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A REVIEW OF MOBILE IP PROTOCOL FOR THE IMPLEMENTATION ON DUAL STACK MOBILITY MANAGEMENT

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ABSTRACT

Network mobility nowadays plays the most crucial roles in delivering seamless mobility connectivity to billions of users around the world, and mostly the process of providing quality services are transparent from user's involvement. While the world itself in the midst of transitioning of the Internet Protocol (IP), IPv4 and IPv6 nodes will roam across the network. However, the current state of implementation and the introduction of the current transition scenario is not focused on the implementation of mobility communications. The trend of increasing user's mobility and the demand of speeding up the transition to IPv6 has obviously triggered the need for developing network mobility management suited for the mixed-IP environment. Current mobility protocols tightly coupled with the IP version due to the particularities of the protocols itself. Considering the scenario IPv6 will become the only protocol version eventually, the deployment will utilize the IPv6 mobility platform to support the dual stack environment. The goal of this investigation is to analyze and evaluate the different in existing IP mobility solution operating in mobile IP network, pinpointing each solution shortcoming and suggesting methods for improving the issues including handover latency, packet loss, and delivery failure, and signaling overhead issues in IP mobility management support protocol to suit the IP mobility support protocol in the mixed IP network environment. This article will present a study of the mechanism involved in various mobility protocols that have been standardized to study the best solution for the implementation of dual stack mobility management.

Keywords: *Mobility management, and dual stack*

1. INTRODUCTION

Internet Engineering Task Force (IETF) has set the standard for the implementation of IP mobility for mobile access to allow users to be able to move from one network to another network while maintaining session continuity. However, the current state of mobility implementation and the introduction of the current transition scenario is not focused on the mobility communications of IPv4 and IPv6 based networks to provide an efficient dual stack mobility platform. However, the transition mechanisms that exists nowadays not able to easily interoperate in the transition mobility scenario. Thus, the method Dual Stack Mobile IPv6 (DSMIPv6) has been introduced to allow roaming between IPv4 and IPv6 communications using Mobile IPv6 features (MIPv6). Analysis of previous studies stated that the implementation DSMIPv6 introduces high signaling cost, delivery delays and the probability of failure of packet delivery [1].

Mobile and wireless communication deal with the ability to maintain session continuity to provide a seamless connection the user. The factor of maintaining session continuity itself consists of several concerns which question regarding the performance of handover latency and mobility management. Furthermore, the concern on mobility management issue also breaks the mobility protocols into two types of approaches which are host based (require mobile node modification to support mobility stack) and network based (serving network or anchor point handles mobility management communication instead of the mobile node). The issue stated brings the implementation efficiency concern into the picture which questions the easiness of deployment and performance related in wireless signaling communication.

MIPv6 act as the catalyst for the implementation of the IP Mobility and was the result of improvement of Mobile IPv4 (MIPv4). Even though MIPv6 being the improved version of

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its predecessor protocol, various constraints are still arising and cannot be overcome in a more efficient manner such as handover latency, packet loss, and delivery failure, and signaling overhead while roaming between networks. Hence, various extensions and enhancement of MIPv6 have been introduced over the past years to tackle such constraints mentioned earlier.

This paper is intended to review the research that has been conducted by the previous researcher to get better picture and assists in the implementation of IP mobility in dual stack environment. Hence, the review was conducted using systematic procedures for obtaining relevant literature via computer search of relevant databases such as IEEEXplore, ScienceDirect, IETF Database, and Google Scholar regarding IP mobility support, procedures, and operation, in various IP mobility scenarios. The goal of this investigation is to analyze and evaluate the different in existing IP mobility support solution operating in mobile IP network, pinpointing each solution shortcoming and suggesting methods for improving the issues. Among the issues mentioned includes handover latency, packet loss, and delivery failure, and signaling overhead issues in IP mobility management support protocol by focusing on protocol criteria which are network architecture, handover management mechanism, and handover management, to suit with the IP mobility support protocol implementation in the mixed IP network environment.

The remaining part of the paper will be organized as follows. First, the review of mobile IP protocols presenting briefly regarding various extension and enhancement of MIPv6, and the comparisons between each approach. Then, we will present the related research regarding the implementation of dual stack mobility management by highlighting the important key of the research. Finally, the summary and conclusion based on the literature review.

2. MOBILITY IP MANAGEMENT

Standard communication protocols mobility has been introduced by IETF through a network mobility management concept in the aims to provide global roaming support wherever a network connection to a network location to another without causing an access disruption to maintain the session continuity. Over the past years, various extensions and enhancement of MIPv6 have been introduced by IETF and researchers. However, the focus for the mobile IP support protocol to operate in a mixed-IP environment was limited. Hence, this study will focus on investigating and analyzing the different in existing IP mobility solution in order to operate seamlessly in mobile communication. Below is the brief summary of the operation and feature of the mobility support protocols.

2.1 Mobile IPv6 (MIPv6)

The design of IP Mobility introduced in MIPv6 protocol is the result of the development, improve design and requirements as well as Mobile IPv4 (MIPv4). As explained in [2], MIPv6 share basic features of MIPv4 while providing a broader scope of improvements for the implementation. Among the improvements that have been introduced are eliminating the need to deploy Foreign Agent (FA) pervasively without causing access disruption during handover operation as the mobile node (MN) will get a new IP address as the handover operation take place. The topology of MIPv6 is as shown in Figure 1.

MIPv6 identifies MN by its permanent global home address, regardless of its current point of attachment to the Internet. A bi-directional tunnel is established between HA and MN current location (care-of address). While a mobile node is away from home, it sends information about its current location to a home agent on its home link via a process called binding. The home agent intercepts packets addressed to the mobile node's home address and tunneled them to the mobile node's current location. Route optimization implementation is possible if both MN and Correspondent Node (CN) are installed with MIPv6 stack.

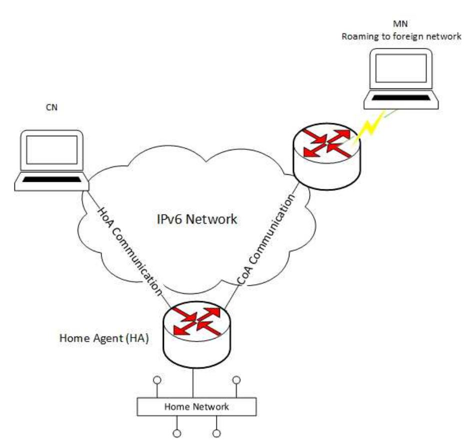

Figure 1 MIPv6 Topology

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2.2 Hierarchical MIPv6 (HMIPv6)

As mentioned in [3], HMIPv6 is the extension to the MIPv6 and is based on local mobility management compared to the latter which is global managed mobility. This mobility management approach separates global and local mobility management domain efficiently compared to MIPv6, which handles the situation all the same. Henceforth, the implementation of HMIPv6 able to reduce handover latency as the signaling process within the domain is handled by HMIPv6 and global mobility management signaling is handled by MIPv6. The figure below shows the topology of HMIPv6.

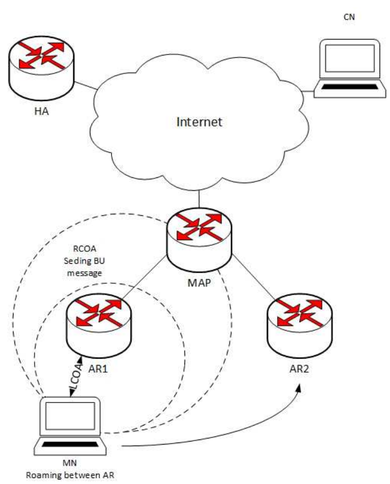

Figure 2 HMIPv6 Topology

HMIPv6 introduces a new node called Mobility Anchor Point (MAP) to assists in handoff process for MN in the HMIPv6 domain. HMIPv6 involves three phases of operation which are MAP discovery, MAP registration, and packet forwarding. The first stage which is MAP discovery is accomplished via sending the Router Advertisement (RA) message to MN, which contains the information of the anchoring MAP. Then, the registration phase will take place. MN need to configure two CoAs', which is Regional Care-of Address (RCoA), and Local Care-of Address (LCoA), and MN will perform binding process between the two address. Binding updates and acknowledgment signaling message will take place between MN and MAP. Next, the last stage of the phase, a bi-directional tunnel between MN and MAP is established. All packets sent by the MN will be tunneled to the MAP, and packets destined to the MN's RCoA are rerouted by the MAP and tunneled to the MN's LCoA.

2.3 Fast Mobile IPv6 (FMIPv6)

Further improvements to the MIPv6 protocol has been implemented and proposed in [4]. The proposed improvements focus on the issue of reducing the latency of handover. This protocol allows the MN to request information about neighboring access point network configuration before performing handover to the new access point. In other words, the protocol aims to configure a new Care-of Address (NCoA) or Previous Care-of Address (PCoA) before the handoff process. The main idea lying behind FMIPv6 protocol is to have the handover latency and loss of packets reduced.

FMIPv6 protocol has two modes of operation modes called predictive and reactive mode which will allow the optimization of the handover process. A predictive handover process is a scenario where MN can detect the need to perform a handover when MN detect decreasing performance in the current link. MN will send a Fast Binding Update (FBU) message to the currently connected access router containing information of its current CoA and access router it plans to switch. The current serving access router will send a handover initiation message to the new access router containing MN information. The new access router will confirm the request by replying handover acknowledgment (HACK) message to the current serving access router. Next the access router will send Fast Binding Acknowledgment message to the MN and will be ready to perform handover. For reactive handover mode; the mechanism is employed when MN unable to anticipate the need to perform handover to another access point. This process will take place when the process already in progress. Compared to the previous mode, FBU message is sent when MN already switches to the new access router. According to [5], the process of discovering access router in FMIPv6 still cause substantial handover delay and could not achieve seamlessly communication access.

2.4 Proxy Mobile IPv6 (PMIPv6)

PMIPv6 mobility management support protocol is developed through the concept of Network-Based Localized Mobility Management [6]. Previous IP mobility protocol described earlier is developed using a host-based approach where MN need to perform signaling to the connected mobility topology when roaming to other network location. This scenario has caused problems including the need to implement the complex

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configuration of host mobility and authentication process for the signaling exchange and routing update. Accordingly, the concept removes the need to install mobility stack on MN.

Through PMIPv6, the mobility functions will be managed by the network entity of the mobility protocol. Based on the PMIPv6 basic operation, when the MN enters the PMIPv6 domain, Mobile Access Gateway (MAG) will perform Proxy Binding Update (PBU) signaling message to Local Mobility Anchor (LMA) containing MN information. Upon receiving the message, the LMA will assign a prefix to MN and subsequently send acknowledgment message along with prefixes that have been included to MAG. At the same time, bi-directional tunneling between MAG and LMA is established. Then MAG will then send Router Advertisement (RA) message to MN for the address configuration. The bi-directional tunneling generated between the LMA and MAG is a platform for data traffic of MN. Traffic addressed to or sent by MN will be extended through the LMA and the MAG and after the decapsulation, traffic will be forwarded directly to the appropriate correspondent node. Figure 3 shows the topology of PMIPv6.

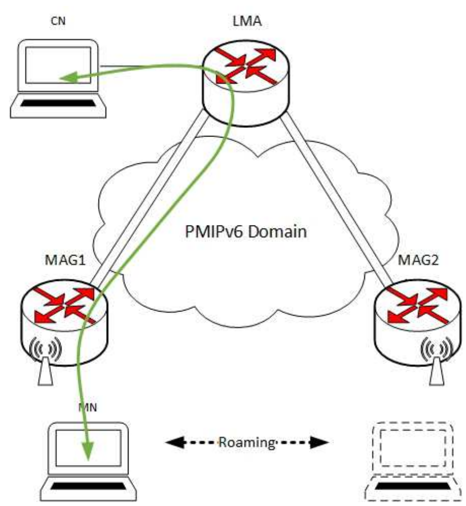

Figure 3 PMIPv6 Topology

Furthermore, the implementation of PMIPv6 also uses the unique MN prefix address compared to other protocol that implements shared prefix approach between MN. Accordingly, Duplicate Address Detection (DAD) does not need to be applied thus contribute to the increase of the performance of the handover protocol. However as tested and analyzed in [7], the author mention that PMIPv6 operation could cause sub-optimal routing because of all traffic that needs to traverse LMA hence causing overhead in the operation.

2.5 Distributed Mobility Management Proxy Mobile IPv6 (DMM PMIPv6)

At present, IETF plays a role in the development and standardization of distributed mobility protocol [8]. Various constraints were identified in the implementation of existing mobility protocols such as sub-optimal routing, mobility problems scaling capabilities, and architectural integrity of the network mobility [8]. Hence, the Distributed Mobility Management (DMM) has been introduced to broaden the scope of the growing mobility management that could cover a broader range of mobility technology.

This IP mobility support protocol was developed based on flat network extended from PMIPv6 mobility support protocol. The mobility anchor point is placed close to the MN, distribution of control and data plane between protocol entities located on the edge of the access network reduce the burden on the signaling process [9] compared to PMIPv6. Network entities involved in the network architecture of the DMM PMIPv6 are Mobility Anchor/Access Router (MAAR) and Centralized Mobility Database (CMD). MAAR serves to perform IP prefix assignment for each MN and unique for each MAAR. Accordingly, MN will receive a new prefix for each new MAAR attached. The second entity involved in this mobility support protocol is CMD. This entity performed mobility binding procedures as carried out on LMA but did not perform any procedures related to data plane communication.

DMM PMIPv6 adopt PMIPv6 solution with enhancement on the protocol's operation functionalities made to the network entities. Regarding the operation, MAAR relies on CMD functionalities to configure routing information of MN's roaming between its point of attachment (MAAR attachment). CMD manages global binding information and sessions of the MN for each attachment and detachment from the mobility domain. MAAR will communicate with the central database to retrieve information regarding MN's location to ensure session continuity during each handoff. The implementation of this solution also introduces signaling overhead. However, it depends on the mobility scenario of the MN in the aspect of traffic's nature and roaming experience [10].

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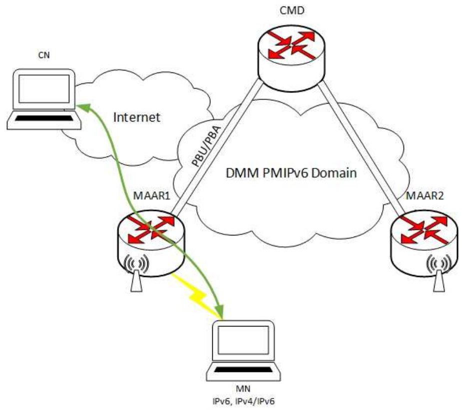

Figure 4 DMM PMIPv6 Topology

2.6 Mobility Analysis

Comparisons between various protocol-based mobility have been conducted through various previous studies. This study briefly examined the architecture, topology, and feature of communication operations performed in each protocol. As summarized in Table 1, the comparison criteria between the mobility protocols were shown. From the review, handover management function plays a critical role in the implementation of mobility management given the burden of signaling contributes to the performance and efficiency of a mobility protocol as the aim of mobility is to gain seamless connection experience by the user.

Also, the implementation of the IP mobility solutions for MIPv6, HMIPv6, and FMIPv6 require modifications of mobility stack feature to be carried out on MN, compared to PMIPv6 and DMM PMIPv6 based solution protocol that does not require any involvement of MN in the mobility management. The review found out via the DMM PMIPv6 implementation, handover latency that occurs during the handover process can be minimized by the separation of control plane and data plane operation compared to the implementation of PMIPv6 protocol. Furthermore, the signaling between entities in the mobility domain does not require communication across diverse and hierarchical network entity (e.g., MAG-LMA, HA-FA, AR-MAP).

Table 1 IP Mobility Support Protocols Solution Comparison

Protocol/Criteria	MIPv6	HMIPv6	FMIPv6	PMIPv6	DMM PMIPv6
Network Architecture Approach	Centralized	Centralized	Centralized	Centralized	Distributed
Mobility Management Mechanism	Host	Host	Host	Network	Network
Handover Management	Yes	Yes	Yes	Yes	Yes
Infrastructure Requirement	HA	HA, MAP	Enhanced HA, AR	LMA, MAG	Enhanced LMA, MAG
MN Modification	Yes	Yes	Yes	No	No
Handover Latency	High	Medium	Good	Good	Better
Route Optimization	Yes	Yes	-	No	No for MN performing handover

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3. RELATED RESEARCH

This section will describe and explain the implementation and issues arises from the previous work to discover key features for the development of an efficient mobility support protocol in the dual stack environment. As it has been known, the transition phase of IPv4 and IPv6 have been going on for years. Hence, the implementation of mobility support needs to take into account the existing IPv4 application and network roaming and communicating on the Internet. The expectation would be the ability of the users to enjoy seamless and transparent service while connecting to the applications and networks regardless of the types of the Internet protocol.

In a dual stack mobility management scenarios based on [11], to make sure the connection to survive, mobility network entities need to maintain two sets of IP for each signaling. So, it is expected that one mobility management protocol to be able to manage the mobility of IPv4 and IPv6 prefixes. The following part will discuss the research and experiment perform in a dual stack mobility management environment.

3.1 Dual Stack Mobile IPv6 (DSMIPv6)

DSMIPv6 specifications extend MIPv6 functionality by allowing MN to use the dual-stack feature to roam in IPv4 and IPv6 networks. In principle, the implementation of this protocol requires MN to manage simultaneously its Home Address (HoA) and Care-of Address (CoA) and update the home bindings information to be able to forward IPv4/IPv6 destined packets. DSMIPv6 defines two situations which are IPv4 Home Address Mobility support and IPv4 Mobility Transport Support. The figure 5 shown is the topology for the DSMIPv6.

In the first scenario, when MN visits IPv6 network to communicate with IPv4 application correspondent node, MN configures its HoA and CoA with a globally unique IPv6 address via Binding Update (BU) message which includes IPv4 HoA option. Upon receiving BU message, Home Agent (HA) will create two binding entries for IPv4 and IPv6 HoA, which both will point to the IPv6 based CoA. Two bi-directional tunnels will be established for IPv4 traffic (IPv4-in-IPv6) and IPv6 traffic (IPv6-in-IPv6). Binding Acknowledgment (BA) message will be sent back to MN for the prefix configuration.

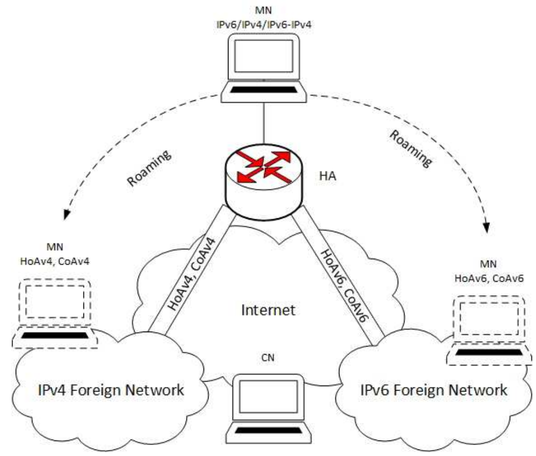

Figure 5 DSMIPv6 Topology

The second scenario, the protocol require MN to be able to configure IPv4 based CoA's. As opposed to the first scenario, the BU message will include IPv4 based HoA option and IPv4 based CoA option. Upon receiving BU message, Home Agent (HA) will create two binding entries for IPv4 and IPv6 HoA, which both will point to the IPv4 based CoA. After that, two bi-directional tunnels will be established for IPv4 traffic (IPv4-in-IPv4) and IPv6 traffic (IPv6-in-IPv4). Nevertheless, [12] mentioned based on the implementation of a test bed testing experiment using Linux operating system that performance issues occur during the handover and affect the overall performance of the mobility stack. Furthermore, based on research perform in [1], the author concluded that the implementation of dual stack mobility result in highest signaling cost, handoff delay and handoff-failure probability.

3.2 Dual Stack Proxy Mobile IPv6 (PMIPv6 Dual Stack)

RFC 5844 [13] has explained in detail regarding the IPv4 protocol support on mobility management technology based on PMIPv6. Motivations and problem statement have been described in detail and the issues and concerns that have been raised in the implementation of the PMIPv6. The scope of the implementation was standardized regarding support for the implementation of a dual-stack scenario such as mentioned in the previous subsection regarding IPv4 Home Address Mobility Support and IPv4 and IPv4 Mobility Transport Support.

As explain in the previous section regarding PMIPv6 architecture operation, network-based

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mobility management mechanism able to significantly reduces signaling overhead and handover latency problem. However in PMIPv6 dual stack implementation aim to extend the protocol to support IPv4. The implementation of PMIPv6 Dual Stack involves MN to be able to configure IPv4 HoA to roam in a PMIPv6 domain. However as explained regarding the scenario involves in dual stack mobility management, in IPv4 Home Address Mobility Support will use IPv6 CoA with the option of IPv4 HoA as the pointer to roam and communicate within the domain. While in IPv4 Mobility Transport Support, the IPv6 address does not need to allocate to enable the IPv4 HoA mobility support. Instead, the PMIPv6 signaling will operate over IPv4 transport network which requires modification over the existing IPv6 signaling.

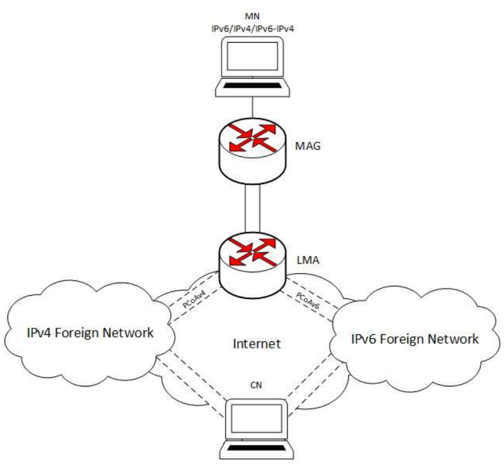

Figure 6 PMIPv6 Dual Stack Topology

The findings and analysis presented in [14] describe how MIPv4 and MIPv6 capable of operating at the same time through the implementation of the PMIPv6 protocol with the dual-stack method. The testing is conducted through scenario IPv4 Home Address Mobility Support and IPv4 Mobility Transport Support, as discussed in the previous section. The experiment implements a test handover for 100 times every 10 seconds while sending a packet at the rate of 10ms each packet. The tests found that the handover latency occurs during the testing resulting 0.4339 seconds in the IPv4 scenario and 0.0526 seconds in the IPv6 scenario for the IPv4 Home Address Mobility Support test. While IPv4 Mobility Transport Support, the authors found an average latency of 0.4523 seconds for handover latency in the IPv4 scenario and 0.0541 seconds in the IPv6 scenario. The author mentions that, even though there is latency that occurs in the process, the author asserts that the amount of time the latency occur can be accepted based on the premise that users know the current situation in advance.

4. OPEN RESEARCH ISSUES

The field of IP mobility support is emerging fast, and offering various direction to pursue. IP mobility allows mobile nodes to maintain the current connection while moving from one subnet to subnet (roaming) to another. However various constraints are still arising and cannot be overcome in a more efficient manner such as handover latency, packet loss, and delivery failure, and signaling overhead while roaming between networks and mixed IP network.

This study believe in order to produce an improvement to present IP mobility solution, researchers can continually provide a better solution to the mentioned issues. The next step is to create synergy among the different IP mobility support protocols which were presented in the previous section. This will create a more efficient solution that could provide seamless communication in mobile communication.

A further research direction to improve seamless communication in IP mobility is to analyze and evaluate the different existing IP mobility solution to operate in a mixed IP mobile network, pinpointing each solution shortcoming and suggesting methods for improving the issues mentioned.

Additional possible future research includes developing a better mechanism to operate in dual stack mobility environment to improve overall operation performance including handover latency, packet loss, and delivery failure, and signaling overhead issues in mobility management support protocol in IPv6 mobility transition scenario.

5. CONCLUSION

In this paper, we have presented clear and detailed specifications of the mobility management support protocol that is to be implemented to become an efficient dual stack platform that can optimize handover performance and minimize signaling overhead compared to the current existing implementation.

Based on the comparative analysis of the mobility protocol specification in section 2, the amount of time could be reduced given the process of the MN to forward the packet to the CN without

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having to traverse central mobility anchor entity (e.g. MIPv6, HMIPv6, FMIPv6). Hence, able to avoid the need to perform packet encapsulation and decapsulation procedure in which led to increased processing overhead.

Therefore, DMM PMIPv6 mobility management implementation shows able to provide the fastest route for the updating and handover process. However, this study involved two types of IP protocol technology, which requires the implementation of research and investigation for the implementation of the IPv4 protocol support scenarios as described in the previous section to get a clear picture as the next step in realizing an efficient dual stack implementation on mobility management.

REFERENCES:

[1] J. Xie and U. Narayanan, "Performance Analysis of Mobility Support in IPv4/IPv6 Mixed Wireless Networks," IEEE Trans. Veh. Technol., vol. 59, no. 2, pp. 962–973, 2010.

[2] D. Johnson, C. Perkins, and J. Arkko, "RFC 3775 - Mobility support in IPv6," IETF, June, pp. 1–165, 2004.

[3] H. Soliman, C. Castelluccia, K. ElMalki, and L. Bellier, "RFC 5380: Hierarchical Mobile IPv6 (HMIPv6) Mobility Management," 2008.

[4] R. Koodli, "RFC 5268: Mobile IPv6 Fast Handovers," 2008.

[5] E. Ivov, J. Montavont, and T. Noel, "Thorough empirical analysis of the IETF FMIPv6 protocol over IEEE 802.11 networks," IEEE Wirel. Commun., vol. 15, no. 2, pp. 65–72, 2008.

[6] S. Gundavelli, K. Leung, V. Devarapalli, K. Chowdury, and B. Patil, "RFC 5213: Proxy Mobile IPv6," 2008.

[7] S. Kassahun, A. Demessie, and D. Ilie, "A PMIPv6 approach to maintain network connectivity during VM live migration over the internet," 2014 IEEE 3rd Int. Conf. Cloud Netw., pp. 64–69, Oct. 2014.

[8] H. Chan, "RFC 7333: Requirements for Distributed Mobility Management," 2014.

[9] F. Giust, C. Bernardos, and A. de la Oliva, "Analytic Evaluation and Experimental Validation of a Network-based IPv6 Distributed Mobility Management Solution," IEEE Trans. Mob. Comput., vol. 6, no. 1, pp. 1–1, 2014.

[10] F. Giust, L. Cominardi, and C. J. Bernardos, "Distributed mobility management for future 5G networks: overview and analysis of existing approaches," Commun. Mag. IEEE, vol. 53, no. 1, pp. 142–149, 2015.

[11] H. Soliman, "RFC 5555 : Mobile IPv6 Support for Dual Stack Hosts and Routers," 2009.

[12] R. Kuntz and J. Lorchat, "Versatile IPv6 mobility deployment with dual stack mobile IPv6," Proc. 3rd Int. Work. Mobil. Evol. internet Archit. - MobiArch '08, p. 49, 2008.

[13] S. Gundavelli, "RFC 5844: IPv4 Support for Proxy Mobile IPv6," 2010.

[14] F. Ren and H. Zhou, "Implementation and Test of PMIPv6 Dual Stack Protocol," in 2012 Sixth International Conference on Innovative Mobile and Internet Services in Ubiquitous Computing, 2012, pp. 305–310.