Measuring IP Performance Metrics on Mobile Network with Heterogeneous Wireless Technologies

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Abstract – The new measurement scheme of IP performance metrics is proposed for the mobile network in heterogeneous wireless network environment. In the proposed scheme, when Mobile Nodes (MNs) inside the mobile network needs to understand the condition of multiple communication paths outside the mobile network, they can get IP performance metrics, such as delay, jitter, bandwidth, packet loss, etc., irrespective of the presence or absence of measurement functionality. At the same time, the proposed scheme does not require the MN to be involved in measuring IP performance metrics. The Multihomed Mobile Router (MMR) with heterogeneous wireless interfaces measures IP performance metrics on behalf of the MNs inside the mobile network. Then, MNs can get measured IP performance metrics from the MMR using L_3 messages. The proposed scheme can reduce burden and power consumption of MNs with limited resource and battery power since MNs don't measure IP performance metrics directly. In addition, it can reduce considerably traffic overhead over wireless links on multiple measurement paths since signaling messages and injected testing traffic are reduced.

Key words – *performance metrics*; *network mobility*; *heterogeneous wireless network*

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1 Introduction

Understanding the dynamic properties of the end-to-end IP performance metrics, such as delay, jitter, bandwidth, packet loss, is beneficial for the proper resource management in existing wired and emerging wireless Internet services. The increasing trend in the wireless Internet services means that the requested performance for a certain service might not be guaranteed, not only because of the air interface bandwidth limitation, but also due to a limitation in the transport network's available bandwidth. Measuring IP performance metrics is a very challenging task due to the heterogeneity of the current systems and the different traffic characteristics of different data flows[1-2]. In the recent decade, the IP Performance Metrics (IPPM) working group in Internet Engineering Task Force (IETF) has defined a set of standard metrics and developed schemes for accurately measuring these performance metrics.

In the near future, airplanes, automobiles, and even people will carry entire networks of IP devices that connect to the Internet, which is called the mobile network. To deal with the mobility support of mobile networks, the IETF created a set of Network Mobility (NEMO) protocols. Through NEMO protocols, mobile nodes (MNs) on the mobile network are unaware of their network's mobility; however, they are provided with uninterrupted Internet access even when the network changes its attachment point to the Internet[3].

Meanwhile, to access the Internet, today's mobile hosts often have more than one wireless interfaces such as WLAN(802.11 a/b/g), WMAN(802.16e, WiBro), WWAN (3 G, HSDPA), WPAN(802.15), etc[4-7]. These mobile hosts are called "multi-homing capable", because they can connect to heterogeneous multiple networks. In recent, the multi-homing has been investigated from an end-node point of view not from a site point of view[8]. Once multiple wireless interfaces are offered, users may want to select the most appropriate set of wireless interface(s) depending on the network environment, particularly in wireless networks which are mutable and less reliable than wired networks. Users may also want to select the most appropriate wireless interface per communication type or to combine a set of interfaces to get sufficient bandwidth or more bandwidth using bandwidth aggregation mechanism in Ref. [9-11].

In this paper, a measurement scheme of IP performance metrics is considered for the mobile network in heterogeneous wireless network environment. There can be often many MNs in the mobile network. The Mobile Router (MR) in the mobile network is capable of changing its point of attachment to the Internet without disrupting higher layer connections of attached devices. To consider the heterogeneous wireless network environment, the MR is assumed to be multi-homing, that is, have heterogeneous multiple wireless interfaces and thus called the

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Multihomed MR (MMR). The MMR enables the multi-path communication outside the mobile network. Thus, MNs inside the mobile network can select the most appropriate communication path depending on the network environment and then communicate with corresponding hosts, such as the IPTV server, media streaming server, web server, FTP server, etc, via the MMR. If MNs want to understand the condition of multiple communication paths, they will measure directly IP performance metrics for each path. Therefore, all MNs inside the mobile network are required to be involved in measuring IP performance metrics and thus have to implement measurement functionality, which can be somewhat burdensome and power consumptive for MNs with limited resource and battery power. In addition, there can be the number of measurement signaling messages and injected testing traffic as shown in the active measurement techniques, which can cause considerable traffic overhead over wireless links on measurement paths. Therefore, to resolve these problems, an alternative measurement scheme of IP performance metrics for the mobile network should be developed.

Therefore, in this paper, the new measurement scheme of IP performance metrics is proposed for the mobile network in heterogeneous wireless network environment. In the proposed scheme, when MNs inside the mobile network want to understand the condition of multiple communication paths outside the mobile network, they can get IP performance metrics irrespective of the presence or absence of measurement functionality. That is, the proposed scheme does not require the MN to be involved in measuring IP performance metrics. The MMR measures IP performance metrics on behalf of the MNs inside the mobile network. Then, MNs can get measured IP performance metrics from the MMR using L_3 messages. These L_3 messages can be defined newly or reused by existing ICMP messages in Ref. [12]. The proposed scheme can reduce burden and power consumption of MNs with limited resource and battery power since MNs don't measure directly IP performance metrics. In addition, the proposed scheme can reduce considerably traffic overhead over wireless links on measurement paths since signaling messages and injected testing traffic are reduced.

In section 2, the characteristics of all links on the communication path are discussed. In section 3, the new measurement scheme of IP performance metrics is proposed for the mobile network. Finally, in section 4, the conclusion is made.

2 Characteristics of end-to-end path

As shown in Fig. 1, this paper considers the mobile network in heterogeneous wireless network environment. The MR is capable of changing its point of attachment to the mobile network, moving from one link to another link. To consider the heterogeneous wireless network environment, the MR is assumed to be multi-homing and thus called the multihomed MR (MMR). The MMR has heterogeneous multiple network interfaces which are categorized by internal and external wireless interfaces. Internal wireless interfaces are connected to MNs inside the mobile network and would be WLAN (802.11 a/b/g). External wireless interfaces are connected to external base stations for WMAN (802.16e, WiBro) and WWAN (3 G, HSDPA). Therefore, the MMR enables the multi-path communication outside the mobile network through these heterogeneous wireless interfaces. Meanwhile, MNs inside the mobile network are assumed to have single wireless interface or heterogeneous multiple wireless interfaces. Corresponding Hosts (CHs) can be the IPTV server, media streaming server, web server, FTP server, etc. MNs inside the mobile network can communicate with CHs on multiple paths via the MMR.

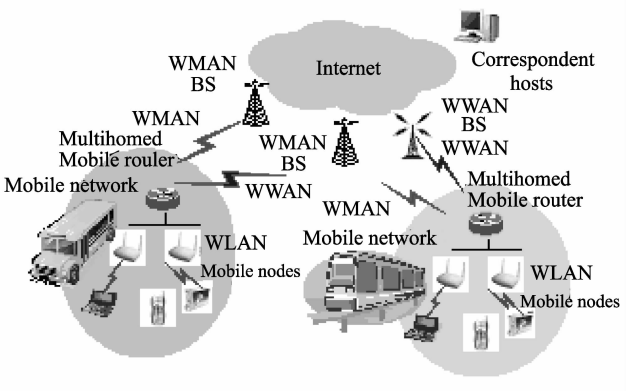

Fig. 1 Mobile network scenario

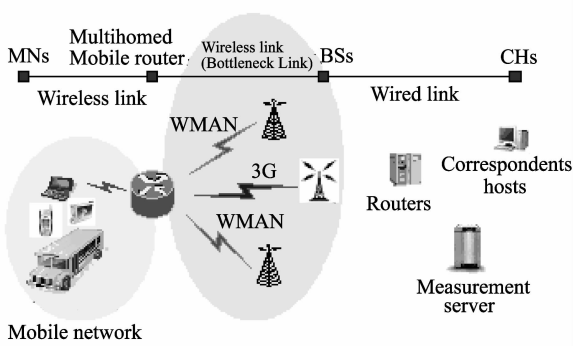

Fig. 2 Links on end-to-end communication path

As shown in Fig. 2, the end-to-end multi-path from MNs inside the mobile network to CHs outside the mobile network via the MMR consists of following three links.

2.1 Link between MN and MMR

Inside the mobile network, the WLAN(802.11a/b/g) will be generally adopted as an air technology due to high transmission speed and moderate coverage. Thus, MNs with WLAN interface can communicate via the MMR with internal WLAN interface inside the mobile network.

2.2 Link between MMR and external BSs

Outside the mobile network, WMAN(802.16e, WiBro) and WWAN(3 G, HSDPA) will be generally adopted as an air technology due to wide coverage. Thus, the MMR with external WMAN and WWAN interfaces can communicate via corresponding base stations (BSs). However, in this wireless link, it is difficult to expect higher transmission speed than that of the wireless link between MNs and MMR using WLAN.

2.3 Link between external BSs and CHs

This link consists generally of routers with high processing speed and wired networks with high transmission speed.

3 Proposed measurement scheme for IP Performance metrics

3.1 Overview of proposed scheme

If MNs inside the mobile network measure directly IP performance metrics, they are required to be involved in the measurement procedure and thus have to implement measurement functionality, which can be somewhat burdensome and power consumptive for MNs with limited resource and battery power. In addition, there can be the number of measurement signaling messages and injected testing traffic, which can cause considerable traffic overhead over the wireless links, such as link between MN and MMR, and link between MMR and external BS, on measurement paths. In addition, as mentioned in Section 3, the wireless link between MMR and external BS is likely to be overloaded network link, that is, "bottleneck link". Moreover, if there are many mobile networks connected to external BS, this link is likely to be "tight link". This means that IP performance metrics of the end-to-end multi-path might be mostly influenced by the wireless link betwee MMR and external BS.

With the consideration of these problems, in this paper, the new measurement scheme of IP performance metrics is proposed for the mobile network in heterogeneous wireless network environment. In the proposed scheme, all MNs inside the mobile network can get IP performance metrics irrespective of the presence or absence of measurement functionality. That is, the proposed scheme does not require the MN to be involved in measuring IP performance metrics. The MMR with heterogeneous wireless interfaces measures IP performance metrics on behalf of the MNs inside the mobile network.

3.2 Main components

As shown in Fig.2, main components on the end-to-end measurement path consist of MNs, MMR, and measurement server.

MNs inside the mobile network are assumed to have a single wireless interface or heterogeneous multiple wireless interfaces. When MNs want to get IP performance metrics to understand the condition of multiple communication paths, they can request to the MMR using the L_3 message. Also, MNs can get IP performance metrics that the MMR provides periodically.

The MMR measures IP performance metrics on behalf of the MNs inside the mobile network. Since the MMR have heterogeneous external wireless interfaces such as WMAN (802.16e, WiBro) and WWAN (3 G, HSDPA), the MMR enables the multi-path communication outside the mobile network and thus can measure IP performance metrics for all paths through these heterogeneous external wireless interfaces.

The measurement server is a host that receives testing traffic, calculates performance statistics, and response results of IP performance metrics to the MMR.

3.3 Operation procedure

3.3.1 Operation between MMR and measurement server

On the multi-path between the MMR and the measurement server, IP performance metrics can be measured using existing measurement schemes. Existing measurement schemes can be classified into two categories: passive measurement and active measurement[1-2]. Passive measurement schemes use the trace history of existing data transmission. While potentially very efficient and accurate, their scope is limited to network paths that have recently carried user traffic. Active measurement schemes, on the other hand, require injecting testing traffic into network in order to realize measurements. The basic idea of active measurement is that the MMR injects test traffic into the multi-path to the measurement server. Then, the measurement server receives testing traffic, calculates performance statistics, and response results of IP performance metrics to the MMR. The MMR receives and stores them to provide for MNs inside the mobile network.

3.3.2 Operation between MMR and MNs

When MNs want to get IP performance metrics from the MMR to understand the coodition of multiple communication paths, following two methods can be available:

① Unsolicited Reqeust and Response: Irrespective of the request of MNs, the MMR broadcasts periodically measured IP performances metrics to MNs inside the mobile network.

② Solicited Request and Response : A specific MN requests and then the MMR unicasts measured IP performance metrics to the corresponding MN.

Request and Response messages can be defined by the Internet Control Message Protocol (ICMP) message format in Ref.[12]. For example, for unsolicited request and response, the unsolicited Router Advertisement (RA) message format in Ref.[13] can be reused by the modification of type field. For solicited request and response,

Route Solicitation (RS) and Router Advertisement (RA) message formats in Ref.[13] can be reused by the modification of type field.

Using obtained IP performance metrics, MNs can understand the condition of multiple communication paths for heterogeneous multiple wireless interfaces. Then, MNs may want to select the most appropriate path per communication type. If the condition of all communication paths is unfavorable, MNs with heterogeneous multiple wireless interfaces can connect to the corresponding BS directly, not via the MMR.

3.4 Advantages

The proposed scheme can reduce burden and power consumption of MNs with limited resource and battery power since MNs don't measure directly IP performance metrics. In addition, the proposed scheme can reduce considerably traffic overhead over wireless links on measurement paths since signaling messages and injected testing traffic are reduced.

4 Conclusions

This paper has proposed the new measurement scheme of IP performance metrics for the mobile network in heterogeneous wireless network environment. In the proposed scheme, all MNs inside the mobile network can get IP performance metrics irrespective of the presence or absence of measurement functionality. That is, the proposed scheme does not require the MN to be involved in measuring IP performance metrics. The MMR with heterogeneous wireless interfaces measures IP performance metrics on behalf of the MNs inside the mobile network. Then, when MNs want to understand the condition of multiple communication paths, MNs can get measured IP performance metrics from the MMR using L_3 messages. The proposed scheme can reduce burden and power consumption of MNs with limited resource and battery power since MNs don't measure directly IP performance metrics. In addition, the proposed scheme can reduce considerably traffic overhead over wireless links on measurement paths since signaling messages and injected testing traffic are reduced.

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