An Intelligent Technique to Improve Quality of Service (QoS) in Multihomed Mobile Networks

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Abstract

The usage of mobile network is significantly growing and it can be used in mobile platforms such as airplane, train, bus, car, etc. It is very useful for day-to-day activities of human beings. A mobile network can be connected to the Internet anywhere at anytime. But all these comforts depend on the technological aspects. The differences between the application demand and network performance are inevitable. These differences determine whether the Quality of Service (QoS) is met or not. There are different types of Internet applications and mobile network interfaces. The Internet applications are file transfer, telephony, video conferencing, etc. The QoS requirements will vary from one application to another application. The mobile network interfaces are GPRS, IEEE 802.11x, WiMAX, etc. The data rates will vary from one interface to another interface. This paper aims to propose an intelligent technique which forwards data packets via suitable network interface. The outcome of this paper greatly improves QoS in multihomed mobile network.

Keywords: *Quality of Service, QoS, Multihomed Mobile Networks*

1. Introduction

The Mobile Network (MN) means the movement of complete network. When a complete network moves from one place to another place, the resources and services are also moved. The movement of resources and services poses greater complexities. The need of the hour is to reduce or remove these complexities in order to get the benefits to a greater extent. There is variety of mobile networks such as Personal Area Network (PAN), Car Area Network (CAN), Body Area Network (BAN), etc. These networks can work properly only when they have uninterrupted Internet connectivity.

The QoS is an important factor which paves way for more customer satisfaction and more profit for the service providers. If the service provider is not able to increase customer satisfaction and profit will be suffered. Balancing the application demand and network performance is a great challenge. There are three significant scenarios exist in maintaining the application demand and network performance. First, the application demand is high and the network performance is low which leads to no QoS. Second, the application demand is low and the network performance is high leads to wastage of resources. Third, the application demand is equal / approximately equal to the network performance leads to increase QoS. Third scenario is the ideal where QoS is achieved without wasting resources. The QoS must benefit both the customers and service providers. Scenario 1 and 2 shows that customer and service provider is affected respectively.

The MN has atleast a Mobile Router (MR) that changes its point of attachment to the fixed infrastructure from time to time. The MR will take care of the connections of all nodes in the mobile network. The node in the MN can be called as Mobile Network Node (MNN). An MR can have GPRS, IEEE 802.11x, WiMax network interfaces. When an MR maintains these interfaces up and has multiple paths to the Internet, it is said to be multihomed. In mobile environments, MRs often suffer from scarce bandwidth, frequent link failures and limited coverage [theirry pp.2]. Hence, there is need to utilize the bandwidth effectively. Certainly, the outcome of this paper will find a way to reduce / remove some of these issues.

The rest of this paper is organized as follows. Section 2 presents the motivations and related works in the multihomed mobile network environment. Section 3 analyzes various network interfaces and QoS requirements. Section 4 proposes an intelligent technique to forward data packets via suitable interface. Section 5 shows research findings in graphical from. Section 6 focuses on conclusion. Finally, references are listed.

2. Motivation

The challenges in mobile wireless networks are greater than the fixed wireless networks. There are various factors involved for these challenges. As mobile network is managed by the single or multiple MRs, the major overhead is with MRs. The mobile network can also be called as NEMO, NEtwork MObility (i.e. the Nework that Moves). Multihomed NEMOs: Where a NEMO has multiple connections to send packets over in order to support load balancing or a redundant fall-back connection in case the primary connection is lost [1].

Mobile routers can be shipped with multiple network interfaces such as IEEE 802.11a/b/g, WiMAX, GPRS, etc. The flows have to allocated to appropriate paths concerning about application demand and network performance [2]. The mobiware testbed consists of 4 ATM switches (viz. ATML Virata, Fore ASX100/ASX200s, NEC Model 5, Scorpio Stinger) and 4 base stations. The base stations are multihomed 200 MHz Pentium with 25 Mbps wireline access to the wireline ATM network and 2 Mbps WaveLan air-interfaces to a number of mobile devices based on Pentium PCs and notebooks [3].

WLANs technologies including IEEE 802.11 series and Bluetooth, 3GPP technologies such as GPRS and 3GPP2 such as CDMA2000 and UMTS allow mobile equipments to be connected everywhere and at anytime [4]. Mobile terminals are able to access the Internet from anywhere using wireless technologies such as IEEE802.11a/b/g, GPRS or Bluetooth [5].

Mobile terminals such as mobile phones, laptops or Personal Digital Assistants (PDA) are more and more often shipped with multiple network interfaces. If these interfaces can be maintained simultaneously, the node has multiple paths to the Internet and is said multihomed [6]. For a mobile network, multihoming translates into either the MR being multihomed or several MRs being used to attach the mobile network to the Internet [7].

The MR was configured using NEMO to keep connected to the Internet. The MR has multiple interfaces such as Ethernet, IEEE802.11b, 2G/3G cellular cards in order to form a multihomed mobile network [8]. Furthermore, when a host has several IPv6 addresses to choose between, it is said multihomed [9]. This happens for instance when a mobile host or a mobile router has several interfaces simultaneously connected to the fixed network or when a mobile network has multiple MRs.

Multihoming offers three main benefits to hosts: it allows route recovery on failure, redundancy and load-sharing. However, for the moment there are no requirements for protocol defining how to use several interfaces inside a MNet. The Nautilus project [10] recently set up within theWIDE community in Japan [11] is working on this issue. Multihoming is necessary to provide constant access to the Internet and to enhance the overall connectivity of hosts [4].

A flow may not get expected QoS requirements in all the time [12]. Reliability analysis for GPRS helps to identify the cause of the reliability problem which may have occurred due to loss or duplicate or out of sequence or corruption of packets. It can also identify the combination of parameters that cause this problem. The service providers must use this technique to evaluate the performance of various applications with respect to reliability [13]. QoS prediction technique can also be used to overcome QoS issues in GPRS. It is used to predict reason(s) for deterioration in the QoS [14].

According to the MN topology and the point of attachment of MNNs inside the MN, MNNs may hear different prefixes. When the MN where the MNN belongs to is multihomed, MNN may have the choice of its default router. R. Draves, et al., introduces new options in Router Advertisement to allow any node on a link to choose between several routers [15].

3. Analysis

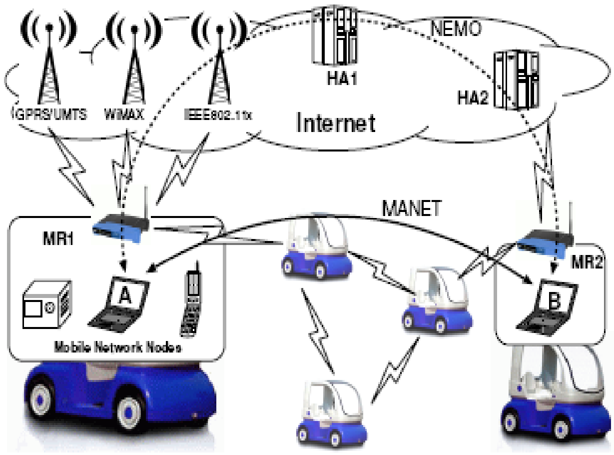

Figure 1. Example Network

This section analyzes various network interfaces and its data rates. Figure 1 is taken from [2]. It shows a mobile network managed by MR1 that in turn has three network interfaces such as GPRS/UMTS, IEEE 802.11x and WiMAX. In other words, MR1 has three paths to connect to the Internet. The maximum data rate for WiMAX is 70-75 Mbps. The maximum data rate for IEEE 802.11x is 54 Mbps [16]. The maximum data rate for GPRS is 172.2 Kbps [17]. Comparatively, WiMAX, IEEE 802.11x and GPRS/UMTS offer high, medium and low data rates respectively. There is a difference between data rate and actual throughput. The data rate is determined by both control packets and payload packets. But, the actual throughput is determined only by payload packets. Generally, the actual throughput is approximately half of the data rate. For example, the actual throughput for WiMAX is 40 Mbps.

The QoS requirements for various applications can be found in [18]. Accoring to Table 1, the applications can be classified as follows. They are high delay-sensitive applications, medium delay-sensitive applications and low delay-sensitive applications. Accordingly, the high delay-sensitive applications are telephony and video conference, the medium delay-sensitive applications are web access and remote login and the low delay-sensitive applications are e-mail, file transfer, audio and video.

Table 1. Quality of service requirements

Application	Reliability	Delay	Jitter	Bandwidth
E-mail	High	Low	Low	Low
File Transfer	High	Low	Low	Medium
Web Access	High	Medium	Low	Medium
Remote login	High	Medium	Medium	Low
Audio	Low	Low	High	Medium
Video	Low	Low	High	High
Telephony	Low	High	High	Low
Video Conference	Low	High	High	High

The outcome of the above analysis shows that there is a relationship between the data rates of network interfaces and the QoS requirements of the applications. The next section proposes a technique to match them.

4. An iNTelligent TECHnique (ANT TECH)

This section proposes an intelligent technique to forward packets based on the application demand and network performance. In other words, ANT TECH helps to match the application demand and network performance. This technique can be used in the Root-MR. The following steps explain the ANT TECH.

Step 1: Identify the number of network interfaces available
Step 2: Determine the data rates / actual throughput of network interfaces and assign its performance in terms of High / Medium / Low
Step 3: Determine the application demand in terms of High / Medium / Low
Step 4: Receives packets from MNN / child-MR
Step 5: Determine the type of packets (High / Medium / Low)
Step 6: If type_of_packets = High then forward packets to high performance network interface (WiMAX)
If type_of_packets = Medium then forward packets to medium performance network interface (IEEE 802.11x)

If type_of_packets = Low then forward packets to low performance network interface (GPRS)

Step 7: Repeat steps 4-6 until the data transfer is over

The ANT TECH is explained as follows. A mobile router in a mobile network has to identify the number network interfaces available such as WiMAX, IEEE 802.11x, etc. A mobile network inside another mobile network creates nested MN. In other words, Root-MR can have zero / one / more child-MRs. If the number child-MR is increased, the overhead is also increased. A Root-MR determines the data rates / actual throughput of all the network interfaces. After determining them, it assigns the performance of network interfaces as high, medium, low. Here, high, medium and low denotes the network interfaces that have high, medium and low data rates respectively. This paper concentrates only on delay-sensitive applications and assumes that all other parameters receive their requirements. Table 1 shows the various applications and its sensitivity to delay.

A Root-MR receives packets from all nodes such as mobile network node (MNN), local fixed node (LFN), visiting mobile node (VMN), child-MR, etc. Each node has some differences in mode of operation. Based on the application demand, the types of packet is determined. For example, video conference application is highly sensitive to delay. Hence, the type of packet for video conference application is said to be high. Likewise, it determines the type of packets for all other applications.

Now, the Root-MR has to check the type of packets. If type_of_packets is equal to high then forward packets to high performance network interface (WiMAX). If type_of_packets is equal to medium then forward packets to medium performance network interface (IEEE 802.11x). If type_of_packets is equal to low then forward packets to low performance network interface (GPRS). The steps 4 - 6 are repeated until the data transfer is over.

Definitely, forwarding packets via appropriate network interface saves network resources, gives customer satisfaction, reduces wastage of resources, etc. This in turn helps to improve QoS in the multihomed mobile networks.

5. Research Findings

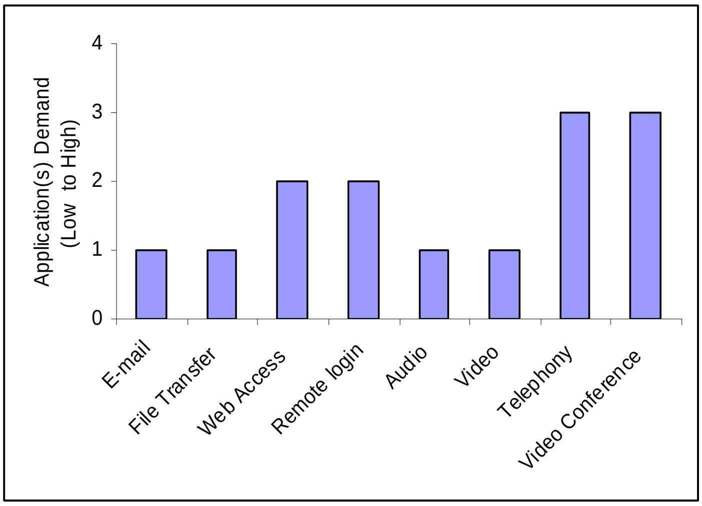

Figure 2. Applications and its demand (for delay parameter)

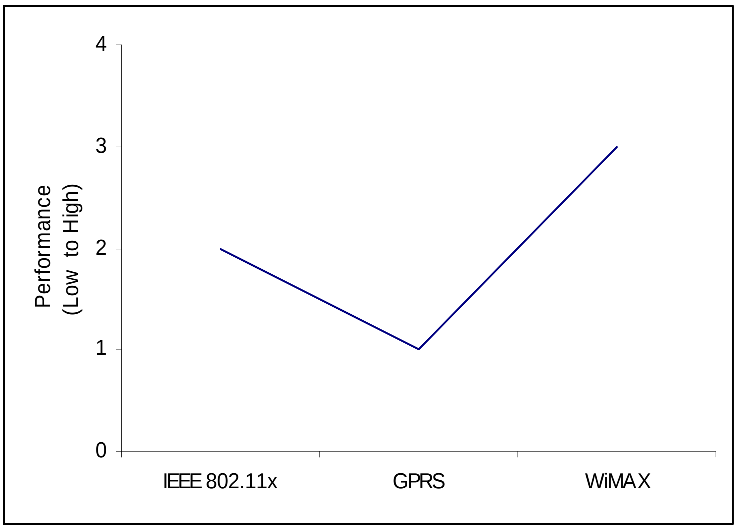

Figure 3. Network interfaces and its performance

This section illustrates the research findings in graphical form. Figure 2 shows the various applications in X-axis and its demands in Y-axis. The demands are related to low, medium and high. That is 1, 2 and 3 indicates low, medium and high demands respectively. Figure 2 reveals that the demand for QoS delay parameter in applications such as e-mail, files transfer, audio and video is low, in applications such as web access and remote login is medium and in applications such as telephony and video conference is high.

Figure 3 shows the network interfaces in the X-axis and its performances in the Y-axis. The performances are related to low, medium and high. That is, 1, 2 and 3 indicates low, medium and high performances respectively. Figure 3 reveals that the performance of GPRS, IEEE 802.11x and WiMAX network interfaces is low, medium and high respectively.

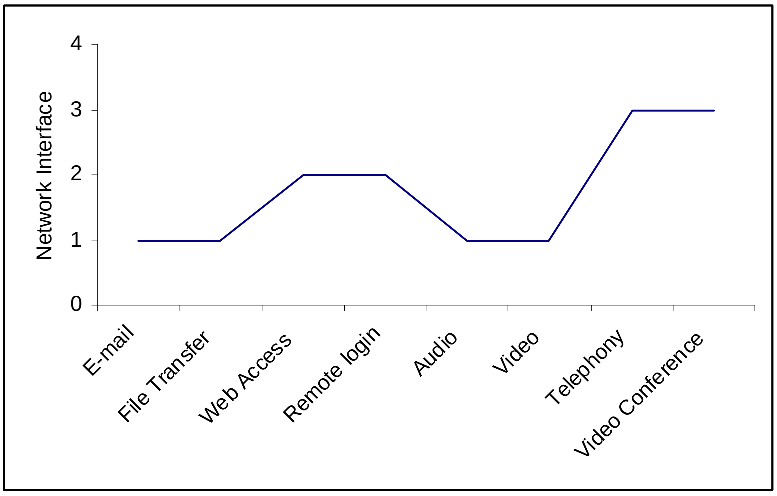

Figure 4. Applications and its suitable network interfaces

Figure 4 shows our research findings in graphical form. It shows the applications and its suitable network interfaces. The numbers in Y-axis such as 1, 2 and 3 denotes GPRS, IEEE 802.11x and WiMAX network interfaces respectively. Our research findings are explained as follows. The low delay-sensitive applications like e-mail, file transfer, audio, video, etc., can use GPRS network interface. The medium delay-sensitive applications like web access, remote login, etc., can use IEEE 802.11x network interface. The high delay-sensitive applications like telephony, video conference, etc., can use WiMAX network interface. It also shows that suitable network interface is selected based on application demand with respect to delay. Ultimately, these findings will help to improve QoS in multihomed mobile networks.

6. Conclusion

The differences between the application demand and network interface are inevitable. The customers have to be satisfied without wasting the resources. The QoS is related to both customers and service providers. In other words, satisfying the customers with wasting of resources or saving the resources without satisfying the customers can not said to be QoS. In this paper, both customer satisfaction and service providers capability is analyzed. An intelligent technique proposed forwards packets via suitable network interface to satisfy both customer and service provider. The research findings show that the customer satisfaction and resource conservation are ensured to the great extent. Though this paper has much strength, it has weakness like processing overhead in the MR. Definitely, forwarding packets via suitable network interface saves network resources, gives customer satisfaction, reduces wastage of resources, etc. This in turn helps to improve QoS in the multihomed mobile networks.

Acknowledgement

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