Service management for multi-operator heterogeneous networks

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***Abstract* - The advent of heterogeneous radio networks which combined under the "Beyond 3G" vision can offer ubiquitous services demands an integrated management approach. We address in this paper an integrated management approach for end-to-end service management over heterogeneous networks in a multi-operator environment. We show how to integrate our solution into the larger context of Web based management, thus allowing the easy integration into already existing management platforms.**

Keywords: Integrated Management, Policy-Based Management, COPS, Beyond 3G

I. Introduction

The advent of advanced wireless network allowing high quality multimedia services to mobile users creates an important market for value-added services offered on top of these networks. Service providers will typically offer such services to end-users. They will interact with different network operators in order to allow service deployment to be done efficiently over a large geographic area. This is the context that will occur when 3G systems will coexist with e.g. WLANs and broadcast networks, also known as "Beyond 3G". One important problem that service providers will face in this context is concerned with the interaction with wireless network operators. The difficulty in this interaction lies mainly in service management capabilities offered to the service manager.

We address in this paper the management of services spanning multiple operators over heterogeneous infrastructure. We propose a service management platform for such services, which can be loosely integrated within already existing network management platforms.

Our paper describes the main problem statement in section 2. Section 3 shows the management approach that we propose and describes its main functionalities. An introduction to related work is given in section 4. Finally, we conclude the paper with references to related work and outlines to future work.

II. Problem Statement

We consider an end-to-end service as illustrated in Fig. 1, where two users are subscribed to service offered by a service provider. Such a service could be for instance to route their call over any available network in order to achieve a better price or quality of service. For the end users, the use of several technologies and/or operators is transparent. They have a contract with the Service provider, or SLA (Service Level Agreement), and the service provider is responsible to meet this agreement.

The service provider will typically have a Service Level Agreement with each network operator through which it may reach users, and must establish with them a communication for assuring that the global end-to-end service is working properly. Thus, he should be able to request connections set-ups, and particular network configuration to the different network operators. Besides these actions, Service Level Monitoring facilities should be possible in order to allow to the Service Provider to verify that the SLAs existing between him and the operators are met.

Additionally, he is responsible towards his individual customers for the delivered service, thus he must be able to monitor the level of the global service in order to assure that the SLAs existing between him and its customers are met. We are aiming to provide management architecture able to be deployed on the service provider side to meet these requirements. There is another important constraint that we must take care of: network operators do already have management platforms in place, and will be not be particularly keen making any major modifications on these platforms. Thus, a loose and light cooperation mechanism is required.

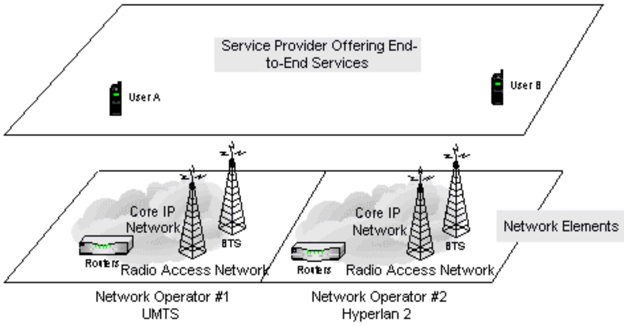

Fig. 1. Multi-operator service delivery.

III. The Management Architecture

Before describing the management architecture, we will briefly present some of the requirements:

- It should be able to express management terms in terms of the end-to-end service and map them to network specific actions;
- It should be able to interact with the wireless networks that are not under its administrative control in order to perform the management tasks. This interaction should be as lightweight as possible, but still be able to allow the monitoring and configuration of the underlying infrastructure. Fig. 2 shows the major components of the architecture.

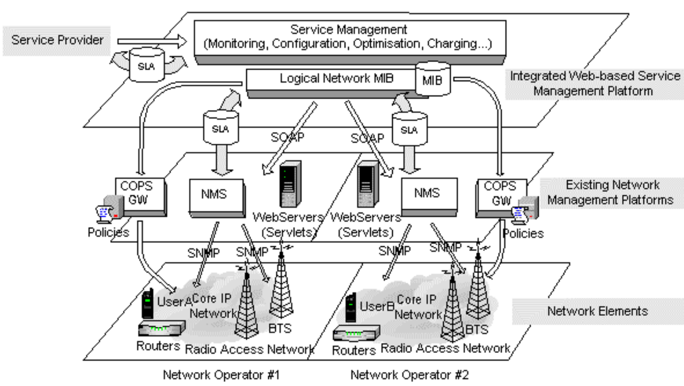

Fig. 2. Management architecture.

At the highest level, the management platform addresses client oriented service management. It allows the establishments of SLAs, which are stored on a LDAP [7] (Lightweight Directory Access Protocol) server. It provides four major operations:

- The monitoring of the individual SLAs in order to verify that they are met.
- The configuration of the underlying network infrastructure, performed by an optimization module;
- The translation of generic SLAs established with individual users to network technology specific SLAs;
- The accounting and charging for billing purposes.

The core component of the management platform is a Logical Network MIB. This is used to represent an abstraction of the real network entities used over the physical network. It can be considered as a virtual network that is optimized by the management platform in order to provide the end-to-end service. Since most network operators will not unveil their real network, such a virtual abstraction of the resources is needed in order to make the service viable. For instance, instead of exposing several network switches, the logical abstraction could be a single switch representing the aggregate connectivity offered by the cloud of switches.

It is based on an integrated network information model, which extends the DMTF [9] proposed CIM [10] model. The reason for such an approach is the need to build an integrated management platform for both the IP network and the radio access one. The proposed extension allows representing the wireless/radio access part of a network. The service management interacts in two manners with the wireless/real network. Pairs of SLAs between the service provider and the network operators give the general framework for this interaction. The first interaction allows the service manager to directly configure the network. It is shown in Fig. 2 as a COPS [5,6] gateway, mapping policies expressed in terms of a logical/virtual network to policies concerning real network resources. The optimization module of the service management platform is responsible to generate a set of policies in order to configure the network. Besides mapping policies expressed on the logical network to real policies which are deployed on the real network, a gateway is needed to allow each respective network operator the management of his network. This is a sine qua non condition in order to guarantee a correct mapping and also to assure network operators that any configuration action is under their control. While this interaction might not be permitted by all network operators, since they might not allow policy based deployment through a third party, the second interaction is requested to communicate requests between the service management platform and the network operators. These requests are, monitoring requests, service requests, and configuration requests (if we assume that the COPS gateway is not allowed).

A. Communication

The communication for these requests is done over HTTP using the SOAP [8] protocol. SOAP (Simple Object Access Protocol) is a lightweight distributed object communication protocol allowing encapsulating self-defined messages over HTTP. The self-definition is obtained by the use of XML [12] (Extensible Markup Language) as an envelope for them. Although, we could have selected other paradigms for communication, we considered SOAP as the right choice for the following reasons:

- On one hand, we need only simple servlet enabled WEB servers for the communication. Thus, no dedicated software infrastructure is needed to be deployed on the network operator side.
- Secondly, using XML to encapsulate management information allows an easy communication of this data. Even though, different formats might be used on each side, translation to and from XML data, can be done without major changes.
- Thirdly, SOAP is encapsulated in HTTP, and thus is not affected by firewalls protecting the network and/or the service provider domain. The messages encapsulated over HTTP can contain monitoring information. This information is obtained by the network operator using its network management platform. Typically, it will be done using SNMP (Simple Network Management Protocol).
- Next, service provider related information is extracted by the network operator and offered to the service provider. Another type of requests is the service requests. These requests contain the necessary information for the individual network operators in order to provide the necessary resource reservation. Such a request is encoded in XML.

Fig. 3 shows a logical model of such a request. A particular Service Provider asks for the configuration.

B. Service Model

We show in this section the relationships among several service level information entities. Fig. 3 illustrates a UML based sub-model of this level. A service request is related to several entities:

- The SLA existing between individual users and the Service Provider. These SLAs stipulates among others, a spatial and temporal dimensions and acceptable Service levels for individual types of services
- A service request contains thus (modeled in the class *SPRequestArg*) information related to the requested types of services (modeled by the class *SetOfServices*).
- An individual service could be video, audio etc. Each service is associated to the individual users (modeled by the class *User*). This association is indirectly given using the class *SetOfUserClass*. This class is used to regroup information related to the spatial dimension of the request (*SetOfAreas*), the desired service levels (*SetOfQlevel*) and pertinent information about the time where the service is requested (*SetOfTimeInformation*).

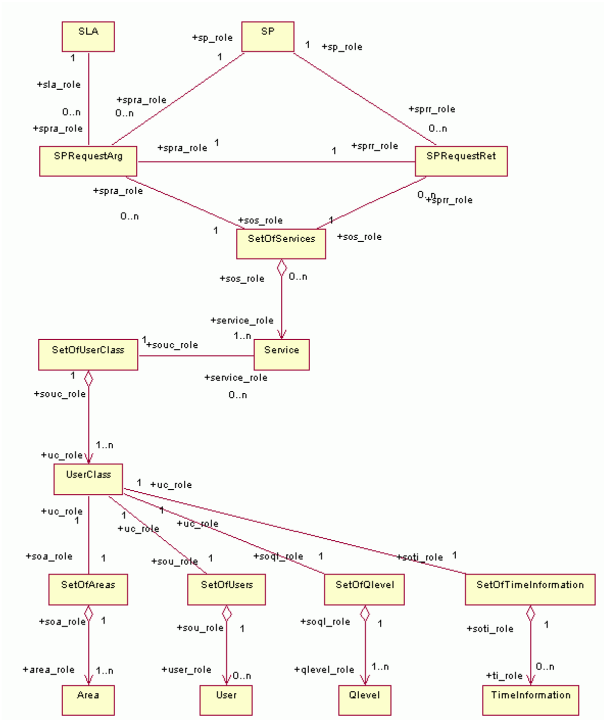

Fig. 3. Service-level information model.

C. Logical Network MIB and Policy based management

The effective service management functionalities depend strongly on the Logical Network MIB and on the COPS Gateway. We illustrate in Fig. 4 the main principles in designing this module. On the right side of this figure, we see how a virtual network is constructed based on abstractions of the real networks. For instance, several routers are aggregated into a global virtual router to provide the connectivity among several network access points. This virtual router exists only as an abstraction at the service platform level. The network operators filter their real management information (connectivity and monitoring information) and push it towards the service platform. The virtual core network is constructed based on abstractions from all real core networks used by the operators. It is a virtual network based on virtual routers. One virtual router can be either the abstraction of a real router, or can provide an aggregated connectivity view for several real routers.

The radio part is modeled in a similar manner. The service platform “sees” its own cells, which are in fact abstractions of the real cell. We see in Fig. 4, that a real cell is divided into vertical cell-lets, where each cell-let corresponds to a set of radio channels. These cell-lets are offered to the service management platform. The latter considers them as forming a virtual radio network. He might not be aware of the real radio characteristics used by the network operator, but management related information is filtered and offered to him. For instance in UMTS, this information concerns cell loading, factors, spreading codes, power control schemes etc.

For the sake of clarity, we have not shown all possible mappings from a cell to a cell-let, but more complicated schemes, where several real cells are regrouped to form one cell-let are possible.

On the left side of Fig. 4, we illustrate how policy-based management is performed on the virtual network and translated onto the real network. The COPS gateway is in fact a distributed system, where a virtual PDP (Policy Decision Point) operates on the logical network. The service platform will deploy policies on the virtual PDP. These policies are mapped to network specific policies and deployed on the real PEPs (Policy Enforcement Point). Each network operator performs this mapping. A gateway exists between the service management platform and each network. The mapping from the virtual policy to the real policy translates configuration actions performed on the logical network into policies deployed on the real one.

For instance, providing Premium type of service for a particular service is mapped into providing this type of service on each network. It is up to the network operator to implement/define its specific premium type of service. The deployment is done using the standard COPS-PR protocol 13, 14, a IETF proposed mechanism for providing policy-based admission control over requests for network resources or to provision policy to network devices over TCP connections.

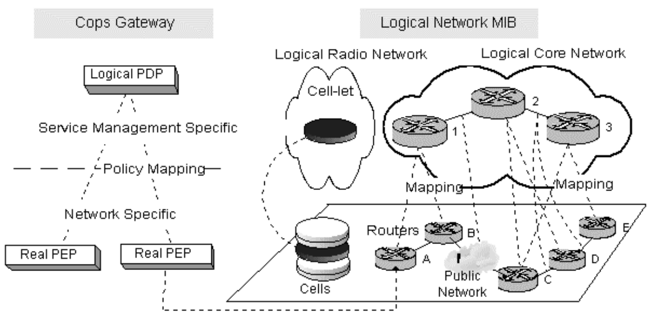

Fig. 4. Logical network information model.

IV. Related Work

Several EU sponsored research projects addressed the joint utilization of heterogeneous access networks, in order to improve the service quality, access and availability [1, 2, 3]. For example, in [1], cellular and broadcast networks are combined to deliver interactive multimedia services to the car. In [2] the combination of UMTS and BRAN is envisaged as a solution for providing users with high capacity in hot spots and [3] aims at designing a system architecture where heterogeneous access networks are integrated and can dynamically have their spectrum assigned to match user demand.

Part of this work was undertaken in the context of the IST MONASIDRE project [4], funded by the European Commission. The scope of MONASIDRE project, which constituted the starting point for our research, is the development of UMTS, DVB-T and HL2 cooperative network and service management systems. This management system was realized as an open, distributed, component-based management architecture, by means of a CORBA-compliant middleware platform. This scheme is different with respect to our web-based service management platform. The main difference between this proposal and our work is that our work proposes a new management framework, based on the combined use of SOAP and COPS protocols within the larger context of web-based management [11]. Whilst the above mentioned work proposed a distributed framework where several platforms interact in order to jointly optimize and manage several network, thus requiring major changes in already existing network management systems, our approach considers the use of a service management platform which is loosely coupled with already existing network management systems.

V. Conclusion

We have addressed in this paper an innovative approach towards joint management of multi-operator and multi-technology networks. Our approach consists in providing a service management platform that interacts with network specific management platforms. Our work could provide a building stone for advanced value-added services offered over large and varied infrastructure in future B3G networks. There is still future work ahead of us. We need in particular to investigate the policy mapping from a logical network to the real network: simple policies are now possible, but consistency checking and providing a common and automatic translation for more complex ones must be still done.

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