A framework for reconfigurable provisioning of services in mobile networks

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ABSTRACT
A very important issue for the introduction of 3G networks, is the flexible and ubiquitous service provision. Basic factors for the achievement of this goal are the introduction of open interfaces for the service accessibility to network information and reconfigurability. This necessitates the introduction of a generic framework for the overall service provision management and respective reconfiguration requirements. Such a framework and generic architecture is presented in this paper.

I. Introduction
The evolution of 3rd generation mobile communications [1] and the evolving software reconfigurable radio system and network concept have brought about a new era in ubiquitous service provision. The most significant near term impact of reconfigurability is likely to be in the field of service and applications innovation, as a tool to allow rapid and flexible service customisation and new degrees of operator differentiation. Contrary to the application specific mobile system design for 2nd generation systems, the potentials for flexible and adaptive service offerings that can be supported by the introduction of reconfigurable mobile systems and networks pave the path for advanced service provision schemes, involving business entities other than the network operator. These entities could have the form of service developers (also termed VASPs, Value-Added Service Providers), service component developers and content providers, to name but a few.

Implementing ubiquity and reconfigurability for service provisioning, becomes an issue of functionality and open interface definition to ensure conformity with any manufacturer design. Hence, appropriate models and specifications have to be introduced to standardize all interactions as detailed as necessary with maximized freedom for changes and flexibility. Modelling features such as flexibility and adaptability implies strong reconsideration of existing approaches. Therefore, in order to meet the requirements for flexible service introduction, adaptability and reconfigurability in future mobile systems and networks, various efforts have been undertaken by standardization work groups and fora towards the introduction of novel models, integrated architectures and open interfaces enabling services to be offered also by independent service providers.

Examples of such efforts are the following:
• Parlay. Parlay is an API that provides 3rd party software developers access to network functionality and allows them to control a selected range of network capabilities[2].
• JAIN [3]. JAIN is a set of Java APIs that aim to enable the rapid development of next generation telecommunications services on the Java platform. The JAIN family of specifications includes a wide range of APIs from Java interfaces to network protocols (TCAP, MAP, SIP, H.323) to high level interfaces to be used by applications for access to network functionality.
• OSA/OISP. OSA is an API aiming to open 3G mobile networks to 3rd party developers [4].

It is worth noting that the co-operation of the various standardisation bodies results to the streamlining of the different specification with each other. Notably, the OSA approach is largely based on Parlay and the JAIN external APIs are streamlined with Parlay.
Other important standardisation activities relevant to service provisioning are in progress by OSGi (Open Services Gateway initiative) [5], the 3GPP MEaE [6] and other groups. This has lead to new approaches in viewing the role of operators/ISPs (e.g., in IETF), and the way operator differentiation can be achieved with the support of service offerings by independent Value Added Service Providers. The main aspect of the aforementioned models and approaches is the introduction of open generic interfaces between the network and the service providers for the deployment of multiple services, as well as to enable operator and third party applications to make use of network functionality through an open standardized interface (e.g., the OSA API).

In the following sections of this paper a generic framework for reconfigurable service provision to mobile users will be introduced, and in more detail the work regarding the implementation of the Reconfigurability Control and Service Provision Manager (RCSPM) will be presented. The RCSPM is the component incorporating the necessary intelligence for third party service and network reconfiguration, handling the terminal capability negotiation, the respective service discovery and adaptable service offering, based on the open interfaces and interaction with the services. Finally, in the last section, the conclusions will be presented.

II. Service provisioning issues

1. Service provision requirements

The forthcoming abundance of 3G services that will be typically developed by many co-operating entities and will need to be deployed on multiple types of networks significantly complicates service deployment and provisioning and demands a higher level of intelligence and flexibility from the underlying network. Therefore, a need is emerging for intelligent and flexible service provision platforms that will mediate between service developers, network operators and end-users. Challenging issues that need to be addressed by such platforms include the following:

- Network reconfiguration for optimal service provision. The multitude of available services, with highly diverse requirements from the network, creates the need for a dynamic and intelligent way of adapting the network to enable optimal service provision.
- Rapid deployment and efficient management of disparate services. Services should be introduced dynamically to the network by their developers, thus reducing time-to-market and increasing the range of services available to end-users. Moreover, post-deployment service management functions like usage monitoring and charging and billing are particularly critical for the commercial exploitation of a service. All these operations should be automated to the highest degree possible.
- Creation of a service one-stop-shop for end-users, where the discovery and optimal provision of a huge number of unrelated services is performed from a single user interface, and is customized to terminal characteristics and user preferences. This, to a large extent, should save users the time and effort of locating and getting familiar with what they need in the plethora of available applications.

2. The need for network reconfigurability

In 2G networks, services provided to mobile users were either rigidly integrated in network equipment or developed with proprietary tools by mobile operators or equipment manufacturers. This situation led to the availability of a limited number of services that were tightly coupled with the type of network and the vendor of equipment they were running on. However, in 3G and beyond, an open marketplace is expected to emerge, where a huge number of diverse services will be developed by Independent Software Vendors (ISVs) and typically will not be targeted solely to mobile networks. This situation creates the need for more flexible networks that can be adapted dynamically to the requirements of the multitude of services that are provided over them. Thus, network reconfigurability becomes an issue critical to the successful development of the 3G market according to the expectations of the market players that have invested in this technology as well as the end-users.

Network reconfiguration to accommodate a service may occur either during service deployment to a network or during service activation and execution. Some examples of the types of reconfiguration actions that would be useful in a mobile network are the following:

- Quality of Service (QoS) provisioning. Network equipment (e.g., routers) could require changes in their configuration, so that they can identify the transport flows corresponding to the usage of a particular service and provide them with the desired QoS. The desired QoS for a service access session by a particular user may be specific to the service (e.g., certain services may require a minimum QoS level to be accessed) and may also depend on the identity and preferences of the user.
- Charging and billing. The system (e.g., as described in [8]) used to gather service usage data, process it and calculate the corresponding charges for the end-user, should be dynamically reconfigurable. This is the
only way it can take into consideration the various charging-related events occurring in the network (tariff updates, tariffing policy changes) and subsequently produce an accurate user bill.

- **Dynamic software downloading.** The optimal provision of a service may necessitate certain software elements to be installed dynamically to the terminal or some place in the network during service deployment or activation. For example, due to limited bandwidth available at the radio communications link, certain service content (e.g., images, audio) should be drastically compressed, so that it can be transmitted in real-time to the user terminal. To do that, an appropriate codec could be downloaded to a node at the edge of the mobile operator’s network as well as the terminal.

### III. A framework for service provision through reconfigurability

#### 1. Generic architecture

To serve the purposes described in the previous sections, a framework for flexible, ubiquitous service provisioning is introduced hereafter (Figure 1).

As also depicted in Figure 1, standard open network APIs introduced by various standardisation fora and working groups (e.g., OSA) are enhanced with interfaces enabling authorised 3rd party applications to perform reconfiguration actions on the underlying network (e.g., QoS, billing policy). The RCSPM includes various functions necessary for service deployment and optimal provision, including facilities for network reconfiguration (see next section for a detailed presentation). The RCSPM interfaces with the mobile user (user access session, service discovery, user profile management) and the service developers (service registration with the framework and deployment). Moreover, a part of the framework functionality (reconfiguration manager) is used to implement the open API reconfigurability extensions.

Before it is offered to mobile users, a service should be registered with the RCSPM. This is an on-line procedure performed by the VASP. During this procedure (also termed service deployment in the context of this paper), a formal description of the service (e.g., in XML) is provided to the RCSPM.
Any reconfiguration actions necessary for service deployment are identified by the RCSPM from this description and are performed automatically, during service registration.

Thus, the RCSPM serves as the necessary server to fulfil and control the reconfiguration requirements on the network side.

2. The RCSPM

In this section we elaborate on the functionality and architecture of the Reconfigurability Control/Service Provision Manager (RCSPM) introduced in the previous paragraph. In order to fulfil QoS requirements, implement service discovery and support of adaptable service provision (based on terminal and network capabilities and reconfiguration features) and finally to support flexible charging schemes taking into account the transport and service charges (flow, QoS, duration, bearer etc.), the RCSPM introduces several functional components incorporating the necessary intelligence for service discovery, reconfigurability management, charging, terminal capabilities negotiation and user / service profile management.

These components are the following:

- **Reconfigurability Manager.** This module serves and controls all the reconfiguration actions that are performed to the underlying network infrastructure. Reconfigurations actions typically are triggered in two ways: 1) By the VASPs during the service deployment (registration) procedure. The necessary reconfiguration actions are identified from the XML-encoded service definition fed by the VASP to the Service Deployment Manager. The latter forwards the appropriate requests to the Reconfigurability Manager. 2) By the services themselves during service execution. Through the reconfigurability extensions to the open network APIs, as shown in Figure 1, network reconfiguration functionality is directly accessible to authorised 3rd party applications. This functionality is implemented via the Reconfigurability Manager. The latter has proprietary interfaces with system elements (e.g., routers, billing system).

- **User Access Session Manager.** A user should log-in with the RCSPM before he can access the services registered with the platform. State information is maintained during the lifetime of a user RCSPM access session.

- **Service Discovery Manager.** This module enables mobile users to quickly and efficiently discover the services registered with the RCSPM. Searches for services can be performed according to criteria such as category and keywords. The service listings produced contain all information that can be useful for a user to select a service (service description, indicative tariffs, etc.). These listings are tailored to the capabilities of

![Figure 2. An XML-encoded service definition](image)

Users may access services after logging-in the platform. The available services (that is, all services registered with the RCSPM) can be located through the service discovery facilities of the RCSPM. Service discovery and provision is customised according to terminal capabilities and user preferences (for the latter the RCSPM employs user profile management logic).

The services themselves are able to access RCSPM network reconfiguration features during their execution, through the proposed extensions to the standard open network interfaces. Thus, the RCSPM Reconfiguration Manager lies below the open reconfigurability API, implementing the functionality exported by the corresponding interfaces.
User Profile Manager. The RCSPM includes user profiling logic, to enable service discovery and provision according to user preferences. The user profile contains information such as user identification data (e.g., name, IMSI, security keys), generic, service independent user preferences (e.g., language, default tariff class), user interface preferences (e.g., font size, preferred media type), as well as a list of user-specific favourite services. The system gives the user the ability to view and update user profile information at any time.

Service Deployment Manager. Through this module the VASPs are able to register their services with the RCSPM framework and thus make them available to mobile users. Service deployment includes insertion of the service information in the service database, as well as certain reconfiguration actions in the network (e.g., configuring network equipment to produce service usage monitoring information). The actions that should be performed during service deployment are determined by a service definition that is provided by the VASP. XML is a highly appropriate way of encoding the service definition. An example service definition in XML is shown in Figure 2. This definition obeys to an appropriate XML Document Type Definition (DTD).

Service Data Manager. This module is an interface to a database of services that is maintained by the administrative entity operating the RCSPM (typically, a 3G mobile operator). This information is used for service discovery, and also for billing purposes. The service database may be dynamically accessed and updated by the VASPs.

The RCSPM has been designed using the Specification and Description Language (SDL) and simulations of the various system interactions have been performed. A message sequence chart produced by a simulation of a successful service registration interaction is depicted in Figure 3.

3. OSA enhancements for QoS reconfiguration

The provision of multimedia services in wireless access environments, where link bandwidth is a scarce resource, raises the requirement for efficient QoS management. To assist in end-to-end QoS provision for multimedia services, the RCSPM provides services with an open QoS policy management interface accessible through the OSA API (Figure 4). In such an architecture the RCSPM SCS serves as mediator between the network entities (e.g., CSCF and DiffServ-enabled edge routers) and the Application Servers (AS) mapping the QoS OSA interface onto the underlying network protocols (e.g., SIP). As part of this interface each multimedia service is given the faculty to request to the network the desired policy that its packets wish to experience while traversing the serving PLMN, with respect to QoS provision. In our prototypical network architecture, the responsible entity for receiving all QoS-related method calls on the aforementioned OSA API and mapping them into the appropriate configuration actions on associated network components (e.g., routers, media gateways, etc) is the Reconfiguration Manager (RM) of the RCSPM.

The QoS policy management of RCSPM is based on the end-to-end QoS provisioning scheme adopted in 3GPP [9], enhanced with interactions required for expanding it across the whole administrative domain of the reconfiguration platform, that is beyond the borders of the UMTS core network. In such a framework, to assure end-to-end QoS provision, the RM interacts with both the QoS provision

Figure 3. Message Sequence Chart for successful service registration.
infrastructure of the UMTS’s Internet Multimedia Subsystem (IMS) (based on the P-CSCF/PCF component) [10], [9] and the DiffServ-enabled edge routers that lie at the perimeter of the administrative domain of the reconfiguration platform.

Figure 4. The RCSPM/OSA API

At first the RM propagate to P-CSCF the information received by requesting multimedia services, about session-level and associated traffic flows description (e.g. transport protocols, port numbers, codecs, etc). Then, additional to the UE and GGSN, it receives the QoS authorisation generated by P-CSCF/PCF on session base, which concerns effective QoS policy mappings and interactions between application, IP and UMTS bearers in both UE and GGSN to provide QoS for the end-to-end service. Each QoS authorisation includes the media flow authorisations in terms of limits on IP resources and restrictions on IP packet flows and destinations (flowspec and filterspec), along with the applicable DSCP values identifying the assigned DiffServ PHB for each flow. The RM exploits this information in order to dynamically install the necessary QoS policy state (e.g. DSCP value per media traffic flow) at the traffic classification component of appropriate edge routers. This procedure takes place as part of an initial session establishment in the IMS between user and service, thus ensuring that all prerequisite QoS configuration issues have been successfully resolved before service execution takes place. As result, during service execution the configured DiffServ routers are able to perform, on per user base, multi-field traffic classification, DSCP marking and traffic shaping in the user plane for the media traffic flows of the service in question. In parallel, they record access accounting data that are delivered to the appropriate post-processing billing system for service’s usage charging. We must note that the use of IntServ/RSVP is not precluded by our proactive approach to QoS policy management, just not examined in the scope of the present paper.

IV. Conclusions

The forthcoming introduction of 3G networks is expected to provide end-users with flexible and ubiquitous access to a plethora of diverse services. Thus, a need is emerging for the introduction of open, intelligent frameworks for advanced service management and provision. Moreover, network reconfigurability appears to be a critical requirement for the 3G era. This paper has introduced a generic framework and architecture for the overall service provision management and respective reconfiguration requirements. With the presented approach, reconfigurability functionality is accessible to services via suitable extensions of open network APIs.

References

[6] 3G TS 23.057: “Mobile Station Application Execution Environment (MEXE); Functional description”.
[10] 3G TS 23.228 “IP Multimedia Subsystem; Stage 2".