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Handoff Performance Analysis for Multihoming-based Network Mobility Scheme

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Abstract

The necessity for multihoming functionality emerged since the standard Network Mobility Basic Support Protocol (NEMO BSP) acquiesces the Mobile Router (MR) to bind single Care of Address (CoA) at once with its Home Agent (HA) only. Besides, NEMO networks are usually attached through the wireless which results in less stable links. There could also be several Mobile Network Nodes (MNNs) behind the MR. Thus, a loss of Internet connectivity has higher impact compared to a single MNN. To ensure a continuous Internet connectivity to mobile networks, it is preferable to use multihoming mechanism in which MR is equipped with multiple interfaces as well as technologies. This paper has proposed a multihoming-based scheme on Proxy MIP6 (PMIPv6) domain for handoff performance analysis relating to handoff delay, packet delivery ratio, as well as throughput at different number of MR, speed and time. After that, it has developed a simulation model to assess the proposed scheme as well as compared it with Network Mobility Basic Support Protocol (NEMO BSP) and multi-interfaced scheme. Results attained from evaluation will support the network engineer to pick a suitable multihoming-based scheme in mobile environment at different number of MR, speed and time.

Keywords: *NEMO BSP, Mobile router, Multihoming, PMIPv6*

1. Introduction

Handoff management is an indispensable module of mobility management. It goals to maintain an uninterrupted Internet connectivity as soon as the Mobile Router (MR) alters its point of attachment [1-2]. In NEMO BSP, the most substantial provisions for handoff management are mainly seamless connectivity that need to be assured regarding location and speed of MR or Mobile Node Nodes (MNN). Moreover, it is desired to support inter technology handoff (*i.e.*, movement among different access technologies) for delay sensitive applications [3-4]. Time sensitive applications such as voice and video is not capable of enduring higher handoff delays. Due to these delay deviances, the protocols (i.e. TCP or UDP) can also experiences. This is because, they are inferred as network congestion [5-7].

Consequently, in order to provide continual Internet connectivity at any time in any place, supporting multihomed NEMO technique is one of the concerned matters between researchers recently. Multihoming is a promising solution for supporting global Internet and it provides other advantages such as seamless Internet connectivity, and flow-based routing by using multiple network interfaces in NEMO. However, multihoming-based schemes vary in address attaining process. This results in variations in handoff latency that decreases handoff performance (*i.e.*, lower throughput and packet delivery ratio). Thus, handoff performance of the schemes

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differs with mobility rate that depends on the speed and number of the MR. For that reason, it is essential to analyze the handoff performance of individual multihoming-based scheme.

The main objective of this paper is to provide a comparative evaluation of the multihoming-based scheme in mobile environment. To performance comparison, two schemes have selected are mainly- NEMO BSP and multi-interfaced schemes [8, 10]. These schemes are the representative of NEMO scheme.

The contribution of this paper includes: (i) proposed a multihoming-based scheme on PMIPv6 domain to support seamless handoff (ii) developed a simulation model to analysis the handoff performance of the schemes via simulation approach using Network Simulator version 3 (NS3), and (iii) new outcomes indicating the effectiveness of multihoming-based scheme for MRs concerning handoff delay, packet delivery ratio and throughput at different number of MR, speed and time. Results achieved in this work will support the network engineer to select a suitable multihoming-based scheme in mobile environment.

The rest of this paper is structured as follows: Section 2 presents basic operation of NEMO BSP and multi-interfaced scheme followed by the proposed multihoming-based scheme in section 3. Section 4 gives the detail of simulation evaluation and outcomes. This is followed by the conclusion in Section 5.

2. Basic Operation of NEMO BSP and Multi-interfaced Scheme

With the worldwide deployment of multiple radio access technologies as well as growing stipulations for continuous Internet connectivity, NEMO BSP has been recommended via the NEMO working group [3]. The elementary chore of this protocol is to form a bi-directional tunnel in the middle of a MR as well as its Home Agent (HA). Data packets are conveyed to the HA by utilizing this tunnel for a MNN in mobile environment. Afterwards, the HA encapsulates data packets as well as ahead them to the MR. In turn, the MR decapsulates the data packets. This is to forward them to the MNN. Actually, it is vital to concern with both the MR and its MNN for NEMO BSP. The handoff procedure with timing diagram of NEMO BSP is depicted in Figure 1. In the car-based mobility, the MR need to perform handoffs frequently as the car travels fast. Higher handoffs delay causes lower network performance (*i.e.*, lower throughput and packet delivery ratio) [8-10]. As a result, the diminution of handoff delay is the most significant requirement to achieve seamless handoff for real time application scenario in NEMO environment.

In order to minimize the above mentioned issues in NEMO BSP, the authors have suggested a multi interfaced handoff scheme in NEMO network [8, 10]. According to these scheme, binding updates are preprocessed inside the MCoA. Because of using multiple interfaces as shown in Figure 2, packet loss can be avoided. Moreover, it is probable to exploit multiple tunnel instantaneously. Through evaluation, it is noticed that multiple interfaced MR can provide better network performance during movement among different access network.

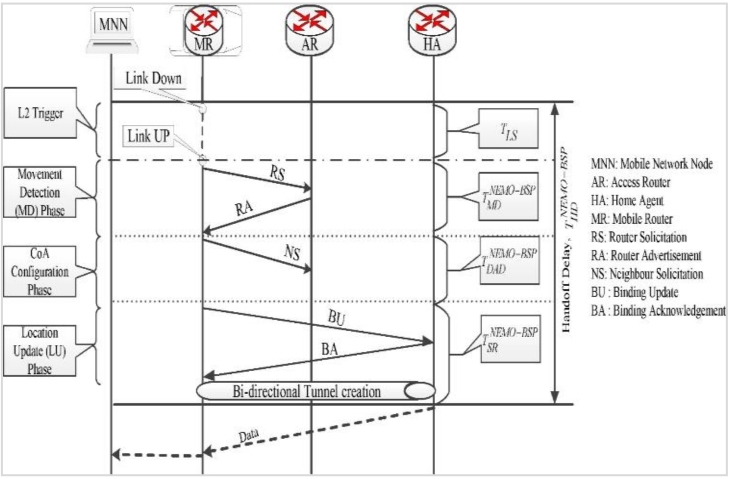

Figure 1. Handoff Procedure of Standard NEMO BSP

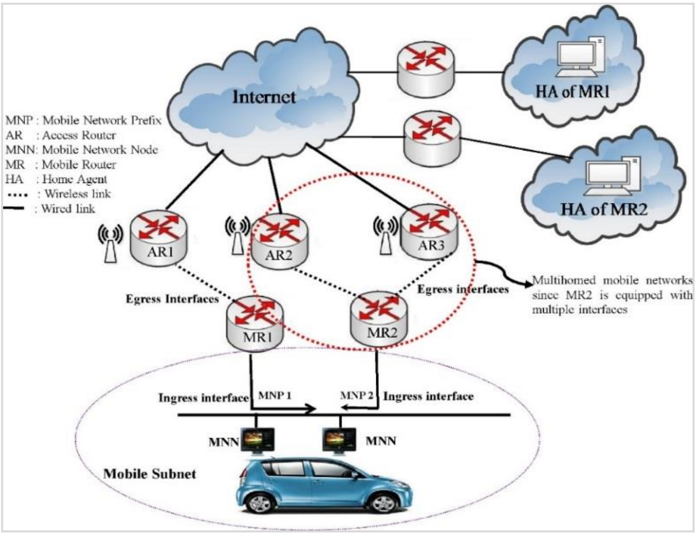

Figure 2. Multi-interfaced Scenarios in NEMO Environment

3. Proposed Scheme

This section propose a multihoming-based scheme on Proxy MIPv6 domain except dealing any mobility related signaling via the entities such as MR or MNN. Entire signaling related task is managed by the network entities (*i.e.*, Local Mobility Anchor (LMA) and the Mobile Access Gateway (MAG)) as in Proxy NEMO (PNEMO) [6-7]. According to the proposed scheme as shown in Figure 3, the LMA and MAG behaves like a Home Agent (HA) and Access Router (AR) in NEMO BSP and multi-interfaced schemes respectively. Consequently, the LMA is capable to retain multiple Binding Cache Entries (BCE) for the MR.

According to the proposed scheme, MR need to accomplish uplink strategies to select the exact outbound interfaces. Henceforth, it is deemed that MR employs single Virtual Interface (VI). This is to hide the Physical Interfaces (PI) as well as to support inter technology handoff as depicts in Figure 3.

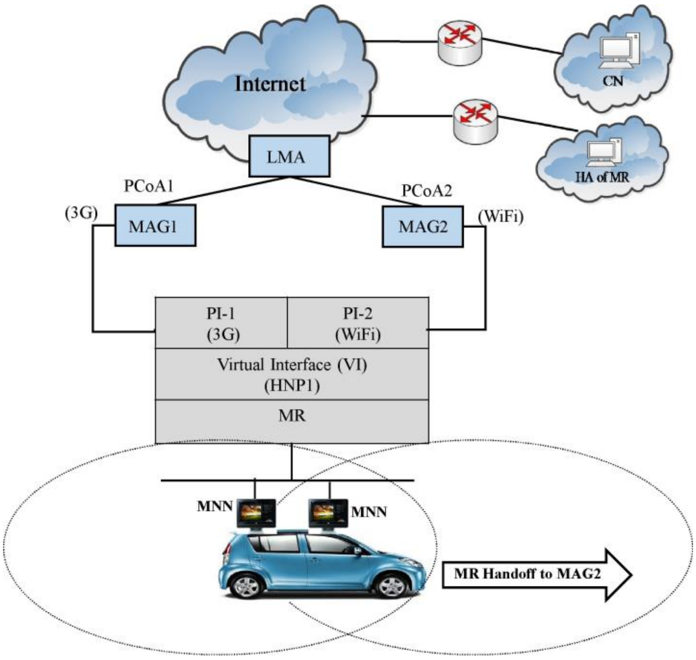

Figure 3. Proposed Multi-interfaced MR to Support Multihoming

A VI coherently bond multiple PI in order to act as a single interface to the L3 (*i.e.*, network layer) as depicts in Figure 4 [12]. VI is placed among L3 as well as L2. It is capable to attach both MAG1 and MAG2 instantaneously by employing several interfaces. Lower as well as upper layers transmits entire packets through the VI layer. The VI maintains a Flow-enabled Routing List (FRL). This contains Home Network Prefix (HNP), Mobile Network Prefix (MNP), Application Flow (AF) type as well as ID of PIs. FRL manages the status of each PI. Moreover, it allocates individual flow to the specific PI. As soon as the MR comes to an overlapping area (*i.e.*, 3G and WiFi), the MR receive the PI information via User Policy Profile (UPP).

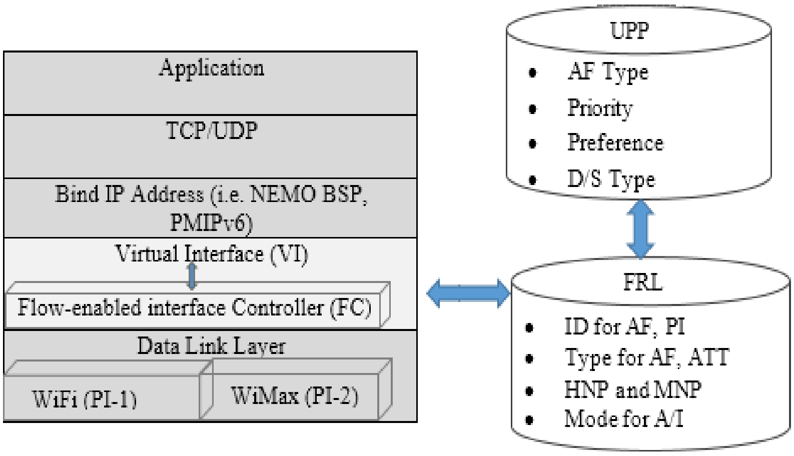

Figure 4. Basic Structure of VI

3.1. Enhanced Packet Processing in the Proposed Scheme

Usually, after receiving the downlink packets at the LMA, it eradicates the packets header. Afterward, it looks for a BCE matching the HNP and MNP of that data packet. Once, the LMA gets a BCE, it sends the data packet to MAG2 of the

BCE. If BCE does not exist, the LMA just drip that specified data packet. According to the proposed scheme, the LMA support inter technology handoff in the proposed scheme. Therefore, it initially utilize the application flow type in the FCE for processing data packet. This is to elect the directing path of the downlink packets. Subsequently, the packets are directed to the MAG corresponding to the HNP of the identical flow for directing.

4. Performance Evaluation

This sub-section evaluates the performance of the proposed scheme via Network Simulator version 3 (NS3) [11]. It need to be noted that NS 3 is capable to supports multiple interfaces completely. NetAnim and gnuplot are utilized to study, visualize or process the figures gained via simulation [11].

The considered simulation scenario is depicted in Figure 5. 3G and WiFi interfaces are on PMIPv6 domain. In the beginning, the MR is attached to the 3G access network though the WiFi access network remains idle. For performance appraisal, simulation has conducted considering the scenarios as follows:

1. Handoff between same access networks (3G to 3G), and
2. Handoff between different accesses networks (3G to WiFi).

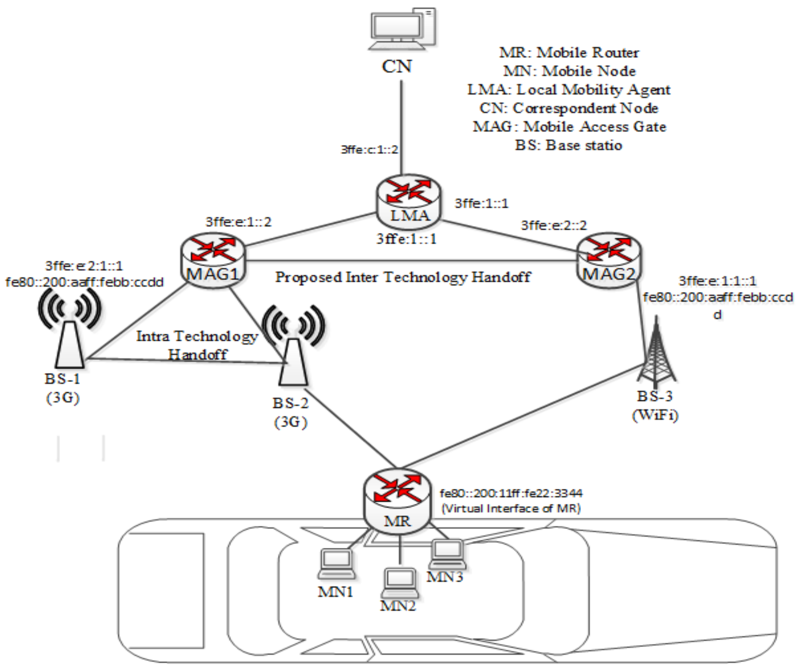

Figure 5. Simulation Scenario of the Proposed Scheme

4.1. Results Analysis

The parameters used for simulation are listed in Table 1 [11].

Table 1. Parameters Used for Simulation

Parameter	Value
Simulator	NS3.12.1
Operating system	Linux Ubuntu 12.04
Packet size	1024 bytes
No. of connections per MR	2
Types of technologies supported by MR	3G and WiFi

Figure 6 shows the average handoff delay of the proposed scheme, NEMO BSP and multi-interfaced scheme during inter technology handoff as a function of changing speed. Analyzing the same figure, it is perceived that the average handoff delay for all scheme increase linearly as soon as the speed change during inter technology movement. It is also apparent that, the proposed scheme and multi-interfaced scheme experiences lower handoff delay. This is due to the use of multiple interfaces. In contrast, the MR requires to inform HA for each movement in NEMO BSP. This increases handoff delay. Moreover, the LMA manages entire local mobility in the proposed scheme. As a result, the handoff rate is not much higher in the proposed scheme. This results in lower handoff delay. The handoff delay in the proposed scheme is less (.015 sec.) compared to NEMO BSP (.022 sec.) and multi-interfaced (.035 sec.) scheme. This lead to network performance improvement.

Figure 7 illustrates the influence of increasing the number of MR on packet delivery ratio. The speed is set at 60 m/sec. Packet delivery ratio is measured in percentage as in Figure 7. The outcomes elucidates that, increased number of MR does not influence much on the proposed scheme compared to that of NEMO BSP as well as multi-interfaced scheme. This is because, applying multihoming features on PNEMO domain has supportive influence on the packet delivery ratio for the proposed scheme.

Figure 8 depicts the variation of time on throughput. Here, the number of MR is set as 30. It is noticed that the proposed scheme provides maximum throughput compared to NEMO BSP and multi-interfaced scheme. This is because, entire mobility-related L3 signaling messages are swapped through the wireless link in NEMO BSP and multi-interfaced scheme. In contrast, the LMA and MAG controls all the signaling related in the proposed scheme. Moreover, it is also appeared that, the NEMO BSP provides lower throughput compared to the proposed scheme and multi-interfaced scheme. This is because of using single access technology in NEMO BSP. As soon as the MR moves away from current access router (*i.e.*, MAG1 in the proposed scheme/ AR2 in multi-interfaced scheme), it is still capable to transmit data traffic via the new access router (*i.e.*, MAG2 in the proposed scheme/ AR3 in multi-interfaced scheme).

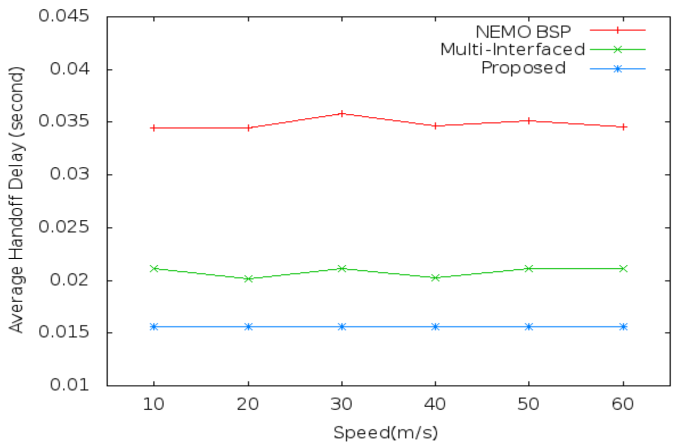

Figure 6. Average Handoff Delay vs. Speed

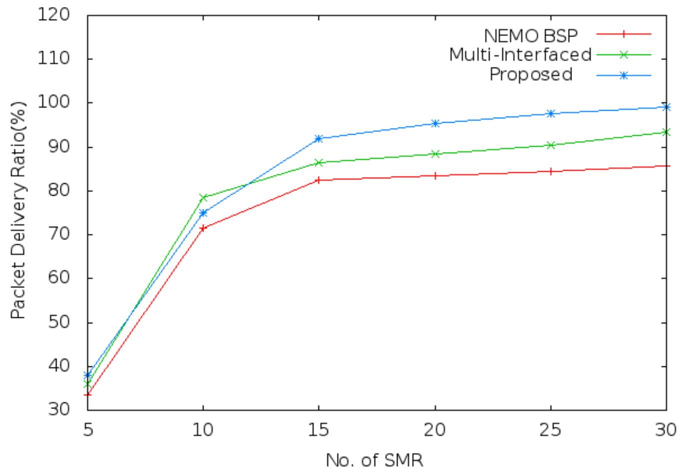

Figure 7. Packet Delivery Ratio vs. No. of SMR

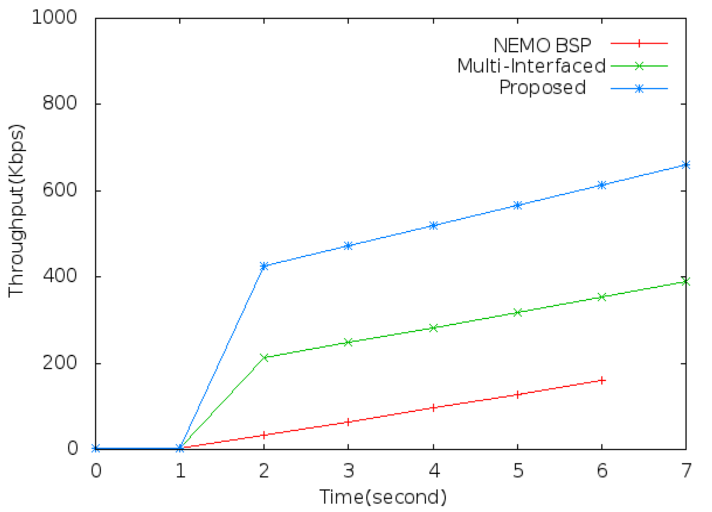

Figure 8. Throughput vs. Time

5. Conclusion

This paper offered a multihoming-based scheme to provide continuous Internet connectivity on PMIPv6 domain. The performance of the proposed multihoming-based network mobility scheme is evaluated using NS3 simulator and compared with the NEMO BSP and multi-interfaced scheme. The achieved outcomes showed that the proposed scheme has attained noteworthy enhancement by maximizing the throughput, packet delivery ratio as well as reducing the handoff delay compared to the NEMO BSP and multi-interfaced scheme. Combined mechanisms are recommended for link selection as future work. This is to handle with a bigger set of wireless access technologies.

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