

2. Telecommunication environment

A large number of business relationships between the network operators, the content providers and the independent service providers foster the service configuration and deployment processes. These Business-to-Business (B2B) relationships, together with Customer Relationship Management (CRM) and Enterprise Resource Planning (ERP), are handled by the Business Horizontal of the operator's Business Support System (BSS). Network operator's BSS is characterized with a two-layered architecture where the Business Horizontal handles industry generic business processes while Charging Control handles telecom specific charging operations [Prepaid postpaid convergent charg-

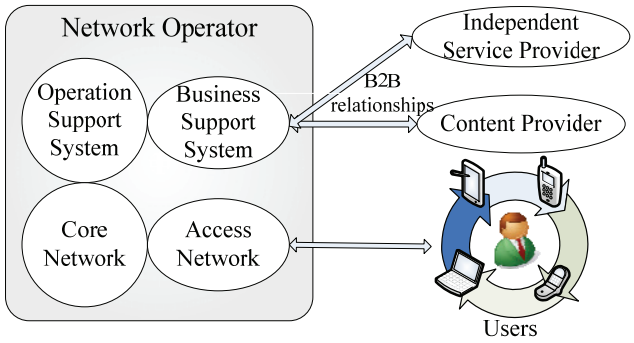

Fig. 1. Participants of the service provisioning process

ing, 2005]. The entities involved in the service provisioning process are shown in Figure 1.

Charging becomes one of the essential issues in the service provisioning process because the services are not offered to end users for free and especially since there are several parties (i.e. the network operators, content providers, service providers, users) involved in the service provisioning process. Providing services to users that are not credit-worthy can presents a risk of revenue loss for the network operators based on their fixed infrastructure cost. Debts towards the content providers and the independent service providers are another risk the network operators face due to inefficient credit control of users.

Until now the charging schemes used in mobile telecommunications were quite simple. The users are charged based on their subscription and call duration. Nowadays this scheme is being alternated as a consequence of the advent of 3G mobile systems, the expanding dominance of the Internet Protocol (IP) on the network infrastructure, the technological development of mobile phones and other user equipment. Some of the advanced charging schemes are the location-based and the content-based schemes. They require new mechanisms for collecting and processing all the information related to the chargeable event [Koutsopoulou et al. 2004].

Flexible pricing models are of vital importance for the service providers concerning the dynamic requirements that dominate on the mobile communication market [Schmid et al. 2005], especially since the interest is increasingly shifting away from the flat rate charging towards usage based or event based charging [Ghys, and Vaaraniemi 2003]. Another popular trend is outsourcing of accounting and charging processes to specialized business partners [van Le, van Beijnum, and Huitema 2004] to avoid complicated charging architectures.

A large part of the services offered in 3G mobile networks contain multimedia sessions that are composed from a different number of audio and/or video communications with a certain quality of service (QoS). Different layers and aspects have to be taken in account to charge the user for the usage of these services. Some of the pricing factors that can be applied to a service charge include: base fee, transport, content, application/service, time, user type, discounts, etc [Foll et al. 2005].

Taking into consideration growth of the portfolio of new attractive services which are offered to users, the existence of user related constraints, the importance of business decisions and charging the users for the provided services, there is a need for the automation of business-driven service provisioning process. Automation of service provisioning process will reduce the service time-to-market which is one of the most important requirements of the 3G mobile networks [Houssos et al. 2002].

This paper proposes a mobile and intelligent agent based solution for proactive optimized service deployment and charging-aware service provisioning in a multi-provider environment of the 3G mobile network. The research integrates the network operator's BSS with OSS using mobile and intelligent agents for business support.

3. Intelligent Software Agents

In vast and dynamic pervasive computing environments it is hard for users to identify and activate services that match their needs [Lindberg et al. 2007]. In the designed multi-agent system, intelligent software agents, supported by AI (*Artificial Intelligence*) mechanisms, are used to impersonate users, network operators, service providers and content providers in the volatile and heterogeneous environment of the 3G mobile network, in order to enable automated interaction and coordination [Trzec, and Lovrek 2006, Trzec, Lovrek, and Mikac 2006].

The dynamic and distributed nature of both data and applications in the 3G mobile network requires computer programs to not only respond to requests for resources but to intelligently anticipate and adapt to their environment while actively seeking ways to support their principals. Therefore, an intelligent software agent is an autonomous program which acts on behalf of its principal while conducting complex information and communication actions over the Internet. Intelligent software agents enable automated process execution and coordination, thus creating added value for its principal.

An intelligent software agent [Bradshaw 1997, Chorafas 1998, Cockayne, and Zyda 1998, Jezic, Kusek, and Sinkovic 2006, Kusek, Lovrek, and Sinkovic 2005] must possess some intelligence grounded on its knowledge base, reasoning mechanisms and learning capabilities. Depending on an assignment of particular agent there are differences in types of information contained in its knowledge base, but generally this information can be divided into two parts – owner's profile and agent's knowledge about environment. It is very important to notice that the agent's knowledge base does not contain static information. Adversely, the agent continuously updates its owner profile according to the latest owner needs, what allows the agent to efficiently represent its principal in pervasive environment of 3G mobile network, thus realizing calm technolo-

gy concept. Additionally, the agent also updates knowledge about its environment with the latest events from its ambience and with current state of observed parameters intrinsic to its surroundings, thus realizing context-awareness. Context-awareness describes the ability of the agent to provide results that depend on changing context information [Bellavista et al. 2006]. An agent executes tasks autonomously without any interventions from its principal, what makes it an invisible servant, just as Weiser envisioned [Weiser, and Brown 1997]. An agent must be reactive, so it can properly and in time respond on impacts from its environment. An agent does not just react on excitations from its environment but is also taking initiatives coherent to its tasks. Well-defined objective is inevitable prerequisite for proactivity. Efficient software agent collaborates with other agents from its surroundings: it is cooperative. If an agent is capable of migrating between heterogeneous network-aware terminals interconnected through ubiquitous 3G mobile network, this agent is called mobile software agent. An agent has a lifetime throughout which the persistency of its identity and its states should be retained, so it is characterized by temporal continuity.

4. Automated Business-driven Service Provisioning

The existing 3G mobile network infrastructure is oriented towards providing point-to-point links between users and services. With the increased need for point-to-multipoint communication (e.g. mobile TV service needs to be accessed by many users simultaneously), a clear need arose for the support of efficient broadcast/multicast functions. In order to establish broadcast and multicast services in the 3G mobile networks, 3GPP (http://www.3gpp.org) and 3GPP2 (http://www.3gpp2.org/) have introduced the specification for broadcast/multicast services. In 3GPP, the work entity is called Multimedia Broadcast and Multicast Service (MBMS). MBMS Broadcast-Multicast Service Center (BM-SC) entity is responsible for providing and delivering mobile broadcast services [Bakhuizen, and Horn 2005, Luby et al. 2006].

4.1 Multi-Agent System for Distributed Software Deployment

On the BM-SC node we installed the Remote Management Shell (RMS) agents that are a part of the Multi-Agent RMS (MA-RMS) system [Jezic et al. 2004, Kusek et al. 2003] used for distributed software deployment. This multi-agent system provides software component mobility where software components can be seamlessly relocated from one network node to another. The MA-RMS enables software delivery to the remote system, remote software installation and uninstallation, remote software starting and stopping, remote execution of two software versions in selective or parallel mode and remote versions replacement.

4.2 Business-driven Service Provisioning Process

3G mobile networks will transform the existing relationships in the telecom industry so the users are going to be directly connected to a single service provider. As stated before, main actors of the service provisioning process in 3G mobile networks are network operators, content providers, independent software providers and users. Due to increased number of actors in the service provisioning process, one of the problems will be how to effectively charge mobile users for services in 3G mobile networks. The efficient charging of mobile services in telecommunication systems architecture includes different types of nodes and mobile equipment. Behaviours, location and even balance of the user's account should be taken into consideration during the service provisioning process. Therefore we are proposing an automated business-driven solution, which will help the operator to efficiently introduce the new service to the users that will more likely desire to use it.

The Figure 2 shows the system's proposed architecture that allows business decisions to be implemented more easily with special emphasis on elements important to charging. Important components of the presented architecture are described later, while the communication between the main entities is described in Chapter 5.

In order to increase their income, reduce operating costs and satisfy new user demands, network operators have to tune their provisioning operations according to business strategies of the operator. Software agent decisions are guided by the business strategies that reflect the changes in a competitive environment (telecom market). Furthermore, the business strategies provide sustainable competitive advantage in the future as they take into account user behaviour and B2B relationships in the telecom market.

Operator's defined business strategies will be stored in the rule engine. Each business strategy contains business rules for the deployment of a new mobile service. Business rules are formal statements about enterprise data and processes. They define or constraint some business aspect (www.businessrulesgroup.org). In our multi-agent system we use action enabler rules. They initiate an action after checking conditions and finding them true [Charfi, and Mezini 2004]. The business rules contain all important parameters about our new mobile services such as: type of the service content, the mobile terminal type, the location of service execution, the season period, types of the target users (e.g. *"Take five"* users categories [Andersson et al. 2006]); the software components required for the service execution on mobile terminals, QoS and the time needed to execute the business strategy.

The Charging Server stores the information about user's accounts as well as the tariffs for the services that are offered to the users. It can provide Content and Event based charging between the operator and the content providers using its Service Charging Application Protocol (SCAP) part. The flexible charging of multimedia services is executed according to defined service tariffs.

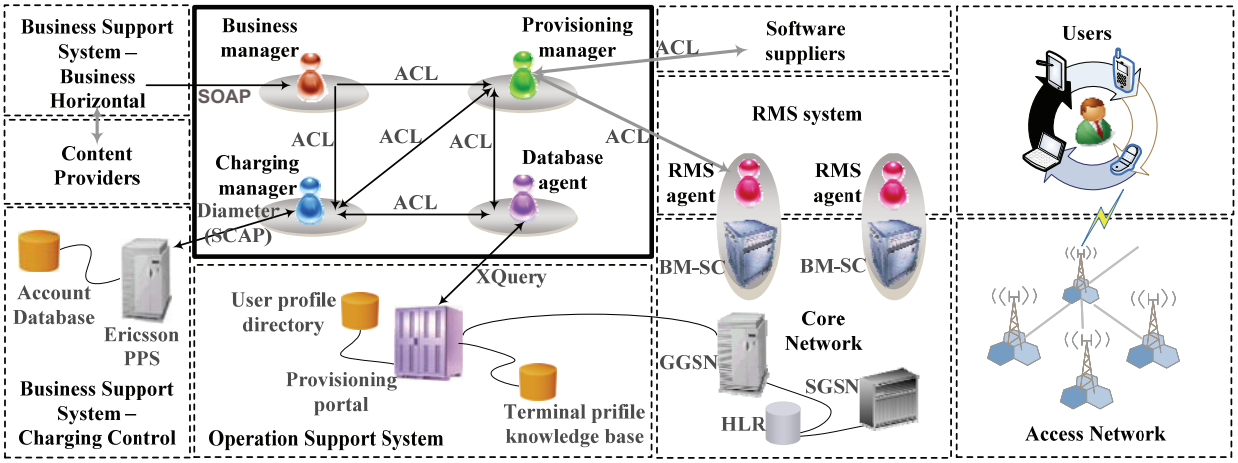

Fig. 2. Multi-agent system for automated service provisioning in the 3G mobile network

The Provisioning portal provides interface towards user preferences, context information and device capability information. User Profile Directory stores users' profiles which contain information whether the user subscribed to software upgrades on mobile terminals or not. It also contains a list of International Mobile Equipment Identity (IMEI) numbers that uniquely identify type of mobile terminals that are used by the users. The Terminal Profile Directory contains information about the characteristics of mobile terminals from different vendors.

The Home Location Register (HLR) is used for mobility management in the mobile network with the information about the user's current location.

5. Real-World Challenge: Automated Selection of Target Users

This section presents a multi-agent approach to the automated selection of target users in a telecommunication surrounding. We propose a solution for solving a real-world challenge in a 3G mobile network environment.

Business Manager Agent (BMA) is an interface towards the network operator's Business Support System. When all of the prerequisites of the business rules have been fulfilled, the Java Expert System Shell (JESS) rule engine (http://herzberg.ca.sandia.gov/jess) [Hill 2003] will inform the BMA to start the process of automated service provisioning [Vrancic et al. 2007]. After the content providers and software suppliers release a new version of the software component for a particular type of a mobile terminal, they will send a notification to the BMA. The announced software component will not be retrieved from the software supplier's download server until a business strategy is ready for execution. Then, the Software Retriever Agent (SRA) will download the software component and the RMS agents will deploy it to the BM-SC nodes so that the end users can download it on their mobile phones and use the new service.

The Charging Manager Agent (CMA) serves as an interface towards the Charging Server. The CMA, after receiving the request from the BMA, checks the balance of user's account. The checking will be done according to the constraints specified in the notification that is sent by the BMA. The amount of messages that are sent to the CMA determines the maximum number of strategies that need to be executed.

Since the message from the BMA contains the targeted type of users for the new service that is being deployed, CMA has to find actual mobile users (their International Mobile Subscriber Identity (IMSI) numbers) that match the requested type. So, the CMA contacts the Database Agent (DBA) who has the access to the database with user profiles. The DBA checks the database and returns the IMSI numbers of the users that belong to a specified user type to the CMA. This is shown in Figure 3.

The CMA checks the received user accounts to see which users have enough money for a particular mobile service, as shown if Figure 4.

In the meantime, the BMA can dedicate itself towards finding an optimal execution sequence of business strategies. Optimization is achieved by using the genetic algorithm approach [Dumic et al. 2007]. After determining the sequence of business strategies, the BMA sends the result

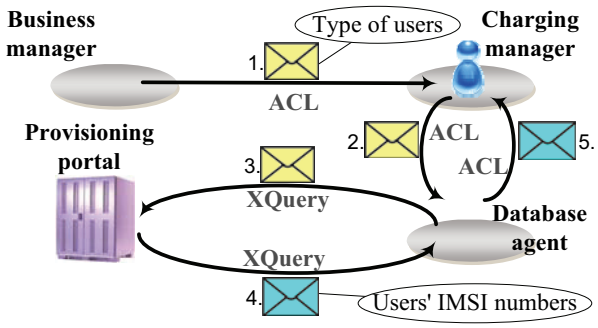

Fig. 3. Finding the IMSI numbers

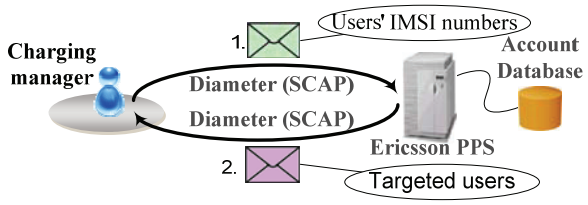

Fig. 4. Checking the users' accounts

to the Provisioning Manager Agent (PMA). The PMA is responsible for coordination of SRAs, as well as for the actual deployment process executed through the RMS system. The parameters (content type, location, time, QoS, user type) are needed to find potential target users (the users who really want the particular mobile service and are within the location area denoted by the business strategy).

After receiving the optimal execution order from the BMA, the PMA contacts the DBA to find those potential users and sends a message with a list of those users (their IMSI numbers) to the CMA as shown in Figure 5.

Now, as the Figure 6 shows, the CMA can finally make an intersection of both users' lists for the specified strategy The CMA sends the result to the PMA. After receiving the final list of targeted users, the PMA will handle the process of service provisioning to those users. First, the SRA will receive the list of software that needs to be bought from Software Suppliers. Once the software is bought, RMS agents can start the migration and installation of that software on the remote BM-SC nodes. After the installation is completed the users can start to use the new service on their terminals using the Access Network.

Conclusion

Agent technology is imposed as a solution for the service provisioning problems in the 3G mobile networks. MA-RMS multi-agent system, which consists of intelligent and mobile agents, has provided an automation of service deployment and configuration processes in the service execution environments for the 3G mobile networks. In this paper we proposed an extension of our multi-agent architecture in order to automate business-driven service provi-

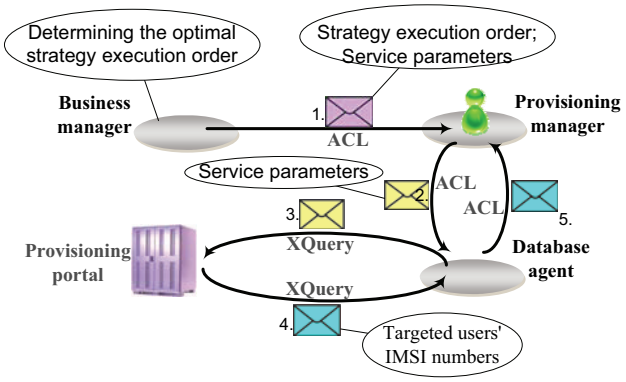

Fig. 5. Finding the targeted users

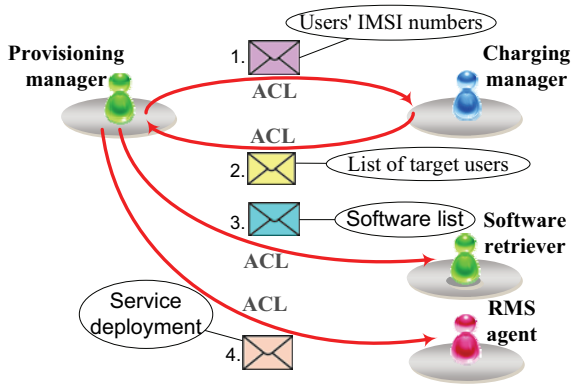

Fig. 6. Matching the targeted users list and starting the software deployment process.

sioning process in the 3G mobile network. It allows operators to automatically extract the list of potential users when introducing new services. Possible extension of this research can be made towards the context-aware provisioning of IMS-enabled ubiquitous services.

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