CHAPTER 3

EFFICIENT FAST HANDOVER NEMO+ IN HOMOGENOUS SCENARIO

3.1 INTRODUCTION

STBH algorithm lacks the support of ensuring the session continuity of all nodes in the network if the Point of Attachment (PoA) varies. The handover gets delayed if guard nodes are in busy state. STBH algorithm does not fulfill these requirements. This requirement can be enabled in NEMO protocol. In NEMO, a special device called a Mobile Router is defined to extend the Mobile Node of Mobile IPv6 (MIPv6) by adding capability routing between its point of attachment and a subnet that moves with the MR. The NEMO Basic Support ensures this session continuity for all the nodes in the Network, even if the Mobile Router changes its point of attachment. Connectivity and reachability for all the nodes in the Mobile Network is provided without any interruption by the NEMO protocol. This chapter focuses on the Network Mobility Basic Support protocol and its support for vehicular environment. Therefore, enhancement of NEMO+ protocol called Efficient Fast Handover NEMO+ (EFNEMO+) is proposed and explained in this chapter.

3.2 NEMO BS PROTOCOL

Network Mobility (NEMO) (Devarapalli et al. 2005), specifically called as the NEMO Basic Support Protocol provides a feasible mobility solution based on Mobile IPv6 that spotlight supporting the entire networks of IPv6 devices as opposed to just a single host. By means of NEMO BS, mobile networks can afford the hosts with uninterrupted Internet connectivity via a
constant unchanging IPv6 address despite of the actual location of the network. In NEMO BS model, each mobile entity is considered as a Mobile Router that helps to manage the mobility of the entire nodes in the network over its Egress interface and provides its Ingress interface to IPv6 devices as a normal, static IPv6 connection. This is done by initializing the network with a Home Agent located in the Home Network of the MR; in the case of NEMO BS, the HA forwards packets destined to the addresses that are attached to the MR, known as the Mobile Network Prefix (MNP).

Each individual NEMO MR can be associated with one or more MNPs registered to it. When the MR moves around and changes its PoA to the Internet, it constructs a New Care-of-Address (NCoA) based on the prefix of the access network it is currently connected to. The MR then registers this CoA with HA via bi-directional tunnel between one another. The HA then intercepts the packets and forwards them to the MRs current location via the bi-directional tunnel. NEMO BS can support the real-time scenarios involving single and distinct mobile networks that periodically change their point of attachment to the Internet.

### 3.3 NEMO+ PROTOCOL

In NESTED NEMO Protocol (Mc Carthy et al. 2008), packet sent from a node that is connected to the mobile network NEMO 1 to another node on NEMO 2 the following procedure has to be done: The packet has to be tunneled first through the destination NEMO (NEMO2) before it is finally acquired by its Home Agent (HA1) and the packet is then forwarded (without tunneling) to the destination NEMO’s Home Network and is then finally delivered to NEMO over its MR-HA tunnel.
This results in an inefficient Pinball routing in Nested NEMO Networks. Conversely, the resulting routing that occurs in these Nested NEMO scenarios quickly becomes extremely inefficient and is not suitable for real life deployment solutions. To ensure the packets traverse a direct, optimized route when they are transmitted across a Nested NEMO, the route that packets follow in order to reach the entry point of the Nested NEMO (i.e. the Gateway-MR) must also be taken into consideration. The solution to the Pinball Routing problem and ensuring the transmission of data packets via one HA is being solved using NEMO+ protocol.

The NEMO+ protocols can operate independently, and rely upon each other to varying degrees in order to produce the most optimized outcome. NEMO+ protocol is designed with a suite of triad protocols namely Tree Discovery (TD), Network in Node Advertisement (NINA) and Reverse Routing Header (RRH) protocols. This mechanism helps to optimize the performance of handover process in VANET efficiently. Tree Discovery protocol generates the flow of messages out of MR ingress interface. Network In Node Advertisement generates subsequent flow of messages out of MR Egress interface. Reverse Routing Header is used for direct establishment of connectivity to HA without creating the tunnel. The NEMO+ is used to route the packets during handover efficiently. This main advantage of this protocol is that Burrow burden is reduced, Registration is done in advance before the handover process, which helps to avoid Packet loss and Traffic congestion over the packets are reduced.

3.3.1 Tree Discovery

The Tree Discovery protocol supports MRs to choose the MR in their neighborhood that has the better path to the Internet. Tree discovery protocol helps to find the complete paths used by all the nodes in the network
using the Neighbor Discovery method using IPv6 protocol. These paths are found through ICMPv6 messages and are expressed as tree branches initiating at the Internet gateway (root) and last node at the MRs (leafs). Upon getting such type of messages, the MR selects the best path from the available path.

3.3.2 Network in Node Advertisement

The Network in Node Advertisement protocol messages the prefixes of the sub networks to the MRs located close to an interconnection point. These types of messages provide communications between mobile nodes from different networks without the involvement of home agent’s even though it is connected to the same path.

3.3.3 Reverse Routing Header

Reverse Routing Header protocol improves packet forwarding using the last MR Internet Protocol address as the source address for all packets. The earlier source IP address is stored in a listing in the packet header, which includes the IP addresses of all earlier MRs that has forwarded the packet. As the source IP address received with the interconnection point is the IP address of the last MR. The packet is forwarded to the home agent of this last router prior to send to the Internet. The listing all IP addresses of the MRs is added to the home agent in the reverse direction, while it receives the packet from the Internet. So, the packet is transferred to the originating mobile node.

3.4 PROPOSED EFFICIENT FAST HANDOVER NEMO+
     METHOD

The proposed EFNEMO+ method takes NEMO+ as its base by registering the MR to HA. This is done in advance, to fasten the handover in
network. The tentative registration to HA is completed concurrently before the occurrence of the real handover. The MNN transmit the packets among MR and NAR in different path, but not over the burrow between PAR and NAR with the aim of minimizing the burrow burden and redundancy during handover. To improve the packet transmission to the destination network, the triad protocol of NEMO+ namely Tree Discovery, Network In Node Advertisement, Reverse Route Header are employed in proposed work.

The Efficient Fast Handover NEMO+(EFNEMO+) is designed to increase the delivery of packets in the vehicular network. In EFNEMO+, Tree discovery is used to elucidate the flow of message in connection with MR entering the interface. NINA is used to register the MR to HA. RRH is used to ensure packet delivery and avoid the pinball routing issue in the network. EFNEMO+ is established to estimate the flow of binding to access the destination network multiple networks supported on mobility configuration.

3.4.1 Connecting Multiple MR Using TD

The first step is to initiate EFNEMO+ to detect and connect multiple MR in the network with IPV6 Route Advertisement (RA), neighbor discovery. It also helps to enhance through MR to convey the TD that permits MR to distribute information to other MR’s that connects to its ingress interface. This helps the MR to connect with other MR’s to form the tree structure using Tree Information Option (TIO) which is augmented in RA. TIO has the information related to the TD that makes decision on the connectivity of one MR to another MR. This TIO information is used to prevent the router from looping and to determine bandwidth level with respect to the Internet connectivity.
Mobile Router
MR1, MR2, MR3

Router MR1 connects to internet MR3 attached

MR2 make informed connection with MRs

M1 connected to internet

Distance of MR to Internet

Yes

If M2 selects MR1 based on TD

Yes

Internet provided to MR2, MR3 through MR1

No

BW of MRs internet link

Yes

End

No

Figure 3.1 Flowchart representing MRs selection using TD
Spontaneous attachment of MR design graphs by itself that are not accepted to form loops, because looping may conflict the MR when it is listening to RA from its own Ingress interface to access the internet. The aim of TD is to prevent router from looping.

This is achieved through TD, that provides the information regarding the router selection and it carries another information such as whether MR in the tree is connected to internet, or how long each MR in the EFNEMO, or the bandwidth capability of MRs Internet. Figure 3.1 shows the procedure of selection of the well-organized mobile router using TD with the purpose of maintaining internet services to all the other mobile routers in an optimized manner to prevent looping during routing.

3.4.2 Advertising the Availability of MRs

The next level of EFNEMO+ protocol is to use the NINA protocol to make sure the routes of all MN gets attached to the tree structure of EFNEMO+. MRs runs with NINA protocol that provide RA to TIO, with NINA response, which maintains all previous information details that are currently managed by MR. Once the NINA response is received, the source of RA is added to TIO and it starts transferring the NINA message to MR currently attached. This process is repeated until the entire MR in the network is assessed.

As with TD, NINA inherits activities of EFNEMO+ MRs by increasing the NA with Network in Network Option (NINO) messages. TD increases RA messages to act MR as mobile router to its ingress interface. While MR is in out of ingress interfaces, acts as individual host, the advertisement of messages get completed by using NA messages. Route propagation model is used in addition to NINA for the regular updation of
MR. NINA helps to hide the changes in the topological structure of MR and the ensure the reachability of MR as it also hides the movements of the sub tree from parent in entering the interface of MR. Finally, the MR nearer to the gateway-MR prolong less mobility and theroutes are managed for more prefixes. Meanwhile, the MR which is farther from gateway-MR monitor for mobility of the other MR and the routes are managed for less prefixes.

3.4.3 Ensuring the Packet Delivery

To ensure the efficient delivery of the packets beyond the Gateway-MR a RRH protocol is introduced to prevent the occurrence of pinball routing. In RRH, each MR update their HA with current location of the gateway-MR and ensure the direct delivery of packets to their current location using traditional IP routing. As the packets travels towards internet, RRH record the routes of the packets flow. This is done when each MR overwrites the source filed of the outer IPV6 header of the travelled packets and overwrites the existing source addresses are recorded. By this, each MR sends the packets to its actual COA of the gateway-MR as it is source address and the routes are taken back to reach the actual MR by RRH method. This information is stored in HA and successively assigns the destination of the outer IPV6 header to the Gateway-MR COA and RRH is set to the packets to transmit from Corresponding Node (CN) to MR. Before the packets are delivered to destination COA that are recorded in RRH, it first delivers to its Gateway-MR COA. If NINA is not present, RRH is designed to record the path. When NINA is supported by MR, then role of RRH has to record the actual COA of the MR and check correctness of topology in Gateway-MR COA and report it to MRs HA. In the reverse communication from HA to MR, MR acts as a destination COA and the packet will be routed using the NINA protocol.
3.4.4  Handover Process in EFNEMO+

During handover, the MR discover the entire MR’s in the ingress interface network and sends the NINA message to each egress interface of MR that advertised about the subsequent flow of routes in the MR. Then RRH establishes the path between the MR and HA and frequently update the record. The handover operation is divided in two modes: predictive and reactive mode based on Fback message that are received in previous link.

Whenever trigger happens in layer2, it initiates the predictive handover. The neighbor links are obtained by sending the RtSolPr (proxy advertisement) to PAR. When MR receive acknowledgement (PrRtAdv) from HA, MR then creates NCoA for registration. In EFNEMO+, enumerated handover operation and successions timing, it will not send Tentative Binding Update (TBU) message.

Instead, TBU message is entrenched in the FBU message and register NCoA is in advance. These TBU message is encrypted using ECC conveyed to HA through False Binding Update (FBU) and HI message. After receiving the acknowledgement from CN, HA probably use binding information to create an extra entry in the Binding Cache Entry (BCE) for coexisting MR’s HoA. All the vehicles must register themselves with the Mobile Router of a network to utilize the Enhanced NEMO+.

To stay away from the Ping-Pong effect, during handover HA forward the packets to PAR because MR does not move to the NAR after sending TBU message to HA. TBU message contains address of MR's HoA, the NCoA, and the short binding lifetime. In order to avoid burrow burden between PAR and NAR, NAR starts buffering the packets which are sent from HA, and from NAR it reaches destined MNN through various paths.
Figure 3.2 Handover Mechanisms in Predictive Mode
Figure 3.3 Handover Mechanisms in Reactive Mode
In EFNEMO+, the burrow between the PAR and the NAR still remains, the burrow is used when the HA can't handle the TBU message, or the TBU message is not conveyed to NAR. After handover process in Layer-2, through normal BU message MR registers the NCoA with HA and updates it in BCE. Before handover to layer 2, MR has to receive the Fback message from HA to continue in predictive mode else EFNEMO+ operates in reactive mode which is shown in Figure 3.2.

In reactive mode activates, after layer 2 handover is completed, then MR sends the Unsolicited Neighbor Advertisement (UNA) is embedded in FBU to NAR. Then PAR receives the FBU message from NAR. HI, HACK messages are exchanged between PAR and NAR, which creates burrow to forward the packets when Hack message is received by PAR and sends the Fback message to NAR. The packets are delivered to MNN before registering NCoA. Burrow helps to deliver the packets between MNN and HA. When TBU message is not accomplished in predictive mode which is shown in Figure 3.3.

3.5 EXPERIMENTAL ANALYSIS

The performance of EFNEMO+ is measured through the parameter such as packet loss, average delay, control overhead and average throughput. The results show some improvement in the parameter value when compared with existing NEMO+ method.
Figure 3.4 Packet Loss Ratio Vs Handoff_nodes

The Figure 3.4 illustrates the packet loss ratio occurred during handover of proposed and existing methodologies. The packet loss ratio of Proposed EFNEMO+ and existing NEMO+ achieved is 11.5 % & 14.5 % for 5 number of handoff nodes, 21.8 % & 24.5 % for 10 number of handoff nodes, 28.0 % & 30.0 % for 15 number of handoff nodes and 32.5 % & 35.5% for 20 number of handoff nodes during handover. It is inferred from the graph that, the proposed EFNEMO+ method provides less packet loss ratio when compared to existing NEMO+ method during handover. The packet loss ratio is represented by percentage (%).
Figure 3.5 Packet Loss Ratio Vs Node_Speed

The Figure 3.5 illustrates the Packet loss ratio with varying speeds of nodes in the network. The packet loss ratio of Proposed EFNEMO+ and existing NEMO+ achieved is 9.75 % & 14.5 % at node speed of 5ms, 13.8 % & 19.8 % at node speed of 10 ms, 18.0 % & 25.0 % at node speed of 15ms and 26.25 % & 30.5% at node speed of 20ms. It is inferred that, the proposed EFNEMO+ method provides less packet loss ratio when compared to existing NEMO+ method with varying speed of node. The packet loss is represented by percentage (%).
Figure 3.6 Average Delay Vs Handoff_Nodes

The Figure 3.6 illustrates the average handover delay occurred during handover in proposed and existing methodologies. During handover, the average delay achieved by the proposed EFNEMO+ and existing NEMO+ method is found to be 5.8 ms and 7.75 ms for 5 number of handoff nodes, 11.8 ms and 14.8 ms for 10 number of handoff nodes, 22 ms and 25 ms for 15 number of handoff nodes, 28.25 ms and 29.25 ms for 20 number of handoff nodes. It is inferred from the graph that, the proposed EFNEMO+ method provides less average delay when compared to existing NEMO+ method during handover. The average delay is represented by milliseconds (ms).
The Figure 3.7 illustrates that average handover delay for various number of nodes speed in the network represented by milliseconds (ms). The proposed EFNEMO+ and existing NEMO+ method achieves average delay of 5.8 ms and 7.5 ms at the node speed of 5 ms, 11.8ms and 14.75 ms at the node speed of 10 ms, 22 ms and 25 ms at the node speed of 15 ms, 28.25ms 29.25 at the node speed of 20ms. From the graph, it is observed that the proposed EFNEMO+ method provides less average delay when compared to existing NEMO+ method.
Figure 3.8 Overhead Vs Handoff_Nodes

The Figure 3.8 illustrates the overhead occurred during handover for proposed and existing methodologies. The proposed EFNEMO+ and existing NEMO+ achieves overhead of 8.75 and 11.8 for 5 number of handoff nodes, 13.8 and 16.25 for 10 number of handoff nodes, 18.25 and 19.5 for 15 number of handoff nodes, 19.5 and 23.75 for 20 number of handoff nodes during handover process. From the graph, it is found that the proposed EFNEMO+ method provides less overhead when compared to existing NEMO+ method.
The Figure 3.9 illustrates the overhead that occurred for various number of nodes speed in the network. The proposed EFNEMO+ and existing NEMO+ method achieves an overhead of 8.8kbps and 11.8 kbps at the node speed of 5 ms, 13.5kbps and 16.25kbps at the node speed of 10ms, 18.30kbps and 19.50kbps at the node speed of 15 ms, 21.50kbps and 23.50kbps at the node speed of 20ms. From the graph, it is analyzed that the proposed EFNEMO+ method provides less overhead when compared to existing NEMO+ method.
Figure 3.10 Throughput Vs Handoff_Nodes

The Figure 3.10 illustrates the throughput achieved during handover for proposed and existing methodologies. The existing NEMO+ and proposed EFNEMO+ achieve a throughput of 9.75 and 11.8 kbps for 5 number of handoff nodes, 11.8 kbps and 11.75 kbps for 10 number of handoff nodes, 12 kbps and 12.2 kbps for 15 number of handoff nodes, 15.5kbps and 15.75kbps for 20 number of handoff nodes. From the graph, it is observed that the proposed EFNEMO+ method provides high throughput when compared to existing NEMO+ method. The throughput is represented by kilo bytes per second (kbps).
The Figure 3.11 illustrates that the throughput achieved for various number of nodes speed in the network. The proposed EFNEMO+ and existing NEMO+ method achieves an throughput of 9.8kbps and 7.5 kbps at the node speed of 5 ms, 11.8 kbps and 10.70 kbps at the node speed of 10 ms, 12 kbps and 11.90 kbps at the node speed of 15 ms and 14.25 kbps and 15.25 kbps at the node speed of 20 ms. From the graph, it is analyzed that the proposed EFNEMO+ method provides high throughput when compared to existing NEMO+ method.

3.6 SUMMARY

This chapter explained about improved version of NEMO+ called EFNEMO+ that performs efficient handover mechanism. EFNEMO+ method reduces the burden of burrow, traffic and congestion over the network by
tentatively registering MR to HA in earlier before handover occurs. In homogenous network, EFNEMO+ is found to be better in minimizing the average delay, overhead and packet loss when compared with existing NEMO+. This main issue of this work is only suitable for homogenous environment and lack security in communication during handover. In subsequent chapter, Secure and fast handover multihoming based NEMO+ (SEFMNEMO+) method is introduced that support secure handover mechanism in multihomed environment that depends on flow binding to access the target network from multiple networks.