Analysis of Optimal Multihoming Configuration for Vehicular Mobile Networks

Hamada Alshaer † and Iftikhar Afridi and Jaafar. M. H. Elmirghani ‡

University of Leeds.

Abstract: Multihomed vehicular mobile networks can reach Internet through multiple routes using different communication technologies such as WLAN (IEEE 802.11), WiMax (IEEE 802.16), 2.5G (GPRS), 3G (UMTS) and satellite. Internet services are provisioned to these mobile networks through a mobile-router (MR) which manages their entire mobility using network mobility basic support protocol (NEMO-BSP) [5]. However, network mobility can degrade the quality of communication channels which could be manifested in low quality of Internet connection and bandwidth (throughput) as well as data rate variation over a very short time scale. Thus, a mobile traffic management mechanism should be integrated in the MR to optimally distribute traffic among its communication interfaces connecting it with Internet network. This paper studies optimal multihoming configuration for mobile networks through simulations, where the results provide guidelines for designing an intelligent route control scheme which can optimally use available bandwidth on wireless channels connecting mobile router with Internet.

1 Introduction

Figure 1 depicts a vehicular mobile network (NEMO) which can reach the Internet network through multiple wireless and radio access technologies, where each access router (AR) (base station (BS)) provides a gateway for NEMO to connect to Internet. This illustrates one of the multi-homing configurations [7] which enables NEMO to communicate with external entities through different routes via the wireless interfaces of their mobile router (MR). This MR in coordination with a home agent (HA) can manage the entire mobility of NEMO and therefore correspondent nodes can communicate with mobile network nodes (MNNs) on board NEMO anywhere anytime. The MR so as the HA receives downlink traffic which is destined to mobile network nodes (MNNs) and uplink traffic which is destined to CNs and intelligent transport services providers (ITSPs). To this end, traffic management mechanisms should be employed either in MR or HA to guarantee end-to-end (e2e) quality-of-service (QoS) required for uplink and downlink traffic. In this paper we evaluate through simulations traffic splitting mechanisms which aim to optimally distribute traffic among the output links (egress interfaces) of MR, which connect it with Internet. These mechanisms have been integrated with scheduling service disciplines (SSDs), namely round robin (RR) and weighted round robin (WRR), which enable us to analyze through simulations mobile traffic engineering in the MR.

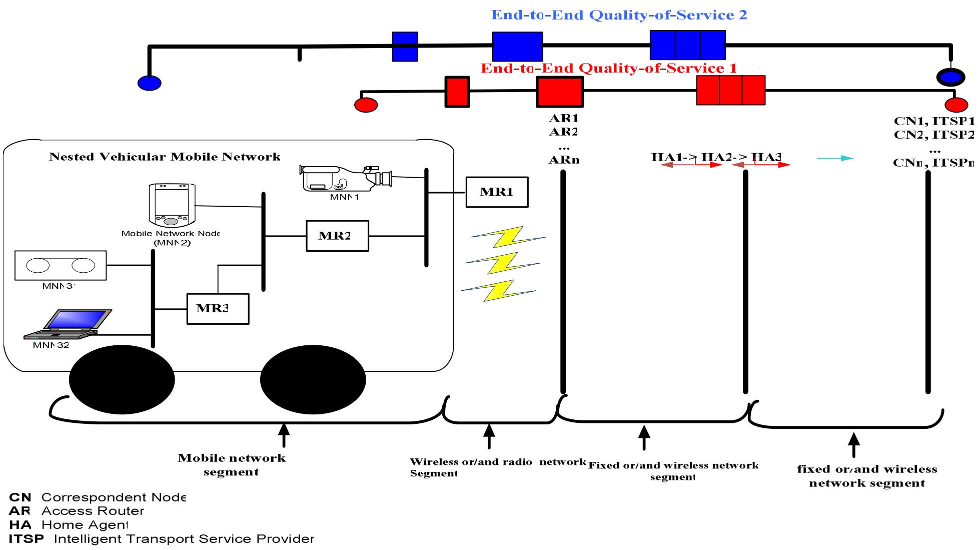

Figure 1. Vehicular mobile network

Following the introduction the paper is organised as follows. Section 2 explains packet and flow traffic splitting schemes. Section 3 explains the scheduling service disciplines integrated with these schemes to realize an optimal multihoming configuration for NEMO. Section 4 provides simulation results. Finally, the paper is concluded in Section 5.

2. Traffic splitting schemes

As the different wireless access links have variable bandwidth and often changes on a short time scale in case of network mobility, MR can get advantage of multihoming by diverting traffic away from congested or failed routes to other possible routes through other egress interfaces (output links). As shown in Figure 1 that the routing paths connecting HA with MR (NEMO) consists of different routing segment of which the segment connecting access routers with MR is the most critical one and more error and QoS degradation prone. MR, therefore, should be enabled to handle traffic at different granularities, (packet, flow, and user) to optimally distribute traffic among active output links of MR. Splitting traffic mechanisms integrated with scheduling service disciplines can be employed to control the flow of traffic to the different output links (egress interfaces) of MR. According to the traffic granularity dispatching from an input link to an output link, there are three traffic splitting schemes [1,2].

2.1.1 Packet-based traffic splitting scheme

Using this scheme, MR_1, shown in Figure 1, dispatches traffic at the packet level to the output links connecting it with ARs. For example, packets of the same flows generated by MNN_1 are dispatched to different output links and thus they may arrive out of order at their destinations.

2.1.2 Flow-based traffic splitting scheme

Using this scheme, MR_1, shown in Figure 1, dispatches traffic to the output links at the flow level, thus traffic flows having the same characteristics can be stripped onto the same egress interface.

2.1.3 User-based Traffic Splitting Scheme

Using this scheme, MR_1 shown in Figure 1 dispatches traffic to the output links based on users preferences; for example, traffic generated by MNN_1 may be always assigned to WLAN while that generated by MNN_2 is assigned to GPRs.

3. Mobile traffic scheduling disciplines

MR uses scheduling algorithms to dispatch traffic to output links based on the employed traffic splitting schemes which is ultimately designed to achieve traffic load balancing among output egress interfaces. In this study, we have evaluated packet and flow traffic splitting schemes using round robin (RR) and weighted round robin (WRR) scheduling disciplines for a multihomed NEMO.

3.1 Round Robin (RR) scheduler

The flowchart shown in Figure 2 describes the process of packets/flows Round robin (RR) scheduler. This schedules every new incoming packet/flow to output access links, WLAN.UMTS or GPRS, in a round robin fashion. It assigns the first packet/flow to the first available link then it creates an entry for this flow in the flow and link tables to keep a record of all incoming packets which have been assigned to a particular access link. Subsequent packets/flows are scheduled to the second available link and so on. If, however, a new packet/flow is detected, then it will be scheduled on the first link and the rest of packets/flows are scheduled in Round Robin fashion onto the other links. Obviously, the class of flow can be considered in order to dispatch it to a specific access link to guarantee its e2e QoS requirements.

3.2 Weighted round robin (WRR) scheduler

The flowchart shown in Figure 3 illustrates the weighted round robin (WRR) which schedules packets/flows according to the weight assigned to the links, which is calculated based on the available bandwidth of each link. So, this scheduler can better handle dynamic traffic than the RR, especially when the access links have different available bandwidth or delay and so RR may under-utilize or over utilize these access links. WRR improves the utilization of these access links. In multi-homed NEMO case, if there are three wirelesses links of 10 Mbs, 5 Mbs and 1 Mbs respectively, then the WRR SSD will assign the first 10 packets/flows to the first link, 5 packets/flows to the second link and the next packets/flows to the third link. MR maintains three tables: One to measure the available bandwidth BE[i], and another to save the number of flows assigned to any of output links and last the link table which saves the number of flows and packets served on any output link. Each time a number of flows or packets are admitted, the available bandwidth array, BW[i], increases the bandwidth of the link to which packets/flows are dispatched. Also the number of flows or packets assigned to each interface is also increased while the flows array is just updated to assign the link to which packets/flows are dispatched.

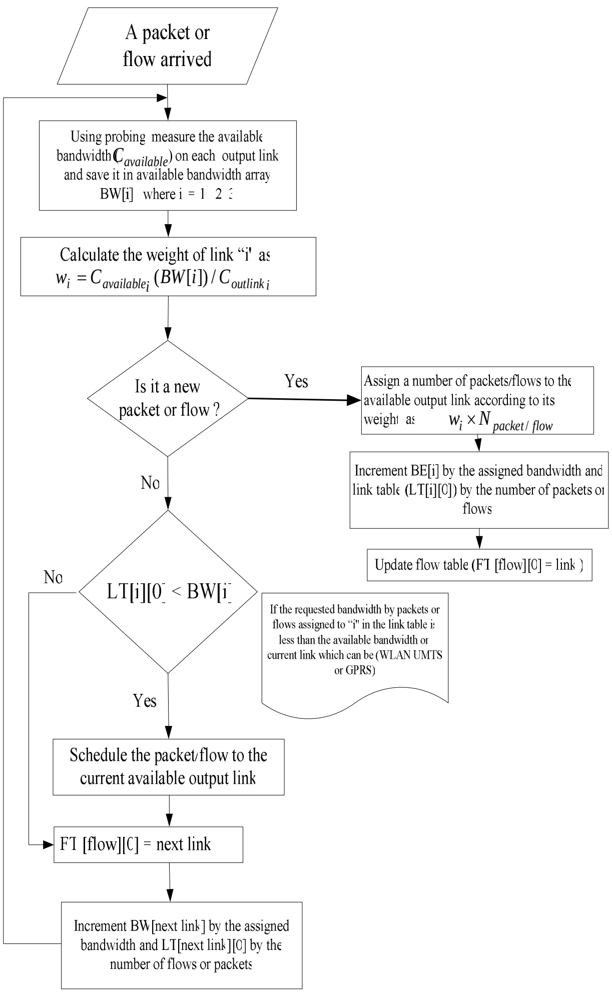

Figure 2. Flowchart of packet/flow Weighted RR scheduler**.**

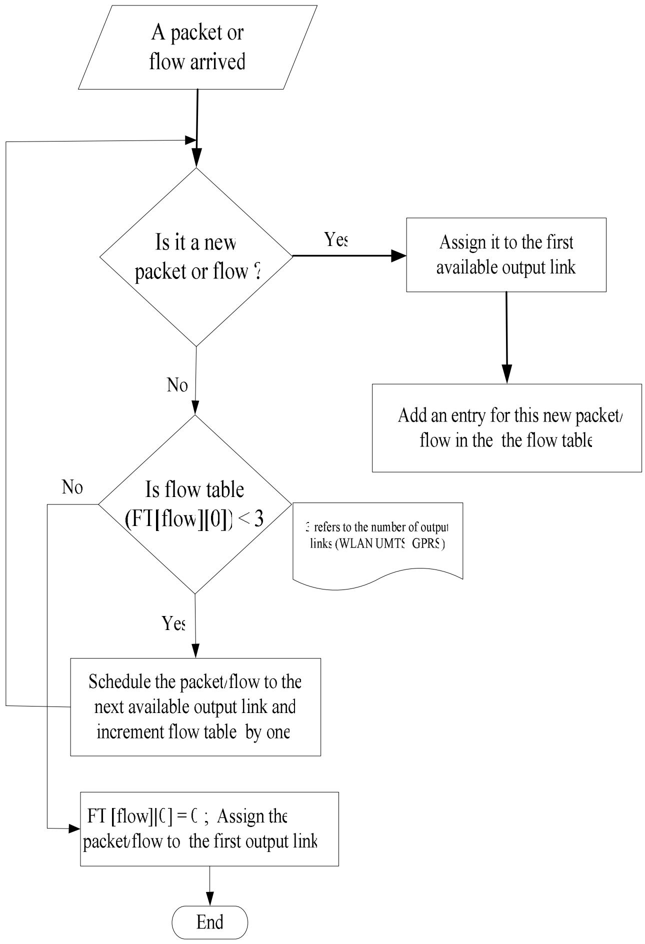

Figure 3. Flowchart of packet/flow RR scheduler**.**

4. Simulation and results

Under OMNeT++, we have conducted simulation experiments on the network topology shown in Figure 1, but with a single MR and single HA. As a result, figure 3 shows us the impact of network mobility on the congestion window size of TCP. It varies on a short time scale as the TCP congestion mechanism sets the threshold to different values based on the measured round trip time value of each connection which differs from one connection to another. Figure 4 shows us the result of congestion window size of TCP when RR is used in the MR. TCP congestion window is less stable than that observed when WRR is employed in the MR. This can be attributed to the fact that MR may under-utilize some links.

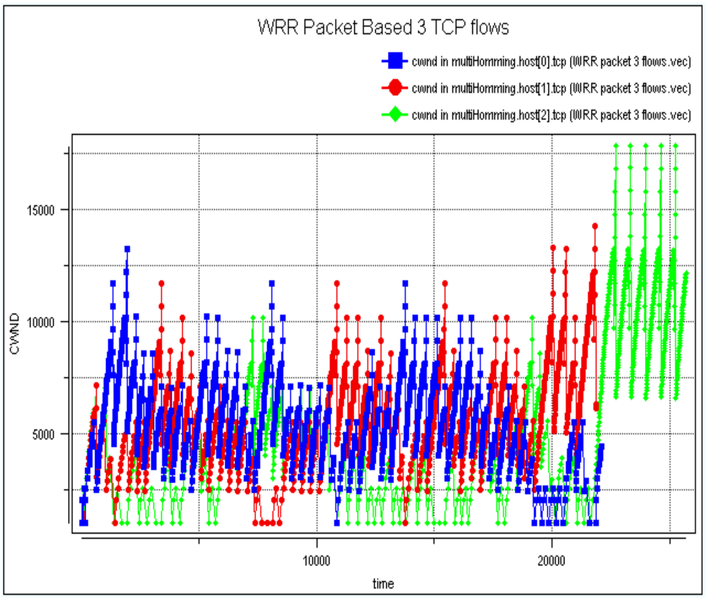

Figure 3. ***PSS Using WRR scheduler.***

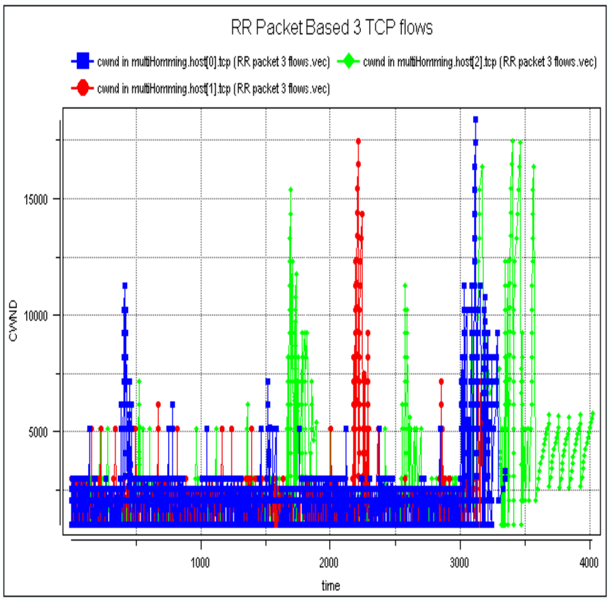

Figure 4. PSS using WRR scheduler**.**

5. Conclusion

The introduced splitting mechanisms and scheduling algorithms provide us guidelines in designing a more elaborate intelligent route control scheme for multi-homed mobile networks [3]. This enables the MR to make efficient use of all available links and thus chooses the best route for MNNs. The combination of global routing through intelligent traffic control mechanisms with local traffic dispatching mechanisms contribute in designing more resilient mobile routing mechanisms which can reroute traffic connections based on their e2e QoS requirements.

References

[1] Albert Yuen Tai Chung.Traffic Engineering for Mult-Homed Mobile Networks. PhD thesis, The University of New South Wales Sydney, Australia May 2007.

[2] F. Guo, J. Chen, W. Li and T. Chiuch, “Experiences in Building a Multihoming Load Balancing Systems”, in Proceedings of IEEE Infocom, vol. 2, 2004.

[3] H. Alshaer, J. M.H. Elmirghani. An Intelligent Route Control Scheme for Multihomed Mobile Networks. to appear in the Proceedings of VTC-fall, 2009.