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QoS AMENDMENT TOWARD SEAMLESS HANDOVER IN NETWORK MOBILITY NEMO

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ABSTRACT

Network Mobility Basic Support (NEMO BS) protocol is an extension of Mobile IPv6. It provides collective mobility for a bunch of nodes in vehicular area network. The standard NEMO BS (RFC 3963) protocol suffers from a number of limitations, such as inefficient routing and increased handover latency. Most previous studies attempted to solve such problems have imposed an extra signalling load. Therefore, the mechanism of proposed scheme is based on Fast Hierarchical Mobile IPv6, which enhances Mobile IPv6 by reducing the latency of address configuration and the home-network registration. In this paper, to achieve seamless handover and delivery of real-time traffic in mobile environment, Differentiated Service model is deployed in NEMO network. The QoS management is coupled with mobility management at the IP level. In order to evaluate QoS within Mobility environment, NS-2 has been used. The simulation results demonstrate that the proposed scheme is a valuable solution for promising NEMO applications.

Keywords: mobile IPv6, FHMIPv6, NEMO, QoS, DiffServ.

INTRODUCTION

In the past few years, there has been tremendous attention given to Internet Protocol (IP) as it continues to shape and reshape our lives. Typically, it is presumed to be today main valuable candidate for the next-generation networks. The traditional IP (i.e. IPv4) was designed for fixed networks and Best Effort (BE) applications with low network requirements such as file transfer, web browser, spreadsheet, E-mail and so on. Consequently, it offers an unreliable service that is subject to packet loss, reordering, packet duplications and unbounded delays. Such service is completely inappropriate for real-time applications for examples, video conferencing, voice over IP (VoIP), and Video on Demand (VoD). As the Internet began to grow at a dramatic rate during the late 1980s and the early 1990s, engineers realized that the current version of IP protocol would not be adequate to meet the demands of the Internet's growth. Moreover, there was no mobility support provided at that time, which made it quite difficult for conventional IP to be used for mobile communications. Therefore, the new version of Internet Protocol (i.e. IPv6) brought some means of Quality of service (QoS) and mobility support. However, it still needs supporting mechanisms since ubiquitous mobile devices and services are widely proliferated. Working on QoS support in IP networks has led to three distinct approaches. Integrated Services (IntServ) (RFC 1633, 1994) is a QoS mechanism proposed by the Internet Engineering Task Force (IETF). This type of architecture is based on per-flow resource reservation. It is assumed that the resources must be explicitly managed in order to meet application requirements. The IntServ architecture proposes two classes of service, guaranteed service and controlled-load service [1]. By mid-1997 service providers felt that IntServ was not ready for large-scale deployment. Thus, due to the problems encountered in implementing and deploying the IntServ/RSVP architecture, another QoS mechanism known as Differentiated Services (RFC 2475, 1998) was proposed. It gives scalable service discrimination without the need of per-flow state and signalling at every hop or router as in IntServ. The DiffServ architecture achieves its scaling properties by defining a small number of different packet forwarding treatments known as Per-Hop Behaviours (PHB). The DiffServ architecture also proposes two classes of service like IntServ, Assured Forwarding (AF) and Expedited Forwarding (EF) [2]. Finally, the Multi-Protocol Label Switching (RFC 3031, 2001) is specified by the IETF mainly to be used in combination with the DiffServ concept. It is an advanced forwarding scheme that extends routing with respect to packet forwarding and path controlling. Moreover, it provides per-flow guarantees but it faces some complexity problems since MPLS domain routers have to run different routing algorithms to find the best QoS paths [3].

The IETF has also proposed a working group known as: Network Mobility (NEMO) (RFC 3963) [4], with the aim of extending existing host mobility solutions (i.e. an individual mobile device) to enable the movement of an entire mobile network in IPv6 as shown in Figure-1. Apparently, statistics showing that it is expected that more mobile users will be connected to the Internet rather than desktop PCs users. To be honest, people are spending time in their mobile phones more than ever before. These mobile users that may move onboard in aircrafts, ships, cars, buses or trains, are interesting to get similar QoS in their mobile terminals as in fixed terminals (i.e. wired networks) in order to run real-time applications properly. Subsequently, they can get the best crystal picture with clear voice without hassling. Therefore, these mobile

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networks should provide not only voice services but also data services for the mobile entity across heterogeneous environments. Combining mobility with QoS becomes a hotspot which is evoked potential investigations with active ongoing researches. A novel two-level aggregation-based QoS architecture was proposed in this paper [5] as a possible solution to provide QoS for NEMO network. QoS aggregation and SLS negotiation have introduced in both node-level and network-level in order to efficiently manage the QoS. A signalling protocol is also proposed to exchange information at both levels (i.e. node-level and network-level) as well as between the NEMO network and the visited network domain. Although, this work analyzes the difficulties faced by moving networks when providing QoS, the signalling protocol needs to be implemented in more detail. The authors in [6] have proposed a novel approach for a scheduling algorithm in network mobility. The authors assessed the performance of priority scheduling and fair scheduling. They proposed a scheduling algorithm named Adaptive Rotating Priority Queue (ARPQP) that implements priority first and fairness second policy. The ARPQP guarantees QoS by bounding the delay for the flows with higher priorities and maintaining the reasonable throughput for the flows with lower priorities. In this paper [7], a Bandwidth-sharing Reservation (BSR) scheme was proposed so that a NEMO can support QoS services. The proposed BSR scheme can support mobility and efficiently manage reserved bandwidth as well. Initially, in order to support mobility the proposed BSR scheme adopts the concept of HMRSVP to make advance passive reservations at neighbour networks. Moreover, seeking for efficient reserved bandwidth management, the BSR scheme reserves a sharing reservation tunnel from MR to its HA. The reserved tunnel is capable to not only increase the bandwidth utilization but also decrease the signal overhead caused by independent reservations from end users. The BSR has designed three reservation adjustment policies to further improve bandwidth utilization. Another attempt in this paper [8] to propose an improved scheme based on FHMIPv6 which mainly implements a combined-detection function between Mobile Node (MN) and Mobile Anchor Point (MAP) and calculates the Normalized Edit Distance to analyze the motion trial and estimate the motion pattern of MN. This scheme enhances the network performance as an intact particularly for MN with the ping-pong motion pattern.

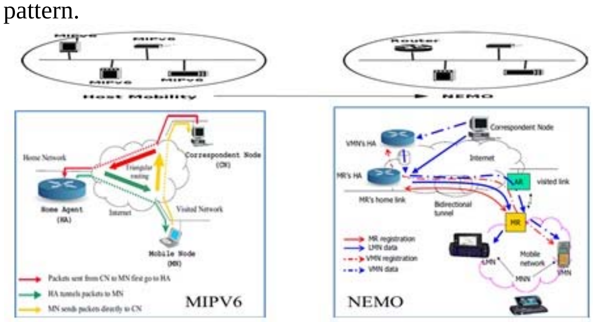

Figure-1. MIPv6 vs. NEMO protocol.

The remaining of this paper is prearranged as follows. Section 2 will deliberate the literature review. Next, section 3 will explore the proposed scheme, its challenge and its method. The performance evaluation and results of the simulation are covered in Section 4. Finally, conclusion is drawn in section 5.

LITERATURE REVIEW

Mobility can be classified into: host mobility and network mobility. Initially, this section will discuss the meaning of handover process. Afterward, host mobility protocols will be introduced in brief (such as MIPv6, FMIPv6, FHMIPv6 and FHMIPv6), in addition to network mobility basic support (NEMO BS) protocol as well.

Handover

Handover (or handoff) is a movement of Mobile Node (MN) or Mobile Router (MR) between two different attachments points (i.e. the process of terminating existing connectivity and obtaining new connectivity). In other words, it happens when the mobile node/router moves away from its HA, where the transmitted signal getting more likely weak. If MN/MR detects decreasing in the Received Signal Strength Indication (RSSI) of its attached access point, it will scan the current available access points and choose the best one with the strongest signal to connect to. Simply, MN/MR will break the connection with the HA and establish a new connection with the foreign agent if it senses stronger signals nearby. There are different types of handover classified according to different aspects involved in the handover such as L2 handover, Intra-AR handover, Intra-AN handover, Inter-AN handover, horizontal handover, vertical handover and so on so forth.

Mobile IPv6

Mobile IPv6 (MIPv6) (RFC 3775, June 2004) is a global mobility management protocol which designs to allow Mobile Node (MN) to maintain ongoing connections using a fix home address while roaming to foreign domains and networks. Thus, the movement of MN away from its home link is transparent to higher-layer protocols and applications. Even though the mobile node is away from the home network, it is always addressed using its home address. The protocol can provide mobility support that combines the experiences gained from the development of Mobile IP support in IPv4 and the new features of the IPv6 such as Route Optimization (RO), additional automatic IP configuration and the increased number of available IP addresses (it is allowing about 2^128 or 340, 282, 366, 920, 938, 463, 463, 374, 607, 431, 768, 211, 456 addresses). It also enables IPv6 nodes to cache the binding of a mobile node's home address with its care-of address, and then to send any packets destined for the mobile node directly to it at this care-of address [9]. In addition, there is no longer need to deploy special routers as Foreign Agents (FAs) that are used in Mobile IPv4. In Mobile IPv6, mobile nodes make use of the enhanced features of IPv6, such as Neighbor Discovery [10] and

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ARPN Journal of Engineering and Applied Sciences

Address Auto-configuration [11], to operate in any location away from home without any special support required from the local router. Moreover, in MIPv6, the home agent (HA) no longer exclusively deal with the address mapping, but each CN can have its own 'binding cache' where home address plus care-of address pairs are stored. This enables 'route optimization' without the need to triangle routing via the HA that occurs in MIPv4 (a CN is able to send packets directly to a MN when the CN has a recent entry for the MN in its corresponding binding cache). The route optimization [12] is now built in as a fundamental part of Mobile IPv6, rather than being added on as an optional set of extensions. To provide those optimizations Mobile Ipv6 requires the exchange of additional messages, defined as IPv6 Destination Options.

In Mobile IPv6, each MN is always given a home address (HoA) by the home network. While away from its home network, an MN is also associated with a care-of address (CoA), which provides information about the MN's current location. A special node Home Agent (HA) is designed to act as proxy for the MN when it moves away from the home network as illustrated in Figure-2. Discovery of new access router (NAR) is performed through Router Solicitation/Advertisement (RS/RA) messages exchange. This procedure is referred to as Movement detection. Moreover, to ensure that a configured CoA (through stateless or stateful mode) is likely to be unique on the new link, the Duplicate Address Detection (DAD) procedure is performed by exchanging Neighbor Solicitation/ Advertisement (NS/NA) messages. If the sequent duplicate address detection process is performed successfully (i.e. after acquiring a CoA) an MN performs binding update to the home agent through binding update (BU) and binding acknowledgment (BAck) messages exchange. The home agent records that binding update in its binding cache. To enable route optimization (RFC 4866, May 2007), BU procedure is also performed to all active CNs. However, return routability (RR) procedure must be performed before executing a binding update process at CN in order to insure that BU message is authenticated and does not originate from a malicious MN. The RR procedure is designed to verify that the mobile node is reachable at both its home address and its care-of address.

The home address must be verified to prevent spoofing of binding updates. While the care-of address must be verified to protect against denial-of-service attacks in which the correspondent node is tricked to flood a false care-of address with packets. Although RR procedure helps to avoid session hijacking, it increases delay of the BU procedure. If the CN sends packet directly to a MN, it won't encapsulate the packet as the HA did when received packet from the CN, instead it makes use of the IPv6 Routing Header Option. When the CN does not have a binding cache entry for the MN, it will send the packet indirectly to the MN's home address. The home agent (HA) will then forward the packet to MN. Once the MN receiving encapsulated packets, it will inform the corresponding CN about the current CoA. However, MIPv6 requires mobile nodes to perform the home network registration and an address resolution procedure, which results in long handover latency and degrades severely the transport protocol performance. As the number of MNs increases in the Internet, the number of BUs increases proportionally and adds a significant extra load to the network. Moreover, the scalability problems arise with MIPv6 since it handles MN local mobility in the same way as global mobility. Therefore, several extensions have been proposed to enhance MIPv6 performance such as Fast Handovers for MIPv6 (FMIPv6), Hierarchical MIPv6 (HMIPv6) and Fast Hierarchical MIPv6 (FHMIPv6).

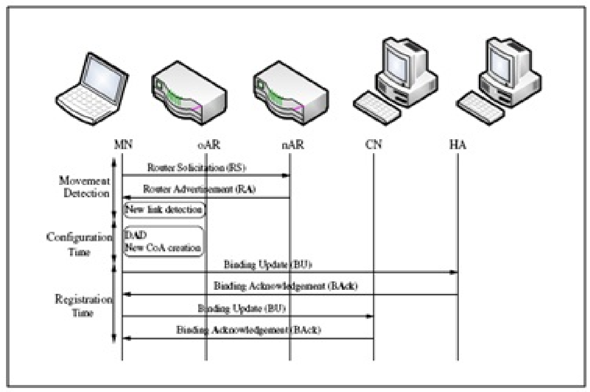

Figure-2. Components of IPv6 handover.

Fast handover protocol

The Fast Handover for Mobile IPv6 (FMIPv6) protocol (RFC4068) is an enhancement to MIPv6 that addresses the following concerns regarding to: how to allow a MN to send packets as soon as it detects a new link, and how to deliver packets to a MN as soon as its attachment is detected by the new AR. The protocol has proposed by the Internet Engineering Task Force (IETF) to reduce handover latency and minimize service disruption by anticipating handover and performing some operations prior to a break of the radio link. Therefore, it is known as low latency address configuration protocol because it configures a valid new address to the mobile node while it is still connected to the previous link (i.e. new care-of address NCoA). The FMIPv6 introduces seven additional message types: Router Solicitation for Proxy Advertisement (RtSolPr), Proxy Router Advertisement (PrRrAdv), Handover Initiate (HI), Handover Acknowledgement (HAck), Fast Binding Update (F-BU), Fast Binding Acknowledgement (F-BAck), and Fast Neighbor Advertisement (FNA).

Fast handover consists of three phases: handover initiation, tunnel establishment and packet forwarding. When an MN is aware of its movement towards an NAR through an L2 trigger, the MN must perform a fast handover procedure. Then, after connecting to the NAR, the MN immediately sends Fast Neighbor Advertisement (FNA) option message without the need for route discovery in order to inform its presence, so that arriving

VOL. 10, NO. 21, NOVEMBER 2015 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

and buffered packets can be forwarded to the MN as shown in Figure-3. There are two types of Fast Handover, the Predictive Fast Handover and the Reactive Fast Handover. The main difference between these two schemes is on the time to establish the tunnel between the PAR and NAR. By the predictive handover, the tunnel is established before layer 2 handover, but by the reactive handover, the tunnel is established directly after layer 2 handover. In other words, Predictive Fast Handover is the fast handover in which an MN is able to send an FBU when it is attached to the PAR, which then establishes forwarding for its traffic (i.e. even before the MN attaches to the NAR). A complement to Predictive Fast Handover is Reactive Fast Handover in which an MN is able to send the FBU only after attaching to the NAR [13].

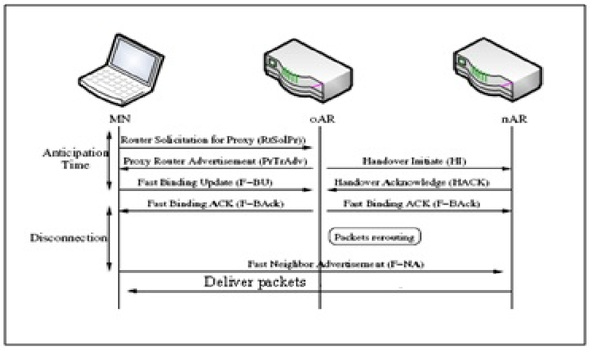

Figure-3. FMIPv6 signaling massages.

Hierarchical handover protocol

Mobile IPv6 handles local mobility and global mobility in the same fashion. So, the mobile node sends Binding Update (BU) to HA/CNs regardless of its movements within or outside the domain. This provokes unnecessary signaling overhead, registration delay, packet loss and latency. To address this problem, HMIPv6 has introduced a new special entity called Mobility Anchor Point (MAP) as shown in Figure-4. The MAP basically acts as a local Home Agent (HA) to separate between local and global mobility. Local mobility management within the local domain is managed by the MAP, while global mobility management is still managed by Mobile IPv6.

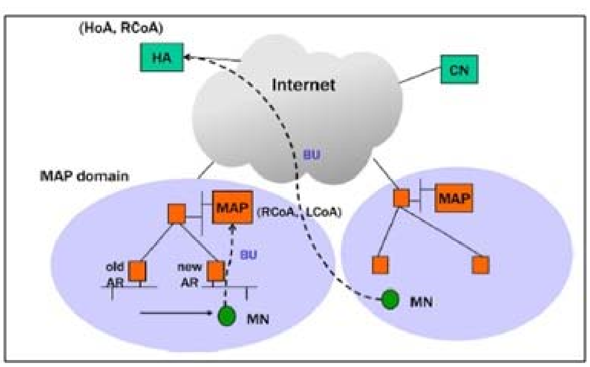

Figure-4. Hierarchical mobile IPv6 (HMIPv6) protocol.

In HMIPv6 a MN has two types of addresses: a regional care-of address (RCoA) and an on-link care-of address (LCoA). The RCoA specifies a particular domain of the Internet and is known as global address. The LCoA is known as locally unique address within the domain. As long as, an MN moves within MAP's domain it does not need to send out BU messages to HA/CNs, but only to MAP when its LCoA changes. Hence, the movement of an MN within MAP domain is hidden from HA/CNs. Accordingly the latency and signaling overhead problem in Mobile IPv6 could be reduced considerably. On the other hand when an MN moves from one MAP domain to a new MAP's domain BU messages need to be sent by the MN to its HA/CNs to notify them of its new location [14].

Fast hierarchical handover protocol

The Combination of HMIPv6 and FMIPv6 tends to provide fast handover scheme in Hierarchical mobile IPv6. F-HMIPv6 protocol is designed to enable an MN to exchange handover signaling message with a local MAP and establish bi-directional tunnel between the MAP and the NAR rather than between PAR and NAR as per FMIPv6. It involves the pre-configuration of the new care-of address used at the new access router by the mobile node at the old access router during the handover and the early binding update (i.e. LBU) at the MAP by the mobile node. Thus, Fast Handover for Hierarchical Mobile IPv6 (F-HMIPv6) reduces the overall handover latency (due to movement detection latency and new CoA configuration), signaling overload and allows more efficient network bandwidth usage [15].

Network mobility protocol

In order to support the movable networks, the IETF has been developed the basic support protocol called as Network Mobility (NEMO) protocol. It permits an entire network to roam by handing over between home and foreign network as in Mobile IP. The Mobile Router (MR), which connects the network to the Internet, runs the NEMO Basic Support protocol with its Home Agent (HA). Basically, the MR performs several functions on behalf of the Mobile Network Nodes (MNNs). Therefore, the protocol is designed so that network mobility is transparent to the nodes inside the Mobile Network. Figure-5 shows the mobility network architecture. Mobile Routers (MRs) act as gateways for the nodes inside the mobile network. The MR has a unique IP address and has one or more prefixes that it advertises to the Mobile Network Node (MNN)s attached to it. Furthermore, the mobile router has two interfaces, egress and ingress. It can access the Internet through the egress interface and detect movements (by listening for router advertisement messages) and registers its location (by sending binding update messages) using the egress interface. It also provides accessibility to its own MNNs, which are attached to its ingress interface that has its own network prefix. There are different types of MNNs: a Local Fixed Node (LFN) that does not move with respect to the mobile network and is supported by the MR to achieve connectivity, a Local Mobile Node (LMN) that usually resides in the mobile network and can move to other networks, and a Visiting Mobile Node (VMN) that is attached to the mobile Home network arriving from another mobile network on a temporary basis and it actually doesn't belong to the mobile Home network. LMNs and VMNs are Mobile IPv6–capable by default. They are usually referred as mobile nodes. Mobile node is typically connected to network that called the home network where MR is registered with a router called Home Agent (HA). The HA is notified of the location of the MR and re-directs packets that were sent by the Correspondent Node (CN) to MNNs [4].

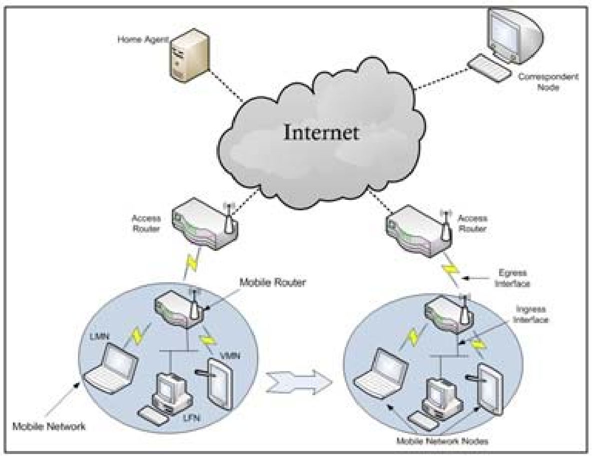

Figure-5. Architecture of mobile network (NEMO).

The MR establishes a bi-directional (MR-HA) tunnel with its Home Agent (HA) to pass all the traffic between the MNNs and the correspondent nodes. When a MR moves away from its home network and changes its point of attachment, it acquires a new Care-of Address (CoA) from the visited network. It then sends a Binding Update (BU) to its HA which creates a cache entry binding MR's home address with its CoA , and creates a tunnel between HA and MR. Also, the MR informs its HA with Mobile Network Prefixes (MNPs). The MNP is used by the MR's HA to intercept packets destined for an MNN within the NEMO. When a correspondent node sends data to a MNN, it is routed to the HA of MR. The HA checks at its cache entry and forwards the packet to the MR using the bidirectional tunnel. Finally, MR receives the packet, decapsulates it, and forwards it to the corresponding node destination in the mobile network. In a simple scenario for network mobility, the network contains a mobile router and a set of mobile nodes. While in a complex mobility scenario, a mobile network may itself be visited by other mobile nodes or other mobile networks (i.e. Nested NEMO and multihomed NEMO). To differentiate between them, Nested NEMO occurs where mobile network is attached to other mobile network or precisely when the VMN is actually MR and it has its own MNNs. In contrary, Multihomed NEMO exists where the mobile network comprises of multi-egress interfaces on MR, multiple MRs in mobile network or mobile networks associated with multiple HAs. As we can perceive from Figure-6 the end-to-end data transmission between a local node MNN and its Correspondent Node (CN) is simple. HA1 will directly forward the flows created by MNN1 to the destination CN and the CN would also send the flows destining to MNN1 directly to HA1. In this situation, all the packets need to be encapsulated once during the transmission.

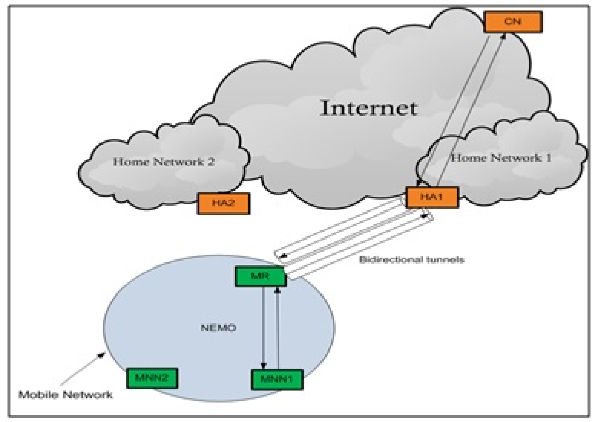

Figure-6. Data transmission for local MNN in NEMO.

However, the situation is become much more complicated if the MNN is a visiting node. In Figure-7 if MNN2 desires to communicate with its CN, there would be a bidirectional tunnel between MNN2 and HA2, according to the design of NEMO.

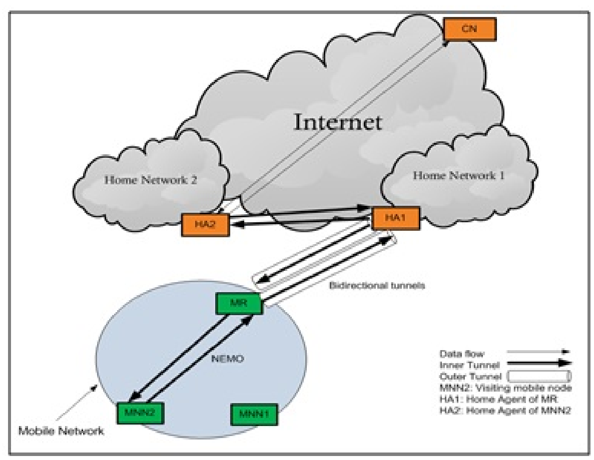

Figure-7. Data transmission for visiting MNN in NEMO.

Moreover, there would be two tunnels exist through the path between MR and HA1, since there is a prior bidirectional tunnel between MR and HA1. The multiple tunnels lead to long delay and large number of signaling messages, which makes it difficult to apply existing QoS mechanisms to NEMO. Consequently, in this

VOL. 10, NO. 21, NOVEMBER 2015 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

paper we focus on a simple topology of Network Mobility Basic Support protocol for the time being.

THE PROPOSED SCHEME

In this section, we endow with an alternate scheme to improve QoS in the native NEMO protocol. The proposed scheme is referred to as DiffServ Fast Hierarchical Network Mobility (Diff-FH NEMO) scheme. We explain its challenge and how the proposed solution works to maintain communication session between MNN and CN during handover. As, we can see from Figure-8 the proposed architecture is based on a simple IPv6 network with mobility support and DiffServ model composite within the network to offer privilege QoS guaranteed service. The entire network literally moves as single unit (e.g. Bus, train or aircraft). The DiffServ Mobile Router (DMR) moves within same MAP domain which is called micro/intra mobility mode. The proposed scheme takes for granted that the DMR in the proposed architecture has the functionally of the Edge Router (ER). So, it will be empower to implement the police. Further details can be found in [16] and [17].

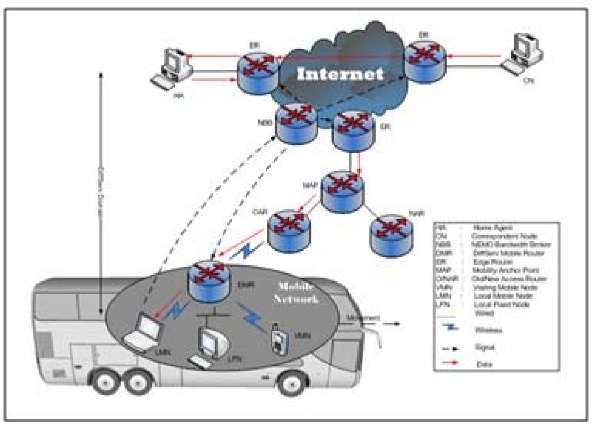

Figure-8. The proposed network topology in micro/intra movement.

The proposed scheme challenge and obstacle

In the standard NEMO Basic Support protocol, when a Mobile Router (MR) changes its point of attachment to the Internet, handover takes place. The handover process encounters different types of delays such as Link layer handover (L2 handover) delay, Movement Detection (MD) delay, Duplicate Address Detection (DAD) delay and Registration delay. The overall handover delays might be unacceptable for certain applications. Thus, reducing the handover latency could be beneficial to real time and non real time applications as well. The proposed scheme functions to reduce the registration delay by optimizing Binding Update (BU) traffic. The mobile router in the proposed architecture DMR only sends a local BU to the local MAP in case of micro movement, rather than the Home Agent (HA) and Correspondent Node (CN), as done in the standard NEMO. If the distance from the DMR to HA/CN is long, this local BU will considerably reduce the time required for the binding update. Moreover, the proposed scheme improves the latency related to Movement Detection and CoA configuration/Verification.

When the MR moves from one link to another, its HA will continue forwarding packets to its previous Care-of Address (CoA) until the mobile router updates the HA about its movement which results in packet losses. Thus, it is important for the MR to update the home agent as soon as movement to a new link is detected.

However, the MR might face some challenges in home network registration process. The problem arises when binding update message is lost due to congestion in the wireless channel or for other reasons. Whereby, the mobile router will be unreachable while it is been away from its home network. In view of the fact that BU messages might be lost due to abnormal condition into the network, this is will invoke a new retransmission of BU request periodically after a timeout. Causing some sort of handover latency for the MR as well as packet losses. Therefore, minimizing or completely eliminating the loss of BU messages is the main key approach in this proposed scheme.

The proposed scheme develops in way to manage the performance of DMR's handover by employing DiffServ to work out the problem of any sort of binding update (i.e. FBU, LFBU or BU) messages loss. The intention is to achieve acceptable seamless handover with desirable QoS required for real time applications.

The mechanism of the proposed scheme aims to utilize the existing building blocks in DiffServ (such as classifier, meter and marker) to improve QoS guarantees service for the mobile network nodes. To accomplish that the Fast Binding Update that launched from DMR to the intended Mobility Anchor Point (MAP) will be given high priority in the flow of Expedited Forwarding (EF) by the ingress edge router (ER) that was embedded within DMR in the proposed architecture as illuminated in Figure-9. This will reduce the probability of reactive mode occurrence. Then considerable signals massages can be minimized in the proposed scheme. In same way the Local Binding Update (LBU) message will be giving high priority as well as Binding Update (BU) message if the DMR moves to a new MAP domain and it required to update the HA and CN. Unlike NEMO BS protocol, all the data packets that have been sent from CN will be buffered into new access router instead of being dropped, since the proposed scheme exploits the advantages of F-HMIPV6 [15].

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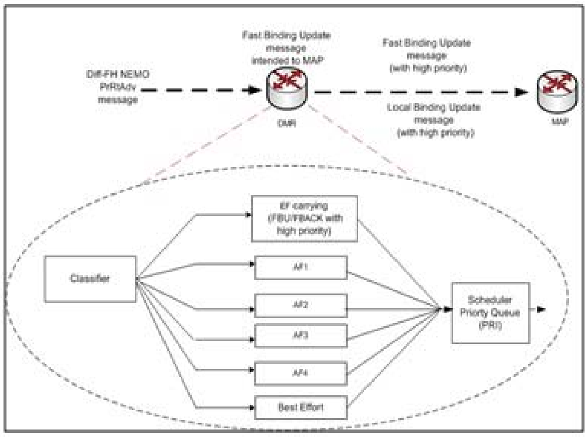

Figure-9. The appointment of high priority to binding massages.

The native NEMO BS protocol is an extension of MIPv6. The Mobile IPv6 defines a new IPv6 header type known as mobility header (RFC 3775). The mobility header is used to carry the Binding Update message in addition to other Mobile IPv6 messages such as Fast Binding Update, Fast Binding Acknowledgment, Handover Initiate, Handover Acknowledge, and Fast Neighbor Advertisement messages. In other words, the mobility header is used as a toggle switch to indicate which message is included on it. When a binding update is included in the mobility header, [MH type] field is set to 5 in the binding update message format. The Fast Binding Update message has a Mobility Header Type value of 8. The FBU is identical to the Mobile IPv6 Binding Update (BU) message. However, the processing rules are slightly different. The [M] flag in NEMO Binding Update message indicates MAP registration (i.e. LBU). When a DMR registers with the MAP, the M and A flags should be set to 1 in order to distinguish this registration from a BU being sent to the HA or a CN (i.e. in case of macro mobility). Moreover, in IPv6 packet header there are 8 bits for Traffic Class field (TC) corresponding to the Type of Service (TOS) in the IPv4 header. The use of this field enables Differentiated Services (DiffServ). In general, hosts or routers can set this field to indicate that certain massages require priority forwarding over others (e.g. real-time versus Best-Effort forwarding). The DiffServ code point "101110" is always being assigned to DS field of packet header that carries FBU, LFBU or BU massages. Accordingly they will be forwarded as the EF flow with high priority [18]. The EF is the premium class of service that can be offered by the DiffServ platform. It provides a flow with small delay and jitter as well as with low packet drop rate. To achieve such performance, EF packets have higher priority than other classes in DS domain (e.g. Assured Forwarding and Best Effort). Expedited Forwarding requests that every router in the cloud of DiffServ should constantly serve EF flow that carrying the binding update message as fast as possible. Since the scheduling queue in Expedited Forwarding flow is very small or almost empty, the FBU, LFBU and BU messages are rarely being dropped. Priority Queue algorithm (PRI) has been chosen as a scheduler at all of ER and CR in the proposed architecture to provide QoS in NEMO networks [19]. It can provide service differentiation by classifying the arriving data to different priority classes. The PRI scheduler at the output link is very strict to ensure that EF will always get better treatment compared to AF and BE class. Also, it has the advantage of being simple and easy to implement as scheduler for traffic at each output link in DiffServ domain.

The modified proxy router advertisement message

For the best handover design, the proposed scheme (Diff-FH NEMO) extends Proxy Router Advertisement message (RFC 4443, March 2006) to include DiffServ QoS desired information on certain Access Routers. This is to notify the DMR with pre-defined the service classes in DiffServ and the current available resource in the AR even before the DMR performs handover to new point of attachment as shown in Figure-9. The new message is referred to as DiffServ-FHMIPv6 NEMO Proxy Router Advertisement (Diff-FH NEMO PrRtAdv) message. It can be seen from Figure-10 that the three sub-fields include the recent available bandwidth and dropping percentage information of each class of service on Access Router. While the last row indicates that the proposed scheme assigns EF flow to any binding updates (e.g. FBU, LFBU and BU). The AR sends (Diff-FH NEMO PrRtAdv) message to the DMR which includes the following information:

- The three classes available by the DiffServ (i.e. the Expedited Forwarding, Assured Forwarding and Best Effort services classes).
- The percentage of drop precedence that is used for policy restriction according to the three classes.
- The available bandwidth reserved for each class.
- Specifying the EF to the Fast Binding Update (FBU) Local Binding Update (LBU) and Binding Update (BU) messages.

Managing and controlling the traffic resource are indispensable for (real-time or non real-time) mobile applications in order to run as they should be. So, if the DMR moves into an overlapping area of multiple Access Routers, it will use the advertised information as criteria to choose instantly the AR with best matched resources available.

8 bits	8 bits	16 bits
Type	Code	Checksum
Subtype	Reserved	Identifier
DSCP=EF	Drop precedence %	Bandwidth (Mbps)
DSCP=AF1, AF2,AF3, AF4	Drop precedence %	Bandwidth (Mbps)
DSCP=BE	Drop precedence %	Bandwidth (Mbps)
DSCP(EF)= FBU+LBU+BU		
Options...		

Figure-10. The format of extended DiffServ-FHMIPv6 NEMO proxy router advertisement message (Diff-FH NEMO PrRtAdv).

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The proposed scheme method

The proposed scheme (Diff-FH NEMO) has two generic methods of operations, predictive and reactive mode. In this paper we focus only when the DMR performs micro/intra mobility movement (i.e. roaming within same MAP domain).

1) Operation of the Proposed Scheme (Diff-FH NEMO) in Predictive Mode of Micro/Intra Mobility Handover:

The detailed description for the operation procedures are given below and the sequence of messages used in the proposed scheme is illustrated in Figure-11. As we know that, the link layer information (L2 trigger) is used either to forecast or rapidly accelerate network layer handover events. DMR can only scan and find the access point (AP) with a better signal to switch to but it does not know whether or not the AP is attached to a new AR. Only the link layer knows the link layer address and AP names. Therefore, based on L2 handover anticipation, the DMR will know its movements toward NAR (i.e. the prefix for its new link) and can obtain a prospective new Care–of Address while still connected to the old AR. The DMR also needs to check whether this address is valid on the new link (i.e. Duplicated Address Detection). Nevertheless this cannot be done until it moves to the new AR.

i. Use The DMR sends a router solicitation for proxy (RtSolPr) message to Old AR in order to request the information of New AR which is a new on-link care-of address (LCoA). The RtSolPr message should contain information about the network prefix, link layer address or identifier of the NAR network.

ii. On receiving of RtSolPr, the OAR replies with the extended Diff-FH NEMO PrRtAdv message that comprises the network prefix of NAR, IP address, link-layer address of the router serving the access point whose identifier the DMR has supplied and QoS awareness information that has been mentioned in previous section.

iii. By means of the prefix information the DMR will configure new CoA (i.e. NLCoA) using stateless auto-configuration or stateful configuration.

iv. The DMR sends Fast Binding Update (FBU) message to MAP with high priority in order to associate previous PLCoA with new NLCoA (i.e. IP address of the NAR).

v. After receiving the FBU message from DMR, the MAP will start handover procedure and send a Handover Initiate (HI) message to the NAR. This HI message comprises the request of verification for pre-configured NLCoA and establishment of bi-directional tunnel for preventing routing failure during handover.

vi. In response to the HI message, NAR verifies the availability of NLCoA through DAD (Duplicated Address Detection) and establishes bi-directional tunnel to MAP by using HACK (Handover Acknowledgement).

vii. The MAP sends Fast Binding ACK (FBACK) messages toward the DMR over PLCoA and NLCoA. This FBAck message is used to report status about validation of pre-configured new CoA and tunnel establishment to DMR.

viii. The old AR binds the old CoA with new CoA and tunnels any packets addressed to PLCoA towards NLCoA through NAR's link. The NAR buffers these forwarded data packets that have been marked with a Differentiated Service Code Point (DSCP) value into IPv6 packet headers, until the DMR attaches to NAR's link.

ix. The DMR announces its presence on the new link by sending Router Solicitation (RS) message with the Fast Neighbor Advertisement (FNA) option to NAR. Subsequently, NAR delivers the buffered packets to the DMR. Moreover, the DMR decapsulates DSCP data packets and forwards them to intend MNN.

x. The DMN gets the RCoA on that MAP's domain and its LCoA from the current AR. Afterward, it sends a Local Binding Update (LBU) with high priority containing both RCoA and LCoA to MAP in order to create the binding between the two addresses. The LBU also includes a mobile network prefix (MNP). When MAP receives LBU with the new LCoA (NLCoA) from DMN, it will stop packets forwarding to NAR and then clear the established tunnel.

xi. In response to LBU, the MAP sends Local Binding ACK (LBAck) to the DMN.

xii. The MAP stores the binding in the Binding Cache (BC) and forwards the LBU to the DMR's Home Agent (HA) and Correspondent Nodes (CN) as well, in order to make them aware of the current RCoA. Next, it is also received (LBAck) in return. However, as far as DMR moves through different ARs in the same MAP domain, it does not need to inform the HA and CN about its movement (i.e. new LCoA), because the RCoA remains unchanged and only the LCoA has been modified.

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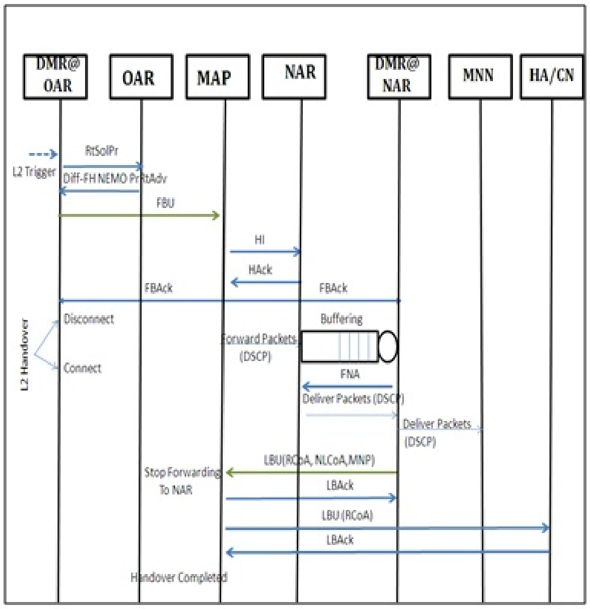

Figure-11. The sequence messages in the predictive micro/intra mode for the proposed scheme.

2) Operation of the proposed scheme (Diff-FH NEMO) in Reactive Mode of Micro/Intra Mobility Handover:

The reactive mode is merely a counterpart to the previous predictive mode. This mode is used to solve the various failure/erroneous situations. The procedure of the reactive mode is shown as Figure-12. The DMR might lose its connectivity to the AR due to sudden degradation in the link, which causes the link layer implementation to switch to new AR before the anticipated time. So, there are two types of failure/erroneous cases could happen due to the DMR's rapid movement from the previous link to the new one:

A. FBU not sent: in this scenario the DMR anticipated its movement but did not have time to send FBU to request the MAP to forward the packets to the new link.

B. FBack not received: in this scenario the DMR sent FBU but did not receive the acknowledgment because the DMR has left the link after sending the FBU.

In order to solve the former case, when the DMR attaches to the new AR, it can send FBU with high priority to the MAP. Since the NAR already received the HI message, a tunnel is setup to MAP. Consequently the FBU is forward via the tunnel and the packets are rerouted to the DMR's new location.

On the other hand, the FBack in the latter case is the confirmation of received FBU. However, the DMR is not determined that the MAP has successfully processed the FBU. Therefore, in order to solve the latter erroneous case:

- As soon as, the DMR attaches to NAR, it will forward FBU with high priority encapsulated in the FNA message to NAR.
- If, NAR detects that NCoA is occupied (namely there is address collision) while processing the FNA, it must discard the inner FBU packet and send a Router Advertisement (RA) message with the Neighbor Advertisement Acknowledge (NAACK) option in which NAR may include an alternate IP address for the DMR to utilize.
- Otherwise, the NAR forwards FBU to MAP which responds with FBack.
- At this time, MAP can start tunneling any packets addressed to PCoA towards NCoA through NAR's link. Then, NAR may deliver these packets to the DMR.

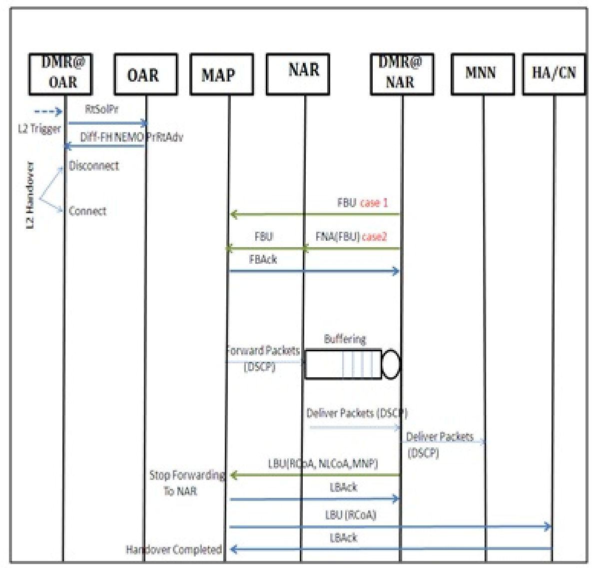

Figure-12. The sequence messages in the reactive micro/intra mode for the proposed scheme.

PERFORMANCE EVALUATION AND RESULTS

This section presents the performance assessment of the proposed scheme (Diff-FH NEMO) that provides QoS solution in mobile network environments. The simulation studies compare the proposed scheme with the standard Network Mobility Basic Support (NEMO BS) protocol for benchmarking. The proposed scheme has been implemented in the network simulator (NS-2) version 2.28 [20], patched with NEMO BS extension [21] which is based on MobiWan [22] that has been built by MOTOROLA Labs Paris in collaboration with INRIA PLANETE team and FHMIP extension as well [23]. Figure-13 shows the simulated topology for intra-domain scenario when the DMR handovers within the MAP area.

The simulation scenario includes Correspondent Node (CN) and Home agent (HA) that are connected to an Edge router (ER) with 2 ms link delay and the transmission rate for the link is 2Mbps. The link bandwidth between ER and the MAPs is 1Mbps link with

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5 ms link delay. Access routers (AR)s are connected to MAPs with 6ms link delay over 1 Mbps links. The ARs are further connected to the Base Station (BS) with 9ms link delay over 0.9 Mbps links. The wireless technology that has been used in the access network is a simple 802.11 between the base stations and the DMR. All nodes have a hierarchical address. The CN is generating Constant Bit Rate (CBR) flow that will be marked with a different DSCP towards a MNN of the NEMO network. UDP source provides constant traffic where no acknowledgments are needed. This type of traffic is usually generated by real-time applications. The "CBR" is configured to generate 1K Byte packets at the rate of 100Kbps. Some of selected simulation values and traffic management algorithms are tabulated in following Table-1.

Table-1. Simulation parameters.

Simulation time	200 (Sec)
Simulation space size	1600 x 800
Pause time	0 (Sec)
Average DMR speed	0.5 (m/s)
The type of data flow	CBR
Transport layer agent	UDP
Admission control	Token Bucket
Buffer management	RED
Scheduler	Priority Queue(PRI)
Routing protocol	NOAH
MAC	Simple IEEE 802.11
Packet size	1000bytes
IEEE 802.11 radius (transmission range)	150 meters

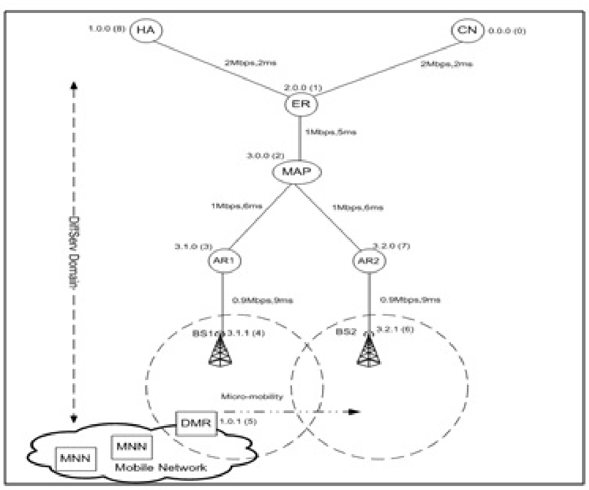

Figure-13. Simulation topology in micro movement.

Figure-14 shows the average throughput comparison between the standard NEMO BS protocol and proposed scheme (Diff-FH NEMO) during various network loads. As we can see from the graph, when the network load increases from 300kbps to 2400kpbs, the average throughput deteriorates conspicuously. The heavy network load will lead to exceeding saturation bandwidth limit for the wired network link and wireless channel which is instigated BU loss and attained less throughputs. The proposed scheme achieves the highest average throughput which is 188Kpbs compared to NEMO BS protocol. However, the average throughput will decrease slightly when the network load exceed 900Kpbs. This is due to the fact that, the proposed scheme implements mechanism to mark and assign binding update massages with high priority since the network does get congested. Moreover, the utilization of resource (i.e. bandwidth) will be improved in the proposed scheme by using EF and AF per-hop behavior to be serviced in a manner to achieve the best throughput in both small and large time scales. On the other hand, under heavy network load the average throughput will decrease rapidly in NEMO BS protocol and it could reach out to 78Kbps which is relatively incongruous to real-time applications.

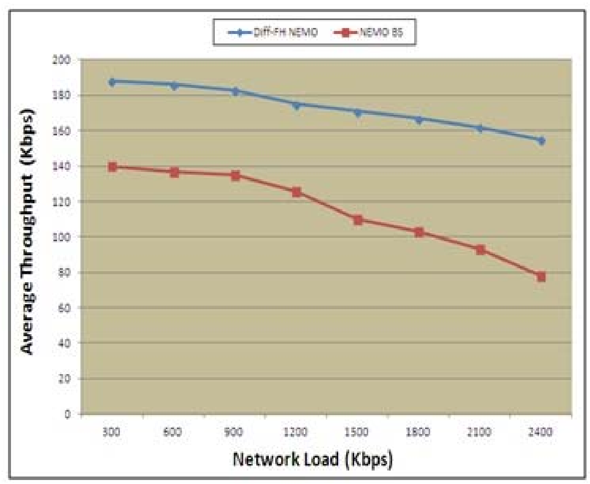

Figure-14. Average throughput result.

Figure-15 presents the impact of adjusting the network load on the average End-to-End delay in case of the standard NEMO BS protocol and proposed scheme (Diff-FH NEMO). It has been observed that, when the network load increases the average End-to-End delay will be amplified (especially when the traffic load was exceeded 0.9 Mbps). The standard NEMO BS protocol noticeably has the worse delay (i.e. 4100 ms) compared to the proposed scheme. Increasing load steers to congestion in the network that could cause End-to-End delay due to loss of the BU. The BU loss in the standard NEMO BS protocol instigates the mobile router to retransmit the BU message to the Home Agent (HA) until an acknowledgement is been received or when the maximum timeout value for binding is accomplished.

This type of retransmission is based on binary exponential back-off or truncated binary exponential back-off algorithm. As stated by this algorithm, the mobile router doubles the time between each repeated retransmission of BU message that has been sent, often as

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ARPN Journal of Engineering and Applied Sciences

part of network congestion avoidance. The first BU would necessitate more time since the HA have to wait for Duplicate Address Detection (DAD) operations which is a critical factor and it would take 1 to 2 seconds possibly. So, it can be concluded that the loss of binding update message has negative impact on the End-to-End delay. On the other hand, the average End-to-End delay remains almost or slightly unchanged in proposed scheme (Diff-FH NEMO) when the network load varies from light load to heavy congestion. The proposed scheme improves the delay related to binding update traffic, movement detection and CoA configuration or verification. Furthermore, it ensures high priority for fast BU delivery and accordingly minimizes the drop probability of fast BU. The extended the Proxy Router Advertisement message will help to reduce the probability of reactive mode occurrence once the fast BU loss due to vast network load. Consequently, the End-to-End delay would be improved and decreased the overhead of the fast BU retransmission compared to the standard NEMO BS protocol.

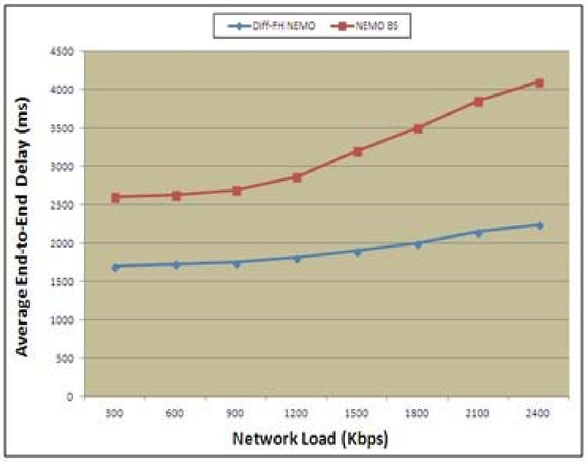

Figure-15. Average end-to-end delay result.

CONCLUSIONS

In this paper, we proposed a new QoS-based scheme into vehicular networks. The handover performance will be adversely affected, as the loss of Binding update (BU) message in NEMO BS protocol does occur. Therefore, we adapt and extend the proxy router advertisement message to provide seamless handover for mobile users in the proposed scheme (Diff-FH NEMO). Network simulation version two (NS-2) tool is utilized to simulate the performance of the proposed scheme. The obtained results reveal that the proposed scheme (Diff-FH NEMO) outperforms the standard NEMO BS protocol in terms of average throughput and End-to-End delay. Amalgamating QoS within NEMO network is fairly yet unexplored area and is certainly demanding further investigations.

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