CHAPTER III

PROPOSED METHOD

In this research, we propose to combine the original protocol of Paging Mobile IP with Mobile IP Regional Registration. Multicasting is used as the packets forwarding mechanism to the Mobile Node (MN) within the Gateway Foreign Agent (GFA) domain to improve the performance of Paging Mobile IP in terms of the handoff latency and the number of lost packets. Mobile IP Regional Registration also improves the performance of Paging Mobile IP in term of signaling cost. Our idea in combining multicasting, regional registration and paging comes from some proposals in [7], [9], [10], [14], and [15]. The details of proposed method are as follows.

3.1 Topology

Hierarchical topology of Mobile IP Regional Registration is used in the proposed method. In the proposed topology, one GFA is a local administrator for some Foreign Agents (FA). These FAs are located within a specific geographic coverage area and grouped into two or more paging areas. Every FA is identified by the network prefix as part of the internet address. Non-overlapping paging area scheme is employed. In this scheme, one FA can only be associated with one paging area. Every paging area has its own unique paging area ID. Similar to original Paging Mobile IP, the Agent Advertisement message is extended to carry the paging area ID. Every FA advertises the Agent Advertisement message periodically so that the MN can detect its location within a specific paging area. A paging table is maintained by each FA. This paging table can be manually set or configured. The MN, the GFA and the FA are assumed to support security, authentication, paging and multicasting. Hierarchical topology of the proposed method is shown in Figure 3.1.

3.2 Registration and Mobility Management

FAs within the GFA domain broadcast Agent Advertisement messages periodically to show their presence and services. Once a MN enters the GFA domain and receives an Agent Advertisement message from one of the FAs, it registers to the Home Agent (HA) by using Registration Request message with GFA's address as the Care-of Address (CoA). The MN is then assigned a Multicast Address. This Multicast

Address is broadcast by every FA in the Agent Advertisement message. This address does not change when the MN moves within the GFA domain. GFA uses this Multicast Address for transmission of downlink data packets from the GFA to the FAs in the multicast group where the MN is now located. Here, multicasting is only applied locally within the GFA network. After receiving the Registration Request message, the GFA updates the state of the MN to be active.

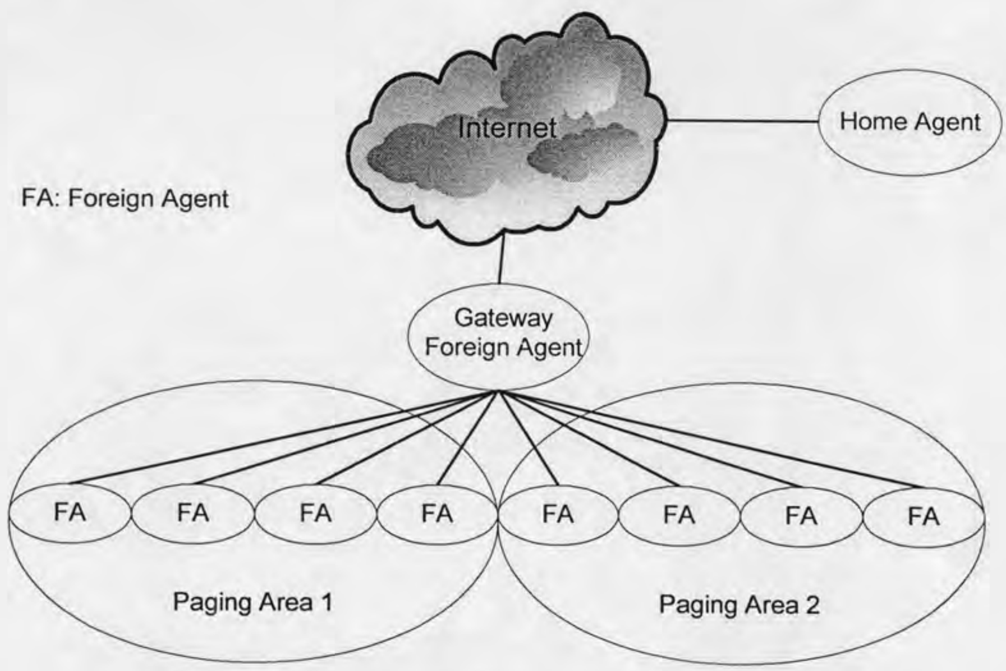

Figure 3.1 Hierarchical topology of the proposed method.

Besides multicast address, the MN also gets a Unicast CoA from its FA. This Unicast Address is used for regional registration and data transmission from the MN to another node in the internet. This address changes every time the MN moves to another point of attachment. After receiving Registration Reply message, the FA and MN update the MN's state to be active just like in the original Paging Mobile IP. The FA puts the MN information in its registration table and sends Registration Reply message to the MN.

The multicast tree is constructed every time the MN registers. After receiving the Registration Request message, present FA sends Protocol Independent Multicast (PIM) Join message to GFA to form the multicast tree. The multicast group members are the FAs surrounding the current FA. The multicast group is set by the way that the current FA sends one message similar to Agent Advertisement message to neighbor FAs every time that FA receives Registration Request from the MN. We call this message Inter-Agent Advertisement message. This message contains the Multicast Address which the neighbors FAs have to join and also has a function as the MN pre-registration message to the prospective FAs within the same multicast group. Neighbor FAs join the multicast group by sending PIM Join message to the GFA after these FAs receive Inter-Agent Advertisement message. The signaling time diagram of initial registration process in the proposed method is shown in Figure 3.2.

Figure 3.2 Signaling time diagram of initial registration in the proposed method.

The method used to detect whether a MN has moved to different network is similar to that of Paging Mobile IP. This method is usually known as Eager Cell Switching. Here, handoff utilizes Agent Advertisement message which is sent by each FA. The MN compares the network prefix obtained from newly received Agent Advertisement message to the current CoA of the last registered FA in its record. If the network prefix from that Agent Advertisement message is similar, the MN does nothing. Otherwise, the MN concludes that it has moved to new FA. If the MN is in active state, it starts regional registration process by sending Regional Registration Request message to the GFA through the new FA. After receiving this Regional Registration Request message, the new FA checks whether it has had the MN's record in the registration table due to the pre-registration from neighbor FA in the same multicast group. If it is the case, the new FA forwards any buffered packets to the MN. Otherwise, the FA puts the MN's record in the registration table and subscribes to the corresponding multicast group. This FA also will trigger the other FAs in the same multicast group to join the group. The MN location will be updated at both the FA and GFA. The processes are quite similar to the initial registration except that the MN does not register to the HA but to the GFA. The regional registration process of an active MN is shown in Figure 3.3 below.

In contrast, if a MN is in idle state, the MN does not conduct regional registration to the GFA when moving from one cell to another within a paging area. However, when an idle MN moves to another paging area, it registers to the GFA to update its location. An idle MN compares paging area ID that it receives in Agent

Advertisement message from the new FA with the MN's current paging area ID in its record. If the paging area IDs are the same, the MN does nothing and only tracks the FA identified using Agent Advertisement message. If paging area IDs are different, the idle MN then should immediately registers with GFA through the new FA.

Figure 3.3 Signaling time diagram of regional registration process of an active Mobile Node in the proposed method.

One important additional feature in the proposed method is the utilization of multicasting within the GFA domain. During active state, the data will be sent by the GFA not only to the current FA but also to the FAs surrounding the current FA under the same multicast group. Current FA is the FA serving the network that a mobile host is currently visiting. The packets are forwarded on the current FA and buffered at other FAs in the same multicast group. As soon as the MN moves to another cell in the same multicast group and registers, the buffered packets are sent to the MN. Using the benefits of regional registration and multicasting, the proposed method can reduce the number of lost packets and handoff latency during handoff process in the original Paging Mobile IP.

The MN will change its state from active to idle if it has not sent or received data for a specified time. In contrast, the MN will change its state from idle to active when it intends to send data or receive Paging Request message from GFA. The FA and GFA restart the MN's active timer each time a data packet is sent to or received from the MN. The MN also restarts its active timer under this situation. Because the proposed method uses multicasting and regional registration, there are differences with the original Paging Mobile IP during the transitions of the MN's state. If the MN changes its state from active to idle, the FA will unsubscribe from the multicast group by sending PIM Prune message to the GFA. The FA will also update its registration table. The GFA will then record the MN's last paging area in the paging table. In idle mode, the MN does not conduct registration and the multicast group for the MN does not exist. On the contrary, different events will happen if the MN's state changes from idle state to active state. In this case, the MN performs regional registration by sending Regional Registration Request message to the GFA through the current FA. The FA and GFA update their registration table to record MN's last location in the network. The FA also built multicast tree and group for the MN as explained before.

3.3 Paging and Data Handling

When there are data packets from the HA to the MN, the HA will first send the packets to the GFA. The GFA then checks the state of the MN. If the MN is in the active state, the GFA encapsulates the packets and sends them to the MN's multicast group. The current FA forwards the packets to the MN, while other FAs buffer the packets. If the state of the MN is idle, the GFA then buffers the packets and starts paging process to find the precise location of the MN. The GFA sends Paging Request messages to all FAs that are in the last reported paging area visited by the MN under the same GFA. Every FA then broadcasts Paging Request message in its own area.

When the MN receives Paging Request message, it will check whether the Paging Request message contains the MN's Home Address. If this is the case and the message is directly from the MN's registered FA, then the registered FA is the same one as the MN's current FA. Thus, the MN deduces that it is still located in the same network as its registered FA. In this case, the MN sends Paging Reply message to the GFA through current FA without registering, and sets its state to be active. Receiving the Paging Reply message, the FA joins the multicast group by sending PIM Join message to the GFA. The FA also constructs the multicast group by sending Inter-Agent Advertisement messages to neighbor FAs. The neighbor FAs then join the same multicast group by sending PIM Join message to the GFA. On the other hand, when the MN detects that it has moved to new cell, the MN conducts regional registration to the GFA through its current FA to update its latest location. The multicast tree and groups are also built as explained in the previous section.

When the FA receives the Regional Registration Reply message from the GFA, it sets the state of the MN to be active and relays the message to the MN. After receiving Regional Registration Reply message from GFA, the MN sends Paging Reply message as the response to Paging Request message. The GFA then forwards the buffered and incoming packets to the MN through the current FA that has joined the multicast groups. Other FAs in the same multicast group buffer the packets and forward the packets to the MN as soon as the MN moves to their service area. Figure 3.4 shows the signaling time diagram when the HA sends packets to an idle MN through the GFA in the proposed method. A MN can simply send data when it is in the active mode. If the MN is in idle state, it first determines if it is still located on the same network that it previously registered with by checking the Agent Advertisement message. If the MN has moved to a new network, then it initiates a registration procedure to update its location record in its GFA and FA before sending data. In this research, however, we focus on downlink transmission of data packets.

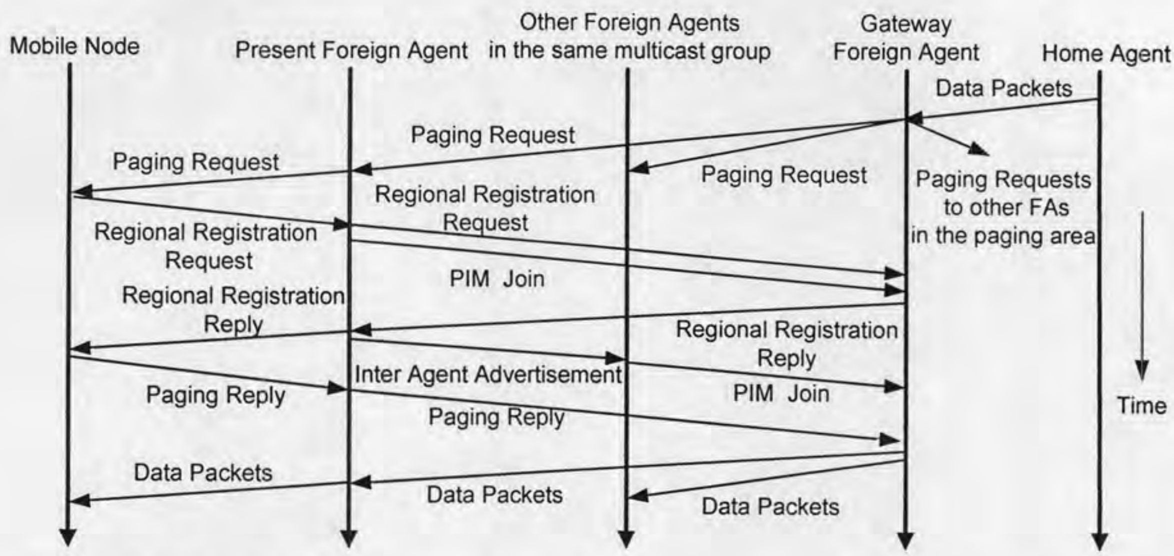

Figure 3.4 Signaling time diagram when the Home Agent sends packets to an idle Mobile Node through the Gateway Foreign Agent in the proposed method.

3.4 Proposed Method with Link Layer Movement Detection

Previous proposed method in this chapter uses Network Layer registration. This proposed method is effective in the network which consists of various devices with different kinds of Physical and Link Layers. This kind of network may occur in the future when various wireless systems can communicate and inter-network with each other. First proposed method has decreased the signaling delay of the MN by only conducting regional registration to the GFA and not to the far away HA. As the results, the proposed method can reduce the handoff latency and the number of lost packets of the original Paging Mobile IP significantly. However, if the wireless system only consists of one type of wireless system such as IEEE 802.11 standard [16], the previous proposed method performance can still be enhanced.

The previous proposed method still uses conventional Paging Mobile IP method for movement detection. In this method, the MN must wait until it receives the Agent Advertisement message from the new FA to initiate the registration process after the MN leaves the former FA. The Agent Advertisement message in Paging Mobile IP is sent by each FA every 1 second. So, there is a big possibility that the MN must wait for the Agent Advertisement message for a quite long time to start the registration process after it moves to new cell. This situation is critical if the MN is in the active state, when the MN is receiving data packets from the previous FA while it is moving to new cell. It still can lead to long handoff latency which may result in high number of lost packets. Therefore, in this sub-chapter we add another proposed method to speed up the movement detection process by using Link Layer information in the IEEE 802.11 system.

Link Layer handoff, as in the Post Registration method and Paging Mobile IP with Post Registration [5] [8], uses Link Layer information to initiate handoff process. Link Layer information such as signal strength, signal to noise ratio (SNR) and bit error rate (BER) are used by the MN for detecting the decaying wireless link. Link Layer also provides the information about the new FA's IP address identifier or the old FA's IP address identifier. The MN concludes if the handoff is about to occur by monitoring those parameters. Link Layer information can be detected by the MN faster than that of Network Layer since the FA broadcasts Link Layer beacon at faster rate than Agent Advertisement message. Typically, each FA transmits Link Layer beacon with 100 ms period. Thus, the MN can detect that it has moved to another cell fast when it uses Link Layer information for movement detection. Indeed, the MN must finish Link Layer handoff before starting Network Layer registration process.

In Mobile IP Post Registration and Paging Mobile IP with Post Registration method, Link Layer information is used as the trigger to build a Bidirectional Edge Tunnel between the new and old FA for transmission of data packets. Association Request message sent by the MN to the FA is used as the trigger. The MN may defer the registration process in Network Layer so that the MN can receive the packets fast when it moves to another cell. In this second proposed method, we use Link Layer information for triggering the new FA to join the multicast group. This idea comes from some references such as References [17] and [18]. Here, the MN can receive the multicast packets faster than the first proposed method from the new FA. The multicast group is only constructed if there are packets for the MN in the active time. The details of the second proposed methods are as follows.

The second proposed method uses the same topology as in the first proposed method. GFA is used for regional registration purpose to shorten the handoff process by reducing the signaling delay when the MN roams in the GFA domain. GFA is also used as the paging administrator if there are data packets destined to the MN. When the MN enters the GFA domain for the first time, it conducts home registration to the HA with GFA address as the Care-of Address. The MN also gets local Multicast Address and Unicast CoA from the Agent Advertisement message of the first FA in the GFA domain. In the second proposed method, the multicast group is constructed based on the Link Layer signaling during the active time. Therefore, the multicast group is not constructed for the initial registration. Link Layer information is also used to trigger the new FA to join the multicast group so that the present FA does not need to send Inter-Agent Advertisement messages to the neighbors FA every time the MN registers with the GFA. The initial registration then is the same as the initial registration of Mobile IP.

As mentioned before, the second proposed method uses different method for movement detection in the active time. Instead of using Agent Advertisement message which is broadcast every 1 second, the second method uses Link Layer beacon which is sent every 100 ms by each FA for movement detection. We adopt this method from Post Registration which also used in Reference [5] to speed up the forwarding of data packets so that the MN can receive the packets even before formal Network Layer registration. In the active time, when the MN leaves the previous FA and enters the coverage area of the new FA, it receives the Link Layer beacon from that FA. The MN then associates with the new FA by sending the Association Request message to it. In return, the FA sends Association Response message back to the MN according to IEEE 802.11. At this point, the FA still sends data packets to the previous FA and the packets are lost since the MN has been of the new FA coverage area. The Association Request message received by the MN will trigger the new FA to join the multicast group. Here, Inter-Agent Advertisement message in the first proposed method is not used to trigger the new FA to join the multicast group. Upon receiving the Association Request message, the FA then sends Protocol Independent Multicast (PIM) Join message to GFA. GFA then sends multicast packets to the previous FA and to the new FA. No buffer is required in the FAs since the packets are directly forwarded to the MN at the new FA. Here, the multicast packets received at the new FA are faster than that of in the first proposed method since the MN can receive packets before it conducts Network Layer regional registration to the GFA. Moreover, the multicast of the packets only lasts for a short period and the waste of bandwidth is therefore minimal. Sometime in the future, the MN receives the Agent Advertisement message from the new FA and registers to the GFA. The GFA only sends the packets to the MN through the new FA after the MN finishes Network Layer Registration. Previous FA then leaves the group by sending the PIM Prune message to the GFA when the MN's active timer in its record is expired so that the MN enters the idle state in the previous FA's record. It makes the bandwidth utilization in Proposed Method 2 is better than that of Proposed Method 1. Figure 3.5 shows the signaling time diagram of the handoff process when an active MN moves from one cell to another.

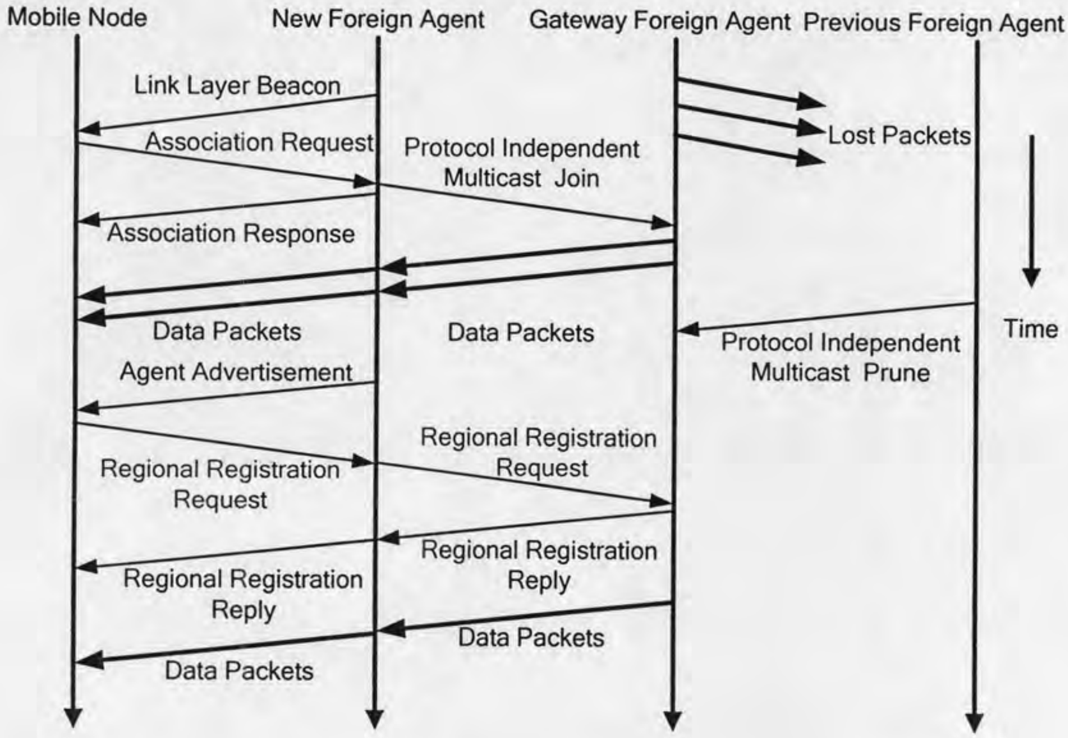

Figure 3.5 Signaling time diagram in the second proposed method when an active Mobile Node moves to new Foreign Agent.

When there are packets for the MN, the packets are first sent by the HA to the GFA. The GFA then checks the state of the MN. If the MN is active, the GFA sends the packets to the MN's multicast group. The multicast group only consists of one member when the MN has conducted regional registration and still located in the coverage area of the same FA it registers to before. The multicast group member increases to be two when the MN leaves the previous FA and conducts Link Layer registration at the new FA. If the state of the MN is idle, the GFA buffers the packets and sends Paging Request messages to all FAs that reside in the last reported paging area. Every FA then broadcast that message in its own area to search for the MN. When an idle MN receives Paging Request message and it has not moved yet from it last registered FA, it sends back Paging Reply message to the GFA and sets its state to be active. On the other hand, if the idle MN has moved to another FA area, the MN registers to GFA by exchanging Regional Registration Request and Regional Registration Reply messages. The MN then changes its state to be active and sends Paging Reply to GFA through the new FA. The FA also sends PIM Join message to GFA to join the multicast group. Receiving Paging Reply message, the GFA forwards the buffered and incoming packets to the MN through the current FA. Here, we only rely on Network Layer registration for paging purposes because regional registration is fast enough so that the time needed to search for the MN is short. Figure 3.6 shows the signaling time diagram when the HA sends packets to an idle MN through the GFA in the second proposed method.

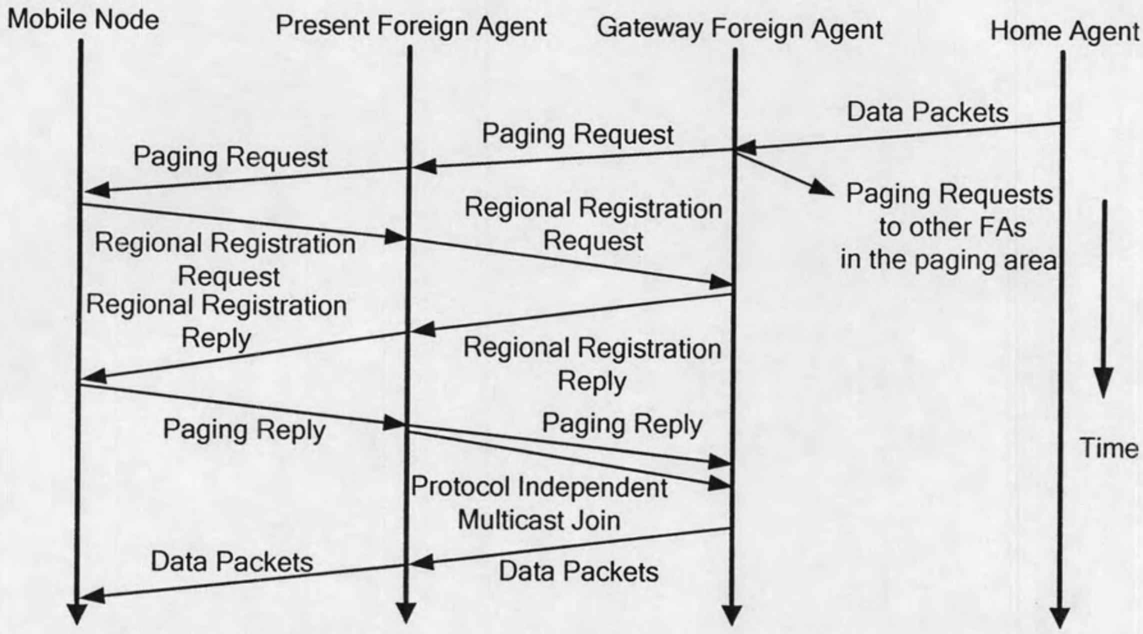

Figure 3.6 Signaling time diagram when the Home Agent sends packets to an idle Mobile Node in the second proposed method.