Two Fast Handover Solutions for the IMS Handover in the Presence of Mobile IPv6 by using Context Transfer Procedures

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Abstract

The growing demand for wireless and mobile services has set the recent research sights on mobility support for next generation IPv6 networks. To provide seamless communications for such networks, Fast Mobile IPv6 (FMIPv6) and Hierarchical Mobile IPv6 (HMIPv6) has been proposed. Moreover, 3GPP has introduced IP Multimedia Subsystem (IMS) as the next generation IP based infrastructure for multimedia services convergence. In this paper we present two context transfer mechanisms based on predictive and reactive schemes, to support seamless handover in IMS over MIPv6. Transferring appropriate session information between old P-CSCF and new P-CSCF, those schemes reduce handover latency time. The performances of the proposed mechanisms are evaluated by simulations.
Keywords- Context transfer; Handover; IMS; MIPv6

1. Introduction

3GPP has presented IMS, to support multimedia services. IMS connection initiation procedure consists of network elements used in SIP based session control [4]. Furthermore, IMS represents reference service delivery platform architecture for the provisioning of IP multimedia services within an emerging mobile all-IP network environment. In order to benefit from the advantages of IPv6, 3GPP has selected it as the IP version supported by the IMS. IMS has been considered as the foundation for future wireless and wire line convergence. Accordingly, MIPv6 has become a global solution to support mobile Internet between various access networks, and one of the fundamental characteristics of IMS is the support for user mobility. However, moving form one access network to another causes MN to change its IP address and some other session specifications. To provide seamless transport, the handover procedure needs to implement specific mechanisms to preserve the session states.

In this paper, two context transfer solution is proposed to transfer the session state between old P-CSCF and new P-CSCF in order to reduce handover latency time. Consequently, as soon as a mobile node moves, the session must be restored in the new P-CSCF. A session state is a set of session information installed by services on P-CSCF in IMS. We calculate signaling cost to evaluate the performance of our proposed schemes.

The rest of this paper is organized as follows. The next section offers a brief overview of the IMS architecture, MIPv6 Protocol and context transfer mechanisms. In Section 3, we present our proposed handover schemes for improving handover latency. In Section 4, the proposed scheme is evaluated using timing diagram and cost analysis. Section 5 presents numerical results and Section 6 concludes this paper.

2. Backgrounds

2.1. IP Multimedia Subsystem Architecture

3GPP use a layered approach for IMS architectural design. As shown in Figure 1, IMS network comprises transport, session control, and application layers. The application layer includes application servers and data bases and provides service logic for users. The session layer includes such functional entities that provide connectivity between users and applications. This layer provides policy decisions, routing, and subscriber management functions. SIP servers and connectivity gateways are the main entities of this layer. The transport layer is responsible for the end user's basic access functions and rules as a connector between IMS core and users. The signaling plane of the IMS is comprised of several functions: CSCF, HSS, gateway functions, service and application servers. IMS entities and key functionalities are shown in Figure 1 [4].

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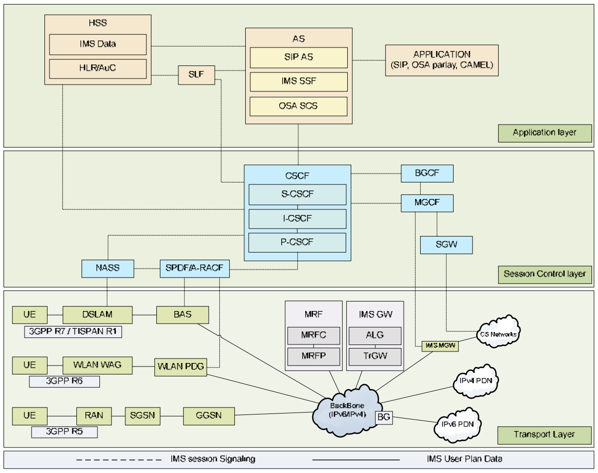

Figure 1. IP Multimedia Subsystem logical Architecture

2.2. Overview of Mobile IPv6 Protocol

MIPv6 is one of the most important protocols to accommodate the increasing demand of end-to-end mobility in IPv6 Internet [1]. The handover procedure in MIPv6 consists of movement detection, Duplicate Address Detection (DAD) for CoA configuration, and Binding Update (BU). There have been a lot of researches to improve handover performance. One of these research issues is to reduce the handover latency. FMIPv6 [2] is a modification of MIPv6 that tries to reduce handover latency by utilizing Layer 2 triggers. HMIPv6 [3]. There are two modes of operations: predictive and reactive. [2].

2.3. Context Transfer Procedure

Context transfer [12] is a network level protocol which transfers connection information between access routers; this mechanism is a handover optimization procedure to reduce the length of interruption [11]. Context transfer is used when the transmission path of a session changes and session-related states are re-located from the network nodes on the old transmission path to the network nodes on the new transmission path. It enables the setup of transmission related state in the new network node prior to the handover, such as establishing security state, reserving resources, assigning addresses/ locators for the mobile node. Second, during the handover execution, context transfer can be used to accelerate the handover process and reduce the amount of data loss [12].

3. Handover procedure improvement

In recent years, there has been a rapid growth in the Need to support moving hosts in mobile networks. Due to the mobility, the UE has to change the point of attachment to the access network that triggers a change of the MN's IP address. Before the UE can continue the session, it has to register to the IMS again. After the registration, the UE has to renegotiates parameters for the session. Fig. 2 shows the message flow for the registration and invite for the IMS in the presence of MIPv6 [5, 10]. This will potentially introduce a long interruption of the ongoing session.

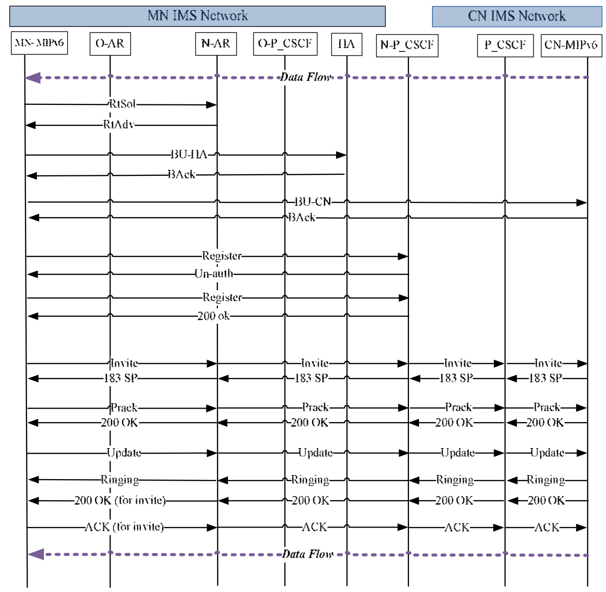

Figure 2. Standard MIPv6 handover in IMS network

3.1. Proposed Context Transfer-based schemes

We assume that a multimedia session is ongoing between two users. After some time, the MIPv6 node performs a handover from the access network where the session was generated to a new access network, where the session should be continued. In this process, the MN changes its IP address which may imply a change of P-CSCF. According to the IMS specifications, the session at the old P-CSCF is terminated, and the MN has to trigger the standard SIP-based IMS procedures at the New P-CSCF (Fig. 3). New P-CSCF does not have information about the MN and its session information, so it has to register in it and re-invite the CN (Fig. 2).

The proposed solutions make it possible to have a handover between P-CSCFs, without losing session state information. Additionally, fewer messages are used for the re-register and re-invite of the MN and shorter handover delay imposed for re-establishment of the session, comparing to the standard scheme which is described in [8, 9]. By transferring the session context (Fig. 3), new P-CSCF receives information about the MN and its session at the old P-CSCF, such as registration state, session states, Final Network Entry point, UE Address, Public and Private User IDs and Access Network Type.

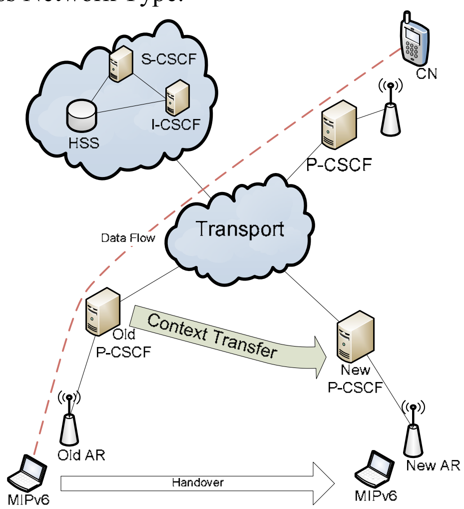

Figure 3. context transfer in proposed handover scenario

3.2. Proposed Scheme 1

In this scheme, the MN knows in advance towards which router it will move and anticipates the transfer to the NAR. Note that this knowledge can be acquired by FMIPv6 and Neighbor Discovery (ND) [6]. The MN sends a Move-notify message to its P-CSCF (Fig. 4) containing the NAR address and the identifiers of the context to be transferred. Afterward, the old P-CSCF sends move-notify to the new P-CSCF and then transfers the context information to that. This information includes registration state, session states, Final Network Entry point, UE Address, Public and Private User IDs and Access Network Type. After receiving Ack, old P-CSCF updates S-CSCF routes information by sending Route update and receives 200 ok. It's worthy to mention that in this scheme the context transfer procedure is performed prior or simultaneous to MIPv6 handover and doesn't cause excessive latency.

3.3. Proposed Scheme 2

In this scheme, the MN has performed a handover before the context transfer is requested. It sends a move-notify message to the new P-CSCF containing the old P-CSCF IP address (see fig. 5). The old P-CSCF is the one that validates the transfer. The New P-CSCF sends a Context Transfer Request message to the old P-CSCF. The old P-CSCF replies with a Context Transfer Message that contains the session information. Finally, after receiving Ack, the old P-CSCF updates S-CSCF routes information by sending Route update and receives 200 ok. In this scheme context transfer does not run simultaneously with MIPv6 handover procedure.

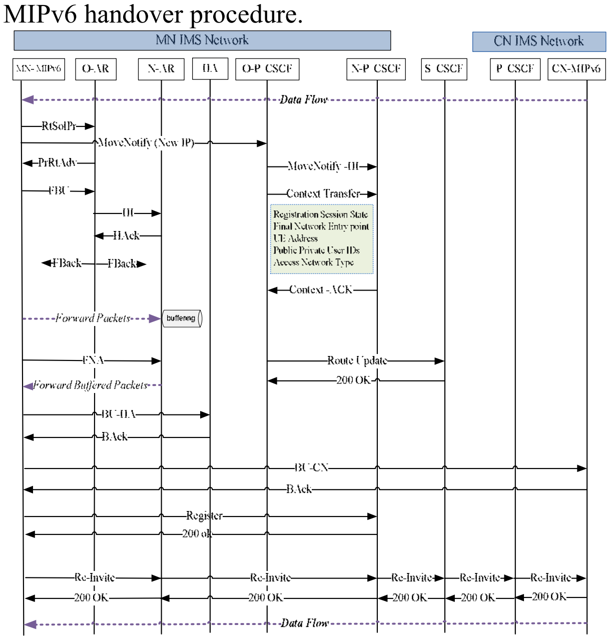

Figure 4. Proposed Predictive FMIPv6 handover in IMS network

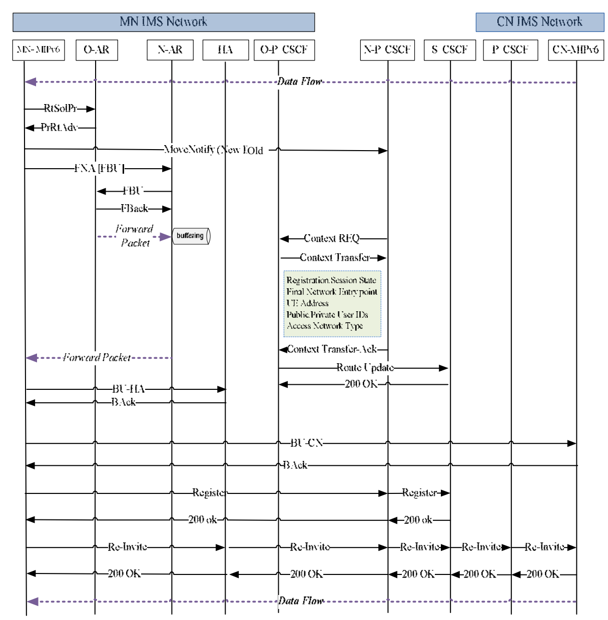

Figure 5. Proposed Reactive FMIPv6 handover in IMS network

4. Performance evaluation

In this section we evaluate the handover delay for the two proposed schemes and compare with the delay of the original MIPv6 in IMS. The analysis is based on a simple model presented in [10] that takes into account the delay of the different entities involved in the handover. For simplicity, we consider the model illustrated in Fig. 6.

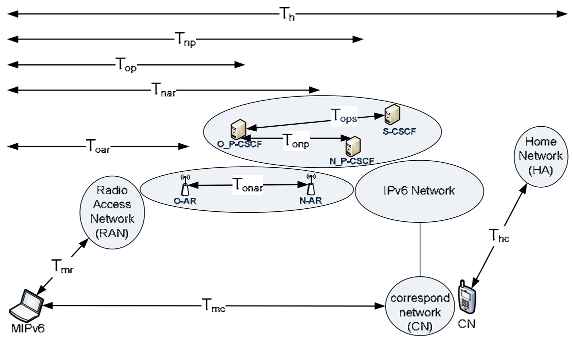

Figure 6. Simple model for analysis

TABLE I. NOTATIONS USED IN FIG. 6

Notations	Description (Delay between)
T_{mr}	The MN and the radio access network
T_{oar}	The MN and the old AR
T_{nar}	MN and the new AR
T_{onar}	The OAR and the NAR
T_{op}	The MN and the old P-CSCF
T_{np}	The MN and the new P-CSCF
T_{onp}	The old P-CSCF and the new P-CSCF
T_h	The MN and its HA
T_{ops}	The old P-CSCF and the S-CSCF

We assume that the delays are considered symmetric and $T_{mr} < T_h$. We do not consider the time needed by DAD process and Return Routability procedure, also the processing and queuing times are not considered. In standard IMS-MIPv6, first the MN sends router solicitation to all ARs in its domain and receives router advertisement from them, then, selects one of them to migrate. Afterward, the MN obtains a new CoA, which takes $2T_{nar}$. Then the MN sends BU to HA and CN and receives Back from them, which takes $2T_h + 2T_{mc}$. Finally the MN should register in the new IMS network, and Re-invite the CN; these procedures take $4T_{np} + 8T_{mc}$. Therefore the overall delay for the standard IMS-MIPv6 handover would be:

$$2T_{nar} + 2T_h + 10T_{mc} + 4T_{np} \qquad (1)$$

In the proposed predictive scheme the handover procedure starts in the same way as for standard scheme with proxy router solicitation/advertisement which takes $2T_{oar}$. The MN then sends Move-Notify that contain new MN's IP address, to the old P-CSCF, which takes T_{op}. The MN sends an FBU to the old AR, which takes T_{oar}. The ARs then exchange HI and HAck, which takes $2T_{onar}$. The previous AR sends an FBAck to the new AR and to the MN, which takes at most T_{oar}. At the same time the old P-CSCF sends Move-Notify to new P-CSCF and then sends context-transfer to the new P-CSCF that contain current session information. After receiving context, the new P-CSCF sends context-transfer ACK to the old P-CSCF. Then the old P-CSCF sends route update to S-CSCF and receives 200 ok. This procedure proceeds concurrently with the handover process avoiding extra latency. After that, the MN sends an FNA to the new AR, which takes T_{nar}. Then the MN sends BU to HA and CN and receives Back from them, which takes $2T_{ha} + 2T_{mc}$. Finally the MN should re-register in new IMS network, and Re-invite the CN; these procedures take $2T_{np} + 2T_{mc}$. So the delay for the proposed Predictive IMS-FMIPv6 handover would be:

$$4T_{oar} + T_{op} + 2T_{onar} + T_{nar} + 2T_h + 4T_{mc} + 2T_{np} \quad (2)$$

In the proposed reactive scheme the handover procedure starts in the same way as standard scheme handover, with proxy router solicitation/advertisement which takes $2T_{oar}$. The MN then sends Move-Notify that contain new MN's IP address, to the new P-CSCF, which takes T_{np}. At this moment the MN has moved to the new AR and has not received an FBAck. It thus sends an FBU encapsulated in an FNA via the new AR to the previous AR. The previous AR sends back an FBAck to the new AR and starts forwarding packets to the new AR if the new CoA is accepted. This procedure takes $T_{nar} + 2T_{onar}$. Then, the new AR delivers the forwarded packets immediately to the MN. After that, the new P-CSCF sends context request to the old P-CSCF. The old P-CSCF sends session information to the new P-CSCF by context-transfer and receives context-transfer ACK after. Then the old P-CSCF sends route update to S-CSCF and receives 200 ok. This procedure takes $3T_{onp} + 2T_{ops}$. Consequently the MN sends BU to HA and CN, and receives Back from them, which takes $2T_{ha} + 2T_{mc}$. Finally the MN should re-register in the new IMS network and Re-invite the CN; these procedures take $2T_{np} + 2T_{mc}$. As the result, the delay for the proposed Reactive IMS-FMIPv6 handover would be:

$$2T_{oar} + 3T_{np} + T_{nar} + 2T_{onar} + 3T_{onp} + 2T_{ops} + 2T_h + 4T_{mc} \quad (3)$$

5. Numerical Result

In this section, we present the numerical performance evaluation for the standard and the two proposed schemes. To evaluate the disruption time, we set $T_{mr} = 10$ ms as in [11 and 7]. Also, we assume $T_{oar} =$ 11ms, $T_{onar} =$ 5ms, $T_{op} =$ 15ms, $T_{onp} =$ 7ms and $T_{ops} =$ 10ms. The delay introduced by the Internet depends on the number of routers and the type of links in the path of datagram transmission. For this reason, we assume the one-way Internet delay over the wired network to be constant, i.e., equal to 100ms. Therefore, we assume $T_h =$ 116ms, $T_{mc} =$ 128ms, and $T_{hc} =$ 114ms.

5.1. Impact of MN to CN Delay

In Fig. 7, it can be noticed that the disruption times for standard scheme gets larger when the delay increases. The proposed predictive scheme gives slightly shorter handover delay comparing with the proposed reactive scheme.

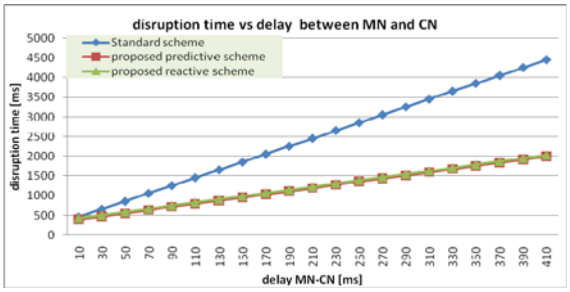

Figure 7. Disruption time versus delay between MN and CN

5.2. Impact of the Delay between MN and HA

In Fig. 8, the handover delays for the proposed schemes are lower than the standard scheme when the delay between the MN and the HA increases.

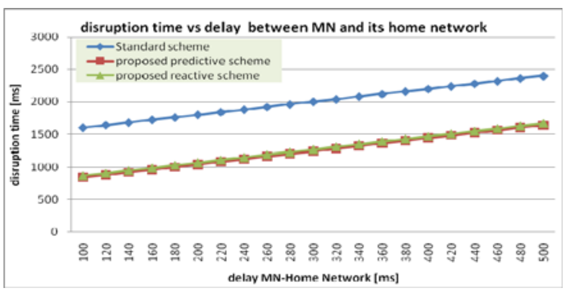

Figure 8. Disruption time versus delay between MN and HA

5.3. Impact of old to new P-CSCFs Delay

The Fig. 9 shows that as the delay between the old P-CSCF and the new P-CSCF is increasing, the disruption time for the proposed predictive scheme would be the lowest. This augmentation is enhanced for the higher values of the old to new P-CSCF delay.

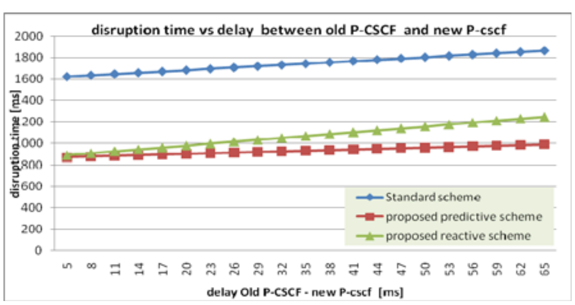

Figure 9. Disruption time vs. delay between old and new P-CSCFs

6. Conclusion

In this paper, In order to improve the performance of the handover procedure, we proposed two handover schemes for IMS networks over MIPv6. To lessen the handover latency, the predictive and reactive proposals make use of context transfer between the old P-CSCF and the new P-CSCF. The session state information transfer prior to the handover, decreases the total time needed for the transactions of the handover process. We investigated the performance of these schemes and compared them with the standard IMS handover without context transfer procedure. Our performance evaluation implies that shorter handover latency is achieved as fewer messages are required for the re-register and re-invite of the CN, and for the session re-establishment.

7. References

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