

The Method for IP Layer Link Aggregation using Flow Information in a Vehicle Mobile Router

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Abstract— This paper proposes a method for the IP layer link aggregation using flow information to use all available mobile interfaces for backbone network access simultaneously in a vehicle mobile router. For this purpose, we present the design of the IP layer link aggregation functionality and the design of the aggregator which is the essential part of the IP layer link aggregation functionality. In the proposed method, the traffic distributor transmits the packets in the same session to only one mobile interface and uses the flow information as an identifier to distinguish each session.

Keywords— aggregation, flow, mobile, vehicle, router, HSDPA, Wibro, WLAN

I. INTRODUCTION

Due to the rapid spread of smart mobile devices which is represented by the smart phone, the user of a smart phone can enjoy the Internet service without any expense in places where Wireless Local Area Network (WLAN) is available. Therefore the mobile network operators are building the WLAN competitively in public places where there are many people to gain service superiority over competitive mobile network operators.

Additionally, the need for using the Internet service based on WLAN in public transportation (e.g., bus, subway and train), is growing up and as a solution for that issue the vehicle mobile router (VMR), which is equipped in a vehicle and provides the Internet service to the passengers in the vehicle, is getting attention.

To satisfy the above requirement, the VMR must provide available mobile interfaces (e.g., Wibro, HSDPA, WLAN, etc.) for connection with the backbone network and also provide the WLAN interface for connection with the users.

Nowadays the mobile network operators have launched the new product which has a Wireless broadband (Wibro) or a High Speed Downlink Packet Access (HSDPA) for backbone access and interworks the backbone access with WLAN for user access.

As a commercial product, Korea Telecom (KT) has launched the *Egg* and SK Telecom (SKT) has launched the *Bridge* in Korea.

But as the above commercial products support only one mobile interface for backbone access at a specific point of time and the Wibro or HSDPA interface used for backbone access has much less bandwidth than the WLAN interface for

user access, the commercial products have the drawback for the number of supported users. Therefore they have a severe restriction in being used in public transportation.

To overcome this restriction, the VMR, which supports multiple mobile interfaces (e.g., Wibro, HSDPA, WLAN, etc.) for the backbone network access, is required. Further more the method, which uses all available mobile interfaces simultaneously, must be presented.

The rest of the paper is organized as follows. In section 2, we explain the related work for the vehicular network. In section 3, we propose the network architecture and explain the method for IP layer link aggregation using flow information in a VMR. And then we explain the operation scenario of the proposed IP layer link aggregation method. This paper is concluded in section 4.

II. VEHICULAR NETWORK

Vehicular networks are a novel class of wireless networks that have emerged thanks to advances in wireless technologies and the automotive industry [1]. Vehicular networks are spontaneously formed between moving vehicles equipped with wireless interfaces that could be of homogeneous or heterogeneous technologies. Indeed, vehicular networks are promising in allowing diverse communication services to drivers and passengers.

III. THE PROPOSED METHOD FOR IP LAYER LINK AGGREGATION

A. Network Architecture

In this paper, the network architecture for providing the Internet service through VMR is presented in Figure 1. While equipped in a moving vehicle, the VMR provides WLAN interface for subscriber's access and connects to the backbone network by using HSDPA and Wibro interfaces. Also it should support multiple HSDPA and Wibro interfaces.

At first, the VMR creates an IP-in-IP tunnel with Mobile Control Platform (MCP) in the backbone network. And then a mobile node in a moving vehicle connects to the VMR by WLAN and in turn connects to the backbone network via the IP-in-IP tunnel created between the VMR and the MCP. Conversely the data, which is transferred from the backbone network to the mobile node, passes by the tunnel between the VMR and the MCP through the MCP and in turn is transferred to the mobile node by WLAN.

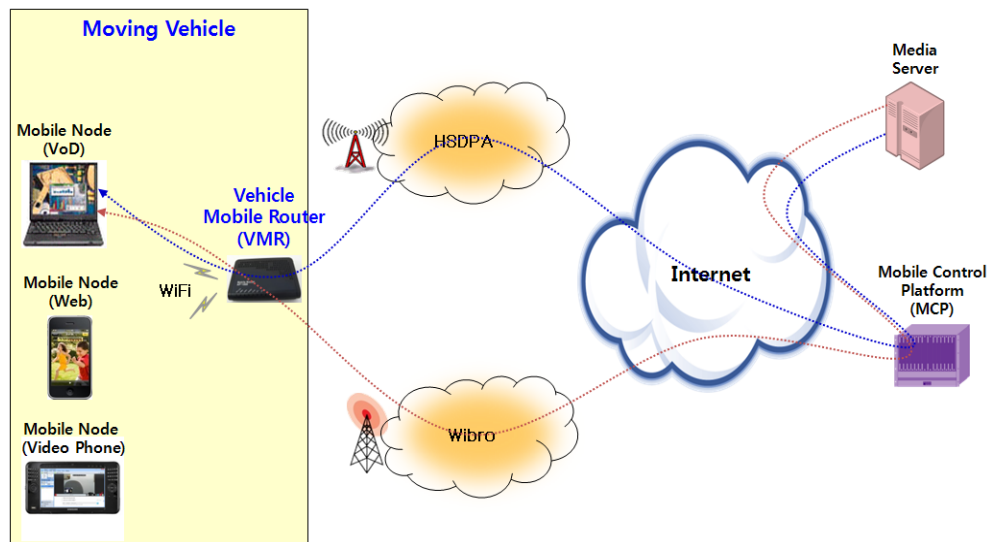


Figure 1. The Network Architecture

B. Proposed Method

To achieve the above purpose, this paper proposes the method for IP layer link aggregation using flow information in a VMR. It is characterized by operating in conjunction with the VMR and the MCP. The VMR identifies the MCP at initial operation by configuring the IP address of the MCP in advance and creates the IP-in-IP tunnel with the MCP.

The functional structure of IP layer link aggregation in VMR is shown in Figure 2. In Figure 2, WLAN interface is used for the subscriber's access and HSDPA and/or Wibro interfaces are used for the backbone network access. The *Aggregator* module which is the essential part in IP layer link aggregation functionality is composed of the *Aggregation Control* part, the *Traffic Distributor* part and the *Traffic Collector* part.

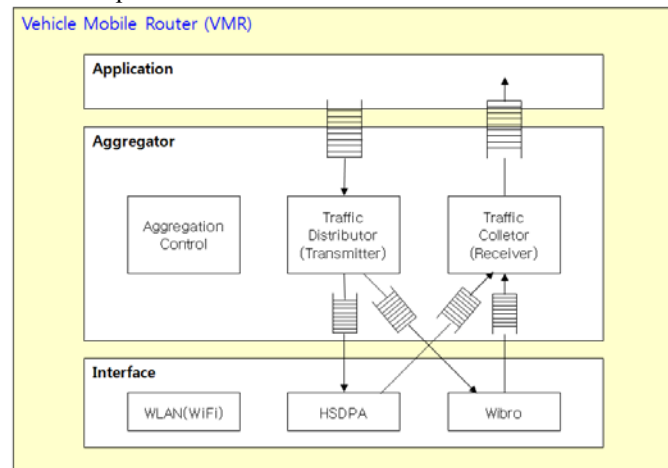


Figure 2. Functional Structure of IP Layer Link Aggregation in VMR

The *Aggregation Control* part communicates with the *Aggregation Control* part in MCP and processes the control message for addition, deletion and management of the

mobile interfaces (e.g., HSPDA, Wibro, etc.) between the VMR and the MCP.

The *Traffic Distributor* part performs the functionality which distributes the traffic to available mobile interfaces in IP layer link aggregation. At this time, it is most important to distribute the traffic not to change the order of packets belonging to the same session when received in the counter side. If the order of packets belonging to the same session is changed by transferring the packets to different mobile interfaces, it necessitates the reordering of the packets belonging to the same session in *Traffic Collector* part of the MCP. And such jobs degenerate the efficiency of link aggregation.

In this context, we propose to transfer the packet belonging to the same session to only one mobile interface so that the packet reordering does not occur. And we insist to use the flow information based on 5-tuple, which consists of source IP address, destination IP address, protocol id, source port number, destination port number, as the identifier to distinguish the sessions.

That is, the packets belonging to the same flow are transferred to one mobile interface. And the *Traffic Distributor* part should distribute several flows to all available mobile interfaces equivalently considering the bandwidth of the corresponding mobile interfaces. Of course, as another deployment alternative, it is also possible to transfer some traffic flows that require the guaranteed Quality of Service (QoS) to one mobile interface (e.g., HSDPA) and another traffic flows that require the best-effort QoS to the other mobile interface (e.g., Wibro).

The *Traffic Collector* part removes the tunnel IP header of the received packets from an available mobile interface. Thereafter it transfers the packet to the upper control module in the system or forwards the packet to the correspondent mobile node.

The functional structure of IP layer link aggregation in MCP is shown in Figure 3. As the MCP is located in the backbone network, it offers only the Ethernet interface. And

the *Aggregator* module which is an essential part in IP layer link aggregation functionality has the same structure as that of the VMR. The roles of the *Aggregation Control* part and the *Traffic Collector* part are identical to those of the VMR.

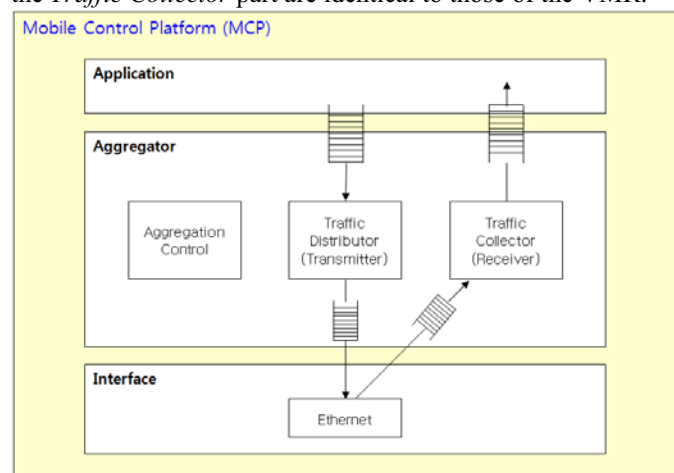


Figure 3. Functional Structure of IP Layer Link Aggregation in MCP

The *Traffic Distributor* part is identical to that of VMR in terms of distributing the traffic based on flow information. But it is different from that of VMR in terms of distributing

the traffic by changing the destination IP address of outer IP header (i.e., tunnel IP header).

In more detail, we assume that the VMR is allocated 123.129.10.10 as the IP address of HSDPA interface and 125.152.10.10 as the IP address of Wibro interface.

In case that the *Traffic Distributor* part in the MCP distributes the traffic based on flow information, if we want to transfer the traffic through a HSDPA interface, the destination IP address of the tunnel IP header is configured as 123.129.10.10. On the other hand, if we want to transfer the traffic through a Wibro interface, the destination IP address of the tunnel IP header is configured as 125.152.10.10.

The packet format between the VMR and the MCP is presented in Figure 4. Regarding the traffic from a mobile node to the backbone network, the inner IP header is the IP header of the packet received through a WLAN interface in VMR. Also the source IP address of the outer IP header is the IP address allocated to the used mobile interface and the destination IP address of the outer IP header is the IP address of the MCP.

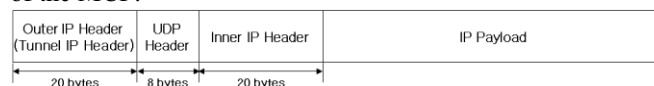


Figure 4. Packet Format between VMR and MCP

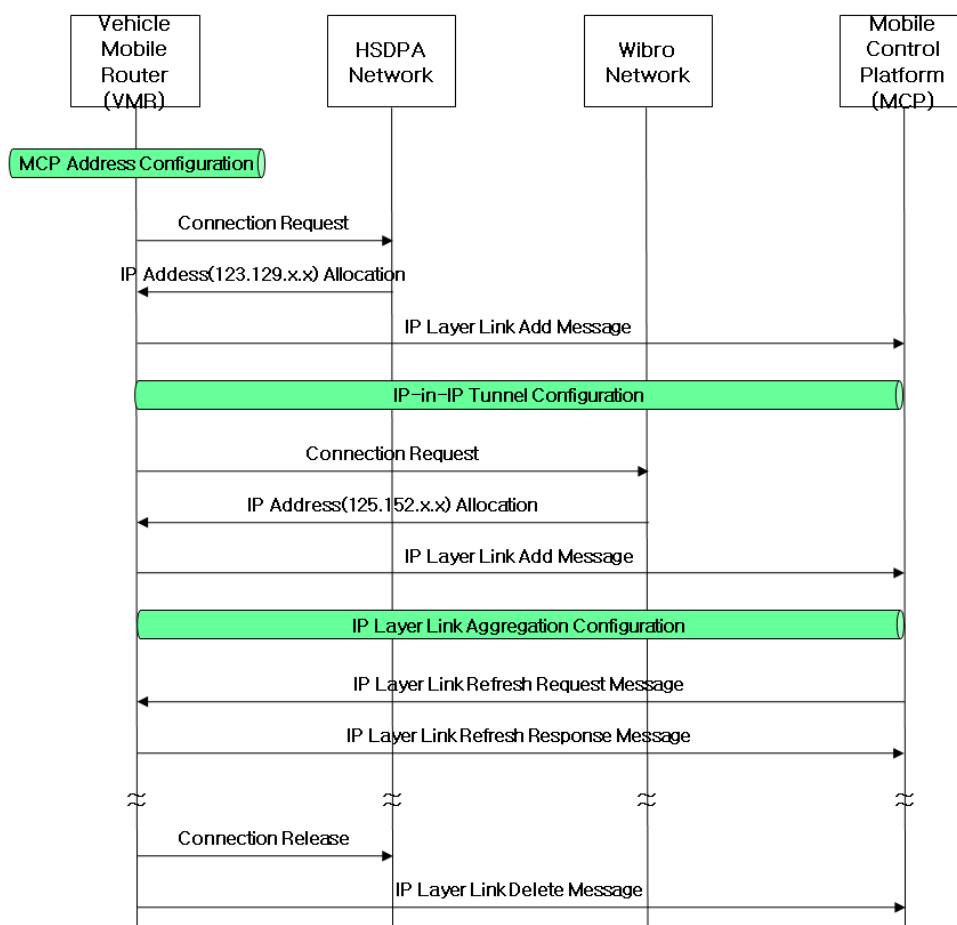


Figure 5. Operation Procedure of the Proposed IP Layer Link Aggregation Method

Moreover, we append the UDP header additionally to distinguish the packets used in IP layer link aggregation. By configuring the destination port number of the UDP header to a specific value, we can distinguish the packets used in IP layer link aggregation. We can also distinguish the control packets from the data packets.

C. Operation Scenario

The operation procedure of the proposed IP Layer Link Aggregation method is shown in Figure 5. When initially operated, the VMR acquires the IP address of the MCP. The IP address of the MCP can be configured by the operator or can be configured automatically by the batch file.

Thereafter the VMR requests the connection to an available mobile interface. In Figure 5, we assume that the HSDPA interface operates firstly. Then the VMR connects to the HSDPA network and an arbitrary IP address (e.g., 123.129.10.10) is allocated to the HSDPA interface of the VMR. The VMR sends the *IP Layer Link Add Message* to the MCP by the packet format shown in Figure 4. After the MCP receives the first *IP Layer Link Add Message* from the VMR, the IP-in-IP tunnel is created between the VMR and the MCP.

The *IP Layer Link Add Message* is constructed to the Type, Length and Value (TLV) format in IP payload shown in Figure 4. And it includes the information about related mobile interface and whether link aggregation is carried out.

In Figure 5, we assume that the Wibro interface operates secondly. Then the VMR connects to the Wibro network and an arbitrary IP address (e.g., 125.152.10.10) is allocated to the Wibro interface of the VMR. The VMR sends the *IP Layer Link Add Message* to the MCP in the same manner of the HSDPA interface. When the MCP is noticed of multiple mobile interfaces from the VMR, the IP Layer Link Aggregation is established between the VMR and the MCP.

Since the IP Layer Link Aggregation is established, the MCP manages the available mobile interfaces by sending the *IP Layer Link Refresh Request Message* to the VMR through the respective mobile interfaces periodically. If there is no response for the *IP Layer Link Refresh Request Message* during the preconfigured number of retries, the MCP regards

the related mobile interface as unavailable and performs the necessary processing.

When any of the available mobile interfaces in VMR has become unavailable, it is possible for the VMR to inform the MCP by sending the *IP Layer Link Delete Message* through other available mobile interfaces belonging to the IP Layer Link Aggregation in order to manage the link status appropriately. Of course, though the VMR doesn't carry out any operation for that event, the unavailable mobile interface will be deleted by the above mechanism.

IV. CONCLUSIONS

In this paper, we intend to resolve the bandwidth problem related to the VMR, which is due to the difference between the bandwidth of the Wibro and HSDPA interface used for backbone access and that of the WLAN interface used for user access. And as a result, we proposed the method for IP layer link aggregation using flow information in a vehicle mobile router.

In the proposed method, the *Aggregator* is composed of an *Aggregation Control* part, a *Traffic Distributor* part and a *Traffic Collector* part. And when a *Traffic Distributor* transmits packets to the partner of the IP layer link aggregation, it is important not to reorder the packets in the same session in the correspondent *Traffic Collector* as well as to use the available mobile interfaces equivalently.

And we propose that the *Traffic Distributor* transmit the packets in the same session to only one mobile interface and use the flow information which consists of 5-tuple (i.e., source IP address, destination IP address, protocol id, source port number and destination port number) as an identifier to distinguish each session.

We are sure that our proposal will contribute to the spread of smart phone and the service enhancement by helping to build the Internet service environment in public transportation.

REFERENCES

- [1] H. Moustafa and Y. Zhang, *Vehicular Networks*, United States of America: CRC Press, 2009.