On QoS Management of H/2 Bearer Service for 3G Telecommunication Systems

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Abstract

3G telecommunication systems encompass a high-speed access network, which can provide high bit-rate bearer services for roaming users, as well as intelligent allocation of backbone network resources for end-to-end QoS maintenance. Emerging applications put extra demand for these features, which technologies such as HIPERLAN/2 (H/2) [1] are called to support. The ETSI BRAN [2] project has specified the basic mechanism for a generic wireless LAN bearer service that can accommodate a set of network layers (e.g. ATM, IP).

We propose a mechanism on how to enhance the QoS capability handling of H/2 bearer for IP services, as well as provide the means to interconnect to oncoming 3G core networks.

1. Introduction

Analog wireless systems such as *Advanced Mobile Phone Service* (AMPS), *Nordic Mobile Telephone* (NMT) or *Total Access Communication System* (TACS) are considered as the first-generation wireless systems. The second-generation was introduced to satisfy the rapidly increasing demand for cellular voice services by using among other innovations, digital coding. *Global System for Mobile Communications* (GSM) is the most widespread standard of the second-generation system.

Today, roaming users require higher bit rate and quality as they get in a fixed network. Third-generation wireless systems (3G) are able to provide QoS to the end-user additionally to higher capacity than the second-generation systems were able to provide. UMTS (*Universal Mobile Telecommunication System)* is the main third-generation system capable to provide QoS to the end user. UMTS is based on *Wideband Code Division Multiple Access* (WCDMA) and provides high bit rate (up to 2 Mbps), lower delays and higher terminal mobility.

HIPERLAN (HIgh PErformance Radio Local Area Network) type 2 platform (H/2) is an ETSI wireless LAN standard designed to enable wireless access to different networks such as IP, ATM, Ethernet with a maximum capacity of 54 Mbps at the physical layer [7].

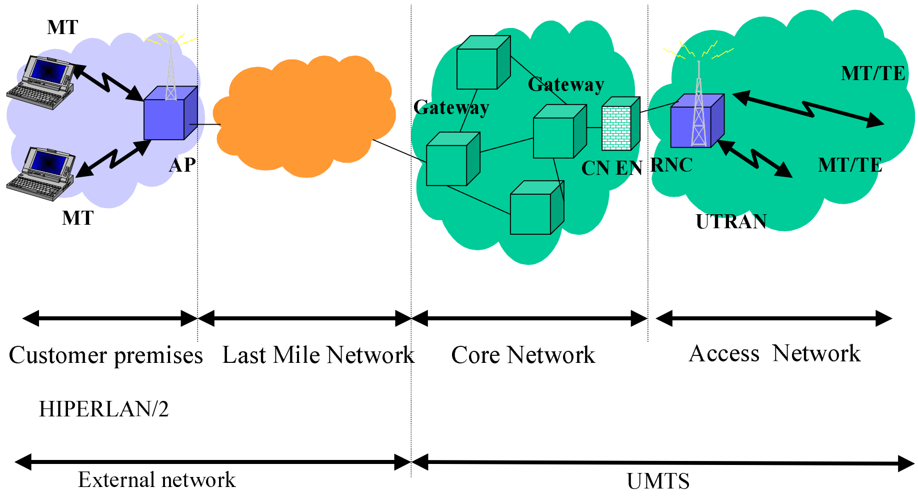

Figure 1 End-to-End scenario combining UMTS network with H/2 premise network through a last mile network which could be for example a FSAN-VDSL (MT: Mobile Terminal, AP: Access Point, CN: Core Network, EN: Edge Node, RNC: Radio Network Controller, UTRAN: UMTS Terrestrial Radio Access Network, TE: Terminal Equipment).

Our work focuses on a scenario where a third-generation system acts as a core network interconnecting two access wireless systems: H/2 and 3G access network (see Figure 1 when the 3G network is UMTS). Because H/2 is an indoor technology, it needs a last mile network (for example an FSAN-VDSL network) to reach the core network. Nevertheless H/2 can be an access network to third generation cellular networks [7] and in the remaining part of the article we will consider H/2 as a last drop network of UMTS.

UMTS Terrestrial Radio Access Network (UTRAN) is responsible for the wireless part of the UMTS access network and provides up to 2Mbps to the *Mobile Terminal* (MT) [6]. UTRAN is connected to the Core Network through a *Core Network Edge Node* (CN EN). The core network can be IP, ATM or any other kind of network. At the edges of the core network, gateways provide connection with existing technologies such as for example GSM, H/2 or VDSL.

H/2 consists on an *Access Point* (AP) and several MTs. The AP can be directly connected to the 3G core network by means of a gateway that incorporates transmission, switching/routing and QoS management functions appropriate for the type of the core network. Our work will focus on an IP core network.

So far there is no specification regarding the adaptation of QoS for IP networks over the H/2 bearer service. Nonetheless, the recommendation by [6] for the UMTS core network is to use the IETF *Differentiated Services* (DiffServ) model. The approach presented in this work for provisioning IP transportation over the H/2 bearer services is based on the same model. DiffServ is based on different *per-hop-behavior* (PHB) for aggregate flows through each DiffServ-aware IP node. The PHB model of the DiffServ approach scales better than the second approach, proposed by IETF, which is the *Integrated Services* (IntServ) for provisioning QoS for IP networks. This model is based on per-hop reservation of resources, which requires complex state machines and state monitoring, therefore leading to scalability problems.

Section 2 gives a brief description of the DiffServ architecture as it is considered by the IETF. Section 3 introduces 3G systems and how they can offer DiffServ QoS. Section 4 presents H/2 and how it can offer DiffServ QoS. A possible mechanism to provide end-to-end QoS is proposed in Section 5. The article concludes in Section 6 and gives some guidelines for future work in Section 7.

2. DiffServ Architecture

In IP core networks, DiffServ is considered as a concrete model for the end user to provide QoS [6]. DiffServ [4], [5] is based on flow aggregation leading to reservation made for a set of related data flows. That particular characteristic of DiffServ results to its inherited capability of eliminating any scalability problems. Another characteristic of DiffServ that benefits its scalability capabilities is the PHB. Each IP packet delivered to a node is forwarded to the next node according to a certain priority. This priority is corresponds to the specific set of flows that the particular packet belongs to.

Two aspects need to be further examined. First, the distinction among IP packets that belong to different set of flows and second the entity responsible to identify the specific set of flows that a certain IP packet belongs to. As far as the first aspect is concerned, inside the IP header (for both IPv4 and IPv6) there exists a specific field called the *DiffServ Code Point* (DSCP) that can be marked accordingly.

For the second aspect, since each flow has its own traffic and QoS characteristics, three general different service categories have been defined for flows with similar characteristics. As a result, it is possible to distinguish among flows that have different requirements (i.e. flows that are delay sensitive need to belong to another category from flows that are loss sensitive). Different flows that belong to the same service category will be treated identically and this treatment is the PHB.

- **Premium Service** is destined for applications that have delay constraints. These applications can typically tolerate only small delays and delay jitter. The DiffServ model guarantees that every premium packet will be forwarded as soon as possible in the intermediate routers, though losses might occur.

- **Assured Service** is destined for applications that have loss constraints. Loss at the network layer does not necessarily imply loss at the transport layer. For this reason, loss at the IP layer may imply extra delay if the network layer protocol is TCP, due to retransmissions. On the contrary, if the network layer protocol is UDP it implies packet loss for the application.

- **Best Effort Service** is destined for the rest of the applications. These applications are considered to tolerate packet losses or time delays (e.g. file transfer or pre-recorded video).

An important element of the DiffServ QoS architecture (called the Bandwidth Broker and presented latter in Section 4) is responsible for the resource management of a specific network domain as well as to receive and reply the requests for additional resources.

3. UMTS QoS and DiffServ

UMTS defines four different QoS classes: *Conversational*, *Streaming*, *Interactive* and *Background*. The main difference between them is how much delay sensitive each class is [6].

The *Conversational* class has strict delay and jitter requirements since it may be used for voice applications. Human reception poses the restrictions for this particular class. *Streaming* class may be used for real time video/audio applications. There are no low delay requirements and the delay variation requirements are less strict than the *Conversational* class. For Interactive class applications, such as data base enquiries, bank transactions etc., low bit error rate is needed and a maximum round trip is required. Finally, *Background* class can be used for background delivery applications such as E-mails, file transfer and any kind of applications that has no particular time delay constraints.

In order for UMTS to cope with DiffServ, each of the four UMTS classes shall be mapped onto the three DiffServ specific classes. The *Conversational* class can be mapped to the Premium class, the *Interactive* to the Assured and the *Background* to the Best Effort. As far as the *Streaming* class is concerned both Premium and Assured can be used depending to the particular requirements of each individual application. Therefore, an efficient QoS mapping is required.

A set of special functions has been considered for both the control and user plane [6] as it can be seen from Figure 2. As far as the control plane is concerned the *Service Manager* co-ordinates the control plane functions and provides the interface with the user plane. The *Translation Function* is responsible for the homogeneity between the internal service primitives of UMTS and any external network. This is the function that decides whether a flow belonging to a certain DiffServ class can be mapped to a UMTS or not. *Admission/Capability Control* checks for the availability of the requested resources and it is responsible to reserve/release them. Finally, the *Subscription Control* checks the rights of the flow from the administrative point of view.

On the other hand, the user plane functions are responsible to maintain the QoS constraints as they are specified. First a *Mapping Function* is needed to mark each data unit with respect to the category of services that it belongs to. Note that the result of the *Translation Function* is used for this purpose. Additionally, if multiple applications run on a MT and have different UMTS QoS requirements the *Classification Function* assigns data units to the corresponded class. The *Resource Manager* is responsible for the assignment of the resources (i.e. bandwidth) among all services that share the same resource (i.e. the wireless medium) according to their specific QoS requirements. Finally, the Traffic Conditioner is responsible ensure that the traffic characteristics of a particular flow do correspond to the agreed ones.

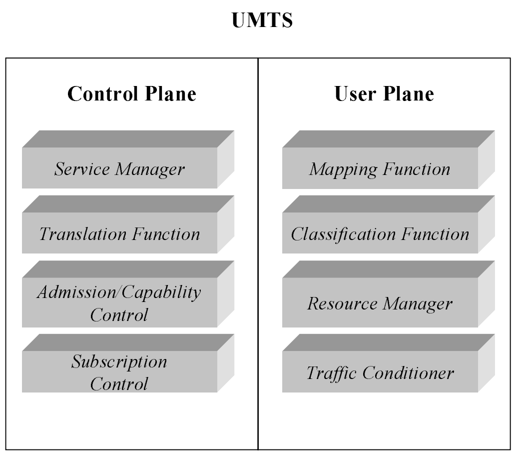

Figure 2 UMTS Control and User Plane.

From the above, it is obvious that the described functions of UMTS for both the control and user plane, can be used to effectively adapt a DiffServ network to UMTS. The objective of the current work is to adapt H/2 to UMTS and provide QoS guarantees. Therefore, an enhanced H/2 architecture needs to be considered. In the following Section 4 this enhanced H/2 architecture, capable to be attached to a DiffServ QoS network, is presented.

4. H/2 and DiffServ

The H/2 platform consists on the following layers [1], [2]: *Physical Layer (PHY), Data Link Control Layer (DLC)* and the *Convergence Layer (CL)*. The higher layers can be IP, ATM or even Ethernet and in this article we will focus on IP. For each of these higher layers there exists a specific convergence sublayer but a common DLC and PHY.

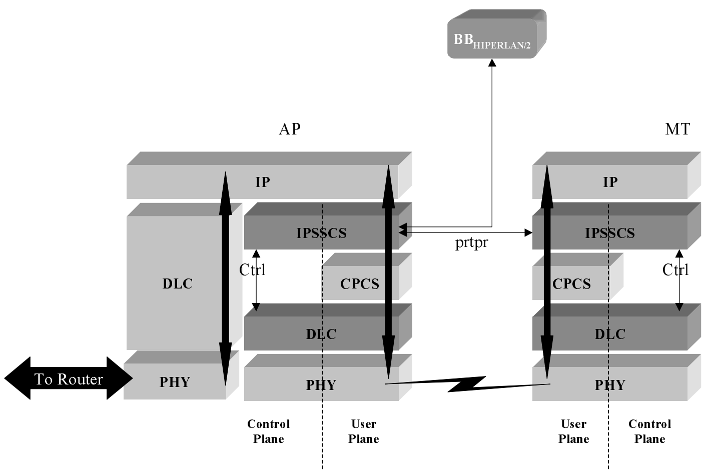

Figure 3 H/2 Enhanced Protocol Stack. In order to provide DiffServ QoS DLC and IPSSCS need to be enhanced and $BB_{HIPERLAN/2}$ need to be added. CL is consisted by IPSSCS and CPCS. The User Plane for the CPCS is transparent.

The Convergence Layer is divided into two sublayers: the *Common Part Convergence Sublayer* (CPCS), which is located just above the DLC, and the *Service Specific Convergence Sublayer* (SSCS) which in our case is called IPSSCS for the concrete IP case. IPSSCS and DLC enhancements can be seen in [3]. In Figure 3 boxes colored dark gray are the elements of the standard H/2 that need to be enhanced (IPSSCS and DLC) and those that need to be added ($BB_{HIPERLAN/2}$ – presented later). All the other entities are as they are described in the ETSI standards of H/2.

The role of the IPSSCS is to adapt the IP layer and its DiffServ QoS parameters to the H/2 specific DLC layer. Its main function is to perform the necessary QoS mapping, exchange control information (Ctrl) with DLC, keep important information and handle all necessary communications when a service request is placed. QoS Mapping is one of the functionalities that IPSSCS should perform.

One of DLC control plane's roles is to receive control information from the upper layers regarding QoS parameters. These parameters are mapped into DLC specific parameters by the IPSSCS. *Peer-to-peer* (prtpr) communication, at IPSSCS, is needed between the AP and the MT in order resource messages to be exchanged. The DLC user plane is responsible for the effective scheduling, the congestion control and the radio resource control.

An important element of the DiffServ QoS architecture is the so-called *Bandwidth Broker* (BB). BB is a special agent that supervises a separate domain of the network. A BB communicates with other elements that are QoS aware, in order to request/reserve resources as it is depicted in Figure 3. Hence, $BB_{HIPERLAN/2}$ can be defined as a special module that reserves the resources and handles of DiffServ QoS control communication between H/2 and any other network.

Furthermore $BB_{HIPERLAN/2}$ should be able to communicate with the Gateway (see Figure 4) to request for resources or to reply to a previous request. The mechanism proposed in Section 5 describes this communication and the functionality that needs to be included inside the IPSSCS.

5. Proposed Mechanism

The proposed mechanism presented in this section aims to provide H/2 with capabilities to be connected to UMTS. Both control and user planes are described and furthermore possible problems are presented.

5.1. Control Plane

$BB_{HIPERLAN/2}$ is located at the AP of the H/2 network system and its role concerns, apart from handling the resource reservation, on communicating with the Gateway that connects H/2 and UMTS in order to handle all DiffServ QoS communication (requests, replies etc.). The Gateway translates with the *TranslationFunction* the H/2 service attributes to CN EDGE and through the *Ext. BS Manager* the requests are communicated from H/2 to CN EDGE and vice versa. Ext. BS Manager is a special entity responsible to communicate with entites aware of QoS outside UMTS. *UMTS BS Manager* is the key element since it handles all communication between the CN EDGE and H/2. It also handles all transactions with *Translation Function* and *Admission/Capacity Control* element. The latter element is responsible to answer whether there are enough resources to satisfy a request or not [6].

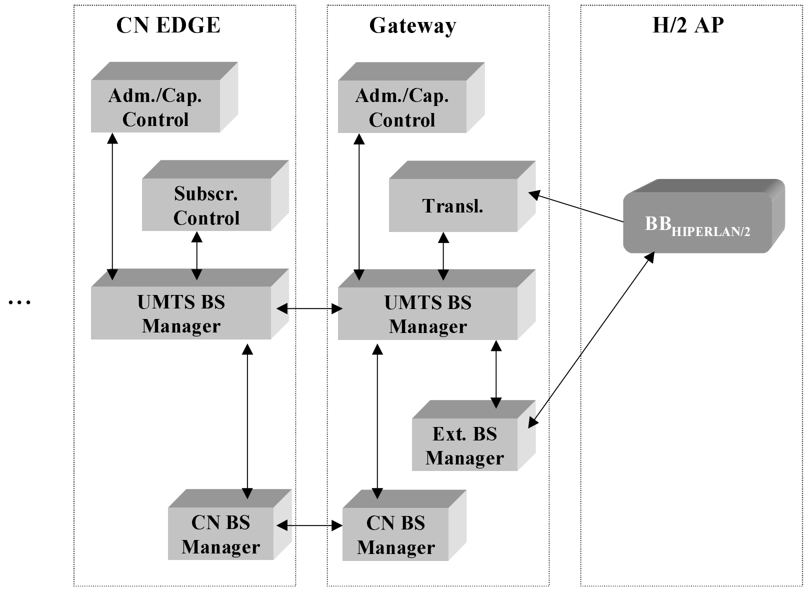

Figure 4 UMTS' special QoS entities communicate with $BB_{HIPERLAN/2}$ to provide all information needed in H/2 (DLC, IPSSCS) in order to cope with DiffServ QoS.

An application running on a MT of H/2 may request resources in order to open a session with another host (either another MT or a host located somewhere in the rest of the network - see Figure 1). The application itself is responsible for providing the characteristics of the resources needed to satisfy the QoS demands for this particular session. The request arrives to IPSSCS that is responsible for forwarding the request to $BB_{HIPERLAN/2}$. On the other hand if the application is running on a host in the rest of the network then the $BB_{HIPERLAN/2}$ will be notified by the External BS Manager.

Figure 5 corresponds to the particular process that should take place in the IPSSCS layer of AP when $BB_{HIPERLAN/2}$ has forwarded a request. As soon as the request for resources arrives, IPSSCS maps the DiffServ QoS parameters to H/2 specific QoS. Then, these H/2 specific QoS requirements are forwarded to the DLC and an answer is received whether it is possible to satisfy the request or not. If the answer is negative then it is forwarded to $BB_{HIPERLAN/2}$. If DLC accepts the request then a positive answer is sent to $BB_{HIPERLAN/2}$ and the IPSSCS table that keeps all relevant information, is updated.

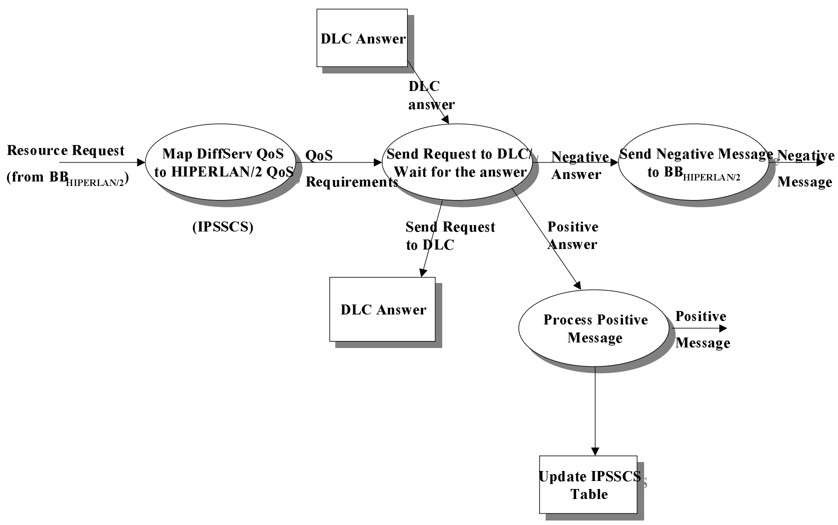

Figure 5 Resource Request originating from the $BB_{HIPERLAN/2}$ arrives at IPSSCS of the AP (AP-IPSSCS).

The Finite State Machine (FSM) depicted in Figure 6 corresponds to the mechanism developed inside H/2 (in particular inside IPSSCS of the AP) in order to provide DiffServ QoS.

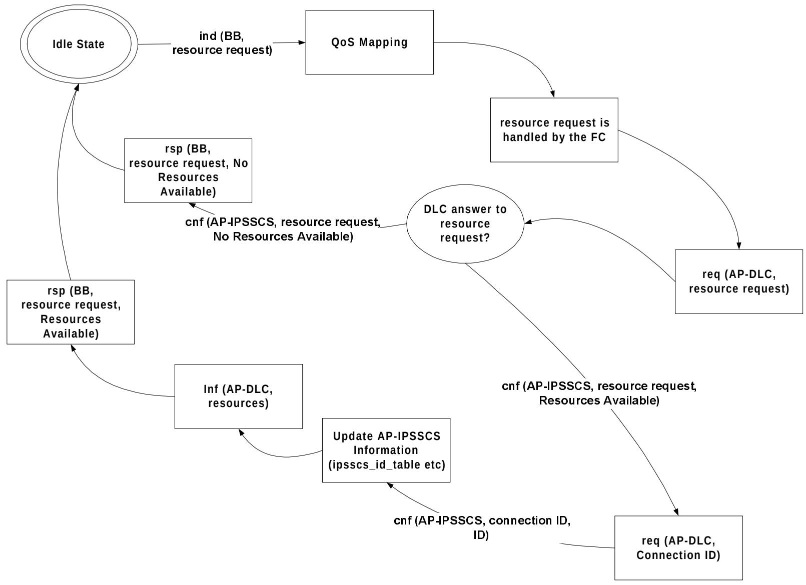

Figure 6 AP-IPSSCS: $BB_{HIPERLAN/2}$ is applying a request for resource to AP-IPSSCS.

In this FSM shown in Figure 6 the double-line ellipse corresponds to the **starting point**. Each ellipse corresponds to a particular **state** where a certain question should be asked in order for an event to occur, and consequently, move to the next state. Each arrow corresponds to an **event** while each rectangular corresponds to **action**s that should take place.

In order the above FSM to be realized (and possibly any other FSM concerning the resource release, connection setup etc.) a set of entities should be added, as it is described in [3]. For the IPSSCS part it involves an entity called the *Message Handler* (MH) responsible for the communication between the H/2 protocol stack and the $BB_{HIPERLAN/2}$. The *QoS Mapping* entity is responsible to assign the specific flow to a category of services. *Flow Control* (FC) is the entity responsible to request/inform both DLC user and control plane. FC will request resources from the DLC and in particular from the *Wireless Call Admission Control* entity (WCAC) inside the DLC control plane and if the request is accepted than it will inform the *Traffic Table* (TT) inside the DLC user plane, accordingly.

The following two figures, Figure 7 and Figure 8, refer to the Message Sequence Charts for the case a request of resources is rejected or it is accepted respectively.

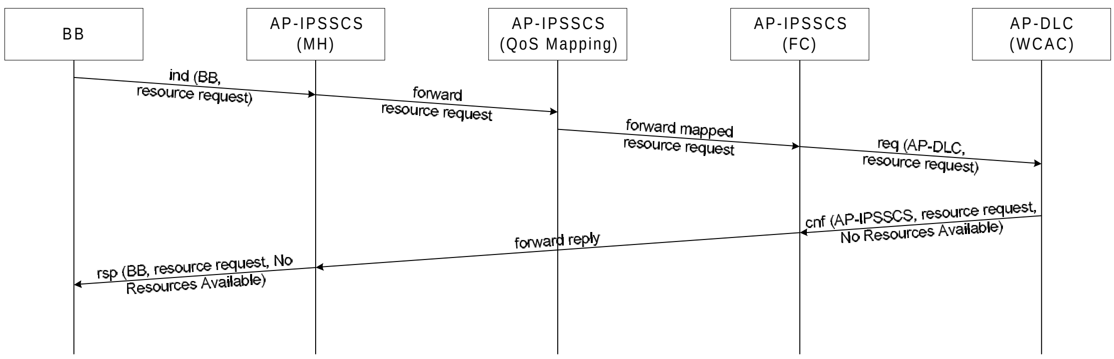

Figure 7 A Request for Resources is applied to the AP-IPSSCS and WCAC (DLC) replies that there are no Resources available to satisfy the particular Request.

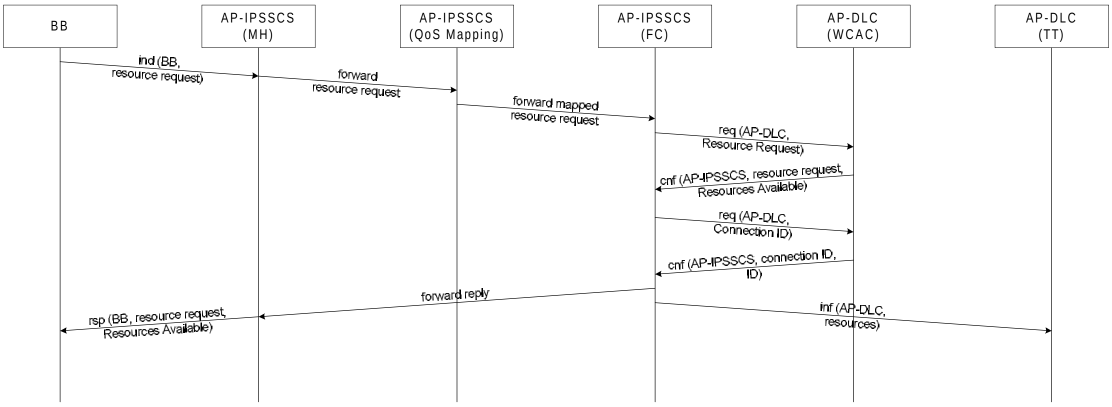

Figure 8 A Request for Resources is applied to the AP-IPSSCS and WCAC (DLC) replies that there are enough Resources in the system to satisfy the Request. Additionally, TT is informed.

5.2. User Plane

Fortunately, the user plane of the H/2 network connected to UMTS is not complicated. As it can be seen from Figure 9, an *External BS* is required to connect the Gateway that resides at the edge of UMTS with AP. There are no specific requirements for this particular interface except to be capable to provide data rates as high as the data rates of the requested resources.

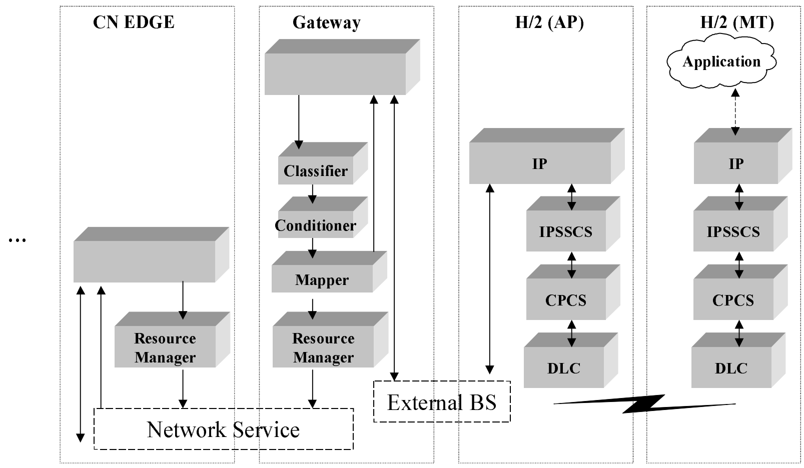

Figure 9 UMTS' User Plane entities connected to the enhanced H/2 network that provides DiffServ QoS capabilities.

5.3. Possible Problems

Since UMTS is expected to provide service for an increased number of users, compared with the number of users that use second generation wireless systems, an increased number of resource requests is expected. Therefore, when a real H/2 network as described above is to be launched, this increased number will result to various undesired situations. For example, if two requests are permitted to request WCAC for resources simultaneously, WCAC is possible to assign the resources to both of them even if the available resources are enough for only one of them. A possible solution is to block all other requests when a request is served.

A second problem is the delays introduced before the system is capable to reply to a specific request. Therefore, special care should be taken during the design and the implementation process for those requests that can be served faster. For example, if a new resource request has arrived immediately after a rejected resource request (that had requested for a lower amount of resources than the new request), and the status of the H/2 system is not changed, then the new request should be rejected without any delay. As a result the undesired situation to disappoint users (because of increased delay to accept them in the system) even though the service provider is capable to satisfy their needs, is avoided.

Finally, the standardization of $BB_{HIPERLAN/2}$ and, in particular, the interface between this entity and UMTS is of great importance before the realization of such a system.

6. Conclusions

The proposed mechanism is an attempt to provide H/2 with a mechanism capable of providing QoS. Mapping between DiffServ QoS and H/2 specific QoS parameters is necessary but this is realistic only if a mechanism like the one presented in this paper is implemented inside H/2.

The important advantage is that all application oriented for 3G Telecommunication system can be supported and their specific QoS requirements can be reserved inside the H/2 domain.

Furthermore, the mechanism can be used by all different H/2 systems that provide their own specific QoS capabilities. Even if the DiffServ model was not under consideration in this particular study it is possible to use any other QoS model that is based on signaling (for example Integrated Services and RSVP).

7. Future Work

UMTS is expected to evolve the next few years. Wireless LANs like HIPERLAN/2 should be ready to provide compatibility with it. All services that rely on the universal nature of 3G systems would demand a fine cooperation between both technologies. The DiffServ model is the current status and therefore an in detail investigation should take placed to identify the most efficient mapping between UMTS classes and DiffServ classes, DiffServ classes and HIPERLAN/2 specific QoS parameters.

Another part that needs extra focusing is the design details of the enhanced H/2 architecture in order to be capable to handle resource requests in the competitive environment of 3G wireless technologies.

8. Acknowledgement

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