2011 Workshops of International Conference on Advanced Information Networking and Applications

- Message from AINA 2011 General Co-Chairs
- Message from AINA 2011 Workshops Co-Chairs
- Welcome Message from FINA 2011 Symposium Chairs
- FINA 2011 Organizing Committee
- FINA 2011 Reviewer List
- Welcome Message from AASNET 2011 Symposium Chairs
- AASNET 2011 Organizing Committee
- AASNET 2011 Reviewers
- Welcome Message from BICom 2011 Chairs
- BICom 2011 Organizing Committee
- BICom 2011 Reviewers
- Welcome Message from the BLSMC 2011 Workshop Chairs
- BLSMC 2011 Organizing Committee
- BLSMC 2011 Reviewers
2011 Workshops of International Conference on Advanced Information Networking and Applications

- Welcome Message from CCS 2011 Workshop Chairs
- CCS 2011 Organizing Committee
- CCS 2011 Reviewers
- Welcome Message from DMWPC 2011 Workshop Chairs
- DMWPC 2011 Organizing Committee
- DMWPC 2011 Reviewers
- Welcome Message from HWISE 2011 Workshop Chairs
- HWISE 2011 Organizing Committee
- HWISE 2011 Reviewers
- Welcome Message from I2NS 2011 Workshop Chairs
- I2NS 2011 Organizing Committee
- I2NS 2011 Reviewers
- Welcome Message from iSeRiM 2011 Workshop Chair
- iSeRiM 2011 Organizing Committee
2011 Workshops of International Conference on Advanced Information Networking and Applications

- iSeRiM 2011 Reviewers
- Welcome Message from MAW 2011 Symposium Chairs
- MAW 2011 Organizing Committee
- MAW 2011 Reviewers
- Message from PAEWN 2011 Workshop Chairs
- PAEWN 2011 Organizing Committee
- PAEWN 2011 Reviewers
- Welcome Message from PAMS 2011 Workshop Chairs
- PAMS 2011 Organizing Committee
- PAMS 2011 Reviewers
- Welcome Message from the QuEST 2011 Workshop Chairs
- QuEST 2011 Organizing Committee
- QuEST 2011 Reviewers
- Welcome Message from SMPE 2011 Symposium Chairs
2011 Workshops of International Conference on Advanced Information Networking and Applications

- Publisher Information (Book version)
Sessions

- The Seventh International Symposium on Frontiers of Information Systems and Network Applications (FINA 2011)
- Session FINA-2A: Distributed and Parallel Computing
- Session FINA-3A: Semantic Web and Systems
- Session FINA-2B: Distributed and Parallel Systems
- Session FINA-3B: Mobile Networks and Systems
- Session FINA-2C: Peer-to-Peer (P2P) Computing
- Session FINA-3C: Mobile Networks and Applications
- Session FINA-1D: Scalable Computing
- Session FINA-2D: Internet Computing and Web Applications
- Session FINA-3D: Opportunistic and Delay Tolerant Networks
- Session FINA-1E: Agent and Dependable Systems
- Session FINA-2E: Intelligent Computing and Applications
- Session FINA-3E: Communication Networks
- Session FINA-1F: Service Oriented Architecture and Applications
- Session FINA-2F: Security
Sessions (cont.)

- Session FINA-3F: Communication Networks and Applications
- Session FINA-1G: Sensor Networks
- Session FINA-2G: Security and Privacy
- Session FINA-3G: Distributed Systems and Network Applications
- Session FINA-1H: Wireless Sensor Networks
- Session FINA-2H: Security and Intelligent Systems
- The Fourth International Symposium on Applications of Ad Hoc and Sensor Networks (AASNET 2011)
- Session 1: Applications of Ad Hoc and Sensor Networks
- The Third IEEE International Workshop on Bio and Intelligent Computing (BICom 2011)
- Session 1: Intelligent Solutions
- The 2011 IEEE International Workshop on Bioinformatics and Life Science Modeling and Computing (BLSMC 11)
- Session 1: Life Science Modeling and Computing
- Session 2: Bioinformatics and Biocomputing
- The First International Workshop on Cloud Computing and Services (CCS 2011)
- Session 1: Cloud Performance and Models
Sessions (cont.)

- The Fourth International Workshop on Data Management for Wireless and Pervasive Communications (DMWPC 2011)
- Session 1
- The Seventh IEEE International Workshop on Heterogeneous Wireless Networks (HWISE 2011)
- Session 1: Applications and Protocols of Wireless Networks
- The First International Workshop on Interworking and Interoperable Networks and Services (I2NS 2011)
- Session 1
- Information Security and Risk Management (iSeRiM 2011)
- Session 1: Security Tools and Solutions
- Session 2: Security Governance and Management Issues
- The 2011 International Symposium on Mining and Web (MAW 2011)
- Session 1: Mining Techniques
- Session 2: Web Applications
- The Sixth International Workshop on Performance Analysis and Enhancement of Wireless Networks (PAEWN 2011)
Sessions (cont.)

- Session 1: Performance Evaluation
- The First International Workshop on Protocols and Applications with Multi-homing Support (PAMS 2011)
- Session 1: Network
- Session 2: Transport and Mobility
- The 2011 International Workshop on Quantitative Evaluation of Large-Scale Systems and Technologies (QuEST 2011)
- The Fifth International Symposium on Security and Multimodality in Pervasive Environments (SMPE 2011)
- Session 1A: Pervasive Network and Communication
- Session 1B: Pervasive Security and Privacy
- The Fifth International Workshop on Telecommunication Networking, Applications and Systems (TeNAS 2011)
- Session 1A: Network Technologies
- Session 1B: Sensor Networking
- Session 1C: Mobile Computing
Sessions (cont.)

- The Seventh International Symposium on Web and Mobile Information Services (WAMIS 2011)
- Session 1: Service Provisioning
- Session 2: Data Models and Query Processing 1
- Session 3: Data Models and Query Processing 2
- Session 4: Web and Mobile Applications
- The Third International Conference on Underwater Networks (WUnderNet 2011)
The Seventh International Symposium on Frontiers of Information Systems and Network Applications (FINA 2011)
Session FINA-3B: Mobile Networks and Systems

- The Research of Locating Methods for Mobile Stations Based on IEEE 802.16e Multi-hop WMANs
  Sheng-Cheng Yeh, Chia-Hui Wang, Wu-Hsiao Hsu, and Ming-Yang Su

  Daisuke Fuji, Toshihiko Yamakami, and Kunihiro Ishiguro

- Extension of Proxy Mobile IPv6 with Bicasting for Support of Multi-homing and Mobility in Wireless Networks
  Ji In Kim and Seok Joo Koh

- An Efficient Model for Cooperative Caching in Mobile Information Systems
  Thu Nguyen Tran Minh and Thuy Dong Thi Bich
Extension of Proxy Mobile IPv6 with Bicasting for Support of Multi-homing and Mobility in Wireless Networks

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Abstract—This paper proposes an extension of Proxy Mobile IPv6 (PMIPv6) with bicasting for multi-homing and mobility support. In the proposed scheme, the Local Mobility Anchor (LMA) extends its Binding Cache Entry (BCE) for support of multiple bindings, and a mobile node (MN) performs the binding update to LMA. To support the handover, the LMA begins the bicasting of data packets to the New-Mobile Access Gateway (N-MAG) as well as Previous-Mobile Access Gateway (P-MAG). The proposed scheme is compared with the existing PMIPv6 handover by ns-2 simulations. From the numerical analysis, we can see that the proposed scheme can reduce the possible packet losses and handover latency, compared to the existing scheme, during handover in the multi-homing environment.

Keywords—PMIPv6; multi-homing; bicasting; handover;

I. INTRODUCTION

The Mobile IPv6 (MIPv6) can be used to support the IP handover in mobile networks [1]. However, there are still a lot of challenging issues to be addressed in MIPv6. One of them is how to reduce the modification of mobile node (MN). For example, to perform the mobility management signaling, each MN should be equipped with the MIPv6 functionality. Such a protocol is referred to ‘host-based mobility’ protocol.

In the wireless network environment, however, it is not effective that each MN performs the MIPv6 due to scarce resources in wireless networks such as network bandwidth or MN power. Above all, it is not easy for MN to implement any mobility software such as MIPv6.

Recently, the Proxy Mobile IPv6 (PMIPv6) protocol was standardized for network-based IP mobility in the Internet Engineering Task Force (IETF) [2]. In PMIPv6, the mobile agent located in the network will perform the mobility signaling instead of MN, and will keep track of movement of MN.

It is noted that the PMIPv6 is used mainly for binding update of locations of MNs. A recent work has been made on the PMIPv6 handover. However, there are still lots of issues that need to be solved in the perspective of seamless handover.

On the other hand, one of the primary issues for mobile networking is the multi-homing, in which MN has multiple network interfaces, e.g., WLAN and 3G network. However, it is noted that the current PMIPv6 was originally designed without consideration of multi-homing.

This paper proposes an extensive handover scheme of PMIPv6 with bicasting for multi-homing and mobility support, in which the PMIPv6 Local Mobility Anchor (LMA) will update its binding cache entry (BCE) and bicast the data packets both to the Previous-Mobile Access Gateway (P-MAG) and New-Mobile Access Gateway (N-MAG) toward MN, when MN is in the handover region.

This paper is organized as follows. Section II describes the related works on PMIPv6 handover and multi-homing. In Section III, we present the proposed scheme of PMIPv6 with bicasting for multi-homing and mobility support. In Section IV, the proposed scheme is analyzed and compared with the existing schemes. Section V concludes this paper.

II. RELATED WORKS

Fig. 1 shows the basic operations of PMIPv6, in which MN moves from P-MAG to N-MAG.

Figure 1. PMIPv6 handover operation
When MN changes its point of attachment, the P-MAG will detect the MN’s detachment and will perform the Proxy Biding Update (PBU) operations with the LMA to remove the binding and routing states associated with MN.

Upon receiving this PBU (DeReg PBU) request, the LMA will identify the corresponding BCE entry and accept the request. After that, it expects to receive the PBU message of the N-MAG for some time. In this period, a certain amount of handover latency occurs. During this handover period, some packet losses may occur. Accordingly, it is not easy to achieve seamless handover.

In the multi-homing environments, it is assumed that the home network prefix of each interface is established when the mobility session is first created for a given interface [3]. Accordingly, it is impossible to create multiple binding entries to a given interface in PMIPv6. To solve this problem, we will extend the binding cache entry of LMA, so as to bind a home network prefix to several proxy-CoAs related to the same MN [4].

III. PMIPv6 WITH BICASTING

To describe the proposed scheme, we will extend the PMIPv6 handover scheme and the binding cache entry of LMA, which can be used to reduce the packet loss and handover latency during handover in the mobile and multi-homing networks.

Fig. 2 shows the reference network configuration and the extension of binding cache entry in the proposed scheme.

In this figure, MN moves from the P-MAG region to the N-MAG region. We suppose that there is an overlapping region between MAGs. When MN is in the overlapping region, the multi-homing MN has the two network interfaces, interface 1 (IF1) to P-MAG and interface 2 (IF2) to N-MAG. Let us assume that IF1 of MN (P-MAG) first turns on, and the LMA assigns the home network prefix 1 to IF1. The MN initiates communications with Correspondent Node (CN), and sends and receives the data packets destined to Home Network Prefix 1 (HNP1) via IF1. Then, the IF2 detects N-MAG, and the IF2 becomes available to N-MAG.

After that, the LMA will begin the bicasting of data packets to N-MAG as well as P-MAG through the two interfaces. The bicasting will be performed to minimize the possibility of packet losses and handover latency during handover, because MN can receive the data packet from any of the P-MAG and N-MAG.

Fig. 3 shows the operations of the proposed scheme.

First, when MN moves to the bicasting region, it detects that a handover is imminent, and thus it performs the link-layer signaling. The P-MAG sends Handover Init (HI) message to N-MAG, where HI messages includes the MN’s IP addresses that are Proxy-CoA (P-CoA), Home address (MN-HoA), LMA address (LMAA), MN’s Identifier, and HNP. When the N-MAG receives HI message, it should examine whether a tunnel to LMA exists or not. If the tunnel has not been established, it should establish the tunnel with LMA.

To establish the tunnel, the N-MAG sends a PBU (with Bicasting Init) message to LMA, which includes MN-Identifier, MN-HoA, and HNP.

When LMA receives the PBU (Bicasting Init) message, it creates a new binding cache entry or modifies the existing binding cache entry [5,6]. If the LMA successfully processes the PBU (Bicasting Init), it sets the tunnel with N-MAG to send and receive the data packets. After successful establishment of the tunnel, the LMA sends a PBA
(Bicasting Ack) message to indicate whether or not the PBU (Bicasting Init) message was processed successfully. If there is a failure, the PBA (Bicasting Ack) message indicates the failure. Otherwise, N-MAG creates a tunnel to LMA and ensures that the data packets with the destination address as Proxy CoA are copied and forwarded to LMA over the tunnel. It also creates a host route for forwarding packets to the MN.

When MN connects to the new link, it establishes a physical link connection with N-MAG (for example, radio channel assignment), which in turn triggers the establishment of a link-layer connection with the N-MAG. An IP layer connection setup may be performed at this time. This step can be a substitute for Unsolicited Neighbor Advertisement (UNA) in [7]. The more details are all access technology specific and thus outside the scope of this paper.

Then, the N-MAG sends a Handover ACK message back to the P-MAG to indicate whether the handover procedure was successfully done or not. The N-MAG sends a PBU (De-registration) message to LMA. This message includes MN-identifier and P-CoA of N-MAG. On reception of this PBU message, the LMA deletes the HNP1 of IF1 in the binding cache entry, and stop the bicasting (i.e., release the tunnel between LMA and P-MAG). In response to PBU (De-registration) message, the LMA sends PBA (Bicasting Stop) message to P-MAG. By this, the bicasting operations are completed.

IV. PERFORMANCE ANALYSIS

In this section, we analyze the performance of the existing PMIPv6 handover and the proposed handover scheme. First, let us compare the features of the candidate schemes, PMIP, PMIP-M (PMIP with multi-homing), and the proposed PMIP with bicasting and multi-homing.

The normal PMIPv6 induces the handover latency that consists of Movement Detection (MD) delay and Proxy Binding Update (PBU) delay. However, the PMIPv6 with multi-homing (PMIPv6-M) gives less handover delay and packet loss than PMIPv6, since the multi-homing MN has several HNPs each interfaces. Finally, the proposed scheme can reduce the handover latency much more, since it uses multiple interfaces and bicasting of data packets to the old and new MAGs toward MN.

Note that in the proposed scheme MN will not release the connection to P-MAG before the handover completion. Thus, the proposed scheme prevents the packet loss that may occur due to a wrong prediction of MN’s movement or handover.

Now, we describe the experimental result for PMIPv6 and proposed scheme using the Network Simulator-2 (NS-2) [8]. In simulation, we consider the MN moves from P-MAG domain to N-MAG domain.

In the test network, MN is initially connected to P-MAG. After 10 seconds in the experiment, we enforced the MN to perform L2 handover to N-MAG. In the proposed scheme, P-MAG detects the MN’s movement at 9.5s, and N-MAG detects the handover completion at 11s. We use the IEEE 802.21 Media Independent Handover (MIH) [9] so as to implement the link-layer triggers from access network.

As shown the figure, the wired link between CN and LMA is configured with a network bandwidth of 100 Mbps and link delay of 50ms, and the wired links between LAM and MAGs have the bandwidth of 100 Mbps and transmission delay of 10ms. On the other hand, the wireless links between MAGs and MN are configured with the bandwidth of 11 Mbps and link delay of 10ms. During the simulation, CN transmits CBR packets with UDP packet size of 1,000 bytes at a transmission rate of 100 packets per second.

Fig. 5 shows the simulation results, in which the handover delays and packet losses are depicted for the three schemes.

Figure 5. Trace of Data Packets Transmitted during Simulation

From the figure, we can see that the PMIPv6 handover incurs more packet losses and larger handover delays than the other handover scheme using bicasting, PMIPv6-M and proposed scheme. On the other hand, the proposed scheme provides lower handover delays and packet losses.
Fig. 6 compares the handover delays of the three handover schemes for different link detection times. In the figure, we can see that as the link detection time increases, the handover delays get larger for PMIPv6 and PMIPv6-M schemes. On the other hand, the proposed scheme gives almost zero handover latency, even though the link detection time is large. This is because the proposed scheme predicts the handover and bicasts the data packet in advance.

Fig. 7 shows the number of data packets that have been lost during handover. From the figure, we can see the existing handover schemes (PMIPv6 and PMIPv6-M) incur some packet losses, and the amount of lost packets get larger, as the link detection time increases. In the meantime, the proposed scheme gives almost zero packet loss.

V. CONCLUSIONS

This paper proposed an extension handover scheme of the PMIPv6 with bicasting for multi-homing and mobility, in which the PMIPv6 binding update is performed in advance and then LMA performs the bicasting of data packets to the N-MAG as well as P-MAG. The LMA is extended to support the multiple Binding Cache Entry (BCE).

From the experimental results, it is shown that the proposed scheme can give smaller handover latency than PMIPv6. This is because the proposed scheme receives the data packet from both P-MAG and N-MAG during handover through any of the multiple interfaces.

ACKNOWLEDGMENT

This research was supported by the IT R&D program of MKE/KEIT(10035245: Study on Architecture of Future Internet to Support Mobile Environments and Network Diversity) and the ITRC program of MKE/NIPA(NIPA-2010-C1090-1021-0002).

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[9] IEEE 802.21, Media Independent Handover Services