

# QoS (techniques/functionalities) for Virtual Home Environment

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## Abstract

VHE(Virtual Home Environment) service provision requires dynamic QoS (Quality of Service) management, which can handle the QoS changes caused by network congestion, user roaming and user's terminal change. Specific QoS manager is needed to monitor and solve the QoS problems. This paper presents possible ways for QoS manager to accomplish dynamic QoS management. Also the cooperation needed from networks and services side is addressed.

## 1 Motivation

Technologies change people's life. One big change in people's way of communication was, when the telephone was invented. The trend nowadays is toward wireless communication, which enables mobile phone users more freedom, both time and location. World Wide Web is a huge information source in which people seek all kind of information. WWW is used to read news, check education material, or shopping etc. For many people, surfing the web has become a part of the daily life. As the combination of these technologies, wireless Internet makes it possible for people to have internet connection not only at home and in the office, but also in the train, bus etc. Wireless Internet is only a sample of many wireless applications. As the technology and network develop, more and more appealing wireless applications will come into people's life. From wired phone to wireless phone, from wired Internet to wireless Internet, the moving from fixity to mobility is evident.

GSM (Global System for Mobil communication) is the 2nd generation (2G) in wireless communication. GSM technology has been very widely used and is familiar to most of people. Due to the capacity of the current GSM networks, multimedia data, like video, is transmitted in reasonably low speed. Comparing with the 2G networks, 3rd generation (3G) networks have the advantage of big capacity. UMTS is the synonym of 3G. The transition from 2G to 3G can't happen in one night. On the way of evolution from 2G to 3G, there are intermediate technologies like High-Speed Circuit-Switched Data (HSCSD), General Packet Radio System (GPRS) and Enhanced Data GSM Environment (EDGE) [14]. All these technologies will coexist for very long time. The future scenario might be like this: the city areas uses UMTS network, the rural places or mountain areas use GSM or GPRS network.

The reason of the success of wireless communication is it makes people to be connected everywhere by having a portable device. As users, they not only want to be connected as they move, but also they want to have all the services they subscribed everywhere. CAMEL is an example of an solution that GSM roaming users can have the same IN services as they are in their home networks. Here portability of service is the key idea.

Virtual Home Environment (VHE) is a concept that aims to solve same problem. VHE promises the users can have the same service experience independent of networks and terminal. Although VHE is a 3GPP project, VHE is aimed for the user of different networks, such as: 2G, 3G, IP networks [12]. VHE concept is studied more detailed in following chapters.

This paper is written to discuss the Quality of Service (QoS) problem in Virtual Home Environment. Requirement for QoS have long been existed in those more demanding application which requires more than “best effort services” from network. According to the VHE definition, user’s service experience should keep the same as in home network when s/he is roaming to another visiting network. Different networks have different capacity, which means the QoS changes as the serving network changes. This kind of change should be transparent from the user. What should be done if the user roams to network that has less capacity than the one that he started the service in the service session? Besides the transparency across the network, change of terminal should be transparent to user also. What about in the case that user change the terminal to a less capable one, say from laptop to GPRS enabled mobile phone? A mobile phone’s receiving rate is much less than laptop. When the user accesses the service from his mobile phone instead of laptop, should s/he get the same bandwidth needed for laptop application from the network?

Although the management of QoS has an important role in VHE, there is still no standard solution for it yet. There are some suggestions about how to solve this problem, but it’s not completed. Some technical details are still missing. This paper will introduce and compare these suggestions, and present some author’s idea about what’s QoS manager, the creation of QoS manager and the communication between QoS manager and network monitor.

## **2 Background**

### **2.1 VHE concept**

#### **2.1.1 VHE definition**

VHE(Virtual Home Environment) is one of key concepts within UMTS system. Different organizations have given definitions to VHE.

Although the definitions from different organizations are slightly different to each other, they have some common points. All definitions state that under the VHE, service providers should be able to offer personalized services to users, and the user should have the same services and interfaces as in his/her home network when s/he roams to another network. Besides the transparency of roaming across the networks, VHE also offers the transparency between terminals. This approach means the user can receive his subscribed services from different terminals. The realization Of VHE improves the portability, flexibility and scala-

|             |   |
|-------------|---|
| ETSI-3GPP   | “VHE is a system concept for personalized service portability across network boundaries and between terminals”  |
| UMTS Forum  | “VHE means that the user will have the same interface and environment regardless the location (personalized user interface independent from the current serving network)” |
| GSM MoU     | “Virtual Home Environment (VHE) is a system concept for service portability in the Third Generation across network border”  |
| ITU/IMT2000 | “VHE is a capability whereby a User is offered the same service experience in a visited network as in his Home system.”   |
| IST VESPER  | “VHE main feature is that the customised environment will be following the user while he/she is roaming within different networks and using different terminals”          |

Table 1: VHE definitions [3]

bility of services [3].

VHE is a concept still under research. VESPER (Virtual Home Environment for Service Personalization and Roaming Users) is the name of the project that engages to define, demonstrate, validate and promote VHE architecture. VESPER has the participants from 11 countries, which include VTT from Finland. The full implementation of VHE is supposed to be ready in March 2002 and the project 2nd prototype review will be ready on October 2002. [2]

Besides VESPER, 3GPP is engaged in the work to realize VHE concept also. There are some different opinions between VESPER and 3GPP. VESPER suggests that VHE should be applied to all kind of networks like: IP, GSM, UMTS; 3GPP VHE is focusing on 3G systems only [12].

### 2.1.2 VHE architecture

VESPER VHE architecture is shown in Figure 1:

In the picture, the function of “VHE components” is to support the VHE functionalities. “VHE components” will be developed by VESPER and will be part of VHE Architecture. At server side VHE functionality is accessed via VHE server API on top, accessing via OSA/Parlay gateways different networks as transport layer [11]. At terminal side VHE functionality is accessed via VHE client API and deals via USAT or MExE with terminal core functions. [5]

From the figure 1, we can see that VESPER VHE takes all kind of networks, like: mobile networks, IP networks and fixed networks, into consideration. It means that VHE concept will apply to all these networks in VESPER VHE architecture.

Concepts about OSA, Parlay and MExE will be introduced in following chapter.

The architecture of VESPER VHE was just presented. 3GPP VHE architecture is different from it. In 3GPP VHE architecture, because only 3G systems, which doesn’t include GSM,

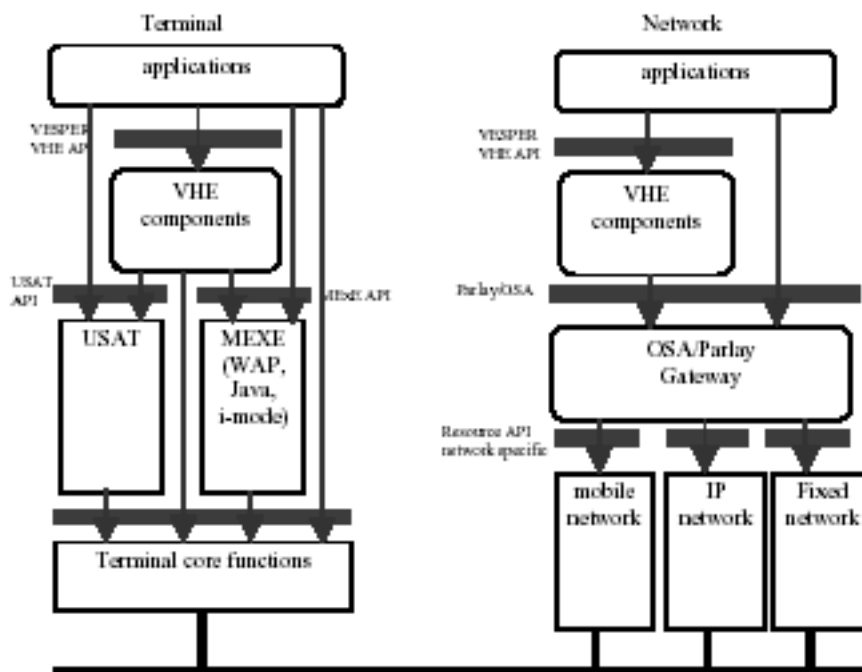


Figure 1: VHE architecture for VESPER [5]

fixed network etc, are considered, so OSA/Parlay, which offer an common network API to service providers are not necessary. There will be more comparison between VESPER VHE and 3GPP VHE in following chapters.

### 2.1.3 VHE service scenario

Following is a VHE service scenario to help readers to have more understandings about VHE service offering.

“Imaging a user that is conducting a multimedia conference in his office using a set of personalized applications, shell and operational interface. The conferencing application runs on the users desktop and offers a certain video quality definition and CD-quality audio connections together with a shared whiteboard service. At some stage the user leaves the conference, but, in order to be reached in case somebody needs him, he suspends his session from his desktop and resumes it from his mobile phone, transferring on it the conferencing application status. The current ongoing image/audio/whiteboard flow is adapted by the application in order to match the resumed terminal capacities. Later on, he receives on mobile phone short messages informing him about the items that his colleagues are dealing with in the conference. As soon as he recognises a subject that he is interested in is going to be discussed, he goes in to his car. In the car, he suspends his session from his mobile phone and resumes it from his console-embedded PC, transferring his ongoing conference status onto the car PC. Both the lower bandwidth available on the PC network and the lower quality of the video degrade the service, but anyway he is still actively participating the conference. The only service that he can partially uses is the

whiteboard service, which is switched to receiving mode, since he can write while he is driving. Then he arrives home, switch on his home PC and again, he transfers his ongoing conference onto this PC. Both video and whiteboard are restored using the same look and feel. Again the user is participating the conference as from his own office, but with a lower video quality, duo to the lower speed Internet access allowed by its digital subscriber line instead of his office LAN.”[10]

## **2.2 QoS concept**

### **2.2.1 QoS definition**

The definition of QoS (Quality of Service) given by ITU-T is “The collective effect of service performance which determine the degree of satisfaction of a user of a service”. On the Internet and in other networks, QoS is the idea that transmission rates, error rates, and other characteristics can be measured and guaranteed in advance [14]. QoS is of particular concern for the continuous transmission of high-bandwidth video and multimedia information. Some applications, which transmit real time data, are more sensitive to the delay; while some applications, are more tolerable to the delay but intolerable to the loss packets.

### **2.2.2 QoS in other networks**

In order to understand the QoS in 3G, it's helpful to have a look of what has been done already in some common networks for accommodating applications need to be QoS guaranteed.

Applications transporting real-time data are most sensitive to time delaying. Samples are video on demand, VoIP(Voice over IP ). The key to guarantee a smooth service provision in this type of application is the bandwidth assigned by networks. If the bandwidth of networks is not enough for the application, problems like delay and packet loss will happen. For ensuring the bandwidth needed by service, different ways are applied in different networks to reserve bandwidth before the service really starts.

IP network is considered as no QoS guaranteed, best effort service. IP network doesn't offer different level of services for transmitting different traffic flows. To support applications having QoS requirements, some protocols have been invented to manage the QoS problem in IP network. Two types of QoS are provided: Integrated service (IntServ) and Differentiated service (DiffServ). IntServ uses RSVP (Resource reSerVation Protocol) to guarantee the QoS per flow by hop-to-hop resource reservation. DiffServ uses a different approach than IntServ. DiffServ controls network traffic by class so that certain types of traffic get precedence. [14]

Comparing with IP network, ATM (Asynchronous Transfer Mode) network has built in support for QoS features. The disadvantage of ATM is that it's too expensive and complicated for most of organizations. Because of this it's mostly used as the network backbone.

There are four main steps of determining QoS: negotiation, mapping, resource reservation and delivery. At the negotiation phase, involving parties solve the problem of what is requested and what can be provided by negotiation; at the mapping phase, the mapping

from application QoS to network QoS are done; in the resource reservation phase, the bandwidth that has been agreed in negotiation is reserved; and the QoS delivery means the performance of a set of actions in order to provide the agreed QoS [11].

These previous experiences of providing QoS of multimedia applications in fixed network can be used in 3G system. Due to the difference between fixed and wireless systems, detailed technologies used may be different, but the principals remain same.

### 2.2.3 QoS in 3G

In 3G networks, the capacity of the network makes it possible for users to have services that transmit video and multimedia information. QoS is required by the guidelines of UMTS development. Users can have the QoS agreements with the operator for his services. QoS management becomes an important and complicated issue that needs to take user's agreement, service requirement, network capacity and user's terminal capability into consideration.

In 3G networks, four different classes QoS have been defined:

- Conversational class
- Streaming class
- Background class
- Interactive class [9]

These QoS classes are mainly different to each other by the delay sensitive factor of the traffic. For example: the traffic of conversational class is very sensitive to delay, while traffic of background is most insensitive to delay.

Conversational class and Streaming class are used to transport real-time data that are very sensitive to delay. Speech should be categorized as conversational class. Applications like voice over IP, video conference should receive QoS of conversational class. Applications like streaming video belong to streaming class since it isn't so strict with delay as long as the time alignment between packets can be preserved. [9]

Interactive class and background class are used to transport data, which are not so sensitive to the delay. One sample application of interactive class is web browsing while background download of emails or files is an application used QoS of background class. [9]

In technical requirements for the UMTS QoS [8], there are two criteria that are related to what is studied next:

- The UMTS QoS mechanisms shall provide a mapping between application requirements and UMTS services;
- Applications (or special software in UE(User Equipment) or 3G gateway node) should be able to indicate the QoS values for their data transmissions

According to these two criteria, the services provider has the responsibility to tell the QoS values needed for the service provision, while the 3G system will map this requirement to the available network services. In the case the network can't offer the sufficient QoS for the service provision, either a message will be thrown to user or service adaptation, which means adapt the service provision to be less demanding to the network, is triggered.

### 3 Analyzes

In previous chapters, the concept and architecture of VHE, QoS in IP and 3G networks are introduced. If the QoS of transmitting high bandwidth data stream can be solved by applying suitable control method to system, how about the QoS problem caused by roaming, network congestion and terminal change? VHE's definition requires the service provision is independent of serving networks and terminals. Here the dynamic QoS management will be studied in detail.

In VHE, according to the definition, service provision is independent of the serving networks and user terminals. The QoS management in VHE should be dynamic to solve the problem caused by roaming, network congestion and terminal change. Situations that affect the QoS in the service provision are following.

1. User roams to another network during a service session. The visiting network's capacity is lower than the home network capacity, so the QoS of service can't be satisfied anymore in the visiting network.
2. Network gets congested or handover happens, so the QoS of network drops under the limitation for service provision. OR network gets less congested, so the QoS of network can fulfill the service provision.
3. User changes the terminal to a less capable one when accessing the service. The new terminal can't support some service features like multimedia.

Both 3GPP and VESPER realize the necessity of dynamic QoS management in VHE [14]. Both of them agree that a QoS manager is needed in the system to manage the QoS change results from network or user efficiently. There is disagreeing between 3GPP and VESPER about the location of QoS manager. 3GPP suggests that QoS manager should locate inside the terminals, while VESPER suggests that a QoS server locates between network and service. Why 3GPP and VESPER have different opinions about VHE QoS manager's location? The reason is VHE in 3GPP is based on 3G environment while VESPER VHE covers all types of networks, like IP, GSM, GPRS and UMTS. No matter where the QoS manager locates, the functionalities of it include:

1. QoS management on behalf of the user.
2. Mapping of the service QoS parameters onto network-specific QoS parameters.
3. Dynamic QoS management including dynamic QoS monitoring and control.

4. Dynamic QoS negotiation. This happens when the QoS drops under the limitation for service provision, then the QoS manager needs to negotiate.
5. Coherent bandwidth allocation (This feature is not supported by the 3GPP QoS manager). It means that the throughput shouldn't exceed the capability of the user terminal, otherwise the QoS manager should consult the service to reduce the throughput.
6. Trigger service adaptation. This happens when the capacity of network drops, the QoS manager should notify service about it, which can start the service adaptation.
7. Priority management (This feature is not supported by the MExE QoS manager). This happens when user is accessing more than one service in his/her terminal, the bandwidth exceeds the terminal's capability. The QoS manager should check the user's preference to decide which service's has higher priority. [12]

From the above QoS manager's functionalities, technologies how QoS manager communicates with the network and service for guaranteeing a smooth service provision can be seen. From the functionality 3, for the network, it needs to provide QoS manager related information, such as: the capacity of network, congestion level. From the functionality 2 and 7, for the service, first it needs to provide QoS manager the required factor such as: bandwidth, maximum delay of service provision; second it needs to provide service adaptation in certain case such as the capacity of network drops. So besides QoS manager, from network side, network monitor which monitors the performance of network is needed; from service sides, service adaptation which enables the service running on various conditions is needed.

Network monitoring is an important part of network management. All the networks use certain ways or protocols to monitor the network performance. Network monitoring can detect the abnormality in the network, such as: if congestion exists or behavior violates security policy somewhere; and takes measurements to reduce the abnormality. VHE QoS manager needs to negotiate with network monitor about QoS issues, such as available bandwidth from network. According to the location of QoS manager, either on server side or embedded inside terminal, there should be different means for the negotiation. A dedicated QoS server is much more complicated than a terminal embedded QoS manager, which makes it more intelligent and supports more functionalities. Different possible ways for QoS manager to inquire needed information from network monitor are studied in following chapter.

Another technology used to support QoS manager functionalities, service adaptation, is not a new idea either. There is experience about this from the Internet side already. Service adaptation is a more intelligent service provision that provides the service tailored for the terminal issuing the service request. Previously the given scenario for VHE service is a good sample of service adaptation. Different types of terminals have different capabilities. The terminal shouldn't receive service over its capability. Means of service adaptation for different traffic such as video, still images, speech and data varies. For example, for video transmission, means like hierarchical video coding scheme, which has different schemes such as: SNR, data partitioning, can be applied in appropriate situation [6].



## 4 Solution

In this part details about VHE QoS manager are studied. The 3GPP and VESPER solutions about the QoS manager are compared.

### 4.1 QoS manager location

As mentioned previously, 3GPP and VESPER do not agree with the location of VHE QoS manager. 3GPP suggests that QoS manager locates inside the terminal in 3G environment. VESPER says that VHE should be for all networks, such as IP, GSM, GPRS and UMTS. For VESPER, a QoS server that does QoS management locates between service and network. Figure 2 shows the difference from both 3GPP and VESPER viewpoint.

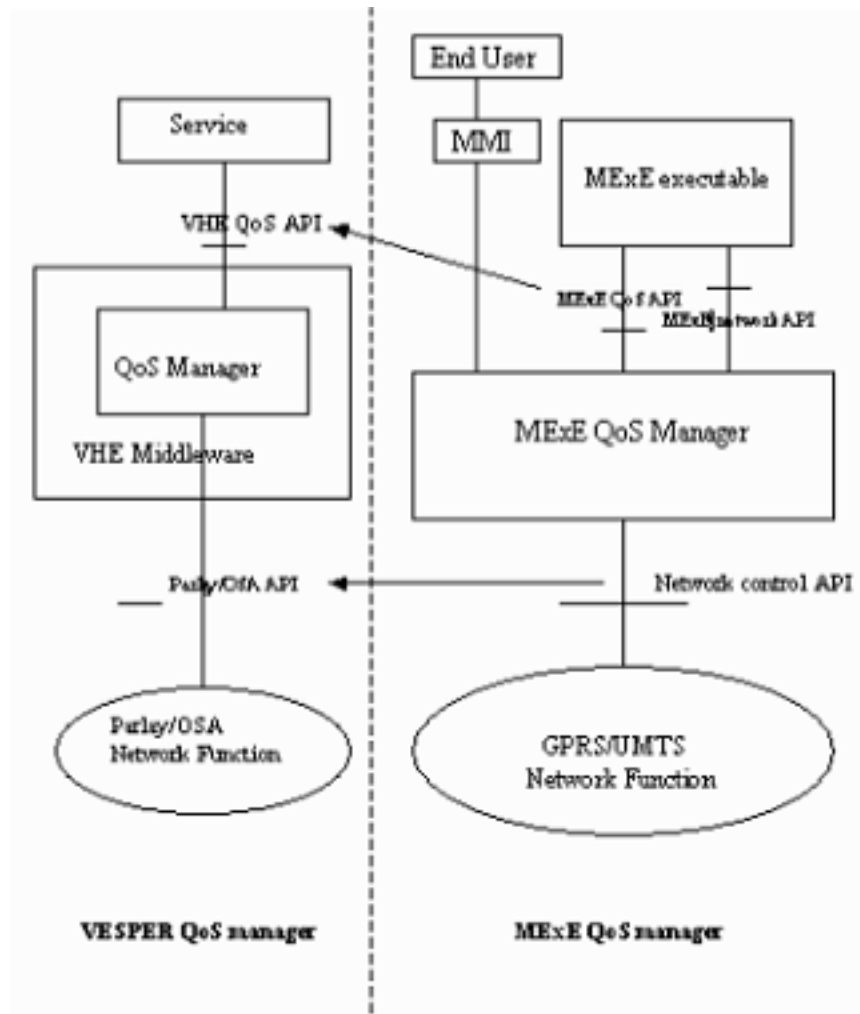


Figure 2: Logical views of the MExE, and VESPER QoS managers[12]

For helping to understand the figure, some terminologies are introduced here:

MExE (Mobile Execution Environment) provides a standardized execution environment

for Mobile Station (MS). It also provides the standardized means to negotiate the MExE MS's supported capabilities with the MExE service provider, allowing application to be developed independent of any platform. [13]

The Parlay group was formed in April 1998 to produce an API specification that would provide solution providers with access to network information and a range of network controls. Parlay API specification is intended to be open and technology independent, so that the widest range of organizations may develop advanced telecommunication solutions. The main specification is defined in the technology independent Unified Modeling Language (UML). [13]

OSA (Open Service Access) enables applications to make use of network functionalities through an open standardized interface. This makes the applications implementing the services independent from the underlying network technologies. OSA is part of standardized work of 3GPP. Network functionality offered to applications is defined in terms of a set of Service Capacity Features (SCF). In OSA, services are implemented by applications by using SCF, which are accessible via the OSA interface towards these SCFs in the network. [13]

The architecture of VESPER would seem better than the one of 3GPP. In 3GPP architecture, the user has to have the MExE terminal for service access. On the other hand, although the VESPER architecture seems more robust because it suits all kinds of networks and terminals, it needs the support of underlying network. In VESPER VHE architecture, services are built on top of PARLAY or OSA. Both PARLAY and OSA don't have the API to support the functionalities of QoS management yet. So for VESPER's QoS management, APIs exposing the network capacity need to be provided.

## 4.2 QoS manager creation

For 3GPP, the QoS manager is embedded in the MExE terminal. For this reason, 3GPP QoS manager can't have too complicated functionalities. Otherwise the MExE terminal's size and price will exceed the user's acceptance level. From the previous QoS functionality list, 3GPP QoS manager doesn't have the functionalities of

- Coherent bandwidth allocation. It means that the throughput shouldn't exceed the capability of the user terminal; otherwise the QoS manager should consult the service to reduce the throughput.
- Priority management. This happens when user is accessing more than one service in his/her terminal, the bandwidth exceeds the terminal's capability. The QoS manager should check the user's preference to decide which service has higher priority.

Because of this, the 3GPP QoS manager is unable to consult the service and to check user's preference when the transmission rate is over the terminal capability.

For VESPER, the central QoS server can be more complicated and capable. It can communicate with network and service all the time. Here the QoS server can manage the QoS of different users by using the 'multithread' technique.

Multithread is a concept in concurrent programming. Every thread is a process has its start and end. Thread runs concurrently with other threads have the similar function as it, but there is not overlapping between threads [14].

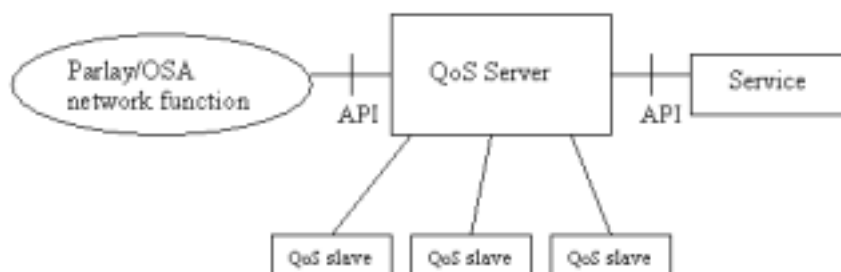


Figure 3: QoS server and slave QoS manager

Every time when user makes a connection to the VHE service, QoS server will produce a thread, which is the slave QoS manager for this connection. The life cycle of the slave QoS manager is the same as the connection. The slave QoS manager process is killed when the connection is set.

The task of every single slave QoS manager is to take care of certain connection, for example: QoS needed for this connection, QoS received from the network (this information can be got from the QoS server). The slave QoS manager justifies if there is problem in the service provision, makes the decision about if the service can continue. The slave QoS manager will inform the QoS server to take actions to solve the problem when it's needed, such as consulting network, triggering service adaptation, checking user's preference.

In the case the user has more than one services from the same terminal which the throughput exceeds the terminal capability, the QoS server will check the user's preference to see which service has higher priority and then stop the thread of the service has lower priority

Thread of QoS manager needn't to communicate with network monitor or service. It's the QoS server's responsibility to consult network monitor and service which are remotely located in most of case. Slave QoS manger gets the information about network and service from the QoS server.

### 4.3 QoS manager's communication with network monitor and service

#### 4.3.1 3GPP QoS manager's communication with network monitor

For 3GPP embedded QoS manager, it can get the information about network capability by signaling or receiving broadcasting message inside network.

Signaling is done by every time the QoS manager signals about what kind of information of network it needs, and the required the information will be signal back to the QoS manager. The disadvantage of signaling is obvious. Because QoS manager needs to inquire the information about network capacity every certain period, so it might need to signal many

times in a service session. It consumes too much energy since the QoS manager is embedded inside the MExE terminal that uses a handheld battery. From the network monitor side, it might get crashed when too many QoS managers signal to it at the same time.

Another approach is the QoS manager is in passive mode of receiving message from network. Network monitor broadcasts information about network's capacity and recent happenings to all the terminals inside the network. Since the QoS manager is embedded in the terminal, it can get the information about the network from terminal. Technologies of using network broadcasting to inform mobile stations about network situation have been used in GSM for long time. There is a lot of experience about it, so it shouldn't have too much technical difficulty with this.

New protocols need to be designed and tested to enable the communication between QoS manager and network. The overhead of developing a protocol should be taken into consideration.

#### **4.3.2 3GPP QoS manager's communication with service**

3GPP MExE MS(Mobile station) has standardized way to negotiate the MExE MS's supported capability with MExE service provider. [13] Because 3GPP QoS manager is embedded inside the terminal, API between QoS manager and MExE executable is needed (as shown in Figure 2). QoS manager can negotiate with service via the "MexEQo" API. QoS manager communicates with MExE executable locally.

#### **4.3.3 VESPER QoS server's communication with network and service**

For VESPER, QoS server locates remotely with network device and service provider generally. The best way for the central QoS server to communicate with network monitor and service is using the OOP technology in telecommunication. Here the idea of ODP is studied:

ODP (Open Distributed Processing) describes systems that support heterogeneous distributing processing both within and between organizations through the use of a common interaction model. There are three main benefits of using ODP: Interoperability, portability and distribution transparency. [13]

Although QoS server and network monitor can use the old telecommunication style by defining protocol and data structure by using ASN.1, using ODP is more efficient and economic. A protocol needs to be tested very carefully before it can be really in use.

CORBA (Common Object Remote Broker Architecture), which is developed by OMG (Object Management Group), is an architecture and specification for creating, distributing, and managing distributed program objects in a network [14]. It allows programs at different locations and developed by different vendors to communicate in a network through an "interface broker"[14]. There are other products similar to CORBA, like DCOM by Microsoft, RMI by Sun Company. Details about how to use these products are not going to be discussed in this paper. The idea is to use certain ORB as the communication framework between QoS server and network device or service provider.

Using CORBA type of ODP as the communication framework between QoS server and network device or service provider can achieve three benefits of ODP, interoperability, portability and distribution transparency. Both side of communication parties are more freely to built the inside components and hide detail to the other side as long as a common interface is defined.

## 5 Conclusion

In this paper, the concepts of VHE and QoS are introduced. The problems and possible ways of managing QoS in VHE are discussed also. Two organizations, 3GPP and VESPER are both engaging in realization of VHE. They have different opinions in some aspects since 3GPP has the focus on 3G systems while VESPER VHE is for all mobile networks like: GSM, GPRS. Due to the difference of underlying network base, they have different solutions to manage the QoS in VHE service provision.

3GPP VHE needs the user to have MExE terminal, where the MExE executable and QoS manager are embedded. There is a standardized way for MExE executable to communicate with MExE service. QoS manager negotiate QoS issues with service via the MExE-QoS API between MExE executable and QoS manager.

VESPER VHE doesn't have requirement on user's MS. In other word, user can have any terminal to access the service. VESPER VHE needs the network APIs which expose the underlying network functionalities. About QoS management, because neither OSA nor Parlay has this kind of network QoS API, some cooperation to develop needed API from OSA and Parlay are needed. In VESPER, a central QoS server, which is much more complicated than 3GPP embedded QoS manager will take the tasks of managing the QoS of all the connections. QoS server negotiates with network and service using ODP technology. Common interfaces between communication parties need to be defined in advance.

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