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Research Article

Development of Analytical Approach to Evaluate (DiffServ-MIPv6) Scheme

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Abstract: The aspiration of Mobile IPv6 is to provide uninterrupted network connectivity while the mobile node is moving between different access points or domains. Nonetheless, it does not provide QoS guaranteed to its users same as the traditional Internet protocol IP. It merely can provide Best-Effort (BE) service to all its applications despite of the application requirements. The future wireless network would be based on IPv6 to provide services to Internet mobile users. Hence, one of main requirements of next generation IP based networks is providing QoS for real-time traffic that will be transporting through MIPv6 networks. This study presents the analytical analysis for the previously proposed scheme (DiffServ-MIPv6) that applies the DiffServ platform to Mobile IPv6 network in order to suit the needs of both QoS guaranteed and mobility in communication. The analytical evaluation is developed to assess the performance of the proposed scheme (DiffServ-MIPv6) compared to the standard MIPv6 protocol in terms of signaling cost. The signaling cost is measured against two factors session-to-mobility ratio and packet arrival rate.

Keywords: DiffServ, mobile IPv6, QoS

INTRODUCTION

Quality of Service (QoS) can be characterized in more than one way. In the field of computer networking it is the ability of the network element (e.g., application, host or router) to provide some level of assurance for consistent network data delivery. In other words, QoS is a set of technologies that enables network administrators to manage the effects of congestion on applications traffic flows by using network resource optimally rather than conditionally adding extra capacity (Bernet, 2000).

The authors in Chalmers and Sloman (1999) divide the various QoS characteristics in two groups, technology-based and user-based QoS parameters. Technology-based parameters contain superior performance in terms of delay, response time, jitter, data rate and loss rate. On the other hand, user-based QoS parameters are more likely subjective. They include categories such as perceived QoS, the visual quality of a streaming video, cost per unit time or per unit of data and the security. As an example, a user browsing the web and watching public news broadcast would be more interested in the quality of the picture rather than its security. A user who is remotely connecting to a corporate network would be most interested in the security of the connection and less interested in costs. Within a few past decades, QoS is certainly not supported over the IP-based networks. Working on QoS support in IP networks, has led to three distinct approaches namely, Integrated Services (IntServ) (Braden *et al*., 1994), Differentiated Service (DiffServ) (Blake *et al*.,1998) and Multiprotocol Label Switching (MPLS) (Rosen *et al*., 2001).

Unfortunately, these approaches were initially designed for static networks without mobility in-mind. Thus, there are not fully adapted to mobile environments yet. In fact, it is anticipated that more mobile users will be connected to the Internet rather than PCs users. These mobile users are interesting to get similar QoS in mobile terminals as in fixed terminals (i.e., wired networks) in order to run real-time applications properly. Above all QoS models, the most promising one due to its simplicity and scalability advantages is DiffServ. Therefore, integrating QoS with mobility support seems to be needed to fulfill the necessity of users.

Mobility can be classified into: Host and Network mobility. Host mobility refers to an end host changing its point of attachment to the networks while the communication between the host and its correspondent node stays uninterrupted. Mobile IPv6 IPv6 (RFC 3775, June 2004), Fast Mobile IPv6 (RFC 5268, June 2008), Hierarchical Mobile IPv6 (RFC 5380, October 2008) and Fast Hierarchical Mobile IPv6 are examples of host mobility protocols. Whereas, Network mobility refers to

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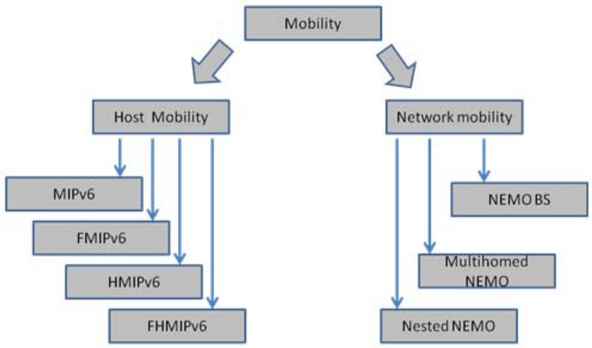

Fig. 1: Mobility extensions

a mobile IP subnet changing its point of attachment to an IP backbone. Network mobility basic support (RFC 3963), Nested NEMO and Multihomed network are examples of mobile network protocols as shown in Fig. 1.

LITERATURE REVIEW

The authors in these papers (Kim and Mun, 2008, 2007) identified the use of differentiated service (DiffServ) model to provide various demand of new application in mobile IPv6 networks. The major contribution of thisstudyis to proposed operational procedures and cost evaluation schemes for seamless connection. Thus during the Mobile Node (MN) changes its point of attachment in network, the QoS requirement would be satisfied. Moreover, priority queue is used to manage three types of services and their performances are evaluated. Even though, the work presented procedures for acquiring the MN's service profile and additive information in the messages according to MN's moving area, fast handoff and security problems need to construct more efficiently.

Quality of Service and mobility for the wireless Internet approach (Garcia-Macias *et al*., 2003) is the named paper that extends DiffServ to control resource utilization on each wireless cell and limits number of active hosts to keep the load sufficiently low. It also adopts the idea of IntServ by adding a QoS signaling for QoS negotiations between mobile nodes and access router. All mobile nodes and access routers provide Diffserv functions, i.e., the edge and core router functions, so that traffic sources are controlled in each wireless cell.

Another work in Jaseemuddin *et al*. (2002) investigated a study of profiled handoff for DiffServ-based mobile nodes, which shows transferring contexts to the new edge routers of wireless subnets helps various marking schemes reach stability earlier. This study is important in designing connection admission control algorithms at the Radio Edge Router (RER). However, more investigation is required to analyze the relative performance impact on the traffic at the new AR caused by the flows that are handed over to the new AR.

METHODOLOGY

This previous research work (Faisal *et al*., 2011) has proposed a new scheme to support QoS in the next generation Internet. It integrates an existing QoS model over IP architecture with the standard MIPv6 protocol. The aim is to suit the needs of both QoS guaranteed and mobility in communication.

The proposed scheme (DiffServ-MIPv6) is built on the use of the basic mechanisms in DiffServ model such as traffic classifier and marker to enforce high priority to a particularly signal message in the standard MIPv6 protocol and then constrains the traffic accordingly. Therefore, these mechanisms expect to minimize the packet losses as well as reduce handover latency in the proposed scheme.

The topology depicted in Fig. 2 is based on IPv6 network with mobility support and DiffServ model supported in the core network to offer privilege QoS guaranteed service. Where, ER is the edge router at ingress/egress of the network, CR is core router in the backbone network, CN is the correspondent node (it is considered to be a stationary node) and MN is the Mobile IPv6 node. Additionally, the Access Router (AR) is connected to one or more Base Stations (BS) to provide connectivity to mobile IPv6 nodes. It is also responsible for resource co-ordination for base stations to which is attached. BB is the bandwidth broker. It used to optimize the existing recourse by allocating and controlling the bandwidth. The models based on BBs decouple the QoS control plane from the data plane. Since many control plane functions are performed per flow, scalability can be greatly enhanced by off-loading these responsibilities from the core nodes (Bouras and Stamos, 2007). For the sake of simplicity, it is assumed that the (ARi) supports functionality of the ingress edge routers. The mobile node intuitively moves from Old ARi (OARi) to a New ARi (NARi) when it performs handover procedure.

PERFORMANCE EVALUATION

Simulation has always been used as valuable tool for the evaluation in the field of networking. However, a few research works have considered the analytical analysis as another method to evaluate QoS in Mobile IPv6. Therefore, the signaling cost seems to be needed widely investigation. This section presents analytical framework to develop the performance of the proposed scheme (DiffServ-MIPv6) and compare it with the standard MIPv6 protocol in terms of signaling cost. The signaling cost is evaluated for various metrics for

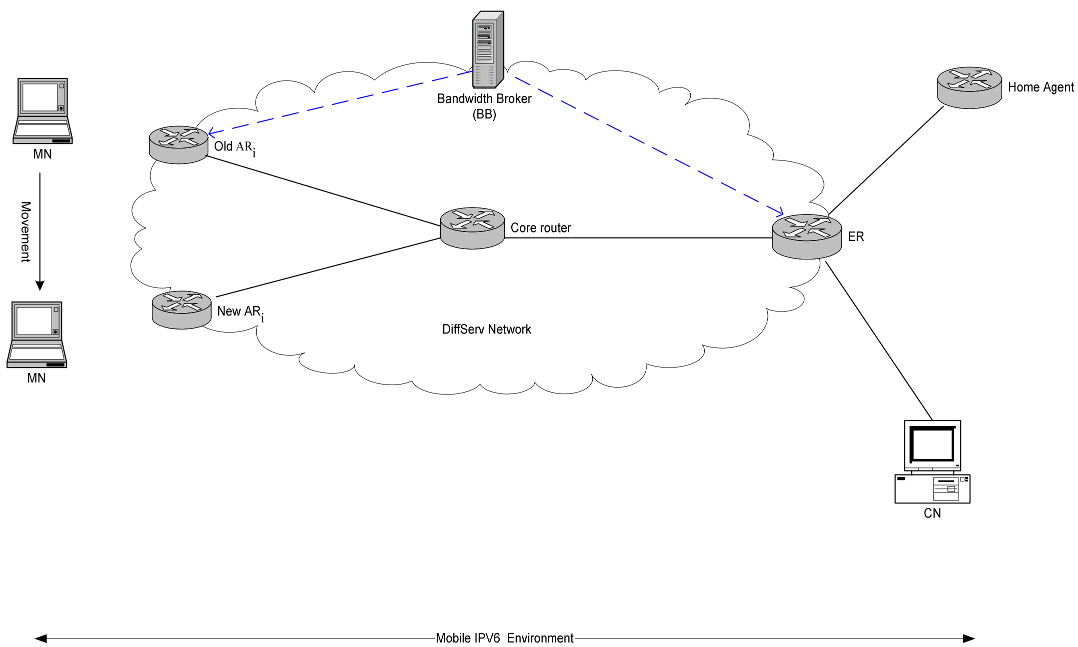

Fig. 2: DiffServ support within mobile IPv6 network

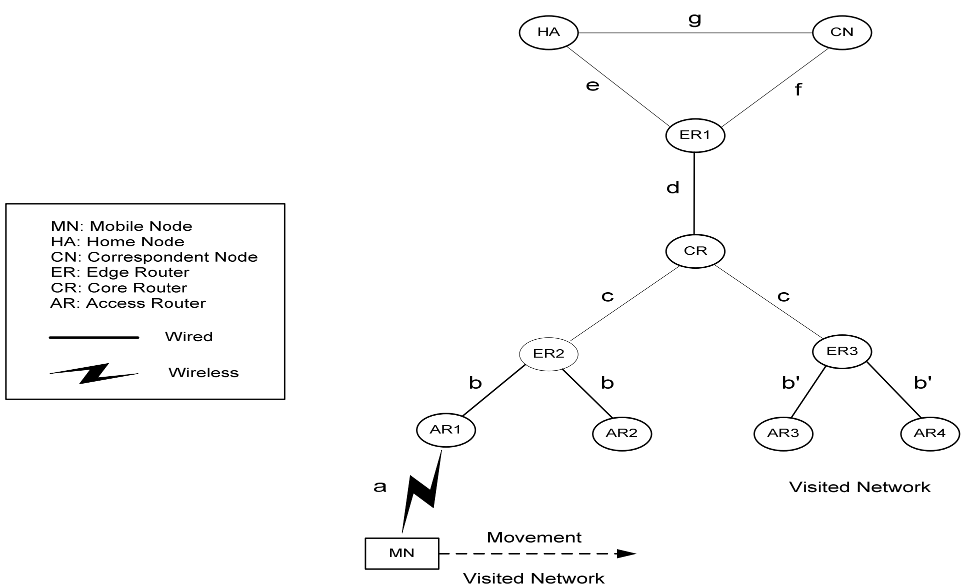

Fig. 3: The network topology used for the analysis

instance session-to-mobility ratio, binding lifetime period, wireless link delay and packet arrival rate. The intention of the analytic model is to demonstrate that the proposed scheme doesn't add much signaling overhead while improving QoS compared to MIPv6.

Figure 3 shows the network topology that is used for analyzing the signaling cost. It is assumed that the coverage area for the Access Network (AN) is circular with M subnets each with size S_{AR}. Also, it is assumed that the CN generates data packets destined to MN with mean rate (λ_p) and the MN moves from one access router (or subnet) to other with mean rate (μ). Packet to Mobility Ratio (PMR) is defined as the number of packets received by the MN from the CN per movement. It has the symbol (P) (Jain *et al*., 1998).
The PMR is given by:

$$P = \lambda_p/\mu \quad (1)$$

The cost for transmitting data packet is η times greater than the control packet.
Here η is the ratio of:

Table 1: Notations used in the analysis

Symbols	Descriptions
C_{rr}	Signaling cost for return rout-ability procedure
C_{hc}	Binding update cost at HA and CNs
C^l	Local binding update cost to HA/CNs
C^g	Global binding update cost to HA/CNs
$C_{X,Y}$	Transmission cost of control/data packets between nodes x and y
$d_{X,Y}$	The number of hops between hosts x and y (distance)
M	Number of subnets in domain
N_{CN}	Number of CNs having binding cache entry with the MN
N_E	Number of edge routers between CN and MN
N_g	Number of domain crossing during inter-AN movements
N_l	Number of subnets crossing during intra-AN movements
PC_X	Processing cost for the control/data packet at node x
C^M_{TOT}	The total signaling cost for the standard MIPv6
C^{MD}_{TOT}	The total signaling cost for the proposed scheme (DiffServ-MIPv6)

$$\eta = l_d/l_c \tag{2}$$

where, the parameter (l_d) is The average length of data packet and (l_c) is the average length of control packet (e.g., ICMPv6). The average processing cost for control packets at HA/CN are assumed to be PC_{HA} and PC_{CN}, respectively, while PC_E is the Edge Router (ER)'s processing cost. PC_E is assumed to be 2 times greater than the PC_{CN} because the edge router has not only forwarded the packets but also managed the MN's service profile and marked the packets (Kim and Mun, 2003).

Signaling cost analysis: In signaling cost analysis, the proposed (DiffServ-MIPv6) scheme is compared with the standard MIPv6 protocol. Basically, in IPv6-based networks Quality of Service can be estimated by packet loss, handover latency and signaling traffic overhead. Analysis of these metrics is very useful to evaluate the performance of any of the mobility management protocols (such as Mobile IPv6). The total signaling cost is C_{total}, which equal to location update cost and packet delivery cost:

$$C_{total} = C_{LU} + C_{PD} \tag{3}$$

C_{PD} is the packet delivery cost and C_{LU} is the location update cost. There are two types of location update that could be happen in the analysis. One happens when the MN is crossing subnet and another one occurs when the binding is about to expire. The first one known as Binding Update (BU) message and the second one refers to as the Binding Refresh (BR) message, receptivity (Makaya and Pierre, 2008). Thus, the total signaling cost C_{total} could be rewritten and calculated as the sum of the binding update cost C_{BU}, binding refresh cost C_{BR} and packet delivery cost C_{PD}. So, Eq. (3) can be written as:

$$C_{total} = C_{BU} + C_{BR} + C_{PD} \tag{4}$$

The authentication and L2 handover latency were ignored in this analysis because their signaling cost is same as the standard MIPv6 and it won't be any change happened in the proposed scheme.

Notations: The following notations will be used throughout this section (Table 1).

Binding update cost: The Mobile Node (MN) completes the location update as it sends Binding Update (BU) to the Home Agent (HA) then to the Correspondent Node (CN) and receives Binding Acknowledge (BA) in return. In the standard MIPv6 protocol which is used as benchmark for proposed scheme, binding update carries out regardless of all types of movement modes (i.e., intra or inter movement). In other words, MIPv6 handles local mobility of a mobile node in the same way as it handles global mobility. As a result, the MN has to send BU message to the HA and CN each time it changes its point-of-attachment regardless of locality. Therefore, the binding update cost for MIPv6 during intra/inter session time interval depends heavily on the computation of the number of location binding updates and it is given by:

$$C_{BU} = E(N_l)\, C^l \text{ or, } C_{BU} = E(N_g)\, C^g \tag{5}$$

where, $E(N_l)$, $E(N_g)$ are the average number of location binding updates when a MN is crossing subnets and Access Network (AN) domain, respectively. They are given by:

$$E(N_l) = \mu_l/\lambda_s \text{ and } E(N_g) = \mu_g/\lambda_s \tag{6}$$

where, μ_l and μ_g are the border crossing rate of MN out of subnet/access router and out of Access Network (AN) domain, respectively. λ_s is the session arrival rate (Fang, 2003). The border crossing rates are given by:

$$\mu_g = \mu_l/\sqrt{M} \tag{7}$$

$\mu_l = 2\frac{v}{\sqrt{\pi S_{AR}}}$, $S_{AR} = \pi R^2$, where, (v) is the average velocity of the MN and R is the access router radius. To realize the signaling overhead analysis, a performance factor known as Session-to-Mobility Ratio (SMR) is used. It represents the relative ratio of session arrival rate to the user mobility rate. The binding update cost can be obtained by:

$$C_{BU} = \frac{1}{\lambda_s}\left(\mu_g C^g\right) = \frac{1}{SMR\sqrt{M}}\left(C^g\right) \text{ Or, } = \frac{1}{\lambda_s}\left(\mu_l C^l\right) = \frac{\sqrt{M}}{SMR}\left(C^l\right) \tag{8}$$

The transmission cost in IP-based networks is proportional of the distance between the source and destination nodes. Besides, according to Xie and

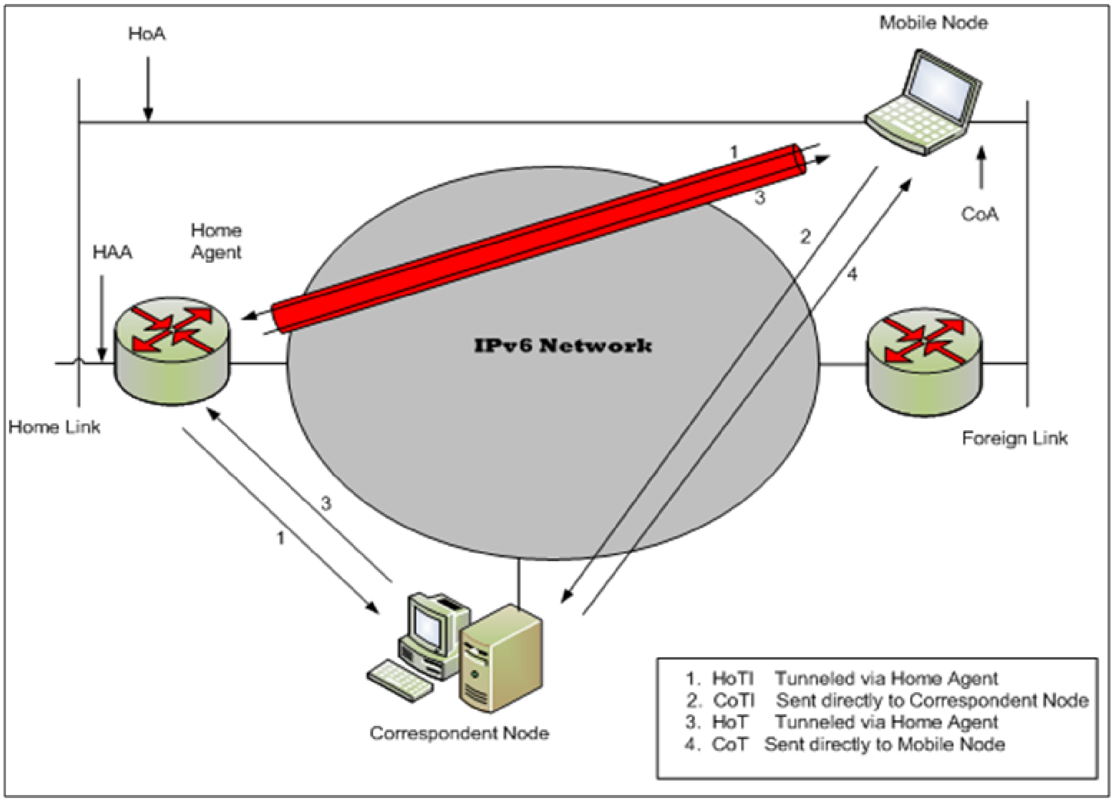

Fig. 4: The return routability procedure (Understanding Mobile IPv6, 2007)

Akyildiz (2002) the transmission cost in wireless link is usually larger than the transmission cost in wired link.

Consequently, the transmission cost of control packet between nodes X and Y belonging to the wired part of a network can be expressed as $C_{X,Y} = \tau\, d_{X,Y}$ while $C_{MN,AR} = \tau\kappa$, where, (τ) is the transmission unit cost over wired link and (κ) the weighting factor for the wireless link. The global/local binding update signaling cost for MIPv6 is expressed by:

$$C^{g}_{MIPv6} = C^{l}_{MIPv6} = 4\, C_{MN,\,AR} + 2PC_{AR} + C^{MIPv6}_{hc} \quad (9)$$

where,

$$C^{MIPv6}_{hc} = 2(C_{MN,HA} + N_{CN}C_{MN,CN}) + PC_{HA} + N_{CN}PC_{CN} + C_{rr} \quad (10)$$

Here C_{hc} is the binding update cost at the HA and at all active CNs, while C_{rr} is the signaling cost due to return routability procedure. Figure 4 is illustrated the transmission cost for HoTI and CoTI messages during return routability procedure.

The procedure of Return Routability process is briefly illustrated as following points:

- The mobile node sends a Home Test Init (HoTI) message indirectly to the correspondent node by tunnelling the message through the home agent.
- The mobile node sends a Care-of Test Init (CoTI) message directly to the correspondent node.
- The correspondent node sends a Home Test (HoT) message in response to the HoTI message (sent indirectly to the mobile node via the home agent).
- The correspondent node sends a Care-of Test (CoT) message in response to the CoTI message (sent directly to the mobile node).

The mobile node sends HoTI message to HA with cost $C_{MN,\,HA}$. The HA processes this message with cost PC_{HA} and afterwards the message is been forwarded to the CN with cost $N_{CN}C_{HA,\,CN}$. In the same way, the CN processes the received HoTI message with the cost $N_{CN}PC_{CN}$ before it responds with HoT message. So, the cost for home address test would be: $2\,(C_{MN,\,HA} + PC_{HA} + N_{CN}C_{HA,\,CN}) + N_{CN}PC_{CN}$. While in the care-of address test the CoTI and CoT messages are exchanged directly between the MN and CN. Subsequently, the care of address test cost is: $2N_{CN}\,C_{MN,\,CN} + N_{CN}\,PC_{CN}$.
The expression of C_{rr} can be deduced as follows:

$$C_{rr} = 2\,(C_{MN,\,HA} + N_{CN}\,C_{HA,\,CN} + N_{CN}\,C_{MN,\,CN} + PC_{HA} + N_{CN}\,PC_{CN}) \quad (11)$$

In the proposed scheme (DiffServ-MIPv6), when the MN performs handover the transmitted control packets that is required to determine the location update cost, have to go through Edge Router (ER). In order to reduce the loss of BU that could happen accidentally, the ER is configured to be giving high priority to BU in the flow of expedited forwarding. However, the processing cost for the edge router is assumed 2 times greater than the processing cost at any nodes because the ER is used to be in charge of admission control, packet classifying and marking.

Similar to the above equations, the binding update cost at the HA and all active CNs for the proposed scheme can be obtained as follows:

$$C_{hc}^{Diff-MIPv6} = 2\,(C_{MN,HA} + N_{CN}\,C_{MN,CN}) + PC_{HA} + N_{CN}PC_{CN} + N_E\,PC_E + C_{rr} \qquad (12)$$

Also, this equation can be re-written as:

$$C_{hc}^{Diff-MIPv6} = 2[2C_{MN,AR} + 2\,\tau\,(d_{AR,ER} + d_{ER,CR} + d_{CR,ER}) + \tau\,(d_{ER,HA} + d_{ER,CR})] + PC_{HA} + N_{CN}PC_{CN} + N_E\,PC_E + C_{rr} \qquad (13)$$

By using Eq. (11) and (13), the global and local binding update signaling costs for the proposed scheme (DiffServ-MIPv6) is derived by:

$$C_{Diff-MIPv6}^{g} = C_{Diff-MIPv6}^{l} = 4C_{MN,AR} + 2PC_{AR} + C_{hc}^{Diff-MIPv6} \qquad (14)$$

Binding refresh cost: Bindings are valid for lifetime included in the binding update message. The mobile nodes should refresh the bindings by sending another binding update before they expire or when the mobile node's care-of-address changes. Mobile IPv6 allows the receiver of the binding update to request that mobile node update its binding entry. This is done by using binding refresh request. The Binding Refresh (BR) message is usually used when the binding cache is in active use but the binding's lifetime is close to run out (Johnson *et al*., 2004). The performance evaluation in the most previous works did not take into consideration the cost of binding refresh and the impact of binding lifetime period. Nevertheless, these metrics may have significant effect on the total signaling cost. Let (T_H) and (T_C), be the binding lifetime period for the MN at HA and CNs respectively. The average rate of sending BR message from CN and from HA would be obtained:

$$\left|{}^{1}\!/\!(\mu_g T_H)\right| \text{ and } \left|{}^{1}\!/\!(\mu_g T_c)\right|$$

where, $\lfloor X \rfloor$ is the integer part of a real number X. Thus, the average binding refresh costs for MIPv6 can be obtained as follows:

$$C_{BR}^{MIPv6} = \left(\left|{}^{1}\!/\!(\mu_g T_H)\right| C_{MN,HA} + \left|{}^{1}\!/\!(\mu_g T_c)\right| N_{CN} C_{MN,CN}\right) \qquad (15)$$

In the same way the average binding refresh cost for the proposed scheme can be deduced as follows:

$$C_{BR}^{Diff-MIPv6} = \left(\left|{}^{1}\!/\!(\mu_g T_H)\right|(\tau\kappa + \tau\,(d_{AR,ER} +$$

dER,CR +dCR,ER +dER,HA + 1μgTcτκ + τ dAR,ER +dER,CR +dCR,ER +dER,CN +NE PCER

(16)

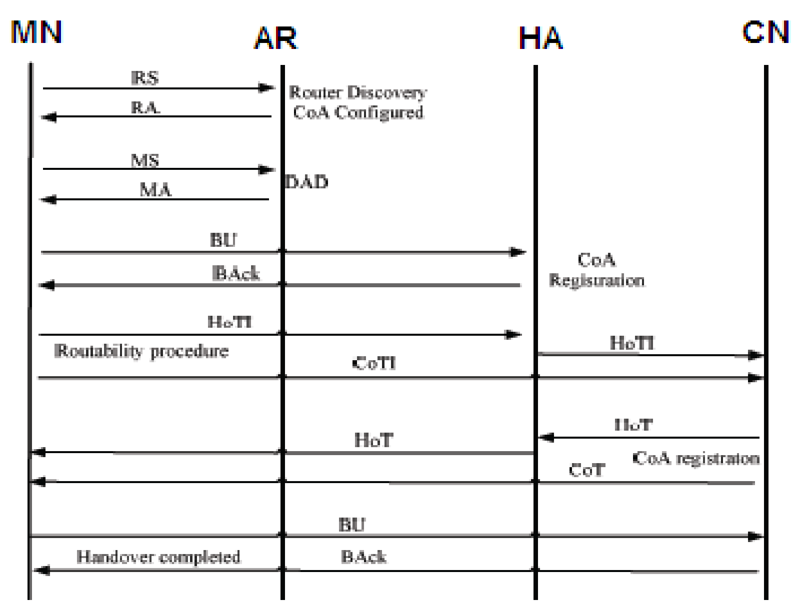

Fig. 5: Signaling messages sequence for standard MIPv6 (Xinyi and Gang, 2009)

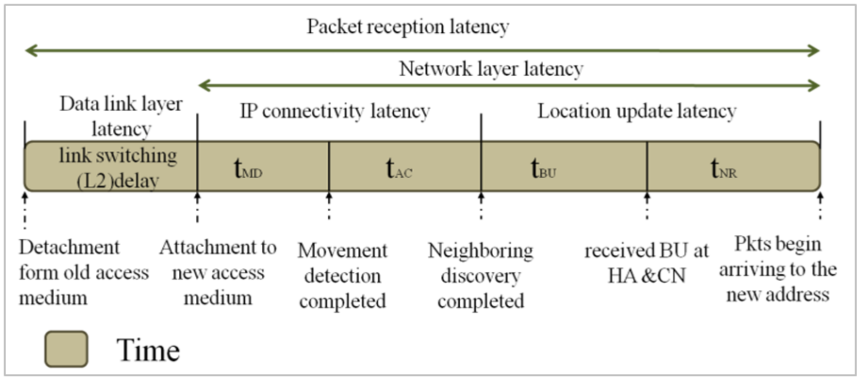

Fig. 6: Handover delay encountering in MIPv6

Packet delivery cost: The packet delivery cost comprises the transmission of the data packet in addition to the processing cost. Also, it could be defined as the combination of packet tunneling cost (C_{tun}) and packet loss cost (C_{loss}). Let α and β be weighting factors which emphasize tunneling effect and dropping effect (where, $\alpha + \beta = 1$). So, the packet delivery cost is computed as follows:

$$C_{PD} = \alpha C_{tun} + \beta C_{loss} \quad (17)$$

The mobile node cannot receive any IP packets on its new point of attachment until the handover completes as in Fig. 5. This period of time is known as handover latency or packet reception latency (t_P). Usually, the handover procedure in MIPv6 is been affected by the latency that occurs in two layers: Network layer L3 handover and Link layer L2 handover. However, in this study the handover latency distributes into three components: link switching or L2 handover latency (t_{L2}), IP connectivity latency (t_{IP}) and location update latency (t_U). L2 latency takes place when a MN detects the decrease of Received Signal Strength Indication (RSSI) of its attached access point (Wei *et al*., 2007). So, it scans the currently available access points and chooses the best one to connect to. IP connectivity latency reflects how quickly an MN can send IP packets after L2 handover while location update latency is the latency of forwarding IP packets to MN's new IP address.

L3 handover latency can be defined by these delay parameters: movement detection delay (t_{MD}), addresses configuration and DAD procedure delay (t_{AC}), binding update latency (t_{BU}) and delay from completion of binding up date and reception of first packet at the new IP address (t_{NR}). Figure 6 depicts the timing diagram associated in the MIPv6 and displays that there is delay before the MN begins to receive packets directly from NAR.

Note that, initially there is no packet forwarding in MIPv6 until the handover is been completed; that is C_{tun}^{MIPv6} in Eq. (17) is equal to zero. Then, only packet loss cost takes a place and it can be computed as follows:

$$c_{loss}^{MIPv6} = \lambda_p c_{cm}^{f} (t_{L2} + t_{IP} + t_u) \quad (18)$$

where, λ_p defines as the packet arrival rate in unit of packet per time. And:

$$c_{cm}^{f} = \eta (c_{CN,PAR} + c_{PAR,MN})$$

is the cost of transferring data packets from CN to MN via PAR when the handover fails. To calculate the location update latency (t_U) in Eq. (18), we should consider the transmission delay causes by forwarding the binding messages from MN to HA and CN (i.e., t_{HA} and t_{CN}), in addition to the delay from return routability procedure (t_{RR}). Simply, $t_U = t_{BU} + t_{NR}$ and $t_{BU} = t_{HA} + t_{RR} + t_{CN}$. In more details $t_{X,Y}$ is one way transmission delay for a message with size (l_c) between nodes X and Y. If one of the endpoints is MN, then $t_{X,Y}$ will be determined by:

$$t_{X,Y}(lc) = \frac{1-q}{1+q}(B_{\omega l} + L_{\omega l}) + (d_{X,Y} - 1)\left(\frac{lc}{B_\omega} + L_\omega + \varpi_q\right) \quad (19)$$

where, q is the probability of wireless link failure, ϖ_q the average queuing delay at each router in the Internet which is presumed to be trivial in this equation (McNair *et al*., 2001), $B_{\omega l}$, B_ω are the bandwidth of wireless/wire link and $L_{\omega l}$, L_ω are the wireless/wired link delay. The handover latency associated in the MIPv6 is given by:

$$D_{HO}^{MIPv6} = t_{L2} + t_{RD} + t_{DAD} + t_{RR} + 2(t_{MN,HA} + t_{MN,CN}) \quad (20)$$

where, t_{RD} is Router discovery delay. The first half in Eq. (17) is represented the process of how to calculate the packet tunneling cost from the CN to MN optimally without going through HA. It obtains by Kim *et al*. (2006):

$$C_{tun}^{MIPV6} = \rho \times (\eta(C_{CN,NAR}^{MIPv6} + C_{NAR,MN}^{MIPv6}) + PC_{AR} \quad (21)$$

By summing up all of Eq. (17), (18) in (21), the packet delivery cost for MIPv6 is as follows:

$$C_{PD}^{MIPv6} = \alpha C_{tun}^{MIPv6} + \beta C_{loss}^{MIPv6} \quad (22)$$

Even though the data packets in MIPv6 forward directly from the CN to the MN avoiding the huge overhead of HA's processing cost (i.e., overcome the problem of triangle routing), they need to bypass through the ER to ensure QoS in the proposed scheme (DiffServ-MIPv6). This may cost extra time at ER for the processing, however this is considered negligible to total signaling cost if we perceive the significant profit of the QoS guaranteed to mobile node. Hence packet tunneling cost from the CN to MN via ER in the proposed scheme is given by:

$C_{tun}^{Diff-MIPV6} = \rho \times (\eta(C_{CN,NAR}^{Diff-MIPv6} + C_{NAR,MN}^{Diff-MIPv6}) + PC_{AR} + N_E PC_{ER} = \rho \times (\eta\tau(d_{CN,ER}^{Diff-MIPv6} +$ dER,CRDiff−MIPv6+dCR,ERDiff−MIPv6+dER,NARDiff−MIPv6+κ+ PCAR+NEPCER (23)

As the result, the packet delivery cost for the proposed scheme (DiffServ-MIPv6) is as follows:

$$C_{PD}^{Diff-MIPv6} = \alpha C_{tun}^{Diff-MIPv6} + \beta C_{loss}^{Diff-MIPv6} \quad (24)$$

The total signalling cost for the proposed scheme (DiffServ-MIPv6) and MIPv6: According to investigation that have done to study all of the binding update cost, binding refresh cost and packet delivery cost, the performance analysis of (DiffServ-MIPv6) and standard MIPv6 protocols would be determined easily. Using Eq. in (9), (15) and (22), we can come up with the total signaling cost of MIPv6 is as follows:

$$C_{TOT}^{M} = C_{BU}^{M} + C_{BR}^{M} + C_{PD}^{M} \quad (25)$$

Similarly, referring to Eq. in (14), (16) and (24), the total signaling cost of (DiffServ-MIPv6) is representing as follows:

$$C_{TOT}^{DM} = C_{BU}^{DM} + C_{BR}^{DM} + C_{PD}^{DM} \quad (26)$$

Numerical results of signalling cost: To generate numerical results from equations derived above, the system parameters shown in Table 2 are used (Lai and Chiu, 2005; McNair *et al*., 2001; Xie and Akyildiz, 2002; Makaya and Pierre, 2008).

Table 2: System parameters

Parameters	Symbols	Values
Control packet size	l_c	96 bytes
Data packet size	l_d	200 bytes
The probability of wireless link failure	q	0.50
Wired link bandwidth	B_ω	100 Mbps
Wireless link bandwidth	$B_{\omega l}$	11 Mbps
Subnet radius	R	500 m
MN average speed	V	5.7 km/h
Number of ARs in AN	M	2
Packet arrival rate	λ_p	10 packets/sec
Wired link delay	L_ω	2 msec
Wireless link delay	$L_{\omega l}$	10 msec
DAD delay	t_{DAD}	500 msec
Router discovery delay	t_{RD}	100 msec
L2 handover delay	t_{L2}	50 msec

Referring to Fig. 3 the distance is defined as the number of hops between different hosts. It is assumed to be equals (i.e., $c = d = e = f = g = 10$). The distance between ingress ER and AR (b, b') are assumed to be = 2 and a is the distance between MN and AR which is set to 1. Further parameters used for signaling cost computation are defined as follows:

$\tau = 1$, $\kappa = 10$, $\alpha = 0.2$, $\beta = 0.8$, $PC_{AR} = 8$, $PC_{HA} = 24$, $PC_{CN} = 4$ and $PC_E = 8$

The location update cost, packet delivery cost and total signaling cost equations were derived and generated for a mobile node in case of the standard MIPv6 and the proposed scheme (DiffServ-MIPv6). Accordingly, the impact of various system parameters has been observed to evaluate the signaling cost ratio for the MIPv6 and (DiffServ-MIPv6). The aim of this study is to provide insight for a new scheme that should be deployed to co-exist with the standard MIPv6 protocol to provide QoS for mobile hosts.

The effect of session-to-mobility ratio on binding update cost: In this scenario, the mobile node performs intra-movement. Where (M) is the number of ARs in the Access Network (AN) which is equal to 2. Session to Mobility (SMR) ratio is varied (from 0.3 to 2.1). Figure 7 shows the cost of binding update ratio for the proposed scheme (DiffServ-MIPv6) and the standard MIPv6 (C_{BU}^{DM}/C_{BU}^{M}) during the handover as function of SMR. It can be observed that when SMR is small, the cost of BU ratio will be increased. However, when SMR is getting to be larger the cost of BU ratio will be decreased. Basically, when SMR is small the mobility rate is going to be larger than session arrival rate. This because of the mobile node changes subnets frequently. Therefore, the cost of BU ratio is increased due to the registration the signaling overhead and the processing

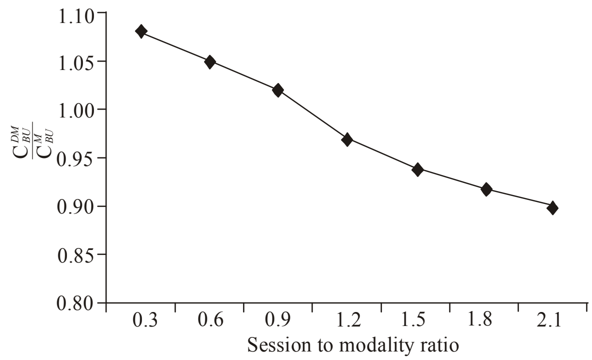

Fig. 7: SMR versus the binding update cost

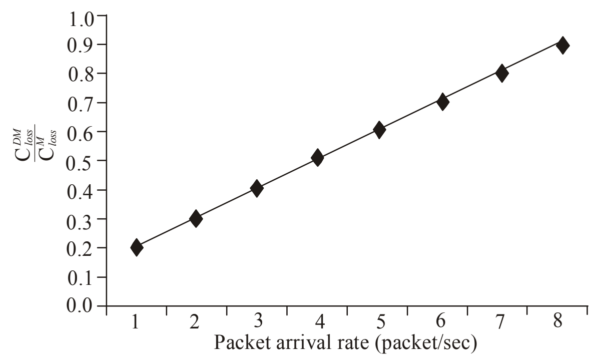

Fig. 8: Packet arrival rate versus the packets loss

cost at the ERs (as in the proposed scheme). While when the session arrival rate is larger than mobility rate, cost of BU ratio will be decreased because the signaling overhead for the registration was decreased. Namely, there is no much movement encountered. The signaling cost in the proposed scheme is increased more than MIPv6 (when the mobility rate is larger than session arrival rate). This because of the transmission cost when the control packets (or BU) transit through the edge router which means the additional processing cost at ER (that is why the cost of BU ratio is increased above zero). However, when mobility rate is low the proposed scheme performs better than MIPv6 due to the processing cost at the ER would be trivial compared to the total signaling cost for BU. Precisely the proposed scheme reduces the overhead of BU retransmission in time of congested where by resulting on less service deterioration for real-time applications (that is why the cost of BU ratio is decreased below than zero).

The effect of packet arrival rate on the packet loss: The impact of packets arrival rate on the packet loss is shown in Fig. 8. Data packet size (l_d) is set to 200 bytes, Control packet size (l_c) = 96 bytes, L2 handover delay (t_{L2}) = 50 msec, the Duplicate Address Detection delay t_{DAD} = 500 msec and the packets arrival rate are varied from 1 to 8. Referring to Eq. (18), the packet loss is a function of packet arrival rate (λ_p). From the figure it can be seen that, the packet loss ratio for the proposed scheme and the standard MIPv6 ($C^{DM}_{loss}/C^{M}_{loss}$) increases proportionally with packet arrival rate (λ_p). The proposed scheme (DiffServ-MIPv6) alleviates packet loss. It outperforms the standard MIPv6 because of the transmission delay for the BU message that have been sent from MN to HA is less than transmission delay in the standard MIPv6 in time of congested. The reason behind that the BU assigns in EF flow. Hence, the proposed scheme is more suitable for real time applications especially when the packets are sent at high rates (λ_p).

CONCLUSION

In this study analytical analysis is developed to investigate the signaling cost. The derivation of the signaling cost for the proposed scheme is compared with the standard MIPv6 scheme for benchmarking. Significant parameters are used for the evaluation such as, session-to-mobility ratio and packet arrival rate. The obtained results demonstrate that the proposed scheme outperforms the standard MIPv6 and doesn't add much signaling overhead while improving QoS for the mobile IPv6 users. In future work more parameters will be considered to evaluate the validity of the proposed scheme such as binding lifetime period and wireless link delay.

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