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Implementation of QoS onto Virtual Bus Network

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Abstract

Quality of Service (QoS) is a key issue in a multimedia environment because multimedia applications are sensitive to delay. The virtual bus architecture is a hierarchical access network structure that has been proposed to simplify network signaling. The network employs an interconnection of hierarchical database to support advanced routing of the signaling and traffic load. Therefore, the requirements and management of quality of service is important in the virtual bus network particularly to support multimedia applications. QoS and traffic parameters are specified for each class type and the OMNeT model has been described.

Keywords: Quality of Service, Virtual Bus, multimedia application and OMNeT.

1. Introduction

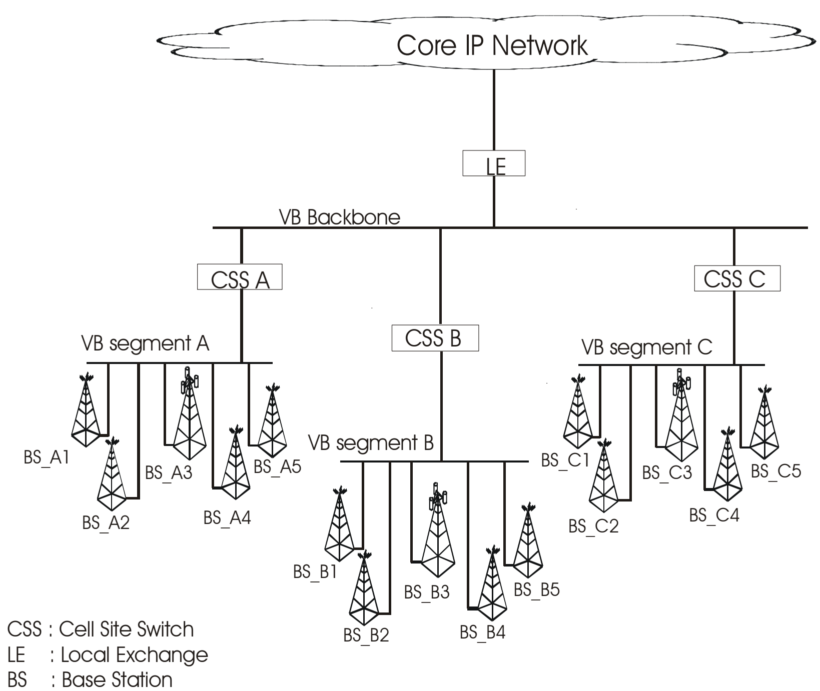
Quality of service (QoS) is an important issue in a multimedia environment because multimedia applications are sensitive to delay. When we are dealing with voice, video, and other time sensitive applications, the degree of network service, including network delay and cell loss ratio is very important. QoS is a broad term used to describe the overall experience a user or application will receive over a network. It involves a broad range of technologies, architectures and protocols. The underlying concepts of bandwidth, throughput, jitter, reliability, perceived quality and cost are functions of QoS (Chalmers and Sloman, 1999). Queuing and scheduling are key components of QoS traffic handling mechanisms. These are available both in standalone network devices as well as in host network components.

QoS has become more of the problem in recent years because there has been a growth of multimedia traffic e.g. voice and video, mixed with more traditional data traffic such as FTP and telnet. An application such as voice over IP has opened up the possibility of more interactive communications between users. Many types of data traffic are very tolerant of delays and packet drops; however voice traffic has different characteristics. Voice is low volume but is intolerant of delay and packet loss. Video is also intolerant of jitter and packet loss, plus it has the added complication of being bursty at times. In addition, the basic goal of quality of service is to provide service differentiation between IP packets in the network. Once a packet is on the core of the network, it generally deserves to be there, providing that the security is intact. Many of the technologies involved in QoS are to do with how packets are dealt with as they enter and leave a network. Merely adding more bandwidth at the edge is only a short-term solution to QoS in that it just addresses capacity and perhaps some congestion problems. Adding bandwidth does not address jitter or add any traffic prioritization features. Packet networks e.g. IP, MPLS, Ethernet, etc. are an attractive alternative to circuit switched networks since they offer higher efficiency when the network is used for many bursty data sources (Aweya et al., 2006). They also require considerably less capital investment for network equipment than their TDM equivalent (Aweya et al., 2007).

2. Previous Research

The virtual bus architecture (Rosilah et al., 2007), (Bodic, 2000) is a hierarchical access network structure proposed to simplify network signalling. A Cell Site Switch (CSS) controls the connection to each Virtual Bus (VB) segment, and a VB Backbone interconnects all the CSS (Rosilah and Irvine, 2006). A Local Exchange (LE) unit provides the interface to the Core IP Network and the outside world as shown in Figure 1.

Figure 1: Virtual Bus Architecture



A distributed hierarchical database is used to support advanced routing of the signalling and traffic loads. Hence, interconnecting the base stations allows part of signalling load to be transferred only over the connected segment. The virtual bus adds broadcast capabilities to this hierarchical access system in both data and signalling information are broadcast over the virtual bus simplifying control and handover (Eltahir and Dunlop, 2001).

3. Hypotheses

QoS is an important issue in a multimedia environment because multimedia applications are sensitive to delay. When we are dealing with voice, video, and other time sensitive applications, the degree of network service, including network delay and cell loss ratio is very important. The current multiple packet generators in the virtual bus network, which use a traditional IP network approach, offer a best-effort service. There is no differentiation between user, applications or even protocols. The packet generator in the network does its best to deliver packets, however no guarantees for QoS are made and with current traffic volumes congestion cannot be avoided. The amount of resource available for different users is limited, which creates a need for quality differentiation. However, a best effort service cannot provide any predictability and reliability in end-to-end packet delivery, making it unsuitable for real-time and mission critical applications. These require the ability to provide QoS i.e., to offer service differentiation based on the requirements of users and applications.

There are basically two motivations for realizing QoS in the network. The most evident motivator is that different applications require different services from the network in order to function properly. For example, a file transfer is not so sensitive to transfer delay but the correctness of information is important. On the other hand, real-time multimedia applications such as VoIP or video conferencing set stringent requirements on end-to-end delay. Another motivator is financial. If an operator provides quality differentiation, it can also charge the customers differently. Some applications such as streaming audio and video would be much better served under the integrated service since they have a relatively constant bandwidth requirement for a known period of time. Integrated services and Resource Reservation Protocol (RSVP) allow Internet real-time applications to reserve resources before they start transmitting data (Moon and Aghvami, 2004).

The research problem is to study what kind of differentiation models the operator can use to support its services approach and what kind of scheduling disciplines would be suitable for implementation. One of the best solutions is used for mapping onto the virtual bus architecture in order to support QoS in the network. The ultimate goal of these QoS mechanisms is to provide differentiated services to the application at the packet generator of the network. These mechanisms usually rely on two procedures (Gallardo et al., 2001) packet classifier and packet scheduler. Firstly, traffic arriving at the edge routers is separated into distinct forwarding classes, e.g. indicated by the Differentiated Services Code Point (DSCP) field in the DiffServ (Shin et al., 2001) model, via a process of packet classification, and then directed to a corresponding queue. The queue scheduling algorithm then determines the rate at which packets from each queue are forwarded given the resources that are allotted to each queue and to the corresponding flows. The aim of the simulations is to study how well the proposed scheduling disciplines are able to support the differentiation model that they are designed for. Another significant goal is to study the effect of the traffic mix on the results. In next generation networks, packet classification (Srinivasan et al., 1999) is important in fulfilling the requirements of multimedia services. Packet classification is a key component that determines to which forwarding class a packet belongs (Baboescu and Varghese, 2005). Obviously, the performance of packet classification is important in the development of new services including VoIP, VoD and video conferencing, which have strict QoS requirements. Our research attempts to develop a new multiple packet generator using a DiffServ method. Here, we are investigating an alternate approach based on packet scheduling rather than queue management.

4. Research Method

The current multiple packet generators in the virtual bus network, which use a traditional IP network approach, offer a best-effort service. There is no differentiation between user, applications or even protocols. The packet generator in the network does its best to deliver packets, however no guarantees for quality of services are made and with current traffic volumes congestion cannot be avoided. The amount of resource available for different users is limited, which creates a need for quality differentiation. However, a best effort service cannot provide any predictability and reliability in end-to-end packet delivery, making it unsuitable for real-time and mission critical applications. These require the ability to provide quality of service i.e., to offer service differentiation based on the requirements of users and applications.

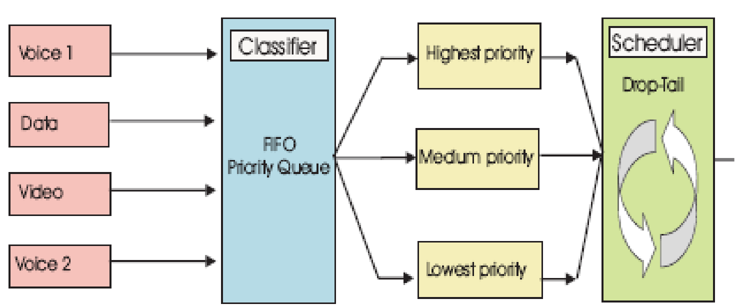
4.1. Model Implementation of QoS

This section will explain the behavior of the virtual bus transport model. End-to-end system incorporating a radio link is used in order to send various packets from a multiple packet generator at the local exchange to the mobile hosts. Two types of model in differentiated services are incorporated: packet classifier model and packet scheduler model. Moreover, we concentrate on the problem of how to map different packet categorizes into different Differentiated Services (DiffServ) levels (denoted as a QoS mapping) in order to maximize the quality of packet delivery. From the application's point of view, the effectiveness of the QoS mapping will greatly depend on the QoS guaranteed for each DiffServ level.

4.2. Packet Classifier Model

In order to apply QoS in the packet generator, initially a packet classifier is required. The packet classification model is used to categorize the mix of incoming traffic to the network. Figure 2 shows the design of QoS generator model for the virtual bus network. We combine the techniques of traditional queue scheduling disciplines, which are First-In First-Out (FIFO) and priority queuing for the design. Priority queuing allows the organization of buffered packets, and then one class of traffic can be serviced differently from other classes. For instance, we can set priorities so that real-time applications such as voice get priority over applications that do not operate in real-time. As shown in Figure 2, within each one of the priority queues, packets are scheduled in FIFO order. Therefore, in this model we use an automatic classification where we can classify traffic based on the type of application in advance.

Figure 2: QoS Generator Model for Virtual Bus Network



4.3. Packet Scheduler Model

The traffic mix used in the simulations, as shows in Figure 2, consisted of video, voice and data. In the differentiated services networks, there are three types of Per Hop Behaviour (PHB); Expedited Forwarding (EF), Assured Forwarding (AF) and Best Effort (BE). The class of traffic is handled in descending priority order. In order to make a priority decision, three types of priority are assessed. Initially, voice is tagged as a highest priority; followed by video traffic for medium priority and finally data traffic for low priority as despicted in Table 1.

Table 1: Priority Order Based on Application

Per Hop Behaviour (PHB)	Priority Order	Multimedia Traffic
Expedited Forwarding (EF)	Highest priority	Voice traffic
Assured Forwarding (AF)	Medium priorty	Video traffic
Best Effort (BE)	Low priority	Data traffic

The UMTS system defines four types of traffic class. Therefore, we map the multimedia traffic onto the four UMTS classes in order to achieve third generation visualization. Table 3 shows the UMTS QoS classes with the category of traffic for each class.

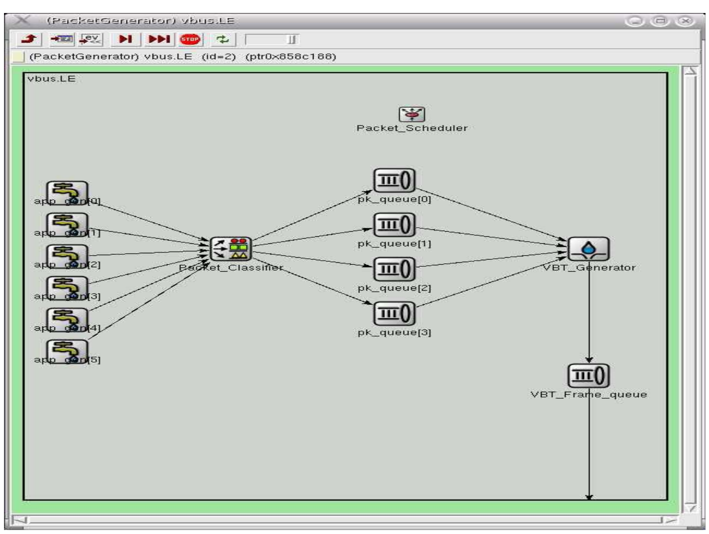
Table 2: UMTS QoS Class

UMTS QoS Class	Types of Traffic	End to End Delay
Conversational	VoIP,video conferencing	0-150ms
Steraming	Audio/Video, video-on-demand	250ms
Interactive	Web browsing, database access	file transfer
Background	SMS, MMS, and email	No

5. Simulation Environment in OMNeT

In support of the simulation, three different scenarios have been considered, where different traffic types were allowed to be mixed. This section will give details of the model of the system in the OMNeT environment. The model implementation of the virtual bus transport comprises two modules as depicted in Figure 3 and Figure 4. Each of the nodes has their own task where they define the model of the system. Two models are applied: the packet generator model and the virtual bus model. The sub-models in Figure 3 are as below:

Figure 3: A Traffic Generator Model in OMNeT



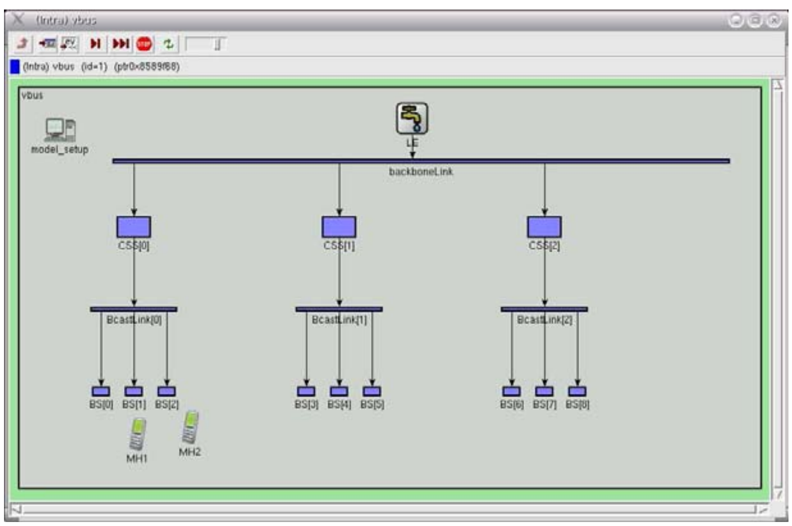
- *App Gen*: Based on the type of the application. Each application generator has its own ID.
- *Packet Classifier:* Classifies incoming packets in the node based on their Class of Service.

- *Pk Queue:* Consists of FIFO queues of finite size, one for each type of traffic class, and a scheduling algorithm. The packets are queued in the right queue based on their Class ID, provided by the classifier object. When the link becomes free to serve the next packet, the scheduling algorithm decides from which queue a packet will be transmitted.
- *Packet Scheduler:* Listing the packet to four types of priority identification. Priority 1 ID, Priority 2 ID, Priority 3 ID and Priority 4 ID.
- *VBT Generator:* Provides the VBT packet length. The details regarding this node will be updated in an input file called 'information.VBT.txt'.
- *VBT Frame:* Provides the length of the VBT frame and the channel data rate.

The packets are multiplexed together and queued for transmission via the output buffers connected with a link. Figure 3 shows the model with six types of generator and four type of queue in support of the packet generator. For simplicity, packets with the same class of service will go to the same queue and different types of service will go to different queues. This is an upgrade of the previous application generator that has been developed. This generator will produce IP packets according to several parameters such as packet size distribution and several Type of Services (ToS) parameters. The task for the Vbus sub-model in Figure 4 is as below:

- *Model-setup:* Three different input files for the network have been created: Genfile.txt, qeuefile.txt, and Css.txt. All of them have their own output file. We are able to input the number of generators, number of CSS and number of queues as necessary.

Figure 4: Virtual Bus Model in OMNeT



- *LE*: The packet generator will be at this node when inter handover occurs.
- *BackboneLink*: Maintains the number of the CSS nodes in order to broadcast the packet to the destination through this node. The entire outcome required from this link appears in 'Result.txt'.
- *CSS:* All CSS have their own address. The packet generator will be at this node when intra handover happens. The results for this node appear in 'Information CSS.txt' file.
- *BcastLink*: Each of them has an ID.
- *BS:* All base stations have their own address. BS will send the packets to a mobile host that is attached to this node.
- *MH:* All MH have their own address. The end-to-end throughput and end-to-end delay are counted at this point.

The input data provides the information required in order to operate the system model. The traffic source and simulation time scale are defined in the input file. In addition, all counters and system components for the performance evaluation need to be initialized before the simulation may begin.

6. Performance Study

In this section we will derive the network performance, in terms of end-to-end throughput and end-to-end packet delay, of a mixed source when the traffic flow is generated with external traffic in the VBT multiplexer.

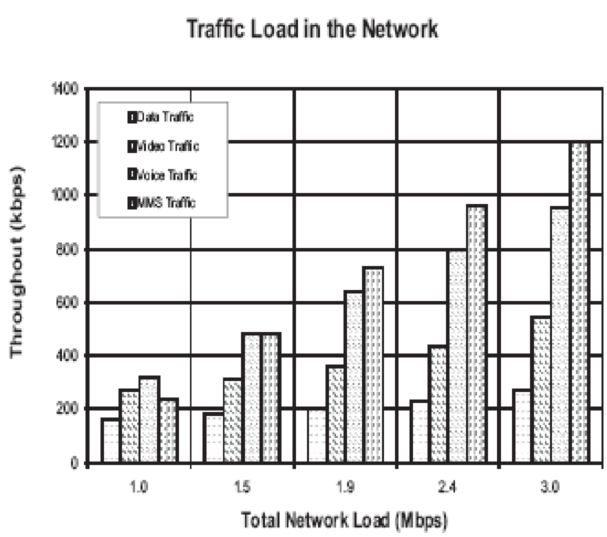
6.1. Traffic

There are four different traffic classes as described in UMTS (Holma and Toskala, 2002), (Prasad, Mohr and W. Konhauser, 2000). In parallel with the traffic classes there must be a number of QoS parameters (e.g. bandwidth, delay, and error rate). With the separate QoS parameters it will be possible to redefine the traffic classes, if needed, to make them more in accordance with possible future application requirements. Priority between subscribers and between applications can be made at admission, preservation and scheduling. Four different traffic classes have been defined by 3GPP according to how delay sensitive the traffic is. The conversational class has the most stringent delay constraint, while the background class has the lowest delay constraint. For that reason, four type of applications will be evaluated in the virtual bus network with the total number of generators used being 10, following the same as the previous scenario. Each generator generates a single type of traffic, but models many different users. In the background traffic, there is no need to use priority, so it remains the lowest priority in the classifier packet queue. The usage of the priority parameter is defined in the next section.

6.2. Results

Figure 5 shows the throughput based on the types of traffic whereas Figure 6 shows the total throughput in the network.

Figure 5: Traffic Load based of Types of Traffic



As we defined previously, voice is in class one, followed by video in class two, data traffic for class three and lastly background in class four. Voice traffic has the lowest delay amongst the traffic while MMS traffic is the highest. As a background service, it does not have any delay issues. The motivation is a conversational class that is meant for the most delay-sensitive traffic, while the background class is the most delay insensitive. Data traffic and video traffic each have 5% of traffic.

Figure 6: Total Throughput in the Virtual Bus Network

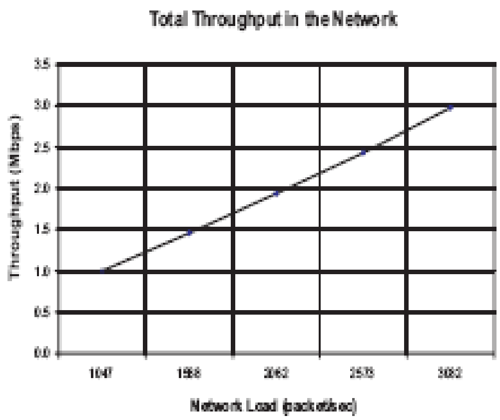


Figure 7 illustrates the average end-to-end delay for the different types of traffic.

Figure 7: Packet Delay based on Traffic

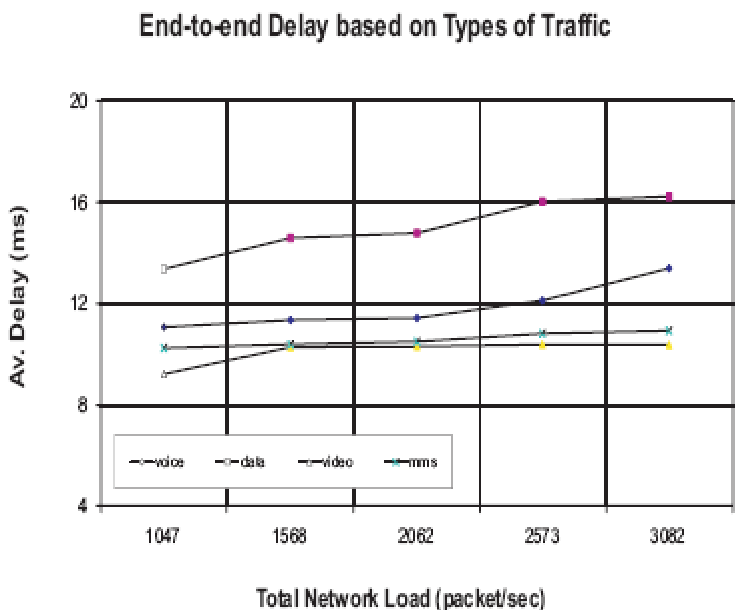
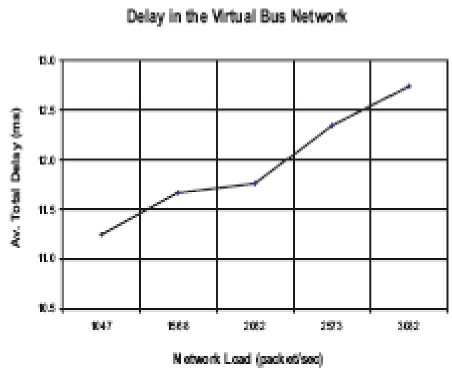


Figure 8 shows the average total delay in the virtual bus network. This delay is assessed to the mobile host as the end node of the network. When the number of packets generated is rising, the delay in the network also increases.

Figure 8: Average Packet Delay vs. Network Load



7. Summary and Concluding Remarks

Queuing and scheduling are key components of QoS traffic handling mechanisms. These are available both in standalone network devices as well as in host network components. More sophisticated devices are able to provide QoS by using intelligent queuing and scheduling schemes as discussed in the literature. A hierarchical scheduling using differentiated services is introduced in this work in order to provide an IP QoS mechanism for the virtual bus network. Differentiated service is provisioned with different priorities for each type of class. However, the simplest virtual bus network devices forwarding traffic from the source interface to the destination interface using FIFO has been selected and implemented. It is important for us to define the queues in advance because the system processes a higher priority queue before a lower priority one. It is possible for a high priority queue to cause packets in a lower priority queue to be delayed or dropped if the high priority queue is receiving a constant stream of packets. Without QoS, the virtual bus network offers best-effort service to each packet, regardless of the packet contents or size. It sends the packets without any assurance of reliability, delay, or throughput.

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