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A Scheme (Diff NEMO) for Enhancing QoS in Network Mobility

[1]Loay F. Hussein, [1]Aisha-Hassan A. Hashim, [1]Mohamed Hadi Habaebi and [2]Wan Haslinah Hassan
[1]Department of Electrical and Computer Engineering, Kulliyyah of Engineering, International Islamic University Malaysia, 50728, Kuala Lumpur, Malaysia
[2]Department of Electronic Systems Engineering, Universiti Teknologi Malaysia, Malaysia

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Corresponding Author:
Loay F. Hussein,
Department of Electrical and Computer Engineering, Kulliyyah of Engineering, International Islamic University Malaysia, 50728, Kuala Lumpur, Malaysia
Tel: +60142375323

ABSTRACT
Network mobility basic support protocol (RFC 3963) is a novel thought for handling a bunch of nodes within a moving vehicular area. Namely, this protocol upholds continuous internet connectivity to nodes by establishing a bi-directional tunnel between Mobile Router (MR) and Home Agent (HA), when the MR of a mobile network changes its point of attachment. The bi-directional tunnel is set up as soon as the mobile router sends a successful Binding Update (BU) to its HA in order to inform the home agent about its current point of attachment. All traffic flow between the nodes in the mobile network and correspondent node must pass through the HA. This leads to sub-optimal routing that can surely disrupt and deteriorate all communications to and from the Mobile Network Nodes (MNN). Even the overheads can be further amplified if mobile networks are nested which is unacceptable for real-time applications that require certain Quality of Service (QoS) restrictions. Therefore, this study endeavors to propose a new scheme that bypasses the HA to cater optimal path and take the advantage of DiffServ to enhance QoS in the network mobility. The performance of the proposed scheme has been evaluated by using Network Simulator (NS-2). Subsequently, it benchmarked with the standard NEMO BSP that was proposed by Internet Engineering Task Force (IETF). The obtained results show that the proposed scheme outperforms the standard NEMO BSP in terms of packets loss rate and the probability of dropping BU.

Key words: NEMO, QoS, DiffServ, route optimization

INTRODUCTION

During the last decade, telecommunications users have increasing requirements. They usually request more multimedia content, a better Quality of Service (QoS) (Ferguson and Huston, 1998) and support of mobility. This constitutes a main challenge that networking researchers are facing nowadays to deal with enormous evolution of wireless networking technology, mobile services and applications. The challenge is further expanded when the demand for mobility is not restricted anymore on a single host. Internet is evolving towards more ubiquitous and pervasive architecture where the mobile users are expected to be able to access different heterogeneous technologies (i.e., having accessibility anytime and anywhere). The Internet Engineering Task Force (IETF) working group has proposed Mobile IPv4 (MIPv4) (Perkins, 2002) and Mobile IPv6 (MIPv6) (Johnson *et al*., 2004) as the main protocols for supporting IP mobility to a single host or mobile node. Various enhancements to the MIPv6 protocol have been already proposed since it is believed that in certain cases Mobile IPv6 could result in a poor performance. These enhancements are Fast Mobile IPv6 (Koodli, 2009), Hierarchical Mobile IPv6 (Soliman *et al*., 2008) and Fast Hierarchical Mobile IPv6 (Jung *et al*., 2005). Nevertheless, we are now witnessing the emergence of mobile networks, namely a set of hosts that move collectively as a single unit such as on ships, trains, buses and aircrafts. To support network mobility, the IETF working group (RFC 3963) has been commissioned to propose NEMO basic support protocol in order to extend host mobility support

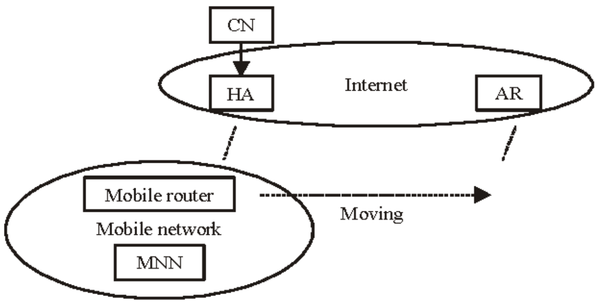

Fig. 1: Basic network mobility (NEMO) elements

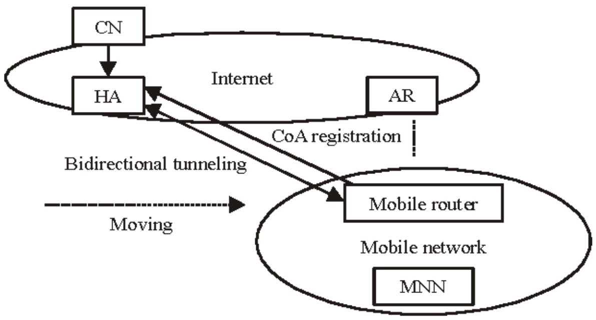

Fig. 2: Network mobility (NEMO) architecture

protocols (Devarapalli *et al*., 2005). NEMO extension is backward compatible with Mobile IPv6. It ensures session continuity and reachability for all the nodes (whether Mobile IPv6 nodes or non-Mobile IPv6-enabled nodes) in the mobile network when it moves or even when the Mobile Router (MR) changes its point of attachment to the internet as shown in Fig. 1.

The mobile router in a mobile network works on behalf of all Mobile Network Nodes (MNNs) to perform mobility functions. It provides continuous connectivity to the MNNs within its network through an ingress interface since the MR advertises a network prefix belonging to the home network topology and all the mobile network nodes configure addresses from this prefix which is known as the Mobile Network Prefix (MNP). Therefore, their addresses and communications are not impacted by mobile router changing its point of attachment (i.e., its Care of Address CoA). Namely, those MNNs are unaware of the network mobility and they don't perform any mobility functions unlike Mobile IPv6. Moreover, the mobility is hidden from correspondent nodes as well. When the MR moves away from its home network, it acquires a CoA as the MN does in MIPv6. To setup a bidirectional tunnel with the HA, the MR first sends a Binding Update (BU) message to the HA and the HA then replies with a Binding Acknowledgement (BA) message. The bi-directional tunnel between the HA and MR have endpoints with the address of the HA on one end and the CoA of the MR on the other end. When packets are originated from a Corresponding Node (CN), they are sent through this tunnel. The MR then decapsulates these packets and forward them to the corresponding MNN. Likewise, the packets are encapsulated at the MR end and decapsulated at the HA when they are originated from an MNN as illustrated in Fig. 2.

The goal of the network mobility is to effectively reduce the complexity of handover procedure and keep the mobile devices connected to the internet. However, the customers of mobile network nodes not only need mobility but also quality. To offer QoS guaranteed service in NEMO network, the proposed scheme deploys Differentiated Service (DiffServ) model (Blake *et al*., 1998). The DiffServ is the most promising model among many of QoS solutions that have been proposed IETF due to its simplicity and scalability advantages. Nonetheless, this approach was initially designed without mobility in-mind. Hence, it is not fully adapted to mobile environments yet, especially in a network that might move as single unit and attach to arbitrary points in the routing infrastructure. Therefore, integrating and cooperating QoS with mobility support seems to be needed to fulfill the necessity of users.

Most of works have been focused in the literature to manage the mobility of a single host. Recently, many of the research proposals have been moved on and extended to improve the performance of the NEMO basic support protocol. However, few of them address the investigation of integrating DiffServ within mobile environment and optimizing the route as well. In this study (Tlais and Labiod, 2005) a new resource reservation protocol called NEMO Reservation (NEMOR) proposed to support QoS guarantee in NEMO context. Authors used generic signaling protocol called NSIS that exploits advantages of both IntServ and DiffServ models to provide a suitable QoS to NEMO. This study builds a virtual tunnel of reserved resources to ensure the aggregation of various flows using RSVP. The claim proposition was developed in two phases: The MR-HA and HA-CN. However, the NEMOR protocol was written as an internet draft and has not been extended for further work. Also, no performance evaluation study was conducted in order to appreciate the benefits and gauge their associated overhead.

ArunPrakash *et al*. (2009) have proposed a seamless handover scheme across heterogeneous networks, by using multiple MRs, each MR has its own Home Agent (HA) that belongs to different Internet Service Providers (ISPs). They advocate that the MR that undergoing the handover process sent two binding update messages to its HA (the first one using HoA of the staid MR instead of its current CoA, the second is to use the CoA of the MR that is not under handover process) to support Network Mobility Basic Support (NEMO BS).

Wakikawa *et al*. (2003), Jeong *et al*. (2004), Lee *et al*. (2004), Perera *et al*. (2003) and Ohinishi *et al*. (2003) have proposed route optimization ways out with the participation of nodes within the network. The generic idea of these schemes requires the MR when in a foreign network to obtain a care-of prefix (rather than just a single address) and re-advertise this location dependent prefix into the mobile network. The mobile network nodes can then auto configure a location specific care-of address which when communicated back to the correspondent nodes leads to optimal routing, as per MIPv6.

Petander *et al*. (2006) addressed the handover performance issue by proposing a novel Make Before Break (MBB) handoff scheme. In MBB scheme, the MR is equipped with two network interfaces, one for data communication and the other for scanning networks. These interfaces will take over the operation of each other, once a better connectivity is found; the scanning interface take over the data transmission and the other reverts to a scanning role.

In crowded motion environments, bottleneck is usually occurred between the access link and the mobile network. Prioritizing the traffic and allocating a minimum bandwidth guarantee for each user is vital in this environment. The reason behind that the challenging issues of the limited and variable wireless link bandwidth the resource management in mobile network. Noor and Edwards (2010) has proposed a dynamic QoS provisioning framework to provide traffic differentiation according to a user class. Resources were provisioned between the mobile router and mobile network nodes. Also, traffic was prioritized according to the user classes. The user class mechanism has provided bandwidth guaranteed for selected traffic classes even though there were worse link bandwidth utilization. However, the concept of route optimization is barely delivered in the model. Chen *et al*. (2010) studied the internet connectivity of multi-interfaced MR equipped with (WLAN-CDMA and GPRS) egress interfaces. An inter-interfaces handover decision algorithm is proposed to provide seamless handover between different interfaces.

MATERIALS AND METHODS

Proposed scheme: The topology depicted in Fig. 3, it based on an IPv6 network with mobility support and DiffServ model composited within the network to offer privilege QoS guaranteed service. The whole network literally moves as single unit.

The proposed scheme (Diff NEMO) aims to suit the needs of both QoS guaranteed and mobility in communication. Taking the advantages of Differentiated Service (DiffServ) approach into a count, our focus is to propose the necessary modification in NEMO to ensure that the seamless mobility with the required QoS parameters can be achieved. Differentiated Service (DiffServ) has been proposed by Internet Engineering Task Force (IETF) to extend the internet to be a QoS-capable, efficient and scalable network supportive. The Differentiated Services (DS) network architecture provides QoS guarantees in a scalable and least complex manner. Service differentiation is desirable to accommodate heterogeneous application requirements and user expectations. It interconnects heterogeneous wire-line/wireless networks with the internet backbone to provide end-to-end QoS and seamless roaming to mobile users. It also permits differentiated pricing of internet service.

The traffic flow that entered the proposed network topology will classify and possibly condition at the boundaries of the network by the Edge Router (ER). Then, the traffic flows are assigned to different behavior aggregates. Each

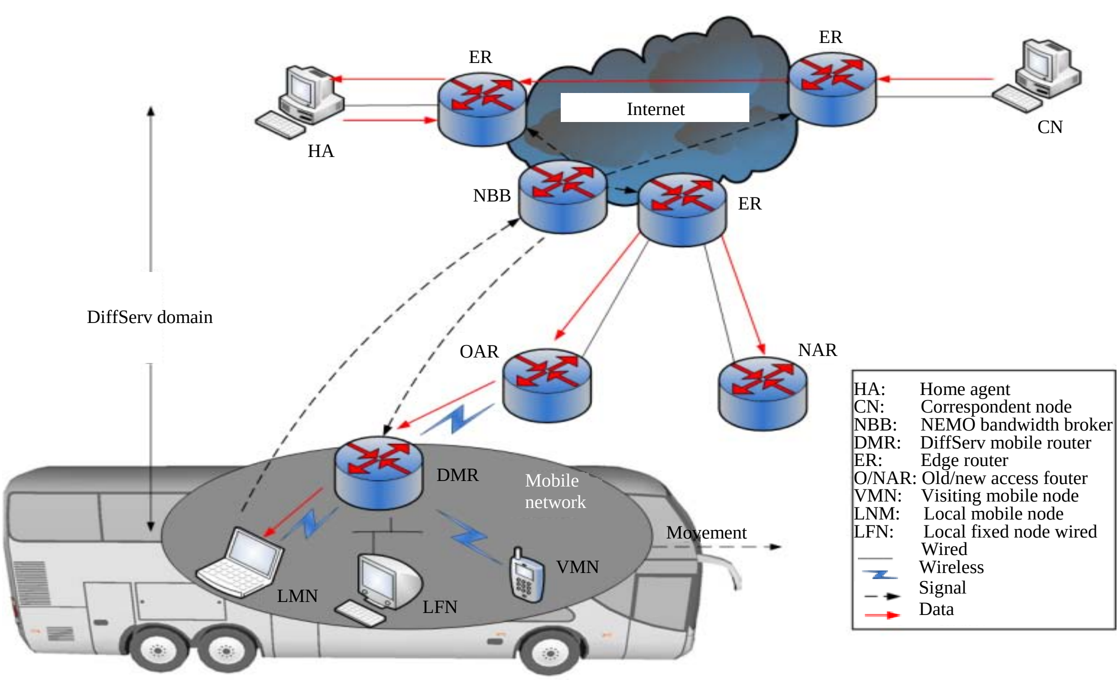

Fig. 3: Proposed network topology

8 bits	8 bits	16 bits
Types	Code	Checksum
Cur Hop limit	M | O | H | Reserved	Router lifetime
Reachable time		
Retransmission time		
DSCP = EF	Drop precedence (%)	Band width (Mbps)
DSCP = AF1, AF2, AF3, AF4	Drop precedence (%)	Band width (Mbps)
DSCP = BE	Drop precedence (%)	Band width (Mbps)
DSCP (EF) = BU		
Options...		

Fig. 4: Format of modified NEMO DiffServ router advertisement message (NEMO-Diff RA)

behavior aggregate is identified by a single DS codepoint. Within the core of the network, packets are classified and forwarded only according to the Per-Hop Behavior (PHB) associated with the DS codepoint. The proposed scheme assumes that the DiffServ Mobile Router (DMR) in the proposed architecture has the functionally of the Edge Router (ER). So, it will be empower to implement the police. Furthermore, the NBB acts as bandwidth broker to manage and monitor the network resource. By allocating resources to forwarding classes and controlling the amount of traffic for these classes, the framework will create different levels of services and resource assurance but not absolute bandwidth guarantees or delay bounds for individual flows. There are different types of Mobile Network Node (MNN):

- **Local Fixed Node (LFN):** This node does not wander with respect to the mobile network. Though, it is supported by the MR to achieve connectivity. Therefore, its IPv6 address is taken from a MNP of the NEMO to which it is attached
- **Local Mobile Node (LMN):** This node often resides in the mobile network. It can also move to other networks. LMN's home network is located in the mobile network. Besides, its home address (HoA) is taken from an MNP
- **Visiting Mobile Node (VMN):** This node is attached to the mobile home network arriving from another mobile network on a temporary basis. It actually doesn't belong to the mobile home network and its CoA is taken from an MNP

Mobile network node defines its requirements using SLA to request resources. In contrary, NBB agent has to perform admission control task by accepting or rejecting bandwidth requests. It maintains a database of parameters, in accordance with which reservations are made and then the DSCP for those services are going to be assigned. The negotiations for bandwidth allocation will initially occur between the MNN and NBB. After which, if the NBB accepts the QoS request to grant the resources, it will configure the edge routers and DMR to help optimizing the existing resources (i.e., controlling the network load).

Binding Updates (BU) message in NEMO is slightly different from that in MIPv6. In MIPv6 a BU contains the CoA and HoA of a mobile node, whereas in NEMO a BU contains additional information about the IP subnet prefix(es) of the mobile network which is called the Mobile Network Prefix (MNP). The BU seems to be the major message that used by the proposed scheme to notify the Home Agent (HA) or Correspondent Node (CN) with a new CoA belong to DMR, thus with new internet attachment point. In case the BU gets lost, the DMR will be unreachable while it is been away from its home network and route optimization with the CN would be unfeasible. This will result of some sort of packet losses for the DMR as well as handover latency, since the HA will continue forwarding packets to its previous care-of address and the retransmission of BU request will occur periodically after a timeout expired. Therefore, minimizing or completely eliminating the loss of BU messages is the main key approach in the proposed scheme in order to improve the location update latency.

The proposed scheme will be given high priority to BU message in the flow of Expedited Forwarding (EF) by the ingress edge router. Moreover, the proposed scheme extends the NEMO Router Advertisement (RA) message (RFC 3963) to include DiffServ QoS desired information on certain Access Routers (AR). 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 DMN performs handover. The new message is referred to as NEMO DiffServ Router Advertisement (NEMO-Diff RA) message. It can be seen form Fig. 4 that the three sub-fields include the recent available bandwidth and dropping percentage information of each class of service at access router. While the following row indicates that the proposed scheme assigns EF flow to binding update. So, if the DMR moves into an overlapping area of multiple ARs, it will use the advertised information as criteria to choose the new access router with best match required resources available.

As we know that, in NEMO Basic Support Protocol (NEMO BSP) the packets to and from the mobile network travel through a bidirectional tunnel (Conta and Deering, 1998) between a Home Agent and a Mobile Router (HA-MR).

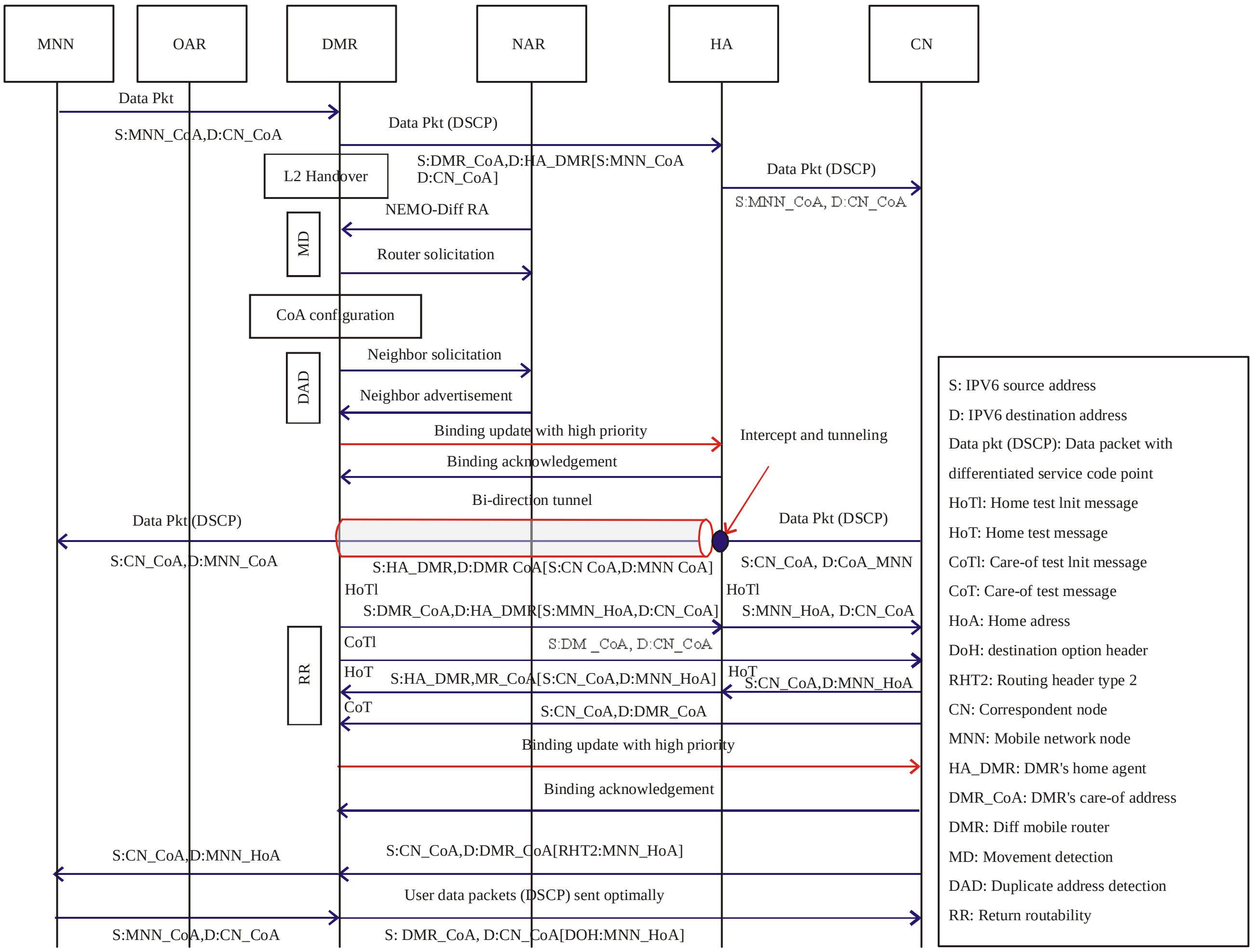

Fig. 5: Sequence messages in the proposed scheme (Diff NEMO)

Tunneling packets via the HA results in the problems of inefficient route and increased header overhead due to encapsulation. This will affect performance degradation of real-time and acknowledgement based data transfers. The problem evolves even further with increasing nested level which causes multiple encapsulation packets travel through multiple HAs. Inefficient routing that occurs in nested NEMO networks is commonly known as "pinball routing problem".

Hence, the proposed scheme optimizes location update traffic and tunneling overhead by employing the standard MIPv6 mechanisms to enable direct path communication between any kind of MNN and CN in the internet. It aims to provide QoS with optimal seamless mobility in communications among the users of mobile network node. Basically, updating the CN with CoA and HoA of the MNN (which is within the MNP) would require significant modifications to the CN. Thus, the idea of the proposed scheme is to enable a DMR to behave as a proxy for any MNN, by performing the packet exchange required by the MIPv6 route optimization procedure. The mechanism of proposed scheme (Diff NEMO) involves three phases: Address configuration, binding update procedure and packet delivery procedure.

Address configuration: The DMR intuitively moves from Old AR to a New AR when it performs handover procedure as shown in Fig. 3. It is used to maintain two addresses: Permanent address which is used when the DMR in its home network and temporary address which is used when the DMR in the visited network. The permanent address is called Home Address (HoA) while the temporary address is referred to as Care of Address (CoA) which is used to provide information about the DMR's current location. The control flows for the proposed scheme is illustrated in Fig. 5. At the first three steps the MNN sends data packets to CN via the proxy DMR. The DMR marks a Differentiated Service Code Point (DSCP) value into IPv6 packet headers and forward packets to the next hop. The only way for the DMR to know that it has been moved from subnets to another (or from OAR to NAR) is by performing movement detection (MD). So, discovery of New

Access Router (NAR) is performed through exchanging two messages, Router Solicitation (RS) and NEMO DiffServ Router Advertisement (NEMO-Diff RA). If the DMR notices the link prefix is changed, it will figure out the movement was occurred. Here the DMR has acquired a new CoA at the time it moved to a new sub-network (via stateless or stateful mode configuration). Moreover, to ensure that a configured CoA 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.

Binding update procedure: After acquiring a CoA, the DMR subsequently registers this CoA with the Home Agent (HA) by sending a Binding Update (BU) message in order to inform about its movement. Also, the DMR will use the information in the new (NEMO-Diff RA) message as hint to forward the BU with high priority. Moreover, the DMR ought to update the HA with Mobile Network Prefix (MNP), since it often delegates one or more address prefixes for use by MNNs inside its network. So, the HA needs to store this information in its binding cache in order to forward packets addressed to the DMR's home address from CN. The CN stores that information in its binding cache as well. Binding cache is usually maintained by both CN and HA. Each entry in the binding cache contains the DMR's home address, CoA, MNP and the lifetime that indicates the validity of the entry. Henceforth, the HA sends Binding Acknowledgment (BAck) message to indicate that forwarding to the DMR is set and creates a binding cache entry that maps the HoA and prefixes of DMR to the CoA of the DMR. According to NEMO terminology (Ernst and Lach, 2007), once the point of attachment of a mobile network changes due to mobility, DMR will perform handover to keep the movement transparent to MNNs. Therefore, the DMR has to carry out the Mobile IPv6 Return Routability procedure on behalf of all MNNs. To enable route optimization for the proposed scheme, BU procedure also has to be performed to all active CNs. However, Return Routability (RR) procedure should occur conclusively ahead of sending a BU message to intended CN in order to insure that BU message is authentic and does not originate from a malicious DMR. Namely, The RR procedure is designed to verify that the DMR is reachable at both its home address and its Care-of Address (CoA). The home address must be verified to prevent spoofing of binding updates (i.e., BU comes from DMR but not from other party). The CoA 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. In short, the return routability procedure is based on home address test (i.e., Home Test Init (HoTI) and Home Test (HoT) messages exchange) and care-of address test (i.e., Care-of Test Init (CoTI) and Care-of Test (CoT) messages exchange). The procedure of return routability process is briefly illustrated as following points as illustrated in Fig. 5:

- The DMR sends a Home Test Init (HoTI) message indirectly to the correspondent node by tunneling the message through the home agent
- The DMR sends a Care-of Test Init (CoTI) message directly to the correspondent node
- The correspondent node sends a Home Test (HoT) message in response to the HoTI message (sent indirectly to the DMR via the home agent)
- The correspondent node sends a Care-of Test (CoT) message in response to the CoTI message (sent directly to the DMR). Performance evaluation and results

Eventually, the DMR registers the binding update message with the CN (forwarded with high priority) and receives the Binding Acknowledge (BA) in return.

Packet delivery procedure: After the registration with the HA has been done, the communication steps proceed by receiving tunneled DSCP data packets in the DMR which have been originated by Correspondent Node (CN). This happens only when a correspondent node either does not yet have a binding for the DMR (correspondent registration is in progress) or does not support Mobile IPv6. Once the DMR registers the binding update message with the CN (which contains CoA's DMR, HoA's DMR and one or more Mobile Network Prefix options) and receives the BA in return, now the CN can only be capable to send the packets optimally direct to the current CoA of DMR bypassing the HA and inject a route to its routing table so that packets destined for addresses in the Mobile Network Prefix will be routed through the bidirectional tunnel. This is occurred to avoid routing traffic via the home network which may cause a potential bottleneck. In the proposed scheme the DMR is held responsible for illegal traffic sent from/to its mobile network nodes even though in route optimization. The Correspondent Node (CN) could be stationary node or mobile node with a CoA (i.e., CN_CoA). The CN will include also with DSCP data packets, type 2 routing header extension that contains the home address of the MNN (MNN_HoA). So, when the DMR receives the packet, it processes the type 2 routing header by remove it and logically replaces the destination address of the packet from the care-of address of DMR to the Home Address (HoA) of the MNN. From the application layer perspective, the data was addressed from the correspondent node address to the home address of the MNN. In same way the DMR sends the packets from its care-of address to CN and it will include destination options extension header which contains home address option that evolved home address of the MNN. When the correspondent node receives the packet, it logically replaces the IPv6 source address of the packet from care-of address of the DMR to the home address of MNN that was stored in the home address option. Again from the application layer perspective, the data was addressed from the home address of the MNN to the correspondent node address.

So, finally the users of the applications will think that, they are still communicating with CN from the MNN's home network and experiencing MIPv6 route optimization. This demonstrates uninterruptable connection to the users of the MNN with QoS assurances. Incoming and outgoing packets are kept marking differently with certain code point to create several packet classes in the proposed scheme.

As long as, the DMR is closer to MNN than the home agent, the route between MNN and the CN can be considered as optimal route. The proposed scheme exclusively relies on IPSec to secure all of signaling messages and tunnels (using IPSec Authentication Header (AH) and Encapsulation Security Payload (ESP) mechanisms).

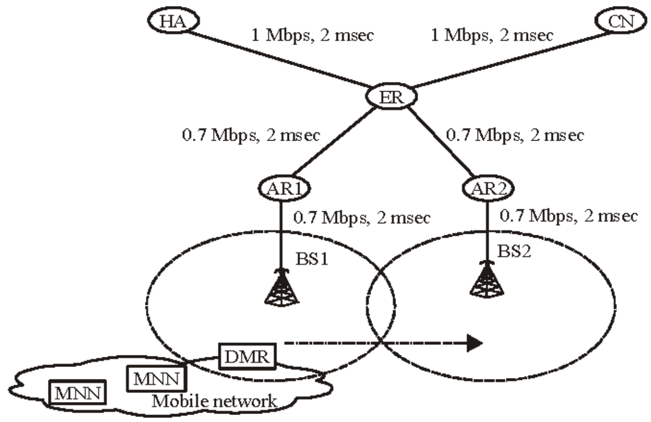

Fig. 6: Simulation setup topology

RESULTS AND DISCUSSION

This section presents the assessment and comparison of the performance of the proposed scheme (Diff NEMO) with the standard NEMO BSP. Packet loss rate and probability of dropping the BUs are the critical performance metrics that have been considered in following scenarios to evaluate the handover mechanism of the proposed scheme. Network Simulator (NS-2) tool version 2.28 has been used (Fall and Varadhan, 2011) for implementation, linked up with NEMO BS patch (Kong, 2008) which is an extension module from MobiWan (Ernst, 2001) built by MOTOROLA Labs Paris in collaboration with INRIA PLANETE team. The simulation space size has been set to 1600 by 800 m and the CBR data-flows are transmitted continually. The measured application is the CBR session which caters constant bit rate without acknowledgement at the receiver. The CBR traffic is usually generated by real time application. The topology of simulated network is presented in Fig. 6.

The simulation time is set to begin from 0 sec and finish at 200 sec. Once the simulation gets started the DMR is positioned nearby HA at the home network and launches an UDP session with CN. A "UDP" agent is attached to the correspondent node. The connection is established form the source "UDP" agent to "null" agent attached to the Mobile Network Node (i.e., LFN). A "null" agent frees the packets received. A Constant Bit Rate "CBR" traffic generator is attached on the top of "UDP" agent at CN. The "CBR" is configured to generate packets with size of 1 kB at rate 100 kbps. The "CBR" is set to start at 20 sec and stop at 200 sec. Correspondent Node (CN) and Home Agent (HA) are connected to an Edge Router (ER) with 2 msec link delay and the transmission rate for the link is 1 Mbps. The link bandwidth between ER and Access Routers (AR) is 0.7 Mbps with 2 msec link delay. The ARs are further connected to the Base Station (BS) with 2 msec link delay over 0.7 Mbps duplex link. The wireless technology that has been utilized in the access network is a simple IEEE 802.11 WLAN (between the base stations and the DMR) with 150 m radius and the overlap of two adjacent cells is 20 m. At 21 sec later from the simulation, the DMR moves within the range of the BS1 that is belonged to AR1. After a while, the DMR signs off from the previous base station range toward AR2 with a rate of 1 m sec^{-1} (approximate human walking speed) at 30 sec from the simulation start time. In the simulation topology, it is presumed that optimizing the resources have been taken under control (i.e., the MNN gets the required bandwidth in all mobile network domains). Consequently, this eradicates the need of NBB for sake of simplicity in simulation setup (since the proposed scheme scenario does not consider multi-homed or nested NEMO yet). Traffic management algorithms that have been chosen during the simulation are, token bucket rate-based policer for admission control, Random Early Detection (RED) for buffer management and priority queuing as scheduler. The MNN at endpoint is the destination while the source CN at other endpoint is considered to be fix node to avoid unnecessary drawbacks of simultaneous mobility (Liu *et al*., 2006).

Figure 7 shows the assessment of packet loss rate between the proposed scheme (Diff NEMO) and the standard NEMO BSP. In the simulation topology, when the wired link delay was varied (from 2-12 msec), the percentage of packets loss increases conspicuously. The reason behind that is the malfunction of the home network registration when the Binding Update (BU) message does experience link congested as per the standard NEMO BSP. The congestion increases proportionately with the wired link delay. In this scenario the congestion of the network is built by setting the total load to more than 700 kbps to achieve highly link congest. So, the channel is battling to cater to all applications with their requirements. Another reason for increasing the packets loss at HA is when the binding lifetime for the BU at binding cache was expired. Consequently, the packets that intercepted by HA to be sent to the intended DMR will be dropped drastically. It can be discerned that from Fig. 7 the proposed scheme (Diff NEMO) considerably decreased the packets loss rate less than the native protocol NEMO BSP. The proposed scheme appoints the edge router in DiffServ to assign the BU with high priority in the flow of Expedited Forwarding (EF). Once the DMR updates the HA and CN successfully, the route

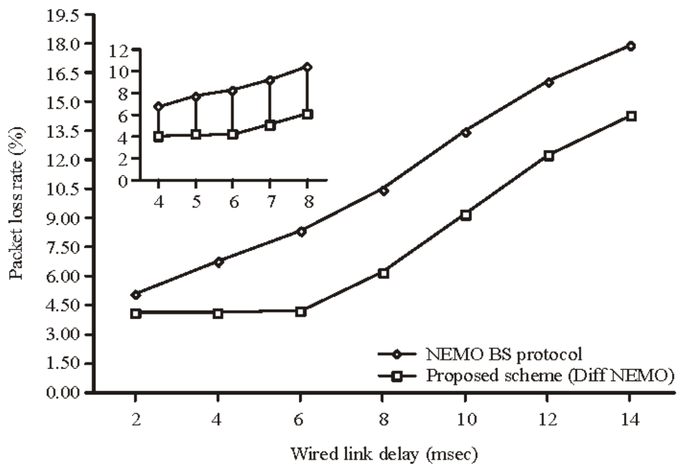

Fig. 7: Packet loss rate vs. the wire link delay

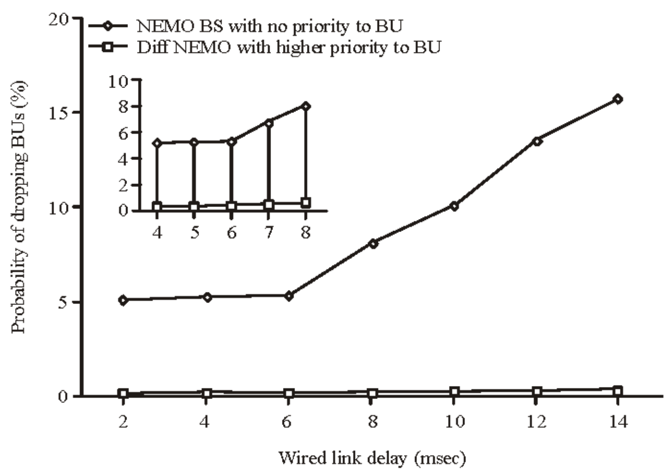

Fig. 8: Probability of dropping BUs vs. the wired link delay

optimization mechanism will be enabled in the proposed scheme to manage maintaining the packet loss slightly low. Accordingly, the overwhelmed losses of the packets were improved.

The graph in Fig. 8 presents the probability of dropping BUs with respect to the wired link delay. It is observed that when the BU doesn't assign with high priority as in the standard NEMO BSP and the wired link delay less than 6 msec, the probability of dropping BUs is about 5% (i.e., the BUs were dropped slightly). While if the wired link delay is raised to more than 6 msec, the probability of dropping the BUs turns out to be greater. This is due to the fact that the wired link delay at that time starts to increase the processing overhead of the network link that was overloaded by more than 1 Mbps to exceed the saturated bandwidth. Therefore, the overall capacity of all the mobile network nodes becomes much greater than the total capacity of the link. As a matter of fact, the probability of dropping the BUs may reach to more than 15% which is adversely affects the handover performance. On the contrary, when the BU is assigned with high priority as in the proposed scheme (Diff NEMO), the drop is not often confronted even though if the network is congested (i.e., it would be very trivial which is suitable to run of real time application e.g., VoD and VoIP and video conferencing).

CONCLUSION

In this study, we proposed a new scheme called (Diff NEMO) to achieve seamless mobility in the NEMO environment. The proposed scheme modified Router Advertisement (RA) message to pre-define the service classes and the current available resources for DMR. It makes the used of Differentiated Services (DiffServ) model to provide quality of service to users of real-time applications in mobile network. Furthermore, it conquers the weakness of NEMO inefficient routing by utilizing the methodology of MIPv6 route optimization. The obtained result from the simulation shows that the proposed scheme has improved the packet loss rate and probability of dropping BUs when the propagation wired link delay was increased. Therefore, the proposed scheme could be embraced to co-exist with the standard NEMO basic support protocol for offering better QoS to the mobile users.

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