A Framework for QoS & Mobility in the Internet Next Generation

Vlora Rexhepi[1,2], Georgios Karagiannis[1], Geert Heijenk[1,2]

[1] Ericsson Business Mobile Networks B.V.;
P.O.Box 645, 7500 AP Enschede, The Netherlands
{vlora.rexhepi, georgios.karagiannis,
geert.heijenk}@emn.ericsson.se
[2] University of Twente, Department of Computer Science,
P.O.Box 217, 7500 AE, Enschede, The Netherlands
{rexhepi,heijenk}@cs.utwente.nl

Abstract. It is expected that the Internet next generation architecture will support applications with different quality of service requirements, independently of whether their location is fixed or mobile. However, enabling QoS in Internet is a tough challenge, and it gets even tougher when the mobile environment with its non-predictive characteristics is introduced. In this paper we propose a framework that will integrate various QoS architectures and mobility protocols and will offer the freedom to users to choose between different wireless and wired access technologies based on certain predefined criteria, e.g. QoS parameters.

Keywords IP QoS, Intserv, Diffserv, RSVP, RSVP aggregation, Mobile IP, SIP, Mobility support, Bluetooth, GPRS

1 Introduction

Enabling end-to-end QoS over Internet is a tough venture, because it introduces complexity starting from applications, different networking layers and network architectures, but also in network management and business models. It becomes even tougher when one is introducing QoS in an environment of mobile hosts, wireless networks, and different access technologies, because of wireless networks dynamically changing topologies and resources. Yet, the need for QoS mechanisms in this environment is greater due to scarce resources, such as unpredictable available bandwidth and variable error rates.

The rapid growth of mobile systems indicates that the future Internet will have to deal with mobile users that will use diverse applications, from the most simple ones like e-mailing and web browsing to real time applications like IP telephony. Thus, providing solutions for enabling QoS over IP without dealing with mobility would result in solutions lacking the inevitable flexibility for the future Internet development.

The current work on the QoS over IP architectures, i.e. Integrated Services and Differentiated Services seems to leave out mobility support, despite its importance. Therefore, in this paper we introduce a framework for QoS and Mobility in the

Internet next generation that will integrate the existing QoS over IP architectures with protocols supporting mobility. We also introduce new entities necessary for the entire framework functionality. Section 2 gives an overview of the current IP QoS architectures and mechanisms, protocols for mobility support and an description of several identified QoS mobility Service classes. A general introduction of the framework, its entities, and protocols is given in Section 3. Section 4 describes an example of the Framework architecture operation. Finally the conclusions are given in Section 5.

2 IP QoS and Mobility

The framework we propose relies on interworking between the current IP QoS architectures, i.e. Integrated Services and Differentiated Services and the protocols supporting IP mobility. In this section we give an overview of the IP QoS architectures and the protocols supporting IP mobility. A number of mechanisms are proposed to improve the flexibility of IP QoS architectures and enable interoperability between them, when it comes to their wider deployment in the Internet. We only mention those that are relevant to our framework. The introduction of mobility in the current IP QoS architectures brings up the need to specify QoS mobility service classes, which are also described in this section.

2.1 IP QoS Architectures and Mechanisms

The efforts to enable end-to-end QoS over IP networks have led to the development of two different architectures, the Integrated Services architecture and more recently, the Differentiated Services architecture.

The Integrated Services (Intserv) architecture [1] uses an explicit mechanism to signal per-flow QoS requirements to network elements (hosts, routers). Network elements, depending on the available resources, implement one of the defined Intserv services (Guaranteed or Control Load service) based on which QoS will be delivered in the data transmission path. The RSVP signaling protocol [2], [3] was designed as a dynamic mechanism for explicit reservation of resources in Intserv, although Intserv can use other mechanisms as well. It is initiated by an application at the beginning of a communication session. But, even though Intserv is designed to provide end-to-end QoS it is currently not widely deployed. As it is emphasized so many times by now, due to maintenance and control of per-flow states and classification, reserving resources per-flow introduces severe scalability problems at the core networks, where the number of processed flows is in a millions range. Consequently the usage of the Integrated Services architecture is limited to small access networks where the number of flows using reservations is modest.

The Differentiated Services (Diffserv) architecture [4], [5], [6] was introduced as a result of the efforts to avoid the scalability and complexity problems of Intserv. Per-flow state is pushed to the edges and the traffic through Diffserv routers is treated on aggregate basis. The service differentiation is achieved by means of Differentiated

Service (DS) field in the IP header and the Per-Hop Behavior (PHB) as main building blocks. At each node packets are handled according to the PHB invoked by the DS byte in the packet header. The PHB defines the externally observable behavior at the node. Two PHBs have been defined, the assured forwarding (AF-) PHB [7] and the expedited forwarding (EF-) PHB [8]. The Diffserv domain will provide to its customer, which is a host or another domain, the required service by complying fully with the agreed Service Level Agreement (SLA). SLA is a bilateral agreement between the boundary domains negotiated either statically or dynamically. The transit service to be provided with accompanying parameters like transmit capacity, burst size and peak rate, is specified in the technical part of the SLA, i.e. the Service Level Specification (SLS). The Diffserv architecture is certainly promising, but there are a lot of open issues related to intra-domain resource allocation mechanisms and inter-domain communication in case of dynamic resource provisioning that need to be defined and researched.

Related to the existing QoS architectures, mechanisms to improve their flexibility and interoperability are constantly being introduced, such as:

- RSVP aggregation, which extends RVSP with support of aggregate reservations across transit domains, in order to reduce the Intserv scalability problems [9], [10];
- RSVP operation within IP tunnels, which is a mechanism for reserving resources in IP tunnels, in order to extend RSVP usage to fixed and wireless networks [11]; and
- Interoperability between the RSVP / Intserv and Diffserv architectures, to let them complement each order in the access and the core networks respectively, in order to provide scalable end-to-end QoS [12].

2.2 Protocols for Mobility Support

Enabling mobile devices seamless communication and access to the Internet via their wireless network interfaces, independent of their roaming in other networks, requires efficient protocols that will be able to inform the network about the changes in their network attachments.

Mobile IP: The Mobile IP protocol is the most common protocol for providing mobility support at the IP layer, transparently to the layers on top, e.g. TCP. The key feature of the Mobile IP [13] design is that all required functionality for processing and managing mobility information are embedded in well-defined entities, the Home Agent (HA), Foreign Agent (FA), and Mobile Node (MN). The Mobile IP protocol allows the MNs to retain their IP address regardless of their point of attachment to the network. This can be fulfilled by allowing the MN to use two IP addresses, the home address which is static and is mainly used to identify higher layer connections, e.g. TCP, and the Care-of Address, which has to identify the mobile's new point of attachment with respect to the network topology. In Mobile IPv4 the Foreign Agent manages the Care-of Address. Mobile IP functionality is realised by using three mechanisms (for a detailed description of these mechanisms see [13]): discovering the

Care-of Address, registering the Care-of Address, and tunnelling to the Care-of Address.

SIP and mobility support: Unlike Mobile IP, the mobility support using Session Initiation Protocol (SIP) [14] proposes a mechanism in handling mobility at the higher layer, that is the application (i.e. session) layer whenever that is applicable. The Session Initiation Protocol (SIP) [15] is an application layer protocol for creating, modifying, and terminating sessions between multiple participants.

Similar to Mobile IP, the mobile host has a home network that is managed by a physical entity called SIP redirect server. The SIP redirect server (SIPS), similar to the HA in Mobile IP, is capable of storing information regarding the location of a mobile host. Every time that a mobile host roams into a new IP sub-network it will inform the SIP redirect server about its new IP address, i.e. it will register. When a correspondent host wishes to communicate with a Mobile Host, it will send an invite message to the SIP redirect server. The SIP redirect server will send the IP address of the Mobile Host to the Correspondent host. If the mobile host is moving during the session, it sends an invite message to the correspondent host to inform him about its new IP address. The correspondent host will use this IP address to send all the subsequent IP user data traffic to the Mobile Host.

The advantages of mobility support using SIP instead of Mobile IP is that there will be no need for tunneling data packets, it is easily applicable to most common applications and thus there is no need for changes of the IP protocol stack of the mobile host. However, the SIP mobility cannot support TCP connections, which limits its usage only for real-time communications using UDP.

Certainly one can use a combination of SIP and Mobile IP, where SIP is used on top of Mobile IP, in which case Mobile IP provides to SIP the same IP addressing transparency as it provides to TCP. Note that specific access networks to the Internet, such as cellular networks have their own mobility support. However, at the moment, they do not provide mechanisms for roaming between different types of access networks.

2.4 QoS Mobility Service Classes

Both architectures Intserv and Diffserv define service classes that can be used by different types of applications. Applications that require hard QoS guarantees for their operation, such as real time applications, e.g. Voice over IP (VoIP), we will call non-adaptive applications. For these applications the Intserv architecture recommends the Guaranteed service model, while Diffserv architecture defines the EF-PHB [8] to support them. Certain applications, e.g. one way voice or video, will require for their operation soft QoS guarantees, i.e. they may be tolerant in terms of delay bounds and jitter. We call such applications adaptive. For these applications the Intserv architecture recommends the Controlled Load service model, while Diffserv architecture defines the AF-PHB [7] to support them.

These service classes do not include the support for IP mobility and therefore roaming users will not be able to use applications with a satisfactory QoS. Therefore, in this

paper we propose and specify two new QoS service classes, which are extensions of the aforementioned classes:

- *Mobility Dependent Locally Guaranteed (MDLG)* is associated with non-adaptive applications. In this service class the QoS requirements can be guaranteed locally in a subnetwork. When the mobile host moves to another IP subnetwork that provides a lower QoS, the application will re-negotiate the QoS parameters by specifying the lowest QoS limit that the application is willing to accept. Note that when a mobile host moves to another IP subnetwork then the handover requests get a higher priority than the new user requests. If the negotiated QoS is lower than its limit than the application terminates the session.

- *Mobility Dependent Adaptive (MDA)* is associated with adaptive applications. This class consists of several relative sub-classes assigned to different QoS levels subsequently. The MDA is similar to the AF-PHB [7] defined by the Diffserv architecture and to the Controlled Load [1] defined by the Intserv architecture. When the mobile host moves to another IP sub-network and if the sub-network satisfies the QoS requirements then the application continues with the same QoS, otherwise it adapts to another sub-class with lower QoS. Afterwards, all the other hosts that are probably connected to the roaming host have to be informed about the reduction in the QoS. Furthermore, the handovers should get higher priority than new user requests of the same sub-class. If there are no resources available for none of its sub-classes than its traffic is treated as best effort traffic.

- *Best Effort* is associated with applications requiring no QoS like file transfers or e-mail. No special provisions are taken for moving hosts.

3   General Description of QoS and Mobility Framework

The QoS and mobility framework architecture that we introduce in this paper is initially intended to be a flexible and open architecture suitable to be applied for a large variety of applications with different QoS demands, different access technologies, i.e. wireless and wired, and protocols. In this section we introduce the requirements that this framework will have to support and present the functional entities and protocols used.

3.1   Design Goal and Requirements

The Internet next generation will have to support a large variety of applications with different QoS demands that are running on different types of wireless or wired terminals connected on various types of networks. This requires that the Internet next generation architecture will have to be very flexible and open, capable of supporting all these different types of networks, terminals and applications. Furthermore, it can be seen that existing QoS management architectures (such as OSI QoS, QoS-A, OMEGA, etc., see [20] for a description of these architectures) are optimized to operate efficiently in small access networks. It is therefore reasonable to consider that a framework should provide the opportunity to support efficient local access QoS

management architectures. Furthermore, regarding the QoS solutions provided in the core networks we believe that a flexible and scalable architecture should be used. In several papers and reports, (e.g. [4], [5]) it is claimed that the Differentiated Services architecture is a flexible and scalable QoS architecture that should be used in the core network of the Internet next generation. We think that their claim is valid.

Based on the above given considerations we have created a list of requirements that should be fulfilled by our proposed framework architecture:

- The IP core network is based on the Diffserv network architecture.
- Both static and dynamic provisioning of resources in the IP Diffserv core network should be supported.
- The access networks may support any of the existing IP QoS management architectures, like Integrated Services Architecture, Differentiated Services Architecture, QoS capabilities of the access technology, overprovisioning of resources, etc. In the situation that an access network operator configures its network in such a way that it becomes overprovisioned, applications may or may not gain the demanded QoS.
- The access networks may support different access technologies, e.g. Bluetooth, General Packet Radio Service (GPRS), Universal Mobile Telecommunication System (UMTS), Wireless Local Area Network (W-LAN).
- Each mobile node that supports multiple access technologies should be able to select the most efficient and cost-effective technology that supports the application QoS requirements.
- Handovers between different access networks and technologies should be supported.
- Global QoS interoperation of local QoS mechanisms should be possible.

3.2 Separation of QoS Session Negotiation and Resource Reservation

Especially in a wireless and mobile environment, it is very important to be able to separate the negotiation of a communication session and its QoS from the actual reservation of the communication resources. In wireless networks the available resources are scarce, and therefore, efficient resource reservation mechanisms should be applied. Efficient resource reservation mechanisms should reserve resources only when it is certain that these resources will be used. Furthermore, the scalability of a network and in particular the scalability of a large IP core network will be enhanced if its resources are only reserved when it is certain that they will be used.

A separation between session layer control (or negotiation) and bearer control (or resource reservation) as proposed in [16] is justified, since negotiating service at the session level certainly adds value to the QoS and mobility framework for several reasons:

- Session negotiation can establish the session before claiming the resources. This avoids an unnecessary reservation of communication resources due to unavailability of a suitable (e.g. high speed, when a mobile host is "on the move") access network, incompatible session / application layer parameters, shortage of resources in the remote access network, or a remote user not accepting the invitation.

- Separation of session negotiation and resource reservation allows for mobility issues to be sorted out before resources are reserved. For instance, the (Care-of) IP address of a mobile host can be obtained before any resources are reserved.

In the Internet protocol suite, separate protocols are available for session control and resource reservation. These are SIP and RSVP.

3.3   Framework Entities and Protocols

The QoS and mobility framework depicted in (Fig.1) consists of three major building blocks: Hosts, local Access Networks, and a Diffserv Core Network. Hosts represents the calling and called hosts, i.e. Host X and Host Y, respectively. The local Access Network includes possible efficient local QoS mechanisms. The Diffserv Core Network is represented as one Diffserv domain, but it may consist of more than one Diffserv domains. Each block includes the main active functional entities that have to be used in the QoS and mobility framework. In the following subsections we will first describe examples of protocols that may be used to provide the intercommunication between the applied functional entities and second we will describe each functional entity per block.
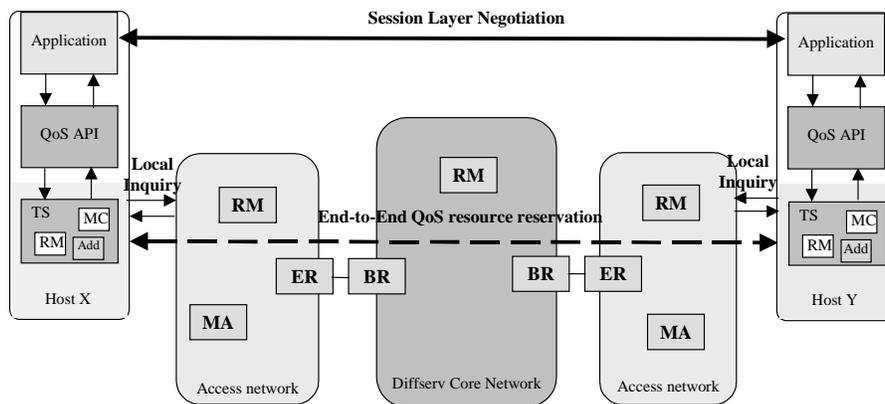

Fig. 1. QoS & Mobility Framework building blocks and protocols

3.3.1 Protocols

The following examples of protocols may be used to interconnect the various functional entities in the QoS and Mobility framework.

- Session Layer Negotiation protocol is any protocol that the Application entities will use for initiating a session between hosts. It might be SIP or H323, or it might be an entirely new protocol, as long as it fits within the framework requirements.
- End-to-End QoS Resource Reservation protocol is a protocol that will be used for resource reservation in the end-to-end path. It might be RSVP, RSVP aggregation, or tunneled RSVP.

- Local Inquiry is a simple protocol, which may be used for local resource inquiry (see Fig.2), i.e. communicating with the access network resource manager. This protocol can be implemented using the SNMP [17] or COPS [18].

3.3.2 Host Functional Entities

The following host functional entities are required for the QoS and mobility framework:

- Application is an abstraction for a QoS aware application. The QoS aware application is any application that is able to specify its traffic and QoS requirements, based on which the QoS API determines to which QoS Mobility Service Class it belong, i.e. its service profile. It is also required that these applications support the session layer protocols. In case of for instance SIP the application will be a SIP client.
- QoS API is the abstraction for mechanisms that based on application attributes (e.g. audio, video) and QoS requirements determine the application's service profile. It will perform mapping of the application service profile in an understandable form for the underlying host Resource Manager and also the mapping of Resource Manager messages in an understandable form for the application itself to let it know whether the session initiation is going to be performed or not. Of course these mechanisms will be able to detect when the host has entered another access domain, e.g. using the Mobility Client. (See also [16] for a similar QoS API definition)
- The host Resource Manager (RM) is the abstraction for the entity that is in fact a QoS decision point for the end host. It will provide the mechanism for resource control within the end host based on request and responses it receives from the QoS API and Local Inquiry protocol messages. The Resource Manager should interpret the QoS Mobility Service class parameters and based on their interpretation and the Local Inquiry protocol messages it should decide on whether there are enough network resources locally for the Application to initiate a session.
- The Mobility Client (MC) is a functional entity that in combination with the Mobility Agent located at the access networks is providing IP mobility management.
- Technology Selector is the entity, which will be part of any mobile host that wishes to select a certain underlying radio technology and/or underlying wired technology supported by an access network. The TS is able to provide this selection by using certain criteria, based on e.g. application's service profile. Depending on the required profile information, the TS will encompass various numbers of functional entities. For example, the TS may encompass the RM, MC but also some other Host entity that will provide the authentication and accounting management (see block ADD in Fig. 1.).

Figure 2 depicts the situation that the host is able and willing to perform the technology selection. In this situation the host is capable of selecting one of the underlying radio technologies, e.g. Bluetooth and GPRS. The main operation is as follows.

The Host needs to start a real time application, e.g. VoIP. The QoS API will perform the mapping of the application requests to parameters that are understood by the TS. If the TS entity has the required profile information to perform the technology selection it will do so and it will inform the application entity (i.e. session client) about it. Otherwise, the TS will sent one request, i.e. TS_Inquiry REQUEST to the Bluetooth access technology and another request to the other access technology, e.g. GPRS. Note that the TS_Inquiry Request message may be sent in either one or more than one messages. These requests will include query information regarding for example: (1) the requested QoS parameters, (2) the authentication restrictions, (3) accounting restrictions, (4) the financial and complexity cost of a connection to the core network, etc. This query information will have to be distributed to all functional entities, e.g. RM, MA, in the access technologies that will be able to answer them. The replies of each queried functional entity will be either sent individually in one TS_Inquiry RESPONSE message or they will all be combined in one TS_Inquiry RESPONSE and sent to the Host TS. The TS by applying the predefined criteria will choose one of the access technologies and it will inform the application entity (i.e. session client) about it.
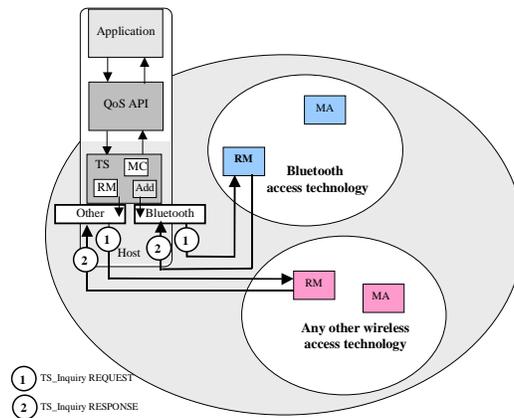

Fig. 2. Example of technology selection accomplished by the host

3.3.4 Diffserv Core Network Functional Entities

In our requirements we note that the IP core network should be a Diffserv network. Therefore, the functional entities that will be located in this block and are used in the QoS and mobile framework should be in full compliance with the Diffserv network architecture definitions. The functional entities that are located in the Diffserv core network region are:

- The Resource Manager (RM) performs the resource allocation and admission control for the core network either statically or dynamically. We assume that it can be centralized (e.g. see [5] or [19]) or distributed within the core network (e.g. see [4]).
- The Border Routers (BR) are standard Diffserv border routers, which should be able to treat traffic aggregates from the adjacent domains in compliance with the

SLS agreement. In some particular cases they might also perform other tasks for interoperation with other, non-Diffserv domains.

3.3.5 Access Network Functional Entities

The functional entities that are located in a local Access Network and are necessary for the QoS and mobility framework are the following:

- The Resource Manager (RM) in the access network is the same as the role of the Diffserv core network Resource Manager. It is responsible for resource allocation and admission control within the access domain. Its specific realization depends on the IP QoS architecture that will be used at the access network.
- Edge Router (ER) is an abstraction for any edge device residing at the periphery or boundary of an administrative domain. Its functionality depends on specific IP QoS architecture used at the access network.
- Mobility Agent (MA) is an abstraction for all the mechanisms that are related to the IP mobility protocols, e.g. Mobile IP and SIP. It may for example represent a Home Agent or a Foreign Agent or a SIPS (SIP redirect server).

4   QoS & Mobility Framework Architecture Operation - an Exemplification

Specific realizations of the framework architecture will depend on the QoS architectures used at the *Access Network*s, management of mobility support, and related protocols.

The operation of this framework architecture can be described as consisting of certain procedures, that can be performed either sequentially or simultaneously, depending on the specific realization of the framework:

- QoS "Session setup": a session is initiated between the end hosts that are willing to start an application.
- QoS "Resource reservation": reservation of the required resources in the access and / or core network.
- "IP user data transfer": the flow of IP user data traffic.
- QoS "Resource release": the reserved resources are released.
- QoS "Session termination": the session is terminated.
- Network attachment: a mobile host attaches to a certain network, using a specific access technology.
- Network detachment: a mobile host detaches from a network

In this section we briefly exemplify the operation of the QoS and mobility framework (see Fig.1). A more detail description of this framework and in particular of its operation can be found in [20]. First, we give an example for the start of the communication, i.e. *session setup*, *resource reservation*, and *IP user data transfer*. Thereafter, we give an example of a hand-over from one access technology to another, using *network attachment*, *network detachment*, *resource release*, and *resource reservation*.

4.1 Start of Communication

For this particular example we assumed the following: the first five procedures described above are performed sequentially. The calling user, i.e. Host X is already attached to an *Access Network* supporting the Intserv QoS architecture and RSVP. It is attached to this network in two ways: using Bluetooth (on his home subnetwork), and using the GPRS access technology (on another subnetwork). The Host Y is also residing in an *Access Network* supporting the Intserv architecture. The *Application* in the Host X and Host Y is VoIP, i.e. non-adaptive with hard QoS requirements belonging to the Mobility Dependent Locally Guaranteed (MDLG) service class. Mobile IP manages the mobility support and *TS* at the host decides on the access technology. Host X and Host Y use SIP as *Session Layer Negotiation* protocol and RSVP enhancements as *End-to-End QoS Resource Reservation* protocol. *Application* entities can be seen as SIP clients also.

QoS "Session Setup"

(S1): A calling user, *Application* entity in Host X, starts up a VoIP session to communicate with the called user – *Application* entity in Host Y.

(S2): At Host X, the *QoS API,* based on application attributes and QoS requirements, determines the Mobility Depend Locally Guaranteed (MDLG) service profile and translates these parameters in an understandable form for the underlying entities. Since, Host X is able to support more than one access technology, by using the technology selection procedure described in Section 3.3.2, *TS* will select the access technology that satisfies the predefined technology selection criteria for MDLG. Suppose for now, Bluetooth is selected.

(S3): By means of a SIP message, the calling user invites the called user, i.e. Host Y to start a VoIP session. The session description in the SIP message will contain the session name, purpose, media and timing information, and additional information regarding the bandwidth to be used by the VoIP application.

(S4): The called user, i.e. Host Y will perform the same procedures as Host X in *(S2)* and it will inform the calling user about the successful session setup completion, if the session is acceptable and the resources for the session are available in the remote access network.

QoS "Resource reservation"

(S5): Since both *Access Networks* support the RSVP/Intserv concept, then the calling user, i.e. RM in Host X, must start the "resource reservation" procedure (sending RSVP PATH messages). In this procedure, the *RM* entities located in the *Access Networks* and *Diffserv Core Network* and in the Host Y will have to interoperate in order to reserve resources negotiated at the session layer. Preferably, in the *Diffserv Core Network* RSVP enhancements are used like RSVP aggregation or tunneling to avoid scalability problems.

"IP user data traffic phase"

(S6) After successful completion of the QoS "session setup" and the QoS "resource reservation" procedure Host X and Host Y may start sending IP user data traffic, i.e. VoIP speech data.

4.2 Handover

If Host X gets out of the coverage of its home Bluetooth network, it has to rely on the GPRS network to continue the session. So, the assumption here is that Host X performs a handover from the Bluetooth subnetwork to the GPRS subnetwork during the exchange of data traffic, in order to remain connected to the Intserv-based access network. This will be handled by the *MC* and *MA* entities, in conjunction with the *RM* entities. The specific example we give here exemplifies a so-called hard handover, i.e. the old link is broken down before the new link is established.

Network detachment / Resource release
Possibly, the network detachment will be performed automatically, because Host X will loose contact with the Bluetooth network, and the soft state for Mobile IP and RSVP will be removed from the network. Alternatively, the state in the network is removed because it is being replaced by a new state, because of network attachment.

Network attachment
 (Si-1): The *MC* entity of the Host X will try to find out from *MA* in the GPRS subnetwork what its new identity, i.e. IP address, is. In Mobile IP this is known as Care-of Address discovery.
 (Si-2): The *MC* will send its new IP address to the *MA* in its home subnetwork, i.e. it will register. From now on, all IP packets will be tunneled to the new IP address.

Resource reservation
(Si-3) Host X and Host Y will keep the current the QoS session setup and will re-initiate the "resource reservation". The resource reservation will be done using the same QoS requirements as before. If the reservation is not successful, the QoS requirements will be renegotiated with the application. This may lead to either successful reservation or session termination.
(Si-4) After successful " resource reservation" data exchanges follow as in *(S6)*.

5   Conclusions

In this paper we presented a new framework for Internet next generation architecture that integrates QoS and mobility. This framework is capable of integrating various wired and wireless access technologies that are using different QoS architectures and protocols. The different QoS architectures located in the access networks can use a Diffserv core network to intercommunicate and provide end to end QoS support. The main advantages provided by this framework are related to the possibility of the session layer negotiation of QoS parameters before the actual network resource reservation procedures take place. This will enhance the scalability of the Diffserv core network and it will reduce the waste of resources in the access networks. Furthermore, the framework provides an efficient way of integrating the existing IP mobility protocols, such as the Mobile IP and resource reservation protocols, such as the RSVP. Further work includes experimenting with combined RSVP / Intserv, Diffserv, Mobile IP and SIP implementations to demonstrate the feasibility of the framework.

6   Acknowledgements

Special thanks to Martin van der Zee, Simon Oosthoek, and Rachid Ait Yiaz for their comments and suggestions, and to Phil Chimento and John de Waal for support.

7   References

1. Braden, R., Clark, D., Shenker, S., "Integrated Services in the Internet Architecture: An Overview", IETF RFC 1633, 1994.
2. Braden, R., Zhang, L., Berson, S., Herzog, S., Jamin, S., " Resource Reservation Protocol (RSVP) Version 1 Functional Specification", IETF RFC 2205, 1997.
3. Wroclawski, J., " The use of RSVP with IETF integrated Services", IETF RFC 2210, 1997.
4. Blake, S., Black, D., Carlson, M., Davies, E., Wang, Zh., Weiss, W., "An architecture for Differentiated Services", IETF RFC 2475, 1998.
5. Nichols, K., Jacobson, V., Zhang, L., " A two-bit Differentiated Services Architecture for the Internet", IETF RFC 2638, 1999.
6. Bernet, Y., Binder, J., Blake, S., Carlson, M., Davies, E., Ohlman, B., Werma, D., Wang, Zh., Weiss, W., "A framework for Differentiated Services", draft-ietf-diffserv-framework-02.txt, February 1999.
7. Heinanen, J., Baker, F., Weiss, W., Wroclawski, J., "Assured Forwarding PHB group", IETF RFC 2597, 1999.
8. Jacobson, V., Nichols, K., Poduri, K., "An Expedited Forwarding PHB", IETF RFC 2598, 1999.
9. Guerin, R., Blake, S. and Herzog, S.,"Aggregating RSVP based QoS Requests", Internet Draft, draft-guerin- aggreg-rsvp-00.txt, November 1997 (work in progress)
10. Baker, F., Iturralde, C. Le Faucher, F., Davie, B., "Aggregation of RSVP for Ipv4 and Ipv6 Reservations", draft-ietf-issl-rsvp-aggr-02.txt, March 2000 (work in progress)
11. Terzis, A. Krawczyk, J., Wroclawski, J., Zhang, L., "RSVP operation over IP Tunnels", draft-ietf-rsvp-tunnel-04.txt (work in progress)
12. Bernet, Y., Yavatkar, R., Ford, P., Baker, F., Zhang, L., Speer, M., Braden, R., Davie, B., Felstaine, E. "Framework for Integrated Services operation over Diffserv Networks", draft-ietf-issll-diffserv-rsvp-04.txt, March 2000 (work in progress)
13. Perkins, C., E., "Mobile networking through mobile IP", IEEE Internet Computing, 1998.
14. Wedlund, E., Schulzrine, H., "Mobility support using SIP", ", Second ACM/IEEE International Conference on Wireless and Mobile Multimedia (WoWMoM'99), Seattle, Washington, August, 1999
15. Handley, M., Schulzrinne, H., Schooler, E., Rosenberg, J., " SIP: Session Initiation Protocol", IETF RFC 2543, 1999.
16. Eriksson, A., Ohlman, B., "A framework for On-demand QoS Bearers over Fixed and Mobile Internet Access", paper submitted to the IWQoS 2000, June 5-7, 2000.
17. Case, J., McCloghrie, K., Rose, M. and S. Waldbusser, "Protocol Operations for Version 2 of the Simple Network Management Protocol (SNMPv2)", RFC 1905, 1996.
18. Boyle, J., Cohen, R., Durham, D., Herzog, S., Raja, R., Sastry, A., "The COPS (Common Open Policy Service) Protocol ", IETF RFC 2478, 2000.
19. Teitelbaum, B., Chimento, P. "Qbone Bandwidth Broker Architecture" at "http://qbone.ctit.utwente.nl/deliverables/1999/d2/bboutline2.html" (work in progress)
20. Karagiannis, G., Rexhepi, V., "A framework for QoS & Mobility in the Internet Next Generation", Internet Next Generation report, located at "http://ing.ctit.utwente.nl/WU4/Documents/QoSMob_a.pdf", (to be provided)