Reza MALEKIAN[1], Abdul Hanan ABDULLAH

Universiti Teknologi Malaysia

Bidirectional and RO Methods for Analysis of Stream-Intensive Applications over Mobile IP Network

***Abstract**. These Applications such as voice over IP present many challenges to the design of mobile networks. The mobile networks are constantly changing and the latest devices like smart phones, mobile enabled laptops such as Windows Mobile and the Windows Phone are truly able to delivering on any mobile broadband. Therefore, the Internet service providers must provide enhanced routing methods for delivering a stream-intensive traffic to the customers. This paper focuses on performance evaluation of mobile IPv6 routing methods. This evaluation is based on end-to-end delay, packet delay variation, and IPv6 traffic dropped.*

***Streszczenie.** Mobilne sieci ulegają stałym zmianom I nowoczesne urządzenia mobilne jak smarfony czy tablety są w stanie dopasować sia)ę do tych zmian. Dlatego zarządzający serwisem Internetowym powinien wprowadzać ulepszone metody dostarczania strumienia informacji. W artykule analizowano możliwości ulepszenia systemu mobilnego IPv6. (**Dwukierunkowa i optymalizowana metoda analizy aplikacji o zwiększonym strumieniu informacji w sieciach mobilnych**)*

Keywords: Mobile IPv6, Routing optimization, Bidirectional tunneling, Stream-intensive applications,
Słowa kluczowe: sieci mobilne, IPv6, strumień informacji.

Introduction

Mobile Internet [1, 2, 3] is a protocol that allows mobile nodes to maintain non stop connectivity with their home addresses regardless of their physical movement. The mobile node (MN) has two IP addresses in Mobile IP networks. One is the home address, which is indicated as the home network address of the mobile node, and the other is the care-of-address (CoA). The home address is a permanent address and each correspondence node (CN) needs this address for communication to the MN, while, CoA is a temporary address. Whenever the MN moves to a new network, it acquires a CoA, which indicates the current location of the MN in a foreign network. In mobile IPv4, the foreign agent which is a router in foreign network, is responsible to assign a CoA to the MN and also assist the MN to detect if it has left the foreign network or not. In mobile IPv6, movement detection is done by the IPv6 neighbor discovery protocol [4, 5]. It enables an MN to discover its current location in foreign network. Using IPv6 neighbor discovery protocol, an IPv6 router broadcasts a router advertisement message to the MN on that network. These messages carry the IPv6 address of the router and network prefix. This message helps the MN to detect whether it has moved out from the current foreign network to another, or whether an IPv6 router is still reachable. The MN combines its own hardware address with network prefix of router advertisement message with the mobile's own hardware address to configure its CoA.

The MN in mobile IPv6 can acquire its CoA by using a stateless address auto-configuration or by stateful protocols such as DHCPv6 [6, 7]. The MN should register this address in the Home Agent (HA) to maintain its connections to the sender(s). Home agent is a router in home network, that is responsible of send and receive packets between MN(s) and CN(s). When the HA receives a new CoA, it updates its binding cache. Therefore, when a CN sends a packet to the home address of the MN, the HA receives it and searches its binding cache [8] to find a record which indicates the home address in the packet and then sends the packet to its current location of the MN.

The authors in [9] proposed a scalable and approach in per-packet forwarding in particular when the CN and MN are mobile.

The authors in [10] proposed sub-based direct tunneling techniques to improve the routing efficiency for mobile IP and a binding optimization technique to reduce the handoff latency for mobile node. The approach in [11] proposed a virtual home agent based route optimization solution.

This paper is organized as follows: we start a review of routing on the mobile IP networks. Then, we present a description of the network topology to evaluate different routing mechanisms. Afterward, we compare the performance of routing optimization against the bidirectional tunneling in cases of end to end delay, packet delay variation, and IPv6 traffic dropped. We finished with general conclusions.

Routing in Mobile IPv6 Networks

Routing methods in Mobile IPv6 networks for routing IPv6 packets from CN to MN and vice versa are bidirectional tunneling and routing optimization (RO) [12].

In bidirectional tunneling mode [13], when CN sends packets to MN, it sets destination address to MN's home address in the IPv6 header of packets and these packets are routed via IPv6 routing methods. Then, HA intercepts and tunnels them to MN. Furthermore, in reverse side, MN sends packets in reverse tunnel to the home agent (HA). The bidirectional tunnel routing mode illustrate in Figure 1. As shown in Figure 1, another problem is that it suffers from tunneling [14] and It would be more serious for application with high traffic volume such as voice over internet protocol (VOIP) that demands demand more bandwidth in the network.

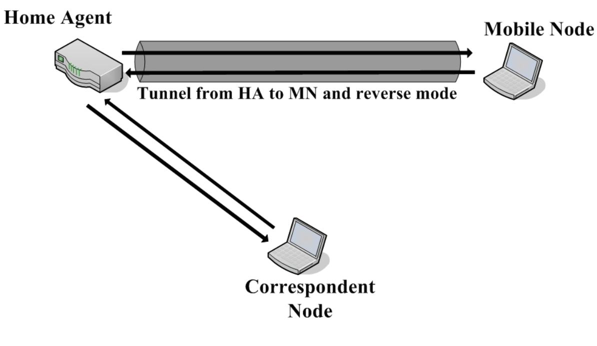

Fig. 1: Bidirectional tunneling

Another routing method in mobile IPv6 is routing optimization. RO is a technique that enables MN registers its binding on HA and also CN and enables CN to address packets to a mobile's current Care of Address (CoA). In

MIPv6, each IPv6 terminals and HA have binding table to support RO and maps the mobiles' home addresses to their CoAs. Whenever a CN node sends a packet to MN, it first checks its binding cache to search and find an entry to the MN. If a binding cache entry is found, the CN sends packets to mobile's COA directly, otherwise, it sends packet to mobile's home address. Then, HA discard packets and send them via tunnel to MN. Next, MN lets CN knows its current location by sending binding update [15]. Finally, CN and MN can communicate directly.

As shown in Figure 2, although, RO reduces the number of packets [16] that have to experience tunneling but it uses tunneling to sending initial packets.

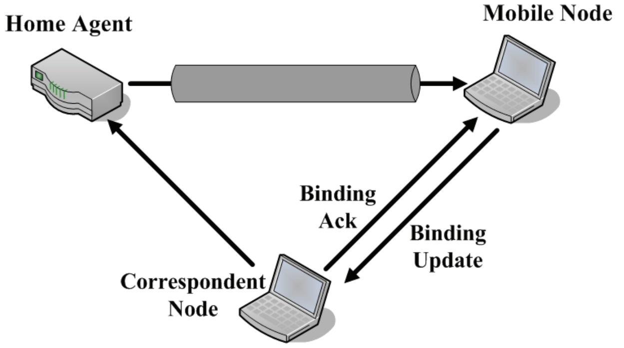

Fig. 2: Routing Optimization in Mobile IPv6

Method

We consider a Mobile IPv6 scenario to carry out a comparison of bidirectional tunneling and routing methods. Simulation results are conducted using OPNET IT Guru [17] which consists of one MN, one CN, one HA, three access routers in various foreign networks, and two intermediate routers that interconnect the MN to the server via IP network, Figure 3. In this scenario, the MN runs a VOIP application as real-time application, which is located in its home network at the starting time. This node moves along the defined trajectory from three departments inside university environments. Then, it goes back to its home network, which is the Mathematics department. The MN's average speed during trajectory is considered to be15km/h. Table 1 illustrates mobile node's attributes.

Table 1. The mobile node's attributes.

Parameter	Value
Mobile node speed	15 km/h
Application running	VOIP
Ebcoder	G.711
Type of Service	Interactive voice

Type of service is set to interactive voice that requires high priority, low latency, low jitter, and controlled bandwidth. To achieve this, the intermediate routers will delay or drop non-sensitive traffic.

Table 2. Class of Service

Class of Service	Code
Best Effort	000
Background	001
Standard	010
Excellent Effort	011
Controlled load applications	100
Interactive Multimeadia	101
Interactive Voice	110
Networking Control	111

Based on table 2, class of service values range from 0(best effort- low priority) to 7 (network control- high priority). Besides, encoder used in our network topology is G.711 also known as pulse code modulation (PCM). It is a PCM of voice frequencies on a 64 kbps channel.

The aim of this paper is to compare end-to-end delay, average end-to-end delay, and packet delay variation, and Ipv6 traffic dropped in the two popular routing methods over Mobile IPv6 network.

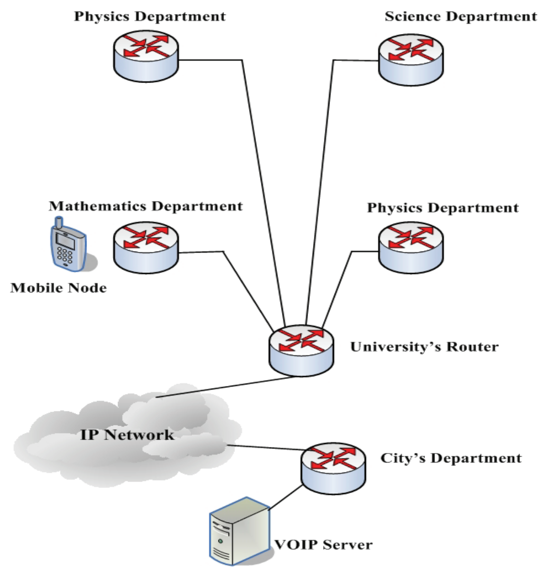

Fig. 3. Network topology

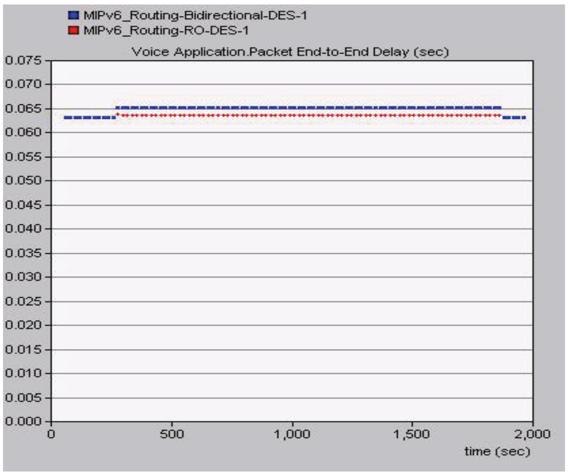

Fig. 4. End-to-end delay

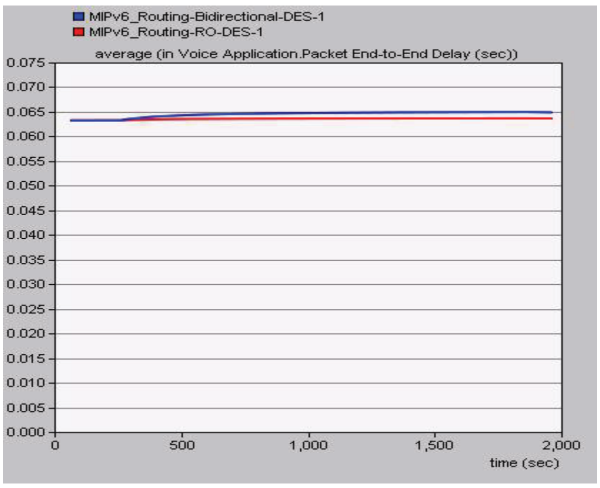

Fig. 5. Average end-to-end delay

Simulation Results

End-to-end delay and average end-to-end delay [17, 18, 19] are depicted in Figures 4, 5. Flow analysis calculates the delays encountered by packets as traffic flows propagate a network. Flow analysis calculates packet delays using an average packet size of 243 bytes. Flow analysis includes various delay components when calculate the end-to-end delay for a traffic flow such as link transmission delay, link propagation delay, link queuing delay, and IP CPU processing delay. Based on these figures, when the MN is located at the home network (i.e. between 0 to 300 and after 1800 seconds), the minimum end-to-end delay is much smaller than when it is moved to a foreign network in both bidirectional and routing optimization methods. The main reason is the MN ignores mobile IPv6 protocol when it remains in the home network and uses the IPv6 protocol to communicate with the CN. When the MN moves to foreign networks, it utilizes the Mobile IPv6 protocol. It thus needs to register its CoA in the HA and send/receive packets via a tunnel. Figure 4 shows that the end-to-end delay increases along the time based on MN movement to foreign networks, while, at 1800 seconds, the end-to-end delay drops mainly because the MN goes back to its home network.
Beside, as shown in Figures 5, 6 when MN is located at its home network, the end-to-end delay and packet delay variation for both of routing methods are same. Once MN move to one of foreign networks, routing optimization method improves end-to-end delay and packet delay variation in comparison with bidirectional tunneling because of direct communication between mobile node and VOIP server. If HA finds any entity in its binding cache for arriving packet, it delivers packet directly to the MN, otherwise, first packet experience tunneling and after registration process subsequent packets addressed directly to the MN.

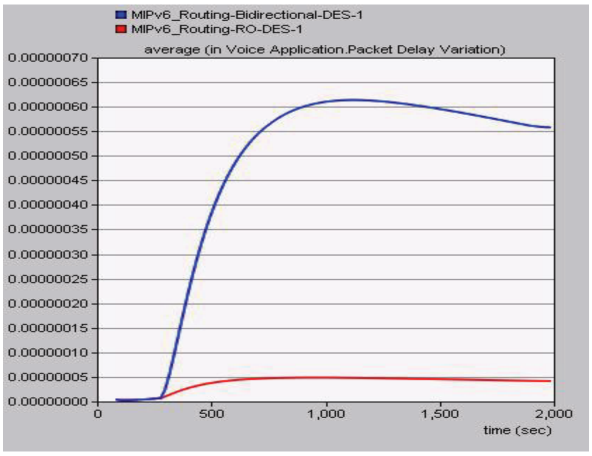

Fig. 6. Packet delay variation

Figure 7 illustrates gaps at 200, 800, 1400, 1800 seconds when the MN roams between access routers at different departments in our scenarios. In this case, packet loss occurs when the MN leaves its current access router and enters to a new foreign network [20]. Whenever an MN moves to a new network (for example, science department), it will be unreachable for a period of time that referred as handover latency. This period of time for real-time applications, such as VOIP, which are time sensitive should be very small. MN performs following actions in this period of time; obtaining and validating a new Care of address (CoA) that identifies the current location of the mobile node; obtaining authorization to access the new network, making the decision that a handover should be initiated.

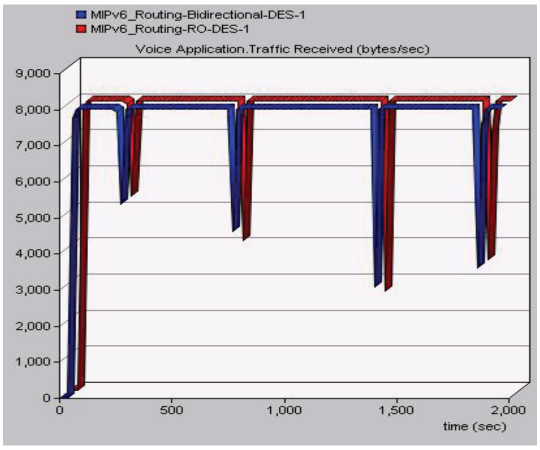

Fig. 7. Traffic Received (bytes/seconds)

As shown in Figure 8, there are gaps between periods of time that the MN roams in foreign networks. MN is not capable to receive any packet from the HA or CN, although, there are active researches for improvement of handover [21, 22, 23]. Therefore, Traffic will be dropped at these time. IPv6 traffic dropped illustrated in Figure 8.

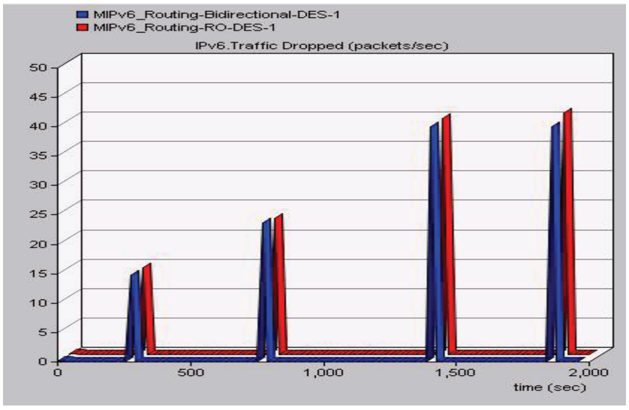

Fig 8. IPv6 Traffic Dropped.

Conclusions

In this paper, we have compared and analyzed performance of routing optimization versus bidirectional tunneling. This evaluation was based on end-to-end delay, average end-to-end delay, and packet delay variation. Simulation has been conducted using OPNET IT Guru. Stream-intensive applications such as voice over IP present many challenges to the design of mobile networks. Besides, the mobile networks are constantly changing and the latest devices like smart phones require sufficient level of quality of services. As we shown in simulation section, existing routing methods suffer tunneling, where control messages like PATH message is encapsulated in tunnel. As a result, the PATH message is virtually invisible for intermediate routers. An interesting direction for future work, with possible practical significance, is new proposals for solving this problem.

REFERENCES

[1] Perkins C., RFC3344: IP mobility support for IPv4, *Internet engineering task force*, August 2002, http://www.ietf.org/rfc/rfc3344.txt
[2] Perkins C., Johnson D, Arkko J., RFC6275Mobility support in IPv6, *Internet engineering task force*, July 2011, http://www.ietf.org/rfc/rfc6275.txt
[3] Samjani A., Mobile Internet protocol, *IEEE journal of potentials*, IEEE, 20(2001), no 1, 16-18

[4] Narten T., Nordmark E., Simpson W.,Soliman H., RFC4861: Neighbor discovery for IP version 6, Internet engineering task force, September 2007, http://www.ietf.org/rfc/rfc4861.txt
[5] Iapichino G., Bonnet C., IPv6 mobility and ad hoc network mobility, overview report *Inst. Eurocom Department*. Mobile Com, Sophia Antipolis, France (2008), RR-8-217
[6] Fenner B., RFC4727:Experimental values in IPv4, IPv6, ICMP, UDP, and TCP headers, *Internet engineering task force*, November 2006, http://tools.ietf.org/html/rfc4727
[7] Singh S, Bhatia A, DHCPv6 based IPv6 auto-configuration mechanism for subrordinate Manet, *Proceedings of the IEEE Asia-pacific conference on computing*, Yilan, Taiwan (2008), 237-242
[8] Bi Y., Song M., Song J., Seamless mobility using mobile IPv6, *proceedings of the mobile technology and application* (2005), 1-8
[9] Le D., Chang J., Tunneling-based route optimization for mobile IPv6, *Proceedings of the International conference on wireless communications, networking and information security*, Beijing, China (2010), 22-27
[10] Wu C.H., Cheng A.T., Lee S.T., Ho J.M., Lee D.T., Bidirectional route optimization in mobile IP over wireless LAN, *Proceedings of the vehicular technology* (2002), 1168-1172
[11] Gao Q., Acampora A., A virtual home agent based route optimization for mobile IP, *proceedings of the IEEE conference on wireless communications and networking*, Chicago, USA (2000), 592-596
[12] Hsu W.H., Shieh Y.P., Yeh S.C., DiffServ-based bandwidth constrained anycast routing in a mobile IPv6 network, *International journal of communication systems*, 24(2011), no 2, 139-152
[13] Le D., Guo D., Wu B., Parr Gerard, Mobile IPv6 in WLAN mobile networks and its implementation, *Proceedings of the international conference on personal, indoor and mobile radio communications*, Beijing, China (2003), 1430-1434
[14] Le D., Fu X., Hogrefe D., End-to-end tunneling extension to mobile IPv6, *Proceedings of the IEEE consumer communication and networking conference*, Las Vegas, USA (2007), 120-126
[15] Taha S., Shen X., Annonymous home binding update scheme for mobile IPv6 wireless networking, *Proceedings of IEEE global communications*, Houston, USA (2011), 52-57
[16] Chen H., Trajkovic L., Simulation of route optimization in mobile IP, *Proceedings of workshop on wireless local network*, Tamoa, Florida (2002), 63-65
[17] OPNET technologies Inc., OPNET Modeler Accelerating Networks R&D, www.opnet.com
[18] Malekian R., Abdullah H.A., Saeed R.A, A cross- layer scheme for resource reservation based on multi-protocol label switching over mobile IP version 6*, International journal of the physical science*, 6(2011), no 11, 2710-2717
[19] Malekian R., Abdullah A.H., A mathematical model to determine the maximum end-to-end delay bound on label switched path for real-time applications over mobile IPv, *International journal of the physical science*, 6(2011), no 12, 2958-2964 Malekia
[20] Samolej S., Szmuc T., HTCPN-based analysis of priority Internet requests scheduling, *Preglad Elektrotechniczy*, 10(2010), nr 9, 174-178
[21] Perez-Costa X., Hartenstein H., A simulation study on the performance of mobile IPv6 in a WLAN-based cellular network. *Elsevier Computer network Journal, special issue on the new Internet architecture*, 40 (2002), no 1, 1-10
[22] Perez-Costa X., Torrent-Moreno M., Hartenstein H., A simulation study on the performance of hierarchical mobile IPv6, *Proceedings of the international teletraffic congress*, Berlin, Germany, (2003), 1-10
[23] Prez-Costa X., Torrent-Moreno M., Hartenstein H., A performance comparision od mobile IPv6, hierarchical mobile IPv6, fast handovers for mobile IPv6 and their combination*, Sigmobile mobile computing and communications review*, 7 (2003), no4, 1-15

***Authors**: Reza Malekian, Faculty of Computer Science and Information Systems, Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia, E-mail: reza.malekian@ieee.org; Prof. dr. Abdul Hanan Abdullah Faculty of Computer Science and Information Systems, Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia.*