Experimental evaluation of real-time packets transmission during vertical handover process on mobile ipv6

S Praptodyono1*, A S Pramudyo1, A Irfan1, M I Santoso1 and A Osman2
1 Electrical Engineering Department, Universitas Sultan Ageng Tirtayasa, Jl. Jend. Sudirman Km. 3, Cilegon, Indonesia
2 School of Computer Sciences, Universiti Sains Malaysia, Jl. Sungai Dua, Penang, Malaysia

*Email: supriyanto@untirta.ac.id

Abstract. The Internet user is growing incrementally over the world. Most of them use mobile devices to connect to the internet. They aim to stay in connection every time and everywhere. Thus, they use mobile IP communication to get always connected to the internet while they move to another place. Fortunately, the telco infrastructure has reached many places in the world. Also, the video file transmission is now becoming a new trend, especially a short movie transmitted via social media. The huge of the internet connection caused the scarcity of Internet address. It was anticipated by introducing IPv6 that supported the mobility by presenting the Mobile IPv6. This paper evaluates the performance on the MIPv6 mechanism on transferring video when the user moves to another place that usually different network infrastructure. Therefore, the vertical handover does not disturb the quality of the video transmission. The experimentation results show during the vertical handover, the addition delay and packet loss is low especially when the network is overlap. If the network is not overlap, the main factor for the handover delay and packet loss is the distance between home network and a new network.

1. Introduction
The Internet has changed human life over the world. Most of their activities today are conducted digitalizing through internet technology. This condition caused the internet user to increase day to day that has reached 57.3% of the world population connected to worldwide technology [1]. The internet statistic shows internet growth after the Y2K until 2019 reached 1,125%. The extremely growth of Internet users is triggered by the massive developing of mobile devices. Based on [2], as of February 2017 among internet users, 49.7% of them access the internet via mobile devices. By the year 2018, the global mobile data traffic reached 19.01 exabytes per month. It was predicted the global mobile data traffic reaches 77.49 exabytes per month in 2022. Also, most applications nowadays support video transmission through the internet, such as social media and YouTube. A video that naturally is liked by the millennial generation over the various short movie that could be transferred through media social. It is expected the video transmission reached 82% of all global internet traffic by 2021 [3]. In term of video transmission, web audience expects a high quality of video that triggers the content personalizing.

Internet users require a unique internet address to get connected with the giant network. Unfortunately, the current internet protocol (IPv4) that has only 4,294,967,296 IP address cannot provide an IP address anymore, especially in Asia that reached 2 billion internet users [1]. Some ISPs
use NAT technology to extend their public IP to become more private IP [4]. However, due to the internet user growth has reached more than a thousand percent, the NAT technology could not be used. Luckily, the IETF has developed a protocol named IPv6 to solve the internet address problems. As a new internet protocol, this technology also provides mobility support to the IP based video transmission called Mobile IPv6 [5].

As the current mobile internet technology provides high-quality video transmission, IPv6 adoption is still low. Based on Internet Society report, the current IPv6 traffic exceeds 15% [6]. The document shows in some countries, major mobile networks are driving the IPv6 adoption such as Japan (NTT - 7%, KDDI - 42% and Softbank - 34%), India (Reliance JIO - 87%) and the USA (Verizon Wireless - 84%, Sprint - 70%, T-Mobile USA - 93%, and AT&T Wireless - 57%). However, there is no other option to do except adopting IPv6 technology. In the case of the mobile application for video transmission using Mobile IPv6, the performance of the video requires to be evaluated. This paper intends to assess the video transmission using Mobile IPv6 mechanism. The rest of this paper introduces the related works in Section 2 and the methodology in Section 3. Section 4 discusses the results obtained from the experimentation using various scenario. The last is Section 5, that is the conclusion of this paper that also shows some future works.

2. Related Works
As discussed in the previous section, most of the Internet user need high-quality video transmission. This has attracted several researchers to work on this area, such as [7-11]. The author of [7] worked at exploring the IPv6-based evolving technology trends to find out a supporting mobile video communication. It also addressed the rapid expansion of the video-based market sector. The study found some advantages of IPv6 in supporting video communication. The flow label field introduced in the IPv6 main header can support better real-time traffic. Using this field, routers can recognize end-to-end flow to which the packets transmitted. Furthermore, the IPv6 protocol could make video transmission improved. However, this paper does not provide empirical data on supporting its narration.

Authors of [8] simulated a video transmission over PMIPv6. They proposed a new protocol called PMIPv6-SH (PMIPv6 seamless handover). The researchers then analyzed the simulation results to know the performance of video transmission over the proposed mechanism. PMIPv6-SH works based on localized mobility management protocol. They claimed the proposed protocol performs better than PMIPv6-MIH and PMIPv6-MIH+ND. However, the packet loss in the protocol is still high that requires to be improved. Also, the protocol has not been implemented in a macro mobility domain with a high-speed movement. Paper [9] is a continuous improvement of the PMIPv6-SH that was conducted in a micro mobility domain with a high-speed movement of MH under intra-domain approaches. It presents a new result of network-based mobility management protocol implementation. The results indicate reducing lengthy handover latency, packet loss, jitter, and the same time increase throughput and video quality. The analytical analysis described in this paper showed that the PMIPv6-SH performs well to other than network-based mobility management protocols.

Performance comparison of video transmission was done in [10]. It compared the conventional video transmission over MIPv6 and its enhancements (FMIPv6, HMIPv6, and FHMPV6). The authors consider the impact of various parameters such as degree of mobility, wired link delay, jitter, error rate, and throughput. The simulation was conducted by the network simulator that allows an investigation of the behavior of the protocols involved. This paper concludes the handoff brings latency that affects video transmission. All protocols simulated suffer packet loss on the transmission. The transmission performance is degraded when the latency is higher than the round-trip time between the mobile node and the correspondence node. However, mobility protocols with lower handoff latency, do not necessarily improve video transmission performance.
A joint framework for QoS and QoE for video transmission over wireless multimedia sensor networks (WMSN) was proposed in [11]. The proposal includes a novel framework to support QoS in WMSNs. To enhance the Quality of Experience (QoE), the authors used a light-weight Error Concealment (EC) scheme. The main objectives of the proposal are to maximize the network throughput and to cover-up the effects produced by dropped video packets. They also used Scalable High efficiency Video Coding (SHVC) to control the data-rate at multimedia sensor nodes with variable Quantization Parameters (QPs). The authors claimed the experimental results indicate that their proposed framework can efficiently adjust large volumes of video data. However, there are certain network distortions, but it can effectively conceal lost video frames.

3. Methodology
An experimental Mobile IPv6 (MIPv6) network was set up to implement video transmission, as shown in figure 1. The network represented all elements required at MIPv6, including Home Agent (HA), Foreign Router (FR), Mobile Node (MN) and Correspondence Node (CN). The first scenario (as shown in Figure 1(a)) is used when the Mobile Node (MN) moves from access point 1 to access point 2. The measurement is done in an overlapping condition between the two wireless area. The second scenario is when the MN away from access point 1, but it has not been connected with the access point 2, as shown in Figure 1(b).

![Figure 1. Scenario MIPv6 vertical handover (a) overlapping (b) non-overlapping.](image)

The network elements are connected each other with IPv6 address as listed in table 1. Ubuntu 16.04 LTS was used as an Operating system that supports vertical handover operation. For video streaming, the correspondence node was installed by Sub Sonic software. Four video formats were used in the experiment includes AVI (audio video interleave), FLV (flash video), MKV (matroska video), and MP4 (MPEG-4). To know the performance of video transmission during the handover process, two scenarios have been conducted in the topology (figure 1). The performance includes network throughput, delay, and packet loss during video transmission when vertical handover occurs.

| Table 1. IPv6 address of each node. |
|------------------------------------|
| **Node** | **Interface** | **IPv6 address** |
| Home Agent | Interface 1 | 2001:db8::fff:100b::1/64 |
| | Interface 2 | 2001:db8::fff:100a::2/64 |
| Foreign Router | Interface 1 | 2001:db8::fff:100b::2/64 |
| | Interface 2 | 2001:db8::fff:100c::2/64 |
| Correspondent Node | | 2001:db8::fff:100b::3/64 |
4. Result and Discussion

This section provides the results of the experiments of the two-scenario implemented. It can be seen in figure 1; the MN is first connected to AP1 that is associated with the HA (MN at home). When the MN moves to the AP2 region, it changes the connection. Since the MN moves to another network (different router), it is considered as vertical handover. However, as the advantage of Mobile IPv6, the MN does not change its home IPv6 address (HoA) as shown in figure 2. It generates new care of address (CoA) that is then reported to HA using BU message transmission.

![Figure 2. Captured IPv6 packets transmission between MN and CN.](image)

Even though the MN's IPv6 address is still the same, the handover mechanism has occurred, and message passing happened. Figure 3 shows the message transmission in the handover process includes neighbor discovery mechanism, generating a new CoA, sending a BU message and communication between MN and CN. In this case, the experiment was used the tunneling mechanism for the handover.

![Figure 3. Message passing on the vertical handover process.](image)

The neighbor discovery mechanism is shown by two pairs of ICMPv6 messages: router solicitation (RS) - router advertisement (RA) and neighbor solicitation (NS) - neighbor advertisement (NA). Several measurements were conducted to analyze the network throughput, delay, and packets loss during the handover process. Table 2 shows the network throughput of scenario 1 and scenario 2. This data can be analyzed to know the impact of MIPv6 vertical handover to the quality of video transmission.

In term of network throughput, for all of video file format shows a reduction of the throughput value. The AVI file has the highest reduction (5.72%), and the MP4 file has the lowest reduction (0.22%). The reduction has theoretically happened because, in scenario 4, the MN's connection is
down when the MN out from AP1 area. The connection will be up when the neighbor discovery process is successfully done. Otherwise, the MN cannot generate a new CoA that makes it fail to connect with the CN. In this experiment, the process is normally conducted, but the traffic is lower than in scenario 1. This is because, in scenario 1, the MN is directly connected with the AP2 without getting a loss connection with AP1 first. In overall, it can be said that the vertical handover degrades the network throughput when the MN moves to a new network outside the HA's range. It may lose its connection first before connecting to the new network.

| Table 2. Network throughput on MIPv6 vertical handover. |
|--------------------------------------------------------|
| Scenario | Network Throughput (kbps) | AVI | FLV | MKV | MP4 |
|----------|---------------------------|-----|-----|-----|-----|
| Scenario 1 | 339.4 | 354 | 265.2 | 267.2 |
| Scenario 2 | 320 | 334.5 | 263.3 | 266.6 |
| Reduction | 19.4 | 19.5 | 1.9 | 0.6 |
| % Reduction | 5.72% | 5.51% | 0.72% | 0.22% |

The second parameter analyzed is the delay during the vertical handover. The handover delay is the time required to get a new connection. It was measured from the time MN sends an RS message to a new router (Foreign Router) until the MN receives a binding acknowledgment (BA) message from its HA. As in figure 3, in between the two messages, there are several messages passing between MN and FR to generate a new CoA. The mechanism is router discovery and neighbor’s discovery that known as neighbor discovery protocol as standardized in RFC 4861 [12]. The CoA generation is either using stateless or stateful autoconfiguration. Table 3 shows the handover delay for scenario 1 and scenario 2.

| Table 3. Delay of the vertical handover. |
|----------------------------------------|
| Scenario | Delay of the Vertical Handover (ms) | AVI | FLV | MKV | MP4 |
|----------|-----------------------------------|-----|-----|-----|-----|
| Scenario 1 | 4.206958 | 3.609281 | 4.577595 | 4.955638 |
| Scenario 2 | 6.173976 | 5.05673 | 6.941382 | 7.393703 |
| Addition | 1.967018 | 1.447449 | 2.363787 | 2.438065 |
| % addition | 47% | 40% | 52% | 49% |

Table 3 indicates that scenario 2 has delay higher than scenario 1. The addition percentage is significant (more than 40%) for all video format. This can be understood because, in scenario 2, the MN loss connection with its HA before getting a new network. Only when it receives a BA message from its HA, the packet transmission is continued. Hence, the continuing packet transmission depends on the time to find a new network.

| Table 4. Percentage of packet loss. |
|------------------------------------|
| Scenario | Percentage of Packet Loss (%) | AVI | FLV | MKV | MP4 |
|----------|-------------------------------|-----|-----|-----|-----|
| Scenario 1 | 1.3 | 1 | 1.5 | 1.6 |
| Scenario 2 | 2.5 | 2.4 | 2.5 | 2.7 |
| Addition | 1.2 | 1.4 | 1.0 | 1.1 |
| % addition | 92.3 | 140 | 66.67 | 68.75 |

The distance between networks also affects the packet loss, as shown in table 4. The table lists the packet loss on the two scenarios. All video format gives law packet loss (less than 3%). It means the connection is almost without loss. In the case of scenario 1, it can be understood because the handover
is directly performed since the coverage network is overlap. In the other side, scenario 2, there is a distance between scenario 1 and scenario 2. During the new network discovery, the connection can be a loss.

Furthermore, the packet is dropped in the way of traveling. This can be seen in table 4; the percentage of packet loss in scenario 2 is higher than scenario 1. If the distance of the two networks is longer, the packet loss will be higher. It can be concluded the speed of new CoA generation that is influenced by the availability of a new network is the main factor to the handover delay in MIPv6. Another factor that can influence the packet loss in congestion in the network. This happens in a general network. The congestion can also be caused by a malicious activity such as a denial of service (DoS) attack and distributed denial of service (DDoS) attack.

5. Conclusion

Experimental results have been analyzed to evaluate the performance of real-time video transmission during vertical handover on MIPv6. The performance is stable when the MN moves to a new network that overlaps with the home network. The connection between MN and CN is only down during the CoA address generation. If the address generation is faster, the new connection will up faster. In case the new network is far from the home network, the MN needs to travel from the home network to the new network. This traveling condition causes the connection down, and the MN is discovering a new network. The connection will be up once the MN has completed the CoA address generation.

References

[1] World Internet Users and 2019 Population Stats 2019 [last accessed 28 July 2019] Available from: https://www.internetworldstats.com/stats.htm.
[2] Mobile Internet - Statistics and Facts 2019 [last accessed 19 February 2019] Available from: https://www.statista.com/topics/779/mobile-internet/
[3] Streaming Video Trends 2018 2019 [last accessed 19 February 2019] Available from: https://video.ibm.com/blog/ai-video-technology/streaming-video-trends-2018-top-5/.
[4] Aoun C and Davies E 2007 Reasons to move the network address translator-protocol translation (NAT-PT) to historic status Request fo Comments 4966.
[5] Soliman H 2009 Mobile IPv6 support for dual stack hosts and routers Request fo Comments 5555.
[6] Internet Society State of IPv6 Deployment 2018 2019 Online [last accessed 28 July 2019]: https://www.internetsociety.org/resources/2018/state-of-ipv6-deployment-2018/
[7] Ladid L and I P Chochliouros I P 2012 The Impact of IPv6 on Video-to-Video and Mobile Video Communications Proceeding of IFIP International Conference on Artificial Intelligence Applications and Innovations.
[8] Hassan M M and Hoong P K 2011 Performance simulation and analysis of video transmission over proxy mobile IPv6 in a micro mobility domain Proceedings of the international conference on telecom technology and applications (ICTTA).
[9] Hassan M M and Hoong P K 2013 Seamless handover integrated solution for video transmission over proxy mobile IPv6 in a micro mobility domain Journal of Network and Computer Applications 36(1): p. 66-76.
[10] Qu W, Qin Y, Zhou H, and Zhang H 2006 Simulation-based performance comparison of video transmission over MIPv6, FMIPv6, HMIPv6, and FHMIPv6 Proceeding of IET International Conference on Wireless, Mobile and Multimedia Networks pp. 1-4.
[11] Usman M, Yang N, Jan M A, He X, Xu M, and Lam K M 2017 A joint framework for QoS and QoE for video transmission over wireless multimedia sensor networks IEEE Transactions on Mobile Computing 17(4) p. 746-759.
[12] Narten T, Nordmark E, Simpson W and Soliman H 2007 Neighbor discovery for IP version 6 Request for Comments 4861.