

A QoS-ensured Transmission Scheme with Content-based Priority for Mobile Cluster Users

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Abstract

As the increasing of mobile hosts and hand sets, communications between mobile users become popular and important. By a mobile cluster network we could realize co-operation and resources share among mobile users. In this paper we propose a QoS-ensured transmission scheme with content-based priority for mobile cluster users. In our scheme some mobile hosts form a mobile cluster network, which is a kind of LAN. All mobile hosts will share the total capacities of the cluster network and the outside interface. We divide all mobile hosts into different priority degrees based on the content type of them. As a result we could realize making good use of the bandwidth resources of the total system under the condition that the arrival traffic is asymmetric. We could also realize optimizing the performance of high priority traffic under the condition that the total system lies in overload status.

1. Introduction

Recent advances in computer technology has not only multiplied the processing speed of desktop computers, but also given birth to a new generation of powerful portable units such as personal handy phone systems (PHS), portable cellular telephones, and personal digital assistants (PDA). The increase in portability has pushed a new era of mobile computing [1]. There are limitless possibilities for mobile applications. While potential applications exist in commerce, education, medicine, government, public safety, and numerous other areas.

Although protocols for use in wired networks abound, it is well known that these protocols cannot provide adequate functionality or performance in wireless networks. As wireless networks have much higher error rates, lower bandwidth, and more-frequent outages than wired networks, attempts to use wired-network protocols have resulted in disappointment.[7] For example, the performance of conventional TCP when a wireless link is

in the end-to-end path is poor because Top's congestion control and avoidance algorithm works best for networks that experience low packet loss. Mobility also presents a challenge to current protocols, because they were designed primarily for fixed hosts, and routing packets to mobile hosts requires new mechanisms. Because wireless base stations and mobile routing nodes are generally less capable than wired-network counterparts, wireless networks often suffer from excessive delay and latency. New protocols, or extensions to existing protocols that take mobility and the wireless environment into account, must therefore be designed, studied, and prototyped. Moreover, these protocols need to operate in both wired and wireless networks, if they are to be usefully integrated into future networks. As wirelessness and mobility challenge the assumptions used to design protocols for wired, fixed networks, so too will wirelessness and mobility open new types of applications. While it remains to be seen exactly which novel applications will emerge, one can be assured that applications that incorporate location or position information will require special support from routing and configuration protocols. Likewise, multimedia applications are expected to find special niches in wireless mobile networks. [6]

Wired and wireless networks both must provide the QoS support required by applications. Although current wired networks provide limited QoS, it is universally agreed that a richer set of QoS levels is needed to allow emerging applications to use these networks. In particular, multimedia applications, which exchange data, voice, images, and video, make exacting demands on the QoS delivered by a network. Although significant research and development efforts are now targeted at how best to provide QoS, there is no consensus on the right approach. Research in providing QoS in wireless mobile networks is necessary to ensure that advanced applications will be supported and that wireless and wired network QoS principles will be compatible and interoperable. [10]

At present the wireless network has only rates from tens of Kbps to a few Mbps, so the transfer rate cannot generally satisfy the communication services requirements

such as transfer of multimedia data, and real-time communication which should guarantee the delay time. To realize the optimization of QoS we form all the mobile hosts into a mobile cluster network. In an area where a number of mobile hosts can construct a temporary network to support co-operation for people gathered in the area. The network is called cluster-type network or Ad Hoc network[2].

Ad Hoc network is one kind infrastructureless network, which has no counterpart in today's networks. Basic assumptions in current networks, including the notions of a quasipermanent fixed topology and symmetric links, might not apply to such new networks. Accordingly, researchers will have to gain a better understanding of how to design the data link, network, and transport protocols for these networks.

In a mobile cluster-type network environment, which is composed by mobile hosts, we want to make good use of the capacities inside and outside of the cluster-type network and realize communications with outside networks finally.

In SHAKE system a protocol, shared multiple paths protocol for a cluster-type network environment is proposed [3]. Each host in the cluster can share other hosts' communication links or paths. The network topology is considered as a ring type network. A mobile host can freely select any communication path and any kind of medium to communicate with the outside. For those hosts that have no link with outside, the communication can be also done through the relay hosts. Although it can make full use of the transfer rate outside, it cannot meet the factual communication requirements. We think in fact the paths are different in quality such as different capacities or error characteristics, and the hosts are different in communication contents, so the hosts should be served differently. And also the total transmission requirements maybe excess the maximum throughput of the outside network and in this case we should throw some packets away in advance. Based on the above consideration we will propose a content-based priority transmission scheme with QoS for a mobile cluster network.

Multimedia is expected to be a major traffic source on future wireless mobile networks, and the design of appropriate application-specific transport protocols will play an important role in the provisioning of such services. These transport protocols must interact seamlessly with their peer counterparts on the wired backbone network as well as wired sub networks.[8]

Users could be divided into different priority degrees by data types [4]. The user who is assigned a priority degree will access the channel and be served in advance at a big probability. Users could be also assigned dynamic priority degrees, and their priority degrees will be changed

by the current traffic from different sources[5]. And even preemption priority degrees could be used and at this time the user with preemption priority will preempt the service when other users are being served.

In our proposal, we will assign a group of constant degrees to the mobile hosts in a cluster-type network. And the priority mobile host will select its path to the outside network in advance.

The remainder of this paper is organized as follows. Section 2 outlines the approach of our scheme for supporting QoS support for mobile hosts in cluster environments and also gives a detailed description of the scheme. Section 3 gives some performances results and a discussion of advantages and limitations. Section 4 summarizes our paper and presents our conclusions.

2. QoS-ensured Transmission Scheme with Content-based Priority

In this section the content-based priority transmission scheme with QoS for a mobile cluster network will be described. In the first subsection we give the model of a

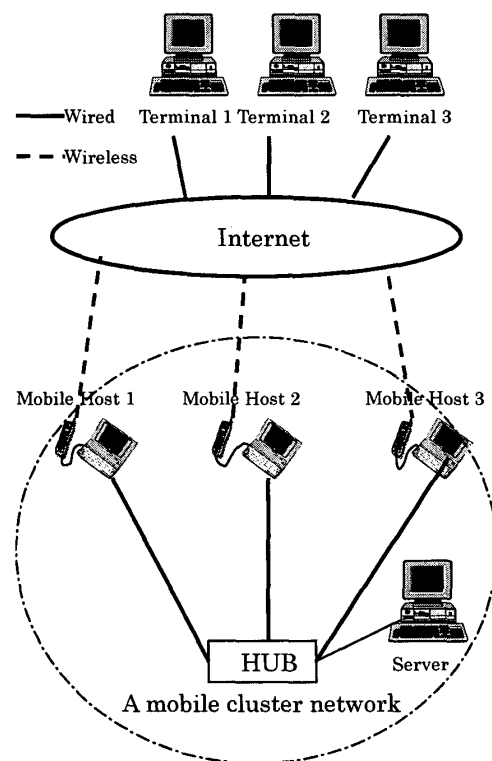


Figure 1: An example of the system

mobile cluster network. In the second subsection we introduce the QoS parameters, which should be ensured in the system. In the third subsection the content-based priority transmission scheme will be given.

2.1 A Mobile Cluster Network

As an alternative to cellular networks, infrastructureless or ad hoc networks are designed for use in areas where there might not be permanent signal coverage. These are networks in which the transmission range of a node is limited and the topology of the network is dynamic, so that multihop communication is necessary for nodes to communicate with each other. The reliance on wireless multihop communication to maintain connectivity among nodes places added complexity on the design and operation of these networks. The dynamic nature of the infrastructureless network challenges current routing techniques.

Figure 1 shows a mobile cluster network and the outside network. Inside the mobile cluster network all mobile hosts are connected to a hub. The server in the cluster manages and maintains the communications inside and outside the mobile cluster network. Outside the mobile cluster network every mobile host has its individual communication path with outside terminals. The outside network could be Internet, PSTN and so on.

The communications between the mobile hosts inside the mobile cluster network follows the LAN standardization. The communications between a mobile host in the mobile cluster network and an outside terminal follows the point-to-point protocol (PPP). Any mobile host in the mobile cluster network can be selected as a relay host to transfer data from or to another mobile host.

2.2 QoS Parameters in the System

QoS in a wireless mobile network is substantially more complex than in a purely wired network, because the wired network deals with integrated services in a relatively static manner. It is sufficient to establish or guarantee that the end-to-end path has adequate resources to deliver an information flow between end users with the negotiated QoS. With resource reservation one can prearrange for resources to be dedicated for the duration of the flow, thereby guaranteeing the bandwidth, delay, and error rates contracted for by the application. Such a contract remains in effect so long as no resource fails. The situation in a wireless mobile network is much more volatile, because a mobile node's end-to-end path is likely to change as it moves through the network, and the wireless link is subject to wide fluctuations in performance and reliability. Resource reservation is thus complicated by the need to consider not only resource

availability on the initial end-to-end path but also on other paths likely to be used as the node's position changes. Research in techniques for reserving resources in such a way as to minimize the probability that a flow will be blocked when it is rerouted in response to a node's movement is essential in cellular and ad hoc wireless networks.

The main QoS parameters considered for the mobile computing environment are *packet delay*, *packet loss rate*, *delay jitter* and *throughput*.

Packet delay in the mobile computing environment is the time required by a packet to travel from a sending mobile host to the receiver. It consists of mainly two components: *propagation delay* and *congestion delay*. *Propagation delay* is the packet propagation time and is dependent on the length of the data flow path over which the packet travels. *Congestion delay* is the time spent by a packet in the queue at the routers. Since the buffer size in a queue at a router is limited, packets arriving at a full queue are dropped.

Packet loss rate is the fraction of the packets dropped per flow.

Delay jitter is the variation of the delay between the arrivals of successive packets.

The quality of a flow is also dependent on the amount of data carried by the flow per unit time, called *throughput*.

To provide services in the mobile computing environment, a network is designed to provide sufficient guarantees on these QoS parameters.

Mobile hosts' mobility has a significant impact on these QoS parameters. When a mobile host moves from one location to another, the data flow path changes. As a result, the propagation delay of packets may change. The available bandwidth in the new path may not be sufficient to provide the throughput that it was receiving at the previous path. Therefore, the mobile hosts may have to adapt to the changes as they move.

Based on the above considerations, content-based priority transmission scheme is proposed to ensure the QoS parameters of priority mobile hosts in mobile computing environment.

2.3 QoS-ensured Transmission Scheme

In the content-based priority transmission scheme with QoS, we can form a mobile cluster network in which all mobile hosts are nearby. Each mobile host in the mobile cluster network has two interfaces. One is linked to the HUB of the mobile cluster network; the other is linked to the outside network. So every mobile host has a path, which could be used to communicate with the outside network. In our scheme, all mobile hosts communicate with each other by the wireless LAN protocol. To

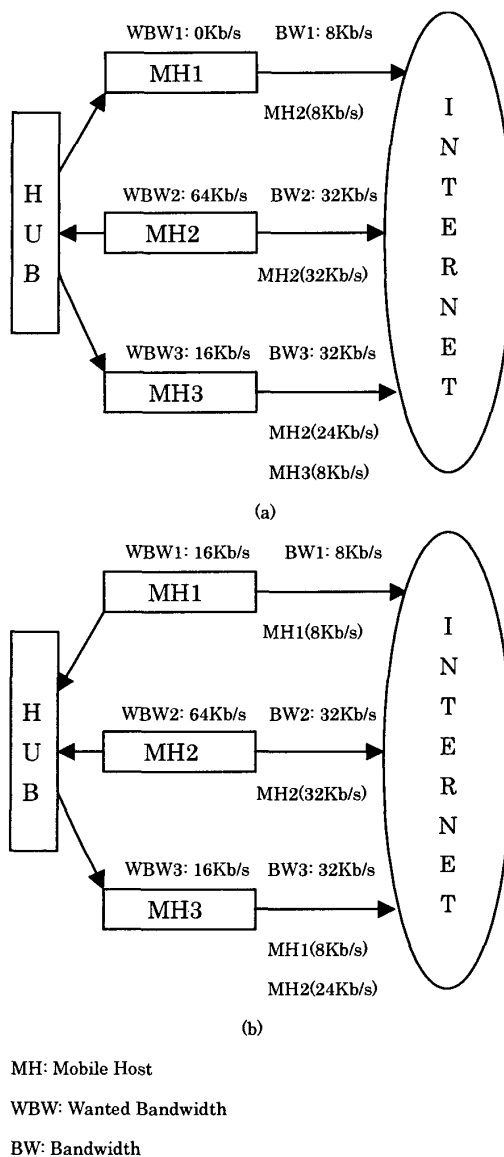


**Figure 2: (a) Paths Assignment with Priority at T1
(b) Paths Assignment with Priority at T2**

communicate with the outside network, all mobile hosts share the multiple paths outside the local cluster network. We think that by sharing multiple paths we can increase the end-to-end transfer rate of data packets, reduce the packet delay time, and equalize the network load when the burst traffic is dispersed into several paths. Thus all

mobile hosts could make real-time, reliable and lossless communications with outside.

And also, because the mobile hosts have different communication requirements and the packets from each mobile host have different characteristics, such as different delay time limit, different bit error rate request and so on, we divide all mobile hosts into several different priority degrees. For example, control information is delay-critical and loss-critical service. Audio and video signal is also delay-critical service but its delay with mini-seconds is still tolerable[2]. Common data packets are not delay-critical but loss-critical.

Figure 2 gives an example. In Figure 2 there are 3 mobile hosts MH1, MH2 and MH3, by which a mobile cluster network is formed. MH1 has an 8Kb/s interface with the outside network and the other two MHs have a 32Kb/s interface. MH1 sends or receives burst data so it is assigned to the highest priority degree. MH2 takes part in the video conference with the outside network so it is assigned to the second priority degree. MH3 sends common data to the remote terminal and is assigned to the third priority degree.

At moment T1, the wanted bandwidth of the 3 mobile hosts is 0, 64Kb/s and 16Kb/s. MH2 enjoys the interface of MH1, a part of MH3 and itself. MH3 could only use the remainder 8Kb/s bandwidth.

At moment T2, MH1 need send burst data to the remote machine, so it will occupy the 8Kb/s interface of MH3 and 8Kb/s interface of its own. MH2 will possess the 24kb/s interface of MH3 and its own. MH3 could not access any outside interface.

Thus we realize that the mobile host with content-based priority could communicate with outside network accurately and timely and also its QoS parameters will be ensured.

At the start of the communications, every mobile host send information to the server in the cluster network about its service content type, wanted channel bandwidth and wanted time to own that channel bandwidth. Based on the report from all the mobile hosts, the server in the cluster will assign them to different priority degrees. Then the mobile host with the highest priority degrees can freely select the paths to the outside network. The paths it selects could be one and even more than one. All the mobile hosts will select their path by the turn of priority degrees until all the paths and channel widths are eaten up or all the packets have enough channel bandwidth to be transmitted. Every mobile host will report to the server in any time when it wants to begin or end its communication with outside terminals or changes its communication content type. Thus the server could realize the dynamic management and maintenance of the communication between inside mobile hosts and outside terminals.

Figure 3 shows how our proposal works. Anytime when

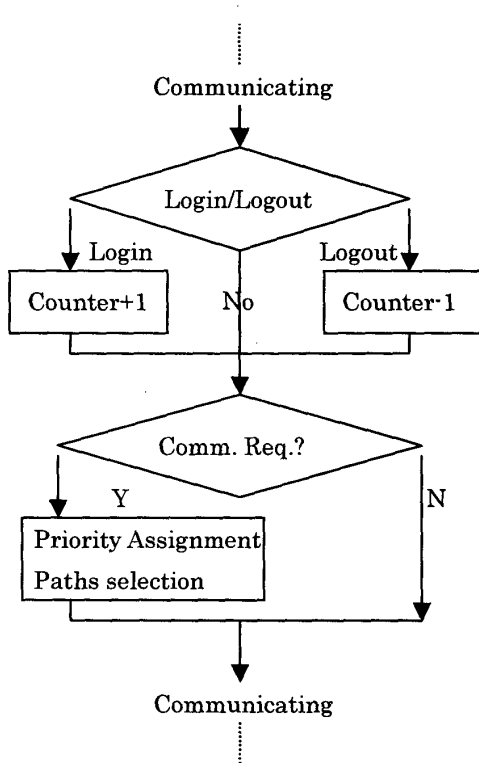


Figure 3. Proposal Function Components

a mobile user logs in or logs out the cluster network, the counter will change by step 1. No means that no mobile user logs in or logs out the cluster network. Every time when a mobile user logs in/out or a mobile user want to change its traffic type, the priority assignment of all the mobile users and the paths assignment will be done again by the proxy server of the cluster network. After this procedure, the communication will be continued. The communication between MHs and the proxy server is request-query mode.

3. Simulation and discussion

In the above section we have described the QoS-ensured transmission scheme with content-based priority for mobile cluster users, here we will describe our simulation results and also discuss them. Subsection 1 outlines the simulation method and Subsection 2 gives the simulation results.

3.1 Simulation Method Description

The simulation system is based on Figure 2 shown in the above section. Our simulation is divided two parts. One is from moment T1, and the other is from T2. The performance parameter we consider is the throughput ratio of the whole system and the throughput ratio of every kind of traffic. They could be got by the equation below:

$$\text{Throughput} = \frac{\text{FBW}}{\text{WBW}} \quad (1)$$

Here, Throughput means the throughput ratio of the total system. FBW means the factual bandwidth of the system and WBW means the wanted bandwidth of the system. We can get FBW and WBW by the below equations:

$$\text{FBW} = \text{FBW1} + \text{FBW2} + \text{FBW3} \quad (2)$$

$$\text{WBW} = \text{WBW1} + \text{WBW2} + \text{WBW3} \quad (3)$$

Similar to equation (1), we could also get Throughput1, Throughput2, and Throughput3 as below:

$$\text{Throughput1} = \frac{\text{FBW1}}{\text{WBW1}} \quad (4)$$

$$\text{Throughput2} = \frac{\text{FBW2}}{\text{WBW2}} \quad (5)$$

$$\text{Throughput3} = \frac{\text{FBW3}}{\text{WBW3}} \quad (6)$$

Here Throughput1, Throughput2 and Throughput3 mean the throughput ratio of traffic 1, 2 and 3. FBW1, FBW2 and FBW3 mean the factual bandwidth of traffic 1, 2 and 3. WBW1, WBW2 and WBW3 mean the wanted bandwidth of traffic 1, 2 and 3.

Our simulation centers around two cases. One is that the system arrival traffic is not symmetric to the corresponding channel, just like the case shown in (a) of Figure 2. The other is that the system lies in overload status, just like the case shown in (b) of Figure 2.

Simulation 1 takes the model shown in (a) of Figure 2. In simulation 1, before moment T1 all the traffic is served generally. At moment T1, the proxy server assigns the 3 MHs to different priority degrees. From then on, all the traffic is served by their priority degrees. In detail they will be assigned different bandwidth by their current traffic and their priority degrees.

Simulation 2 takes the model shown in (b) of Figure 2. In simulation 2, the QoS-ensured transmission scheme with content-based priority will take effect after moment T2.

In our simulation, a general method is utilized as the comparison with our proposed method. In the general method every MH only uses its own interface to communicate with the outside network. Here throughput of traffic means the throughput of the relevant MH.

3.2 Simulation Results

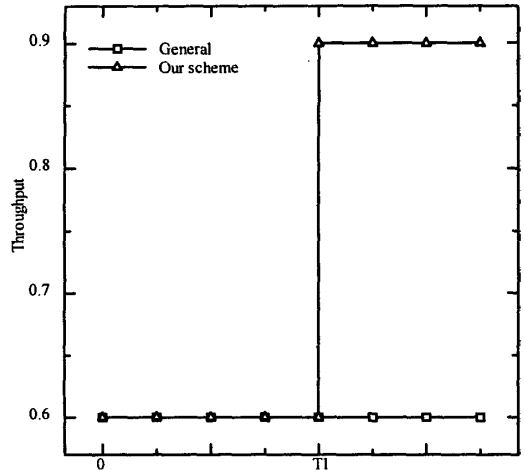


Figure 4: Throughput ratio of the total system at moment T1

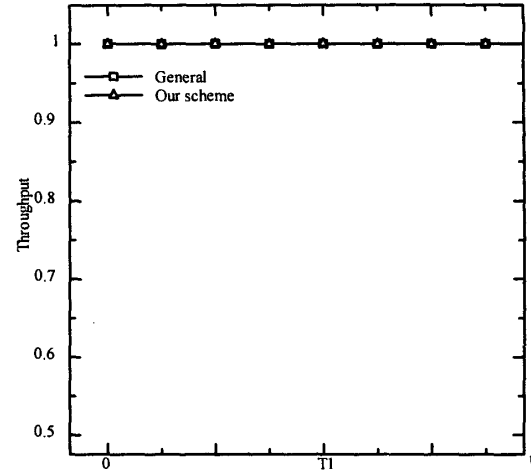


Figure 6: Throughput ratio of MH1 at moment T1

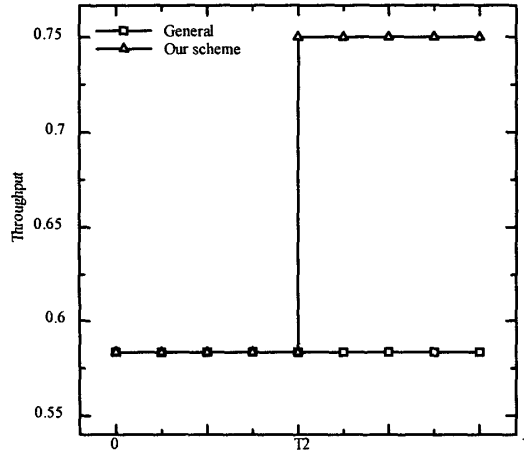


Figure 5: Throughput ratio of the total system at moment T2

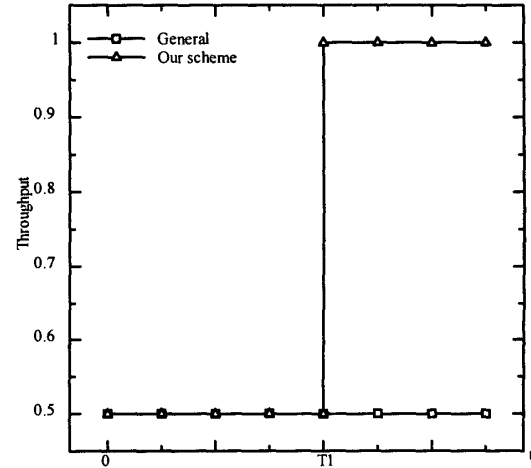


Figure 7: Throughput ratio of MH2 at moment T1

Figure 4 illustrates the throughput ratio of the total system at moment T1. In this figure, before moment T1 the throughput ratio of the total system in our scheme is equal to that in the general method and they are all 60%. When the proposed QoS-ensured transmission scheme takes effect since moment T1, we can see the throughput ratio of the total system could get up to 90%.

Figure 5 above illustrates the throughput ratio of the total system at moment T2. In this figure, before moment T2 the throughput ratio of the total system in our scheme is equal to that in the general method and they are all about 58.3%. When the proposed QoS-ensured transmission scheme take takes effect since moment T2, we can see the throughput ratio of the total system could get up to 75%.

Figure 6 illustrates the throughput ratio of MH1 at moment T1. From this figure, we could see that because the arrival rate is 0Kb/s, so the throughput ratio of MH1 is equal to 100%, however either of the two methods takes effect.

Figure 7 illustrates the throughput ratio of MH2 at moment T1. From this figure, we could see that before moment T1 the throughput ratio of MH1 in our scheme is equal to that in the general method and they are all 50%. When the proposed QoS-ensured transmission scheme takes effect since moment T1, we can see the throughput ratio of the MH2 could get up to 100%, because it occupies up 8Kb/s from MH1 and 24Kb/s from MH3.

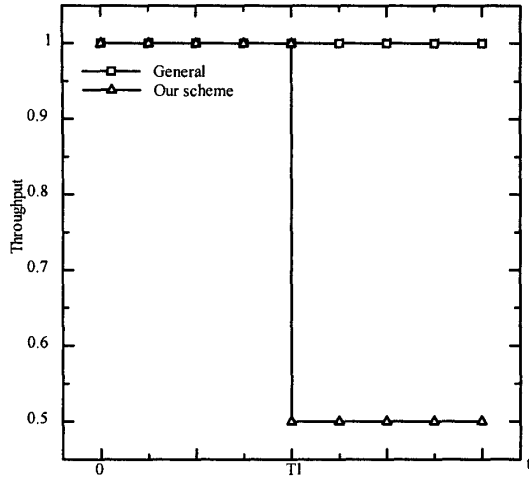


Figure 8: Throughput ratio of MH3 at moment T1

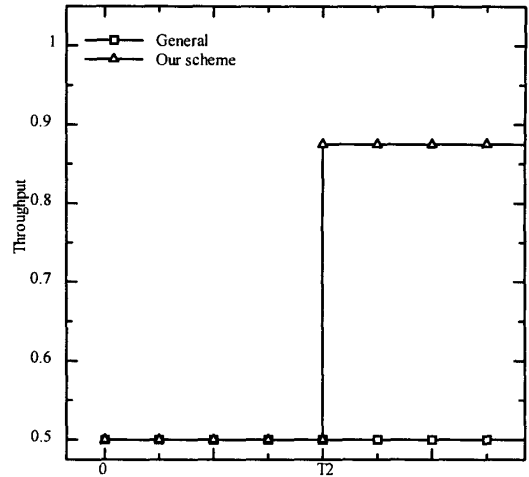


Figure 10: Throughput ratio of MH2 at moment T2

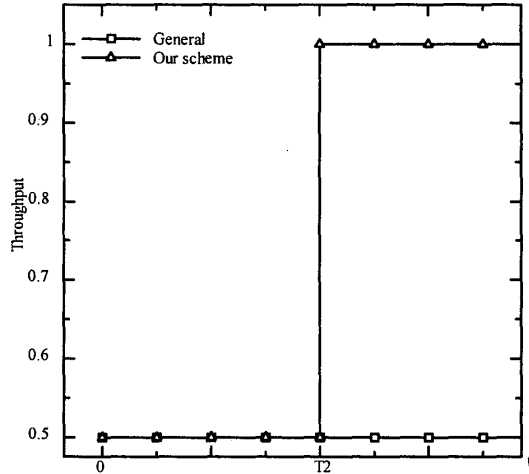


Figure 9: Throughput ratio of MH1 at moment T2

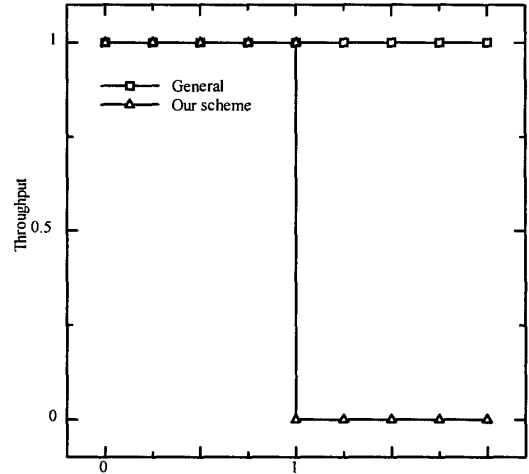


Figure 11: Throughput ratio of MH3 at moment T2

Figure 8 illustrates the throughput ratio of MH3 at moment T1. From this figure, we could see that before moment T1 the throughput ratio of MH3 in our scheme is equal to that in the general method and they are all 100%. When the proposed QoS-ensured transmission scheme takes effect since moment T1, we can see the throughput ratio of the MH3 could only get to 50%. The reason is that MH3's primitive bandwidth is occupied by MH2 at 24Kb/s and only 8Kb/s remains for MH3.

Figure 9 above illustrates the throughput ratio of MH1 at moment T2. From this figure, we could see that before moment T1 the throughput ratio of MH1 in our scheme is equal to that in the general method and they are all 50%. When the proposed QoS-ensured transmission scheme takes effect since moment T2, we can see the throughput

ratio of the MH1 could get up to 100% since it takes up 8Kb/s from MH3.

Figure 10 illustrates the throughput ratio of MH2 at moment T2. From this figure, we could see that before moment T2 the throughput ratio of MH2 in our scheme is equal to that in the general method and they are all 50%. When the proposed QoS-ensured transmission scheme takes effect since moment T2, we can see the throughput ratio of MH2 could get up to 87.5% since it takes up 24Kb/s from MH3.

Figure 11 above illustrates the throughput ratio of MH3 at moment T2. From this figure, we could see that before moment T2 the throughput ratio of MH3 in our scheme is equal to that in the general method and they are all 100%. When the proposed QoS-ensured transmission scheme

takes effect since moment T2, we can see the throughput ratio of the MH3 could only get to 0%. The reason is that MH3's primitive bandwidth is occupied by MH1 at 8Kb/s by MH2 at 24Kb/s and only 0Kb/s remains for MH3.

From the simulation results shown above, we could see that when the proposed QoS-ensured transmission scheme with content-based priority for mobile cluster users is employed under the condition that the arrival traffic is not symmetric, we could make the total system get up to the highest throughput ratio (Figure 4, Figure 5) and thus make good use of the bandwidth efficiency of the total system. When the proposed QoS-ensured transmission scheme with content-based priority for mobile cluster users is employed under the condition that the system lies in overload status, we could make the priority traffic could get better QoS ensurance and the tradeoff is the decrease of the low priority traffic's performance.(Figure 6-11)

4. Conclusion and Future Work

In this paper we propose a QoS-ensured transmission scheme with content-based priority for a mobile cluster network. During the communication of mobile hosts, we form a mobile cluster network in which all mobile hosts are nearby. All the MHs in the cluster will be assigned with different priority degrees. The priority is based on the content type of traffic from the mobile hosts, which compose of the mobile cluster network freely. By assigning priority degrees and paths to the outside network, we could allocate the resources of the local wireless network and the outside channel reasonably.

From the simulation results, we can conclude that the QoS-ensured transmission scheme with content-based priority could realize making good use of the bandwidth resources of the total system to overcome the condition that the arrival traffic is asymmetric. The QoS-ensured priority scheme could also realize optimizing the performance of high priority traffic and the tradeoff is the performance of the low priority traffic gets worse. But it is endurable for the later.

In the future research we will analyze the model mathematically and design a cost function of the total path selection.[9] Not only bandwidth but also other characteristics of the path will be taken into consideration, such as delay, lifetime, bit error rate, and so on. We will also consider multicasting for mobile cluster network users.

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