An End-to-end QoS Architecture for Ensuring The Reliable Delivery of Broadband Applications

Nikos Koutsouris, Teodor Buburuzan, Krzysztof Loziak and Efstathios Sykas

Abstract — In this paper we present a QoS enabled architecture which incorporates additional management functionality so as to ensure the provision of sophisticated broadband applications at the appropriate QoS levels. The architecture exploits the potentials of heterogeneous network environments and the power of emerging protocols like IEEE 802.21 and 802.11r [1].

Index Terms — Network performance management, QoS, IEEE 802.21, heterogeneous networks, IEEE 802.11r.

I. INTRODUCTION

Wireless technologies continue to attract not only immense research and development effort, but also the growing interest of consumers. Of course, details of the technology escape notice, since the majority knows nothing about UMTS or DVB-H, but on the other hand everybody is keen on having a video call or a TV program on their mobile device. People always ask for increasingly sophisticated services, their main demands being mobility and high bandwidth. Nowadays there are a lot of network technologies that are able to meet these user demands, but they also have their limitations. So a new challenge has emerged: to keep consumers satisfied by offering them services at high quality, high availability and without interruptions. In this paper we present an end-to-end QoS architecture that takes advantage of a variety of existing and emerging wireless technologies so as to ensure the delivery of broadband applications at appropriate high QoS levels. The architecture was developed within the IST integrated project DAIDALOS II [1] and exploits the notion of wireless heterogeneous networks, where the terminals are capable of connecting through several radio access technologies (RATs) covering the same area, even simultaneously [2]. Such an environment is very complex but it can be extremely beneficial in conjunction with an advanced service and network management system like e.g. the one presented in [3], [6] and the one described here. The main target of these heterogeneous systems is the exploitation of the advantages each of the underlying network protocol or technology offers. In that sense, the main emphasis is put on seamless and transparent operation, without any interaction required from the user's side. DAIDALOS architecture is based on novel technologies and protocols like e.g. IEEE 802.21 [4] and 802.11r [5], which are described in section II. In section III the DAIDALOS high level architecture is addressed and some conclusions are drawn in section IV.

1 This work was partially funded by the Commission of the European Communities, under the Sixth Framework Program, within the IST integrated project DAIDALOS II (www.ist-daidalos.org)

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II. ENABLING TECHNOLOGIES AND PROTOCOLS

A. IEEE 802.21

IEEE has started working in the direction of standardizing the signaling required in cases that involve two or more 802.x technologies and/or cellular networks. This work has been going on in the IEEE 802.21 working group and their results are used as basis for the mobility related signaling used in our architecture. The IEEE 802.21 standard defines a so-called Media Independent Handover Function (MIHF) that acts as an abstraction layer between different link and physical layers on the one hand and the IP layer hiding the particularities of the transmission technology on the other. This MIHF is present in different entities through the network and its role is to "translate" the mobility related signaling into technology specific commands and information. Three basic Media Independent services are defined by the 802.21 standard: the Event Service, the Command Service and the Information Service. Their usage and deployment is described in [4]. However, this signaling had to be extended since QoS related operation was not defined by the IEEE and was needed in order to have a common signaling platform.

B. IEEE 802.11r

Behind the common communication framework of IEEE 802.21 a wide variety of technologies exist. One of the most popular is a Wireless LAN compliant to the IEEE 802.11r standard [5], which features fast handover execution within a single BSS domain. The main effort of the IEEE 802.11r is focused on reducing the latency of the security binding procedures (pre-authentication) during the performance of a transition between Access Points (APs), however the standard also addresses the problem of a target AP selection. Moreover, a resource allocation mechanism is proposed to support resource reservation during the re-association procedure so as to assure the QoS requirements of real-time applications, which are probably the most important criterion that defines consumers' impression of network mobility potential. Another goal of the fast BSS transition is the introduction of a roaming capability inside the WLAN network similar to that of cellular networks.

III. HIGH LEVEL ARCHITECTURE

The heterogeneous radio environment in DAIDALOS project can be comprised of various network technologies like IEEE 802.11, UMTS, DVB-T/H/S etc. and multiple

1-4244-1459-8/08/$25.00 ©2008 IEEE

administrative domains that can include one or more of these technologies. Each domain can be divided into the core network and one or more Access Networks. The resources in each access network are managed by the so-called QoS Brokers (QoSB), each of them being responsible for a part of the network but still cooperating with other QoSBs if necessary. Other network entities considered in our network architecture are the Access Routers (ARs) and the Points of Attachment (PoAs). An AR has in general several PoAs, which can operate in a single radio technology, attached to it. In order to ensure the QoS level offered to each running application, additional functional components have been developed and incorporated in the aforementioned network architecture. More specifically, Performance Manager (PM) is located in the QoS Broker, Performance Attendant (PA) with Local Balancer Module (LBM) in the AR and Mobile Terminal Controller (MTC) in the Mobile Terminal (MT), as it is shown in Figure 1. Besides these modules, the MIH Functions existing in all network entities provide a unified, technology-independent signaling mechanism between the MT and the network nodes, allowing the support of both Mobile Initiated HandOvers (MIHO) and Network Initiated HandOvers (NIHO) in vertical and horizontal plane.

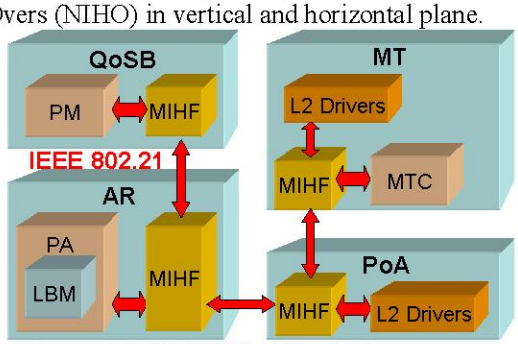

Figure 1: DAIDALOS QoS functional components

In more detail, the main responsibility of the PA/LBM module is the continuous monitoring of the local access network and the preparation of an image of it in terms of MTs' associations, flow related information and candidate handover target PoAs. On the basis of this knowledge in case of PoA overload detection or other optimization trigger, an appropriate technology specific algorithm is executed and a new distribution of flows to PoAs is created. The output of the algorithm is then transformed into several NIHOs relayed to the MTs by means of IEEE 802.21 messages. It has to be noted that this optimization process is short-term and local, as it considers only PoAs belonging to the same AR. One such algorithm will exist per supported RAT, although in DAIDALOS it is developed only for WLAN networks, extending the corresponding QoS mechanism of IEEE 802.11r.

On the other hand, the QoSB/PM module is responsible for the global network resource optimization process in the managed area, which comprises of many ARs of various RATs. Its algorithm is more powerful than this of LBM, since besides traffic demand information, it takes into account network policies and user profile restrictions and it can assign MTs to all available PoAs irrespective of their RAT, but of course always according to the aforementioned boundaries. The output of PM's algorithm, which is based on the maximization of an objective function, is again a set of NIHOs. Furthermore, the PM can assist a MT facing communication problems, like high bit error rate or signal degradation, to select the best interface for each flow, based on the same optimization criteria presented before.

The MIHF entities present in the Network and in the MTs are responsible for relaying the information needed in these handover cases, for both mobility and QoS specific operations. Therefore, the MIHF present in the AR will be responsible for controlling the PoAs connected with that AR. All QoS related functions, like resource preparation, resource activation and resource de-allocation will be addressed to that MIHF which, in turn, will relay them to the corresponding PoA. Then, the same information is passed to the MIHF running in the MT which in turn controls the communication interfaces.

Finally, MTC plays a dominant role in the management and synchronization of all operations at the MT, like e.g. multihoming support, handover preparation and execution, application flow management and communication with the QoS modules of the network. All of MTC's functionality is based on 802.21 services provided by the MIHF at the MT.

IV. Conclusions

The final paper will elaborate on the functionalities of the modules presented above and it will discuss the enhancements necessary to enable the IEEE 802.21 framework handling QoS related operation. Available simulation results will be provided, proving the benefits that derive from the use of this architecture. Furthermore the interactions between the modules will be explained, according to a use case scenario that could be a part of every consumer's daily life, making it better!

Acknowledgment

The authors wish to thank the partners of the Daidalos II Consortium, in particular partners of WP2.

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