Australian Journal of Basic and Applied Sciences, 9(25) Special 2015, Pages: 72-78

ISSN:1991-8178

Australian Journal of Basic and Applied Sciences

Journal home page: www.ajbasweb.com

Integration of Fast Handover and Hierarchical Mobile Internet Protocol with Wireless Mesh Network

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ARTICLE INFO

Article history:
Received 13 June 2015
Accepted 28 July 2015
Available online 5 August 2015

Keywords:
MIPv6, HMIPv6, FMIPv6, WMN

ABSTRACT

Current generation wireless technology has boost rapidly with various mobile Internet protocols which has been introduced to cope with the increasing number of usage to solve the congestion problems and service degrade issues. However, the service provider is not giving out much for users in rural area and urban areas where communication coverage in some areas are limited as communication tower has to be shared and located further away from service locations. In this paper, we have introduced an innovative approach to overcome the coverage issue by integrating 3 types of Mobile Internet Protocol (MIP) which are MIPv6, HMIPv6 and FMIPv6 with Wireless Mesh Network. The integration allows coverage to certain unreachable area within a cell to be reachable such as rural areas, underground facilities and many others. Simulations for this research have been conducted using NS-2 Network Simulation software with patches provided by fellow researcher to accommodate MIP and WMN. At the end of this research, it is proven that the design and develop of HMIPv6 with WMN performs better as compare to the others Mobile Internet Protocols over the Internet**.**

To Cite This Article: Sashikumar Muthut, Wei Siang Hoh, Bi-Lynn Ong, R. Badlishah Ahmad., Integration of Fast Handover and Hierarchical Mobile Internet Protocol with Wireless Mesh Network. ***Aust. J. Basic & Appl. Sci.,*** *9(25): 72-78, 2015*

INTRODUCTION

The current generation mobile Internet users have increased drastically since the introduction of the smart phones and other devices that could be connected to the Internet such as Smart TVs, wireless printers and many others. These excessive usages have cause congestion and intermittent connection issues to rise rapidly (For, D., 2002). Present infrastructures also have some coverage issues as it can't cover specific areas in its coverage area such as underground facilities and high rise buildings. Furthermore, people from rural areas have been receiving limited coverage from the entire major service providers. The lack of connectivity is caused by poor infrastructure as most rural areas have to depend on service tower that are miles away from their province. Since the population in rural are not greater than those in urban areas, Telco companies are not showing deep interest in expanding the coverage radius in these areas. The cost of upgrade at this phase cause high budget and it is less profitable base on business view. En-route for solutions to solve the congestion and intermittent connection issues, Internet Engineering Task Force (IETF) came out with an upgraded IPv4 version of Mobility protocols which are Low Latency Handover and Regional Handover to Fast Handover and Hierarchical with several new updates which is made available to the protocol (Barbudhe, V.K. and A.K. Barbudhe, 2013). Having known the advantages of Fast Handover and Hierarchical Handover, when the IETF proposes the new Internet protocol which is IPv6, it is proposed to integrate the Hierarchical and Fast Handover with IPv6 which namely, HMIPv6 and FMIPv6(Mathur, M., 2012).

HMIPv6 is designed to reduce the amount of signaling and FMIPv6 is designed to reduce the service degradation by minimizing the time during which a mobile node is unable to send or receive IP packets (Yunsheng, G., 2011). Hence, in this research paper, we have introduce a new research field in wireless mesh networks (WMN) which combines Fast Handover Mobile Internet Protocol version 6 (FMIPv6) and Hierarchical Mobile Internet Protocol version 6 (HMIPv6) working harmoniously as inter network and intra network. Researches are less performed thoroughly in these areas where the outcome can contribute big time on coverage area and performance improvement when a user tries to

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access network connection from rural areas, underground building, underground parking bay and many others. Fig. 1 below illustrate wireless network usage diagram.

Fig. 1: Wireless Network Usage Diagram.

Related Works

G.B. Himabindu, A.M. Vedhagrani and S.R. Raj Kumar *et al* (2014) had investigated Performance Evaluation of Mobility Management using Mobile IPv4 and Mobile IPv6 protocols. The authors made comparison between Mobile Internet Protocol Version 4 (MIPv4) and Mobile Internet Protocol version 6 (MIPv6) to identify the best MIP based on parameters such as handoff latency, throughput, packet end to end delay and packet delivery ratio (PDR). The simulation was done using open source software Network Simulator NS-2. The authors concluded MIPv6 performs better compared to MIPv4 in terms of throughput, handover latency, average end to end delay, packet delivery ratio and dropped packets.

Fatma A. Al Emam, Mohamed E. Nasr and Sherif E. Kishk *et al(2014)* had done research On the Performance of Wi-Fi, Ad Hoc and WiMAX Handovers with MIPv4 versus MIPv6. In this research, the authors have done a comparative study between Mobile Internet Protocol version 4 (MIPv4) and Mobile Internet Protocol version 6 (MIPv6) in Wi-Fi, Ad Hoc and WiMAX environments to determined which Mobile Internet protocol (MIP) performs better in terms of performance matrix delay and throughput in those Mobile Internet environment. The simulation was done using open source network simulator software OPNET Modeler and NS-2.At the end of the research, the researchers have concluded that MIPv6 performed better in all the tests carried out compared to MIPv4.

Yan Zhang and Hai Bi *et al* (Zhang, Y. and H. Bi, 2012) had done research on The Simulation of Hierarchical Mobile IPv6 with Fast Handover Using NS-2. In this study, the authors have compared four types of mobile routing protocol to identify the best routing protocol for mobile network, that are Mobile Internet Protocol version6 (MIPv6), Fast Handover Mobile Internet Protocol version 6 (FMIPv6), Hierarchical Mobile Internet Protocol version 6(HMIPv6) and Fast Handover for Hierarchical Internet Protocol version 6 (FHMIPv6) which is combination of FMIPv6 and HMIPv6. Network Simulator version 2 (NS-2) has been used to conduct the simulations. Performance matrixes that have been taken in count are handover delay and jitter. At the end of research, it's been concluded that FHMIPv6 performed extremely better compared to other Mobile Internet Protocol.

Zimani Chitedze and William D. Tucker *et al(2012)* had investigated FHMIPv6-based Handover for Wireless Mesh Networks. In this research, the authors have done comparison in Wireless Mesh Network using Fast Handover with Hierarchical Mobile Internet Protocol version 6 methods which are vertical handover and horizontal handover by emitting MIPv6 performance data as a base result to prepare comparison. The authors have taken in count the performance matrix of throughput, average delay, and packet loss. Network Simulator version 2.32 (NS- 2.32) has been used to conduct the simulation The overall simulation results shows that Fast Handover for Hierarchical Internet protocol version 6 (FHMIPv6) performed extremely well compared to other protocol in Wireless Mesh Network(WMN)(Muthut, S., 2015).

Ambar Yadav, Arti Singh *et al* (Yadav, A. and A. Singh, 2014) had researched on Performance Analysis And Optimization Of HMIPv6 And FMIPv6 Handoff. The research intention was to analyst handoff management protocols of HMIPv6 and FMIPv6 in supporting mobility and latency reduction Management Protocols. The authors have also proposed a new analytical model for MIPv6 optimization protocol. The researchers have completed the simulation by using Matlab 7 software with collecting samples totaling 100 for both FMIPv6 and HMIPv6. They concluded that, the proposed method has significantly reduced handoff latency in both FMIPv6 and HMIPv6.

Terminology:

MIPv6:

Mobile Internet Protocol version 6 (MIPv6) is predecessor of MIPv4 that have been introduced by Internet Engineering Task Force (IETF). The aim is to allow transport layer sessions; TCP connections, UDP-based transactions, to continue even if the underlying host(s) move and change their IP addresses and allow nodes to be reached through a static IP address (Nikander, P., 2003; Ren, K., 2006). An additional add on that have been introduced for MIPv6 is Route Optimization (RO). It allows the packets to be delivered using shortest path. Fig. 2 below illustrate MIPv6 network diagram.

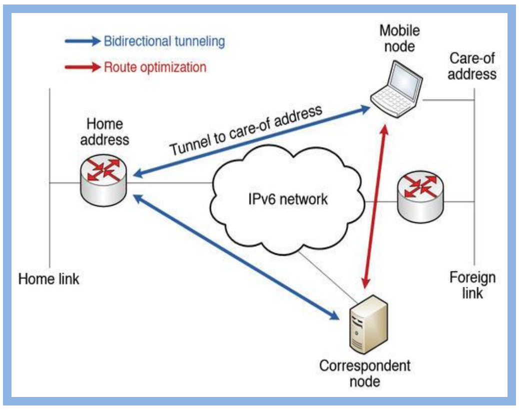

Fig. 2: MIPv6 Network Diagram.

HMIPv6:

Internet Engineering Task Force (IETF) has introduced HMIPv6 based on its predecessor MIPv6 and has implement new technologies to it to ensure the increment in the performance of mobile networking. One of the features in HMIPv6 is Mobility Anchor Point (MAP). Introduction of MAP in HMIPv6 have improve the handover latency and reduced the amount of signaling between the Mobile Node (MN), its Correspondent Nodes (CN) s, and its Home Agent (HA) (Gelogo, Y.E. and B. Park, 2012), network diagram of HMIPv6 is as shown in Fig. 3. Thus, HMIPv6 is more efficient compared to the previous MIPv6 in terms of the handover and broadcasting. The technology also improves the inter network connection and smoothen the users intermittent connections.

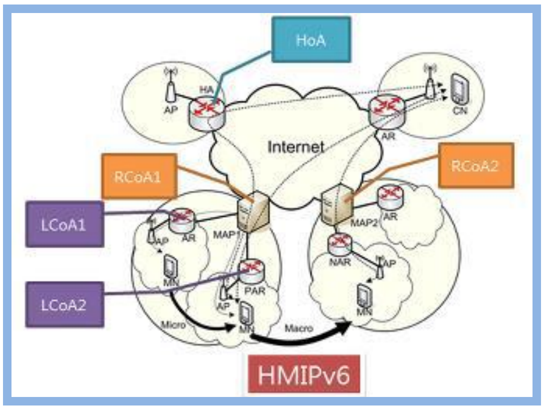

Fig. 3: Network Diagram of HMIPv6.

FMIPv6:

FMIPv6 is another initiative by the Internet Engineering Task Force (IETF) to improve the mobile network for the mobile users. The FMIPv6 is also designed based on the previous version of MIPv6. The FMIPv6 contains three signalling messages anticipation phase that are Router Solicitation for Proxy Advertisement (RtSolPr), Proxy Router Advertisement (PrRtAdv) and Fast Binding Update (FBU) (Khan, S., 2010). The introduction of the new FMIPv6 has Minimize the packet loss and latency due to handoffs process thus have improve the inter network connection and smoothen the users intermittent connections. Fig. 4 below illustrates network diagram of FMIPv6.

Wireless Mesh Network:

Wireless Mesh Network (WMN) as shown in Fig. 5 is a communication made up of radio nodes organized in a mesh topology. Figure 5 below shows

WMN diagram. WMN comprising mainly of mesh routers, mesh gateways and mesh clients, are envisioned to expand Internet access in urban and rural areas (Akyildiz, I.F., 2005). Mesh routers provide route between different mesh clients whereas Mesh Gateways are used to interconnect different wireless networks such as cellular networks and Wi-Fi (Mhatre, V., 2007). The Mesh Client (MC) could be a stationary workstation, or mobile user that communicates across the internet. WMNs provide promising services to the end user in the form of a broadband home networking, community and neighborhood networks (Ahmed, E., 2013).

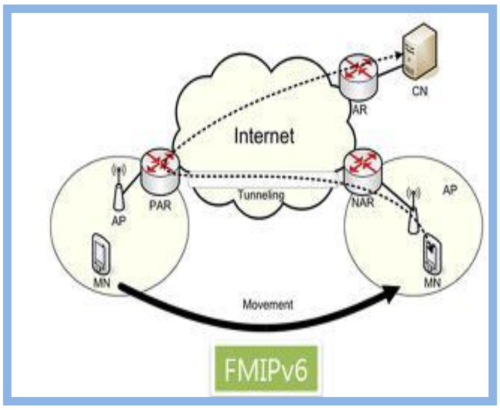

Fig. 4: Network Diagram of FMIPv6.

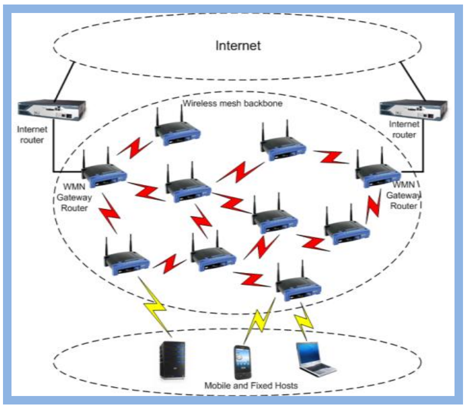

Fig. 5: Wireless Mesh Network Diagram.

Experiment setup:

This experiment was completed by using Network Simulator NS-2 software version 2.31, with additional patch files provide by previous researches such as patch file of Wireless Mesh Network by Department of Information Engineering of University of Pisa, Italy and Patch for Fast Handover and Hierarchical Mobile Internet Protocol was downloaded from Pedro Vale Estrela - NS2 IP Mobility Page. Network topology used in our experiment is shown in Fig. 6 below. The network topology represents inter and intra network connections consist of MIPv6, FMIPv6, HMIPv6 and WMN. Inter network section comprises of 8 routers with 5 wired router and 3 wirelsss router accomplish as base stations. Intra network portion includes 9 Wireless Mesh routers which has been setup in a grid formation to maximised the coverage area. Table 1 below shows connection detail and connection speed of each link and node.

Performance matrix that has been taken considered in this research are End-to-End Delay, Throughput and Packet Delivery Ratio (PDR). End to end delay is sum of the individual delays experienced at each node over a network. A minimum level of delay involve due to time taken to transmit packets through a link. Throughput is the average rate of successful packets delivered over a communication channel and measured in bits per second (bit/s or bps). PDR is ratio of packets that are successfully delivered to a destination/node compared to the number of packets that have been sent out by the sender.

RESULT AND DISCUSSION

The simulation outcomes have been presented clearly in tables and graphs below. The data have been organized based on types of Mobile Internet Protocol which are MIPv6, HMIPv6 and FMIPv6.

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Results have been tabled based on different packet sizes which are 256 KB, 512 KB, 1024 KB and 2048KB. Table 2 below shows simulation results obtain for MIPv6 with WMN. Table 3 below shows simulation results obtain for HMIPv6 with WMN. Table 4 below shows simulation results obtain for FMIPv6 with WMN.

Table 1: Connection Details of Link and Node.

Links	Speed	Queue Type
CN-N1	100 Mbps	RED
HA-N1	100 Mbps	RED
N1-MAP	100 Mbps	RED
MAP-N2	10 Mbps	RED
MAP-N3	10 Mbps	RED
N2-PAR	1 Mbps	Droptail
N3-NAR	1 Mbps	Droptail
WMN	10 Mbps	Full-Duplex
Legends		
CN :Corresponding Node HA :Home Agent MAP :Mobility Anchor Point WMN :Wireless Mesh Network RED :Random Early Detection		

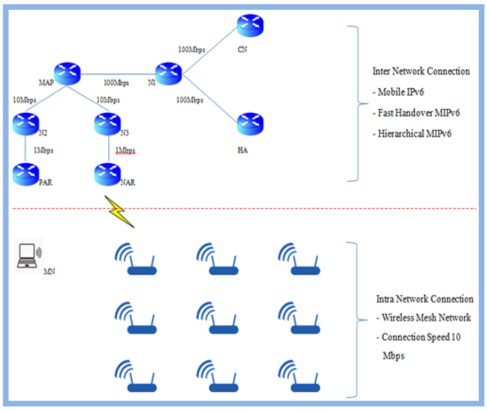

Fig 6: Inter & Intra Network Connection Diagram.

Table 2: MIPv6 with WMN.

Packet Size (Kbytes)	Delay (ms)	Packet Delivery Ratio (%)	Throughput (Kbps)
256	149.43	77.58	1116.16
512	138.64	78.17	2273.28
1024	150.86	80.41	4874.24
2048	152.40	82.47	10403.84

Table 3: HMIPv6 with WMN.

Packet Size (Bytes)	Delay (ms)	Packet Delivery Ratio (%)	Throughput (Kbps)
256	190.14	94.10	980.48
512	179.64	93.27	3829.76
1024	192.86	94.75	8130.56
2048	202.40	97.14	18104.32

Table 4: FMIPv6 with WMN.

Packet Size (Bytes)	Delay (ms)	Packet Delivery Ratio (%)	Throughput (Kbps)
256	187.14	93.27	1914.88
512	179.64	93.27	3829.76
1024	188.86	92.93	7802.88
2048	195.40	96.08	17080.32

Based on results obtain from simulation experiments, MIPv6 with WMN perform well in term of End-to-End Delay. Contrariwise, performance of both PDR and Throughput for MIPv6 declined with less than 82.47% successful packet delivery rate and 10403.84 Kbps throughput which is lesser compared to the amount of transmission. This clarifies the low End-to-End Delay attains by MIPv6 with WMN as many packets have been dropped and contributed to a low PDR and Throughput. Subsequent of MIPv6 with WMN is HMIPv6 with WMN, End-to-End Delay for this protocol has slightly increased contrary to MIPv6's performance, and HMIPv6 with WMN has higher PDR and Throughput. The PDR and Throughput for this mechanism are 97.14 percent and 18104.32 Kbps respectively. This is cause by MAP implementation and Hierarchical movement pattern. FMIPv6 with WMN has a fair performance outcome as it is based on anticipated handover with a slightly lower PDR and Throughput compared to HMIPv6.

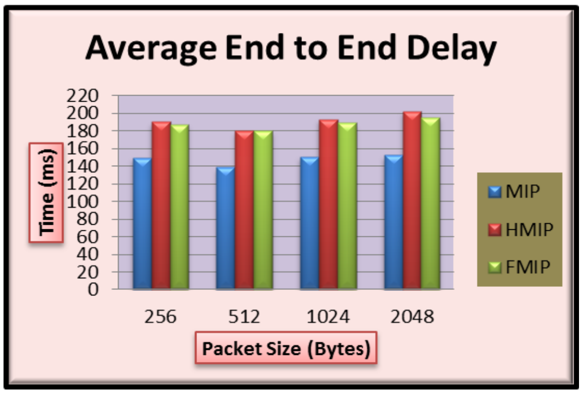

Fig. 7: Average End to End Delay Chart.

Having studied Fig. 7 above, it is observed that as the packet sizes increase, end-to-end delay is increased. The reason is because as the packet sizes increase, the network needs more time to send packets over the Mobile Internet and through WMN. Additionally, it is observed that MIPv6 performs better compared to HMIPv6 and FMIPv6. It is followed by FMIPv6 performs better than HMIPv6. However, end-to-end delay for these 3 mechanisms does not have many differences. Thus, it can be concluded that these 3 mechanisms have not much improvement between the mechanisms with the integration with WMN.

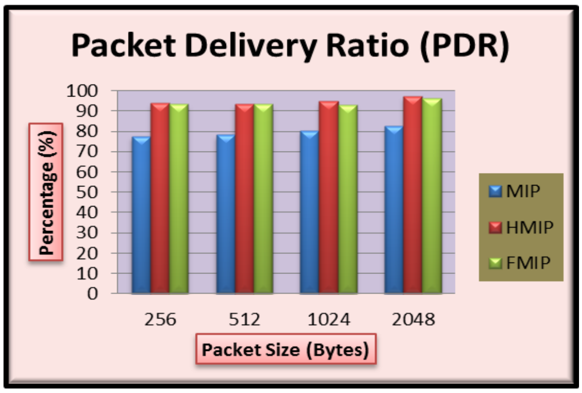

Fig. 8: Comparison Chart of Packet Delivery Ratio (PDR).

Fig. 8 shows the packet delivery ratio (PDR) for MIPv6, HMIPv6 and FMIPv6 with WMN. As observed, as the packet sizes increase, the PDR is increased. The reason is because as the packet sizes increased, network sends more data rather than the packet header. Additionally, it can be observed that HMIPv6 performs better as compare to MIPv6 and FMIPv6. MIPv6 performs the least among these 3 mechanisms. The reason is because HMIPv6 performs the MAP mechanism where same hierarchical network does not need to be sent over the higher hierarchical network. Whereas in FMIPv6, the fast handover mechanism informs the new network about the handover process before it performs the handover processes. Thus, HMIPv6 and FMIPv6 perform better than the original MIPv6.

Fig. 9 shows the throughput for these 3 mechanisms. As shown, as the packet size increase, throughput increases. In addition, it is observed that HMIPv6 performs better as compare to FMIPv6 and MIPv6. For example packet size of 2048 bytes, HMIPv6 has the throughput of 18104.32 Kbps. FMIPv6 has the throughput of 17080.32 Kbps and MIPv6 has the throughput of 10403.84 Kbps. The reason of HMIPv6 performs better than FMIPv6 and MIPv6 is explained as before where HMIPv6 does not need to perform higher hierarchical data transmission if the nodes perform lower hierarchical network communication.

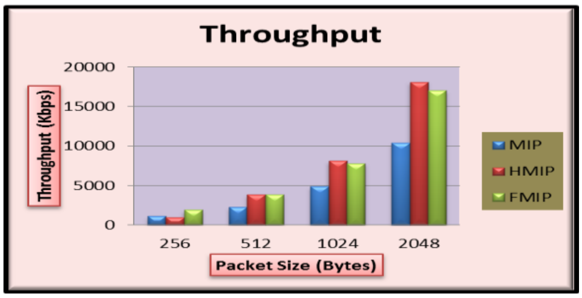

Fig. 9: Comparison Chart of Throughput.

Conclusion:

In this research, performance evaluations of MIPv6, FMIPv6 and HMIPv6 with WMN have been discussed in details in this paper. The aim of the design is to increase the coverage area by not suffocating performance between inter and intra network. Delay in this research increased slightly cause by coverage boost. Additionally, it has increase the throughput and Packet Delivery Ratio (PDR). Having increased the throughput and PDR, these can provide better service quality to the wireless Internet users. Thus, we believe that having introduces this proposed expansion; this improvement is able to improve service quality and service range of wireless communication in areas affected by coverage problems.

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