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Multipath Mobile Internet Protocol for Mobility Networks

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Abstract: The internet data traffic is rapidly increases by twofold or even more in the near future. Most of the data traffic are generated from mobile devices. Due to this explosion of data traffic, existing network architecture is incapable in handling such a massive data traffic. The Network Mobility Basic Support Protocol (NEMO-BSP) is an extended version of Mobile Internet Protocol (MIPv6) that is designed to support seamless communications between homogenous and heterogeneous network domains. But NEMO-BSP is suffer very high binding and tunnel cost. The Proxy Mobility Scheme Protocol (PMIPv6) was developed to overcome issues of binding and tunnel cost. There have been many attempts to reduce the binding and tunnel cost. In this research work a multipath mobile IP protocol is designed that divides data packets on multiple paths (data packers on multiple sub-flows) without tunnel formation in the mobile network environment. the Multiple Mobile Internet Protocol Scheme (MMIPS). The network is divided into domain zones called intra-domain and inter-domain zones. The proposed protocol is aimed to remove the tunnel burden and reduce the packet size which significantly reduce the binding and tunnel cost. An analytical result are show that the proposed scheme binding and packet cost is less than compared schemes.

Keywords: IP Mobility, Mobility Scheme Distributed Mobility, Handover, Multipath IP Mobility.

1. INTRODUCTION

Research in mobile networks is gaining momentum in wireless communication field. Due to fast increasing number of mobile communication devices such as mobile tablets, laptops cellphones etc. This rapid growth is pushing the Internet Service Providers (ISP) and Network providers to provide internet access ‘anywhere’ and ‘anytime’ especially “on-the-move”. The Mobile Internet Protocol (MIPv6) supports individual node mobility, that includes the voice and the data communication. Due to development of high-speed transportation, it becomes necessary to provide internet availability in the public/private transportation or Personal Area Network (PAN). The Internet Engineering Task Force (IETF) has developed a Network Mobility Basic Support Protocol (NEMO-BSP) to enable mobile network communications (Perkins, *et al.,* 2011). In mobile network one or more mobile nodes are attached to a Mobile Access Router (MAR) and move as one unit. The Mobile Access Router (MAR) is responsible to maintain the mobile nodes location update and provide connectivity.

The NEMO-BSP provides support to mobile/movable network that are able to visit foreign IP network domains. Each IP network domain is deployed with multiple access routers or base stations (fixed infrastructure) of different technologies. The Mobile Access Router (MAR) is an intermediate device between mobile nodes and IP access network. The router solicitation message is forwarded by MAR, whenever the MAR enters the coverage zone of a network. The mobile networks (NEMO) is required to achieve the transparent mobility for mobile router and as well for mobile nodes, which are moving as one unit. There are differences between single node IP mobility scheme and network IP mobility scheme. The IP mobility scheme that supports single mobile node is considered as individual entity in the entire network. However, in the NEMO the Mobile Access Router (MAR) is responsible to performs IP mobility operations for all connected mobile nodes. The mobile nodes are not involved in mobility operation. There are three different types of node in the mobile network. (i) Local Fixed Node (LFN) (ii) Mobile Node (MN) (iii) Visiting Mobile Node (VMN) (Devarapalli, 2004).

However, researcher have identified NEMOBSP has few issue that drastically reduce the performance. To cope with the scalability challenge, researchers have proposed new mobility scheme known DMM (Shin, 2013).The MM scheme is still under exploration phases. This scheme provides a concept of a flatter network architecture. In the flatter network architecture, the

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mobility entity is deployed as near to the user as possible. Moreover, DMM scheme divides the control and data units and install them at the edge of a mobile network. Presently, DMM research groups and individual are finding best architecture to mitigate the issues in the centralized entity and in the mobility unit.

The rest of this article is ordered as follows. In section II this article presents the literature review and related work. In Section III, we have demonstrated the proposed multipath Ip mobility protocol architecture and discuss the designing steps. In Section IV, a setup of analytical scenario and parameters that are used in the analytical. Moreover, Section IV, presented and discuss the analytical results. In Section V, presents concluding remarks based on results.

2. LITERATURE REVIEW

The IP mobility scheme was designed to locate the current location of mobile node and support data delivery when mobile node moves to another foreign network domain. The mobility techniques and its type. The mobility is the merging of two sub-operations handoff (handover) (Perera, *et al.,* 2014) (Baldessari, *et al.,* 2007).

The are a large number of mobility schemes which are based on network layer, link layer and transportation layer or cross layer (Perera, *et al.,* 2014). The Multipath Transmission Control Protocol (MPTCP) is an updated version of the TCP, which is still under exploration in IETF (Devarapalli, *et al.,* 2004) The MPTCP works at the transport layer and it support multiple path flows for one session. It means the MPTCP divides the packet transmission over multiple paths which ultimately be combined at the target node. The MPTCP is a suitable candidate for mobility because most internet applications are running over the TCP port. However it is been reported that MPTCP has some critical drawbacks such as, out-of-packets sequence, delay in missing packet and degraded performance on heterogeneous network (Wischik, 2011). The TCP does not maintain the running sessions. Once the point of attachment is changed then all-running sessions need to restart.

The MPTCP however does not need to restart the sessions. The mobile nodes have multiple interfaces such as one is cellular connection and the other is WiFi connection. The MPTCP can utilizes both interface to enhance the performance of running sessions. It is also possible that, there are multiple TCP sub-flows in one MPTCP connection. The MPTCP sub-flows can add or remove from running connection without impacting on the connection. The MPTCP has few designing issues in the use cases of mobile networks (Baldessari, *et al.,*2007). (Do and Kim, 2012) (Gundavelli, *et al.,* 2012) (Pack, 2008)

The Stream Control Transmission Protocol (SCTP) works at transport layer. The SCTP is developed by the IETF (Lee, *et al.,* 2012) for reliable communication over the internet. The SCTP is a reliable and connection oriented protocol, which works in similar manner as TCP and UDP. The SCTP is able to transfer data packets on multiple paths at the same time. That is,the SCTP can forward data packets two different IP address. The recent development of Dynamic Address Reconfiguration (DAR) provides mobility support in the SCTP. The Mobile Stream Control Transmission Protocol (mSTCP) (Huang, 2007) (Lee and Ernst, 2011) is an extension of SCTP to enable mobility support in the SCTP. The mSCTP support mobile node by forwarding the data packet when mobile node is moving between different network domains. However, the mSCTP is not deployed widely due to that most of the devices do not process the forwarding packets and mSCTP uses different API which creates additional issue. There are not many application that supporting SCTP because many to this manufactures are reluctant to add SCTP in the firewalls.

In attempt to improve the TCP throughput, the scheme is called Freeze-TCP (Goff, 2000). The Freeze-TCP enhances the disconnection and reconnection method of TCP. In the Freeze-TCP, at the receiver side the connection is monitored continuously. In the event of connection breaks down the receiver sends an Ack message to the correspondent node. The Ack message contains the information of connection to assist freeze TCP connection. The scheme does not describe the prediction the on break down connection and if connection is not stable the correspondent node cannot forward control packets.

In (Pack,2008) the author proposed the ID/locator network architecture based on Distributed Mobility Scheme (DMS). The suggested scheme implements a mobile router, which is responsible to forward a binding update message on behalf of all mobile nodes. A mobility agent in the proposed scheme is responsible to store the mobile nodes session and mobile router. In the LISP architecture was selected for network mobility to resolve mobility challenges. The scheme is called NEMO-LISP (Wu, 2014). NEMO-based mobility scheme in LISP network. In 2014 Sixth International Conference on Wireless Communications and Signal Processing (WCSP). IEEE.. In this approach the mobile router dealt with signal message for group mobile nodes. Whenever a new mobile node attached to MR, MR sends binding message to the ITR. In this approach the MR performs as a tunnel router for mobile nodes.

The MR has assigned the IP address denotes as Locally Routable Address (LLOC) and MNs has an IP address denoted as a EIDs. MR is responsible to maintain the MN EID and Map with LLOC. Furthermore encapsulate and de-capsulate the IP Data packets to send to the next hop. A mapping server store all the network prefixes in the data base such as Globally Routable Address (RLOC) and LLOC and EID to LLOC. The ITR and ETR with the help of mapping server records finds the best path. In the proposed approach has the MR sends messages with ETR (attached), then ETR request the Map server for registration. The author in (Valtulina, *et al.,* 2014) approach to support Network Mobility under the LISP environment. The mobile router was attached with ITR router (LISP network), MR forward binding message with MR-EID and MNP. Upon receiving the message, the ITR/ETR attaches the host route to MNP for next hop communication. Furthermore, the ITR/ETR requests to the mapping server for registration process. After mapping registration process, the map server advertises itself as a gateway node for accessing the mobile network. Suppose if Correspondent Node (CN) is sending data packet to the Mobile Node (MN), the data packet is forwarded to the ITR. ITR is responsible to check whether MN ID (EID-RLOC) is available in the local mapping server. If it is not available in the local mapping server, then local mapping server will request to the ETR for mapping server. After mapping responses (MN EID with RLOC) the data packet is forwarded to ITR and then via ETR tunnel to the source node.

A mobility scheme was proposed for Network Mobility (NEMO). This scheme is called Identifiers Separating and Mapping Scheme (ISMS). This scheme improves the handover and location with the help of identity and location separation. There are some new terminologies used in the ISMS scheme. The details are as follows. Accessing Identifier (AIDs): it is the IP address for mobile node/router in the customer network. The AIDs address also identify location of nodes. Switching-Routing Identifiers (SRIDs):it is to identify the location of customer node. Customer Network (CN): it is considered a network that comprise of nodes that are available in the ISP. Provider Network (PN) : it is Internet Service Provider (ISP) which is divided into multiple subsection network called domain. Identifier Mapping Server (IDMS): the IDMS works similar to DNS, it provides mapping service for AIDs and SRIDS. The IDMS is implement on reach domain. It is also possible a domain contains multiple IDMS. This scheme distinguishes between AIDs and SRIDs to solve IP address overloaded mobility issue. Furthermore, a mapping method is used to differentiate host and network mobility.

3. **PROPSED NETWORK ARCHITECTURE**

The Multi-Path Mobile Internet Protocol for Mobility Networks (MMIPS) is proposed in this section. The network is divided into two zones, one is inter-domain zone and the other is intra-domain zone. The inter-domain zone contains the heterogeneous Distributed Access Routers (DARs) deployed all over the zone, whereas intra-domain zone contains the homogeneous localized Intra-Domain Access Routers (IDARs) and Intra-Domain Mobile Anchor (IDMA) in the zone. To improve the performance, two different mobility scheme approaches are introduced. The intra-domain zone is managed by network based mobility. This work is an extension of our previous research (Wagan, 2017).

Intra-Domain Zone

The concept of Intra-Domain Zone is shown in **(Fig.1).** It contains Intra-Domain Access Router1 (IDAR1), Intra-Domain Access Router 3 (IDAR3) and Intra-Domain Mobile Anchor (IDMA1). All IDARs in Intra-Domain Zone are deployed with similar wireless technology and are managed by IDMA. The IDMA a is central entity in the intra-domain zone, which deals with all mobility scheme operations for all MARs and MNs. The IDAG acquires the IP address from an IDMA and allocates to the MAR. The MAR1 is responsible to manage signal and data traffic of MNs. MAR1 is an intermediate node that manages registration and de-registration process of Mobile Nodes (MNs).

The Intra-Domain Access Router (IDAR) is to manage mobility and signaling operations on behalf of the Mobile Access Routers (MARs) and the Mobile Nodes (MNs) that are connected with it. The IDAR is also tracking the movement of MAR1.In intra-domain zone, all IDARs are attached to the same IDMA. The IDARs that are attached to different IDMAs will be discarded from the IDAR list or block using access control list

Multipath Transmission Control Protocol (MPTCP)

The Multipath Transmission Control Protocol (MPTCP) is an updated version of the TCP, which is still under exploration of IETF. The MPTCP works at the transport layer and it support multiple path flows for one session. It means the MPTCP divides the packet transmission over multiple paths which ultimately be combined at the target node. The MPTCP is a suitable candidate because most internet applications are running over the TCP port. However it is been reported that MPTCP has some critical drawbacks such as, out-of-packets sequence, delay in missing packet and degraded performance on heterogeneous network. The TCP does not maintain the running sessions once the point of attachment is changed the all-running session needs to restart.

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Inter-Domain Zone

The Inter-domain zone deploys Distributed Access Router (DAR). The DAR is distributed access point which has both functionalities for data and control. In the MPNMMS scheme, the DAR is responsible to deal with uplink and downlink of data traffic. The DAR provides network prefix and manages all traffic coming from intra-domain zone.

The proposed scheme is based on the concept of MPTCP for seamless session on multiple paths and is shown in **(Fig.1).** The main feature of MPTCP is to produce multiple sub-flows of data traffic on different path. By taking the advantage of this concept the proposed scheme develops strategy to implement MPTCP sub-flow in the intra-zone domain, for seamless connection over multiple routers coverage areas and improve the mobile communication performance.

When the MAR1 enters the intra-domain zone MPNMMS domain, the MAR1 has two options i.e. either connects with the IDAR1 or with DAR1. When the MAR1 is attached to intra domain zone, the MAR1 communicates with Intra-Domain Access Router1 (IDAR1) by sending the Router Solicitation (RS) message. The IDAR1generates PBU message and sends to Intra-Domain Mobile Anchor (IDMA).

The IDMA1 is a central entity which maintains all running session sub-flows. The IDMA1 manages multiple IDAGs in the intra domain zone. The IDMA keeps the MARs connected to IDAGs that are associated with IDMA1. These all IDAGs are responsible to forward to all the MAR1 and the MNs important activation to IDMA1 more precisely with the signal and data traffic related messages.

The IDMA1 generates the sub-flow numbers, which can vary from 1 to N sub-flows. The IDMA is responsible to create Network Prefix (NP) and IP address. IDMA sends acknowledge message to the MAR1 through IDAG1. IDMA1 maintains the IDAR's table which contains records of all neighboring IDARs. These IDARs record assists during adding sub-flow for the MNs. The IDAR is responsible for tracking the movement of the MAR1 and updates when the MAR1 reaches to neighboring IDAR, in our case IDAR2 updates the IDMA1.

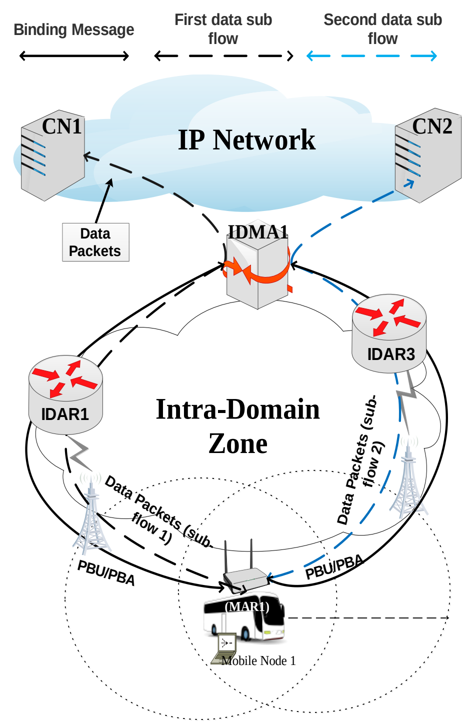

Fig.1: Intra-Domain Zone Network Architecture of MMIPS

The adding of sub-flow in the ongoing data requests is the responsibility of IDMA1. When IDAGs updates the IDMA1 regarding the movement of the MAR1, IDMA1 adds sub-flow according the movement of the MAR1.The IDARs are responsible to track the position of the connected MARs and assists during the change of point of attachment. The figure 1 shows that where MAR1 is first attached with IDAR1 which forward the data traffic and when MAR1 reaches near to the IDAR3, IDMA adds sub-flow by sending notification to the MN1 via MAR1.

A. Initial Registration Steps

The initial registration steps are defined in **(Fig. 2),** when the MAR1 is attached with Intra and inter domains. After successful configuration, the MNs are attached to intra-domain.

Step 1: When the MAR1 enters the Intra-domain zone, the MAR1 sends Router Solicitation (RS) message or received the periodically Router Advertisement message sent by the IDAR1.

Step 2: Upon receiving the RS message, the IDAR1 generates the Binding Update (BU) message for MAR1 and forwards to the IDMA1.

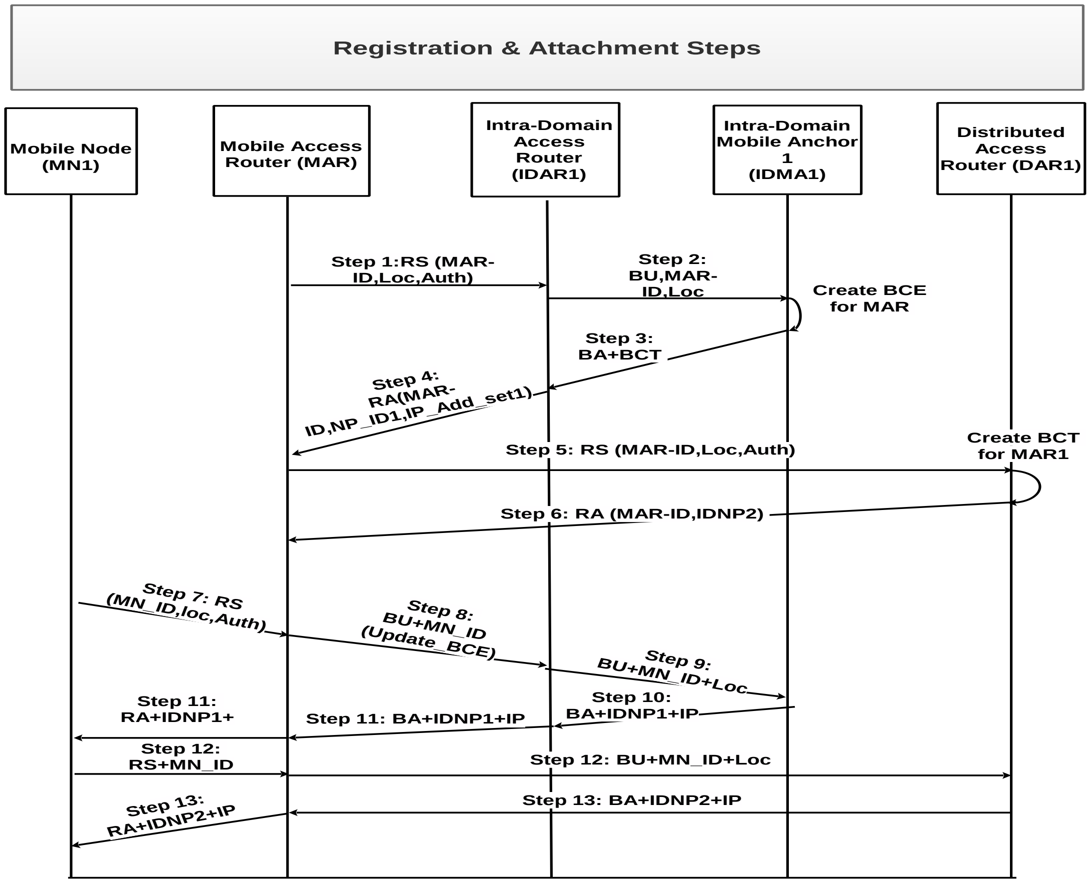

Fig.2: MPNMMS Registration Process & Steps

Step 3 & 4: The IDMA1 generates the Intra-Domain Network Prefix 1 (IDNP1) and updates Binding Cache Table (BCT). After that IDMA1 sends the binding Acknowledgment (BA) message to IDAR1. The IDAR1 sends the configuration to the MAR1.

Step 5 & 6: The MAR1 sends Router Solicitation (RS) message to the Distributed Access Router 1(DAR1). The DAR1 generates the Inter-Domain Network Prefix 2(IDNP2) and updates Binding Cache Table (BCT). After that DAR1 forwards the binding Acknowledgment (BA) message to the MAR1. The MAR1 then setup the configuration sent by the DAR1.

Step 7 & 8: When the MN1 enters the MAR1 coverage zone. The MN1 sends Router Solicitation (RS) message or receive the periodically Router Advertisement message sent by the MAR1. The MAR1 produces the Binding Update (BU) message for MN1 and forward to the IDMA1.

Step 9 to 11: The IDMA1 generates the IDNP1 and BCT for MN1. Then the IDMA1 forwards to the IDAR1.IDAR1 updates the MN1 via MAR1, MN1 then setup the configuration provided by the IDMA1.

Step 12 & 13: When the MN1 enters the MAR1 coverage zone, It sends the Router Solicitation (RS) message or receive the periodically Router Advertisement message sent by the MAR1. MAR1 produces the Binding Update (BU) message for MN1 and forwards to the DAR1. DAR1 generates the IDNP2 and updates the BCT for MN1. Then the DAR1 forwards Binding Acknowledgment (BA) messages to the MAR1. MAR1 then sends settings to the MN1.

B. Intra-domain and Inter-domainOverlapping Zone

The Inter-Domain Zone contains multiple Distributed Access Routers (DARs) throughout the zone, the inter-domain zone configuration where Distributed Access Router 1 (DAR1) is using different wireless technologies. The inter-domain zone is completely distributed and each DAR works independently. The inter-domain zone is configured as distributed mobility, therefore DAR comprises both data and control planes functionalities.

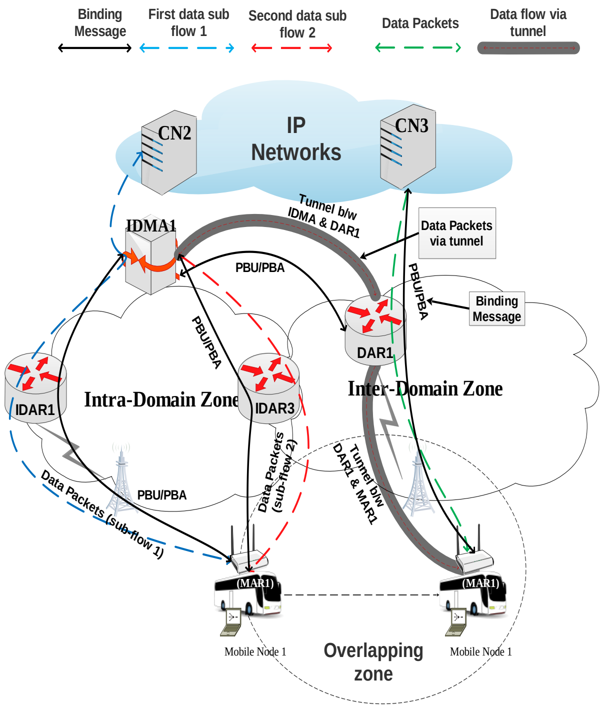

Fig. 3: Handover between IDMA1 and DAR1 Domains

Additional, the DARs establishes bidirectional tunnel between neighboring DAR to provide session continuity. When MAR reaches the edge of intra-domain zone or overlapping zone between Intra and inter domain zone (at the overlapping zone), the Intra-domain Mobile Anchor (IDMA1) requests to Distributed Access Router (DAR1) to create tunnel for seamless session continuity. Each IDMA manages numbers of IDARs, whenever MAR reaches at last Intra-domain Access Router (IDAR) all the running sessions are transferred to DAR1 via the established tunnel. **(Fig. 3)** diagram represents the situation and **(Fig. 4)** explains the operation steps.

C. Handover for IDAR1 to IDAR3 and IDMA1 to DAR1

Following steps are involved when the MAR is attached to IDAR1 and data packets are forwarded from the IDAR1.

Step 1: The IDAR1 detected the MAR and the MNs availability in intra-domain zone, the IDAR1 sends RA message on behalf of the MAR1 and responses back with RS message.

Step 2: The IDAR1 generates PBU message and sends to the IDMA. Upon receiving the PBU message, the IDMA produces Intra-Domain Network Prefix1 (IDNP1) and IP address for the MAR1 and pass to the MAR1. The same process is executed for the MNs that are connected with the MAR1.

Step 3: To create sub-flow of data packets, the IDMA1 forwards synchronize SYN message with MP_Capable option to the Correspondent Node1 (CN1).

Step 4 & 5: In the response, the CN1 sends back acknowledgment SYN_ACK message with MP_Capable, flag options to the IDMA1. Lastly, IDMA1 updates to the CN1 with Flag +Ack acknowledgment message.

Step 6: The MN1 requests to the MAR1 for data service and MAR1 passes the request to IDMA1 via IDAR1. Upon receiving the request, the IDMA communicate with CN1, and CN1 forwards the data packets to the MN1.

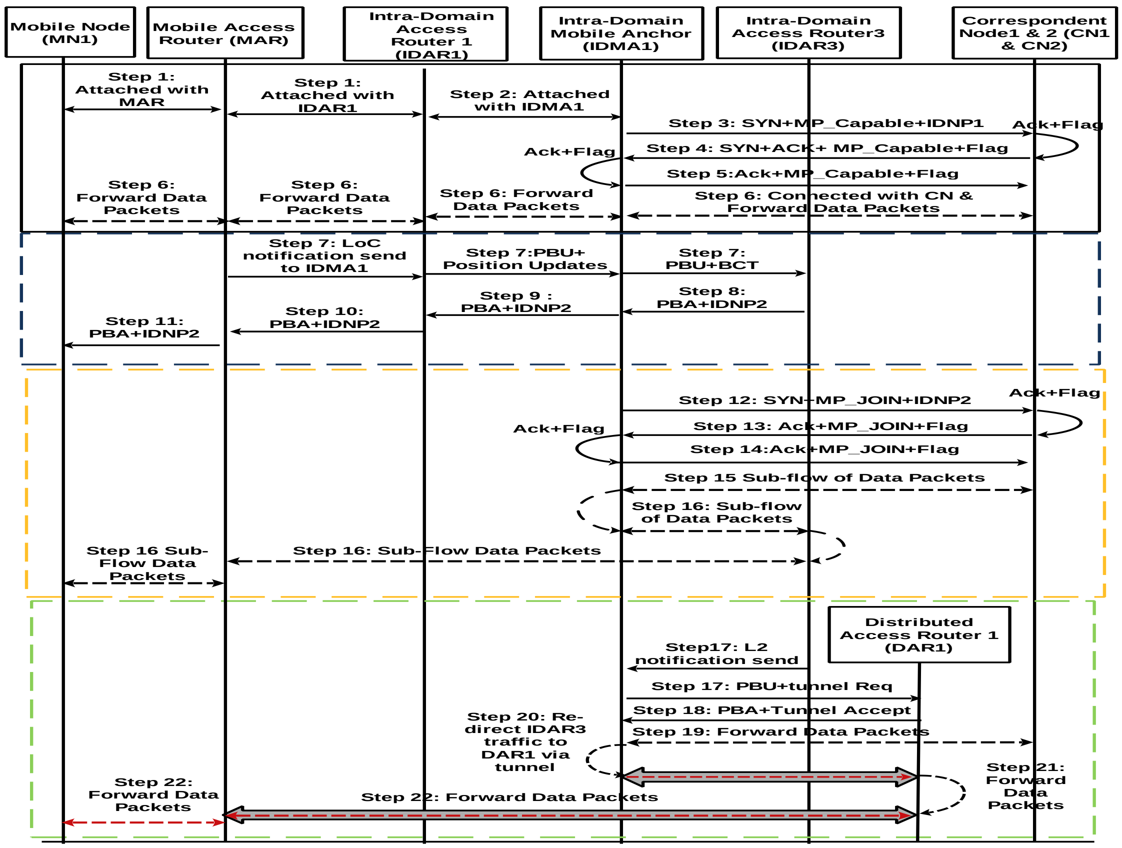

Fig.4: Handovers for IDAR1 to IDAR3 and IDMA1 to DAR1

Step 7: The IDAR1 sends position notification of the MAR1, the IDMA1 forwards PBU+BCT details to the IDAR3. The IDAR3 generates Proxy Binding acknowledgment (PBA) and IDNP2 message.

Step 8 & 11: When the IDMA1 receives the PBA+IDNP2 message, The IDMA1 forwards PBA+IDNP2 to the IDAR1. The IDAR1 forwards the PBA+IDNP2 message to the MAR1 and the MAR1 forwards configuration to the MN.

Step 12: Simultaneously, the generates additional sub-flow of data packets and the IDMA dispatch synchronize SYN message with MP_JOIN option and INDP2 to the Correspondent Node1 (CN1).

Step 13 & 14: In the response, the CN1 sends back acknowledgment SYN_ACK message with MP_JOIN options and flag to the IDMA1. Lastly IDMA1 updates the CN1 with acknowledgment message.

Step 16: The CN1 forwards the data packet (sub-flow of data packets) to IDMA1. The IDMA forwards the data packets to IDAR3.

In Fig. 3. following steps are involved during the handover between IDMA1 and DAR1. When the MAR1 reaches at overlapping zone and perform handover from intra to inter domain. The Fig. 3. shows the situation of handover between IDMA1 and DAR1 and process explained as follows.

Step 17 & 18: If IDMA1 does not find any IDAR in neighboring surrounding area. The IDMA sends the notification to the DAR1. The DAR1 receives the Proxy Binding Updates (PBU) message and tunnel request for the previous running sessions.

Step 19 & 20: The DAR1 receives the request from the IDMA1, the DAR1 generates the Proxy Binding Acknowledgment (PBA) message and send to the IDMA1.The IDMA1 and DAR1 establish the tunnel another tunnel is established between DAR1 and MAR1.

Step 21 & 22: The IDMA1 receives the data packets for the previous running sessions then transfers these data packets to the DAR1 via the tunnel. The DAR1 data packets are forwarded to the MAR1 via tunnel.

D. Network Topology Configuration

This section evaluate the performance of the proposed schemes and compare them to other existing schemes. **(Fig. 5)** demonstrates the scenarios and network topology setup. The analytical scenario was developed for mobile wireless networks. The configuration was designed in such a way that only the MAR movement is considered and MNs are kept fix under the MAR.

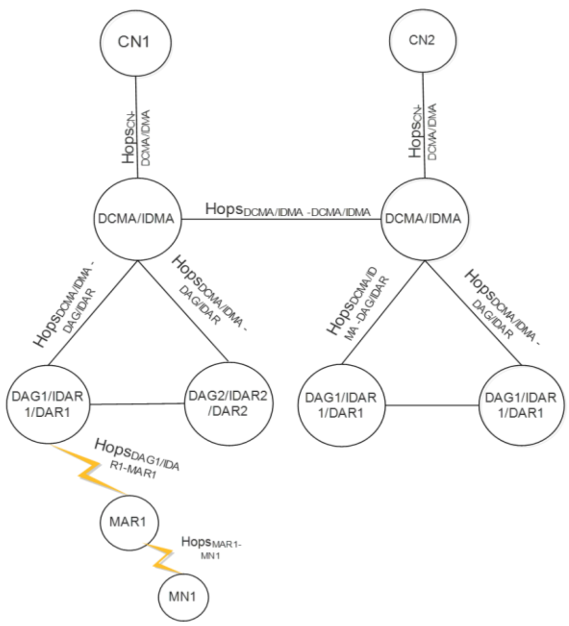

Fig. 5: Network Topology Settings for DMM+PMIPv6 and MPNMMS schemes

E. Performance Metric& Results

The performance metrics considered in this study include sum of signaling cost, handover-delay, and packet loss. In network mobility schemes, the MAR is responsible to provide the network mobility support to connected MNs and track its location. The location update is achieved by interchanging of the PBU and PBA messages (signal message) between the MN, MAR and the network entities i.e between the network entities. Another performance metric, the handoff latency is described as a time between MAR performs handover and not attach to access point. The handover latency is performed in the inter-domain and intra-domain perspectives. Handover is the period during MAR's last receiving the packet form the previous access router and when obtained the first packet from the new access router.

F. Signal Cost

The signaling cost as described is the cost to perform the binding and the location update cost of the MAR or MN. The signaling cost is considered an essential metric because it affects the scalability of the proposed schemes.

(Fig. 6) displays the sum of signaling cost measured as packets size (bytes) of MNs when MAR travelling within different network domains. The sum of signaling cost of rNEMO scheme is highest among schemes. This is due to the needs to update individual nodes which creates singling overhead. The ENEMO scheme reduces the sum of signal cost by about 38% as compared to the rNEMO scheme. However, it is still higher than remaining network mobility schemes. the EPDNEMO. Whereas the MPNMMS scheme sum of signaling cost is less than all comparing schemes.

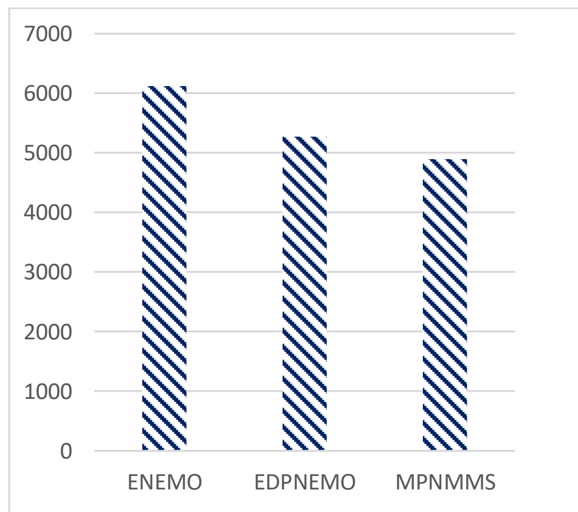

Fig. 6: Impact of binding cost on packet size

G. Handoff Latency

The handoff latency is described as a time MAR performs handover but not attach to access point. The handover latency can occur in the inter-domain and intra-domain environment. Handover is the period during MAR's last receiving the packet from the original access router and when it obtains the first packet from the new access router. During this handover time, MAR or MN does not receive any packet and all packet shall drop during this period. Hence, because of packet drop the service is disrupted. This service disruption causes time-delay to increase which may lead to applications termination and can be a concern in real-time applications. The packet loss is therefore a parameter analyzed in this work, it should be mentioned here that the number of packets lost is proportional to the handover latency.

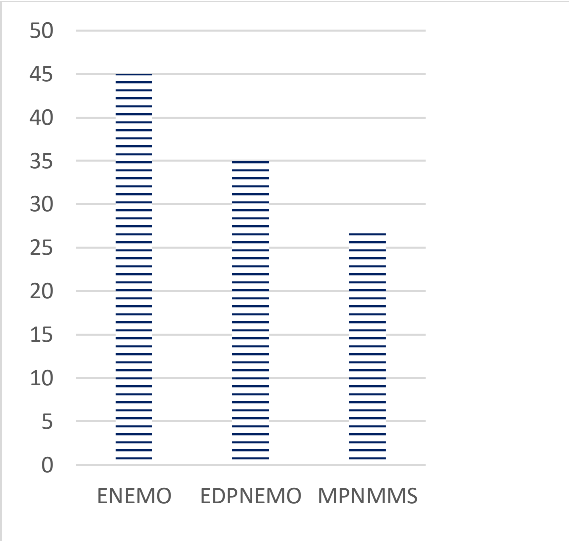

Fig.7: Handover Latency Between Access Routers

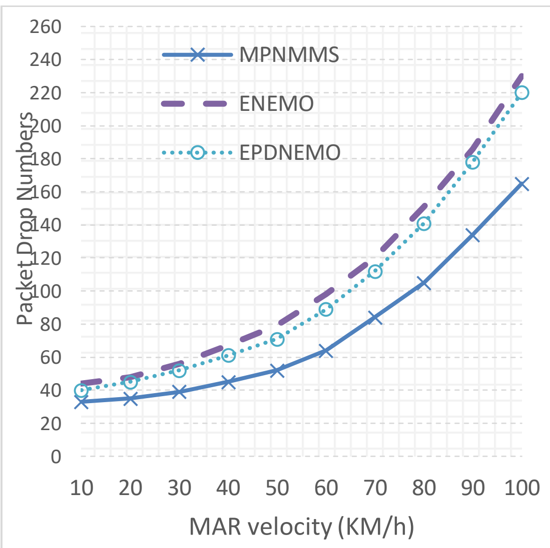

Fig. 8: Impact of MAR velocity on number of Packet Drops

(Fig. 7) illustrates the impact of moving MAR between different DAG network domains on the handover latency. The rNEMO is most expensive in terms of handover latency among the comparing schemes. In the rNEMO scheme, the individual MNs needs to execute the PBU and PBA messages whereby this operation performed on each MNs is highly impacting on the handover delay. The ENEMO incurred next highest handover delay. In the ENEMO, the MAR stores the mobile nodes ID and network prefix NP. This creates additional burden when performing the handover operation, thus creates additional handover delays. The proposed DMM+PMIPv6 and EPDNEMO scheme are showing less handover delay, because the proposed scheme creates tunnel in advance between the DAGs for handover operation.

(Fig. 8) displays the impact of the vehicle moving at different speed on the packets drop. It is noticed that every scheme is affected by variation of speed. The difference gets bigger when vehicle velocity is above 50 (Km/h). The proposed MPNMMS is less in terms of packet drop numbers among all the comparing schemes. The MPNMMS scheme packet loss is approximately 40 when vehicle speed is 10 Km/h. As the speed goes up the number of packet drop increases. When the speed is at 100 km/h a total 170 packets are dropped. The rNEMO is second lowest in packet drop among the comparing schemes. The highest among all scheme is rNEMO whereas ENEMO and EPDNEMO packet drop numbers are high but not as much as rNEMO. EPD-NEMO scheme is slightly performance better than ENEMO in terms of packet drop.

4. CONCLUSION

In this research article a MPNMMS is proposed which is the hybrid scheme in combining the MPTCP and DMM. This scheme divides the data stream flow on multiple paths by using the MPTCP. An IDMA central entity is introduced in this scheme to manage multiple flows and tunnels between inter-domains. The MPNMMS is to reduce the packet overhead and packet tunnel cost. The MPNMMS scheme reduces the tunnel cost and multi-path data flow. The MPNMMS scheme superior in all aspect when comparing in intra-domain. The MPNMMS scheme performs good in packet cost and handover process. The results showed that the MPNMMS scheme outperforms in packet and handover latency during the visit of foreign network domain.

REFERENCES:

Ali-Ahmad, H., M. Ouzzif, P. Bertin, and X. Lagrange, (2013) “Distributed dynamic mobile IPv6: Design and evaluation,” in *Wireless Communications and Networking Conference (WCNC), IEEE*, 2166–2171.

Bertin, P., S. Bonjour, and J. M. Bonnin, (2009) “Distributed or centralized mobility?,” in *Global Telecommunications Conference, GLOBECOM 2009. IEEE*, 1–6.

Baldessari, R., A. Festag, and J. Abeillé, (2007) “Nemo meets vanet: a deployability analysis of network mobility in vehicular communication,” in *Telecommunications ITST’07. 7th International Conference on ITS*, 1–6.

Choi, J. I., W. K. Seo, and Y. Z. Cho, (2015) “Efficient network mobility support scheme for proxy mobile IPv6,” *EURASIP J. Wirel. Commun. Netw.*, vol. 2015, no. 1, 1–13.

Perkins, C., D. Johnson, and J. Arkko, (2011) “Mobility support in IPv6,” Chan, H. A., H. Yokota, J. Xie, P. Seite, and D. Liu, (2011) "Distributed and dynamic mobility in mobile internet: current approaches and issues," *J. Commun.*, vol. 6, no. 1, 4–15.

Devarapalli, V., R. W. Petrescu, and P. Thubert, (2004) "Network mobility (NEMO) basic support protocol,"

Do T. and Y. Kim, (2012.) "Distributed Network Mobility" vol. 6, no. Atc, 319–322,

Do T. X. and Y. Kim, (2015) "EPD-NEMO: efficient PMIPv6-based distributed network mobility" *Wirel. Network*.

Gundavelli, S. K. Leung, V. Devarapalli, K. Chowdhury, and B. Patil, (2008) "Proxy mobile ipv6,"

Goff, T., J. Moronski, D. S. Phatak, and V. Gupta, (2000). Freeze-TCP: A true end-to-end TCP enhancement mechanism for mobile environments. In Proceedings IEEE INFOCOM 2000. Conference on Computer Communications. Nineteenth Annual Joint Conference of the IEEE Computer and Communications Societies (Cat. No.00CH37064) Vol. 3 1537-1545. IEEE.

Giust, F., A. La Oliva, and C. Bernardos, (2011) "Flat access and mobility architecture: An IPv6 distributed client mobility management solution," in *Computer Communications Workshops (INFOCOM WKSHPS), 2011 IEEE Conference on*, 361–366.

Huang, C. M., and C. H. Tsai, (2007). The handover control mechanism for multi-path transmission using Stream Control Transmission Protocol (SCTP). Computer Communications, 30(17), 3239-3256.

Jeon S. and Y. Kim, (2011) "Cost-efficient network mobility scheme over proxy mobile IPv6 network," *IET Commun.*, vol. 5, no. 18, 2656Pp,

Lee J. H. and T. Ernst, (2011) "Lightweight network mobility within PMIPv6 for transportation systems," *Syst. Journal, IEEE*, vol. 5, no. 3, 352–361.

Lee, J. H., T. Ernst, and N. Chilamkurti, (2012) "Performance Analysis of PMIPv6-Based NEtwork MObility for Intelligent Transportation Systems," *IEEE Trans. Veh. Technol.*, vol. 61, no. 1, 74–85.

Makaya C. and S. Pierre, (2008) "An analytical framework for performance evaluation of IPv6-based mobility protocols," *Wirel. Commun. IEEE Trans.*, vol. 7, no. 3, 972–983.

Perera, E., V. Sivaraman, and A. Seneviratne, (2004) "Survey on network mobility support," *SIGMOBILE Mob. Comput. Commun. Rev.*, vol. 8, no. 2, 7–19.

Pack, S. (2008) "Relay-based network mobility support in proxy mobile IPv6 networks," in *Consumer Communications and Networking Conference, 2008. CCNC 2008. 5th IEEE*, 227–228.

Soto, I., C. J. Bernardos, M. Calderon, A. Banchs, and A. Azcorra, (2009). "NEMO-enabled localized mobility support for internet access in automotive scenarios," *Commun. Mag. IEEE*, vol. 47, no. 5, 152–159,

Shin, D. H., D. Moses, M. Venkatachalam, and S. Bagchi, (2013). Distributed mobility management for efficient video delivery over all-IP mobile networks: Competing approaches. IEEE network, 27(2), 28-33.

Valtulina, L., M. Karimzadeh, G. Karagiannis, G. Heijenk, and A. Pras, (2014) "Performance evaluation of a SDN/OpenFlow-based Distributed Mobility Management (DMM) approach in virtualized LTE systems," in *Globecom Workshops (GC Wkshps)*, 18–23.

Wischik, D., C. Raiciu, A. Greenhalgh, M. Handley, (2011). Design, Implementation and Evaluation of Congestion Control for Multipath TCP. In NSDI Vol. 11, 8-8.

Wagan, A. A., and L. T. Jung, (2017). Multilevel hybrid mobility management scheme for NEMO. In 2017 6th International Conference on Electrical Engineering and Informatics (ICEEI) 1-6. IEEE.

Wu, Y., K. Chen, K.. Xue, D. Ni, (2014). NEMO-based mobility management in LISP network. In 2014 Sixth International Conference on Wireless Communications and Signal Processing (WCSP) 1-6. IEEE.

Zhu, K., D. Niyato, P. Wang, E. Hossain, and D. I. Kim, (2011) "Mobility and handoff management in vehicular networks : a survey," no. 459–476.

Zúniga, J. C., J. Bernardos, A. delaOliva, T. Melia, R. Costa, and A. Reznik, (2013) "Distributed mobility a standards landscape," *IEEE Commun.* vol. 51, no. 3, 80–87.