A NEW MECHANISM IN HMIPV6 TO IMPROVE MICRO AND MACRO MOBILITY

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ABSTRACT
The paper proposes new mechanism in Hierarchical Mobile IPv6 (HMIPv6) implementation for utilization in IPv6 Enterprise Gateway. This mechanism provides seamless mobility and fast handover of a mobile node in HMIPv6 networks. Besides it provides continuous communication among a member of HMIPv6 components while roaming. The mechanism anticipates future movement of mobile node and accordingly provides an effective updating mechanism. A bitmap has been proposed to help in applying the new mechanism as will be explained throughout this paper. Instead of scanning the prefix bits which might be up to 64 bits for subnet discovery, about 10% of this length will be sufficient to determine the hierarchical topology. This will enable fast Micro and Macro HMIPv6 in Enterprise Gateway.

KEYWORDS: *Hierarchical Mobile IPv6, bitmap, Enterprise Gateway, Mobility Anchor Point.*

I. INTRODUCTION

IPv6 Enterprise Gateway is an apparatus or device which intercommunicate the public network with enterprise network. The enterprise network includes many sub-networks with different access routers or home anchors. For flexibility, HMIPv6 is used to organize these enterprise networks in hierarchal way. HMIPv6 stands for Hierarchical Mobile Internet Protocol Version 6. HMIPv6 is provisioning the different access areas by assigning mobile anchor point (MAP) to each area. The MAP stands on behalf of the enterprise gateway (home agent) in its particular coverage area. Besides, it will reduce the control messages exchanged and decrease the time when the mobile node roaming to another network. The mobile node can use the local MAP to keep the communication on without the need to communicate with enterprise gateway.

It is known that Hierarchical Mobile IPv6 (HMIPv6) provides a flexible mechanism for local mobility management within visited networks. The main problem in hierarchical mobility is that the communication between the correspondent node (CN) and the mobile node (MN) suffers from significant delay in case of the mobile node roaming between different MAPs or between different access routers (ARs) in the same MAP coverage area. This happens because the MN in the visited network acquires a local care of address (LCoA), therefore it receives the router advertisement (RA) and uses its prefix to build its new LCoA. This process causes a communication delay between the CN and the MN for a while, especially when the roaming happens between different MAPs. This process involves more binding update messages to be sent not just to the local MAP, but also to the enterprise gateway as shown in Figure 1, the messages flow to acquire new CoA starts after MN reached the foreign network.

The patent in [1] anticipates the probable CoA's based on the number of vicinity Access Routers, which means the number of probable CoA in each single movement, and then the MAP should multicast the traffic to all of these addresses. In this paper, the Home Anchor creates the anticipated CoA based on the received bitmap from MN, this Bitmap refers to the strongest signal that the MN was triggered by the foreign router, this means Home Anchor have a single probable address to tunnel the packet to, besides the current CoA.

RFC4260 [2] proposed the idea of anticipating the new CoA and tunnel the packets between the previous Access Router and the New Access Router. The differences between the work in this paper and in [2] is that packet loss will likely occur if the process is performed too late or too early with respect to the time in which the mobile node detaches from the previous access router and attach to the new one, or the packet loss is likely occur in case the BU cache in the home anchor is updated but the layer 2 handover does not complete yet. The work in [3] proposed a scheme that reduced the 82% of the total cost of the macro mobility handover of the original HMIPv6.

Kumar et al. in [4] proposed an analytical model which shows the performance and applicability of MIPv6 and HMIPv6 against some key parameters in terms of cost.

An adaptive MAP selection based on active overload prevention (MAP-AOP) is proposed in [5]. The MAP periodically evaluates the load status by using dynamic weighted load evaluation algorithm, and then sends the load information to the covered access routers (AR) by using the expanded routing advertisement message in a dynamic manner.

In this paper, a solution to the explained problem has been proposed in which the mobile node sends binding update request at the moment when it initiates the movement to the foreign network, and to add a bitmap field to the binding update request to recognize different components of the HMIPv6.

The paper is organized as follows. Section 2 describes the methodology of the proposed mechanism supported by figures; section 3 illustrates the new operation of micro and macro-mobility. Binding update message format is introduced in section 4 where the bitmap idea comes from. Finally, section 5 concludes the work and presents the future work.

II. METHODOLOGY

The objective of this paper is provided by a method for multi-cell cooperative communication comprising: detecting a beacon from a new access router, translating the beacon received from the new access router to a bitmap, sending a binding update request message that contains the bitmap to a current mobile access point, assessing the bitmap, tunneling data packets from a correspondent node through the enterprise gateway to the current destination and to the new destination simultaneously, sending an update message once the mobile node reaches the new destination, refreshing binding cache tables and tunneling the data packets only to the new destination according to the new address of mobile node.

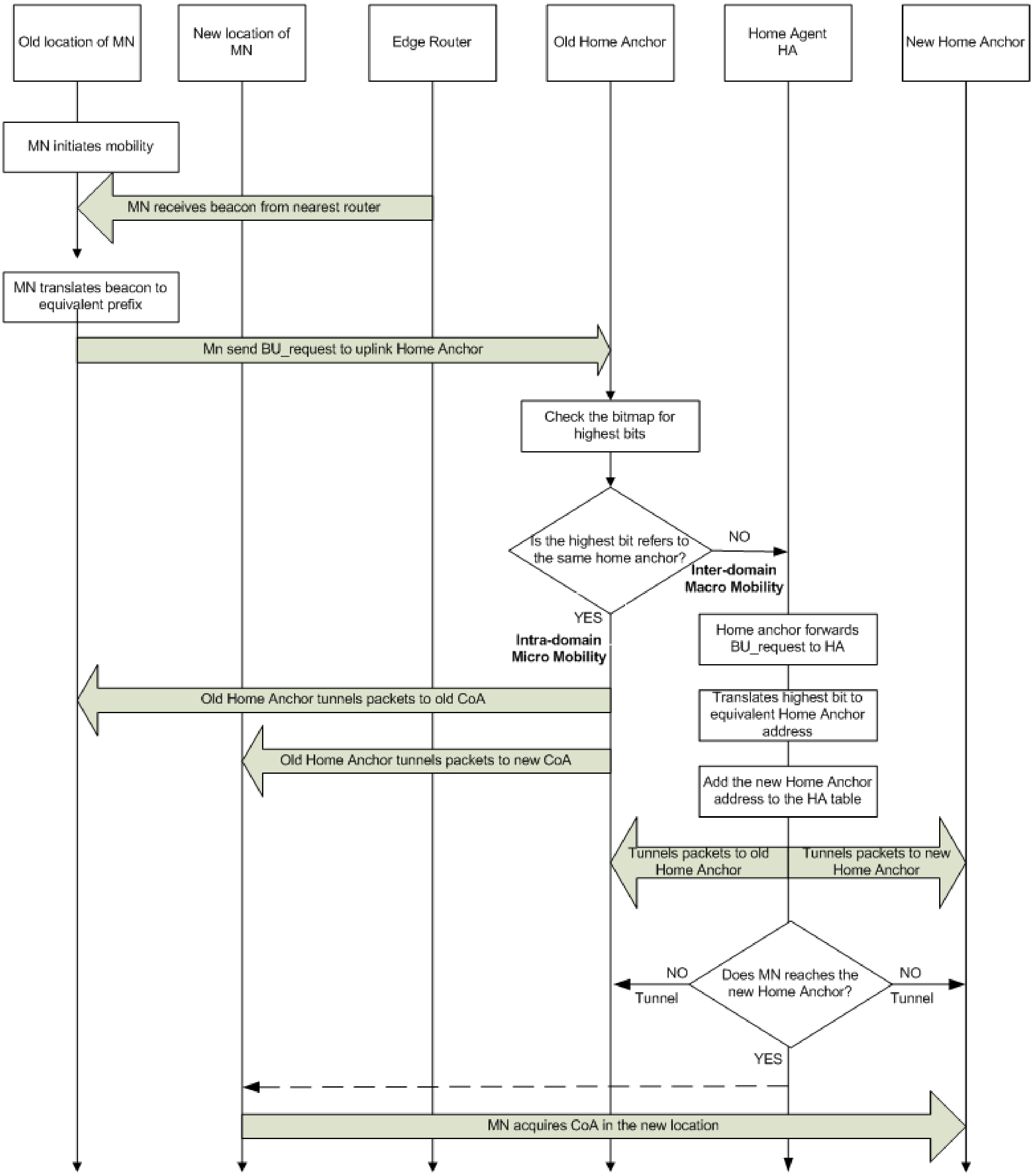

Figure 1 (a): Flow Control of Micro and Macro Mobility Process (part 1)

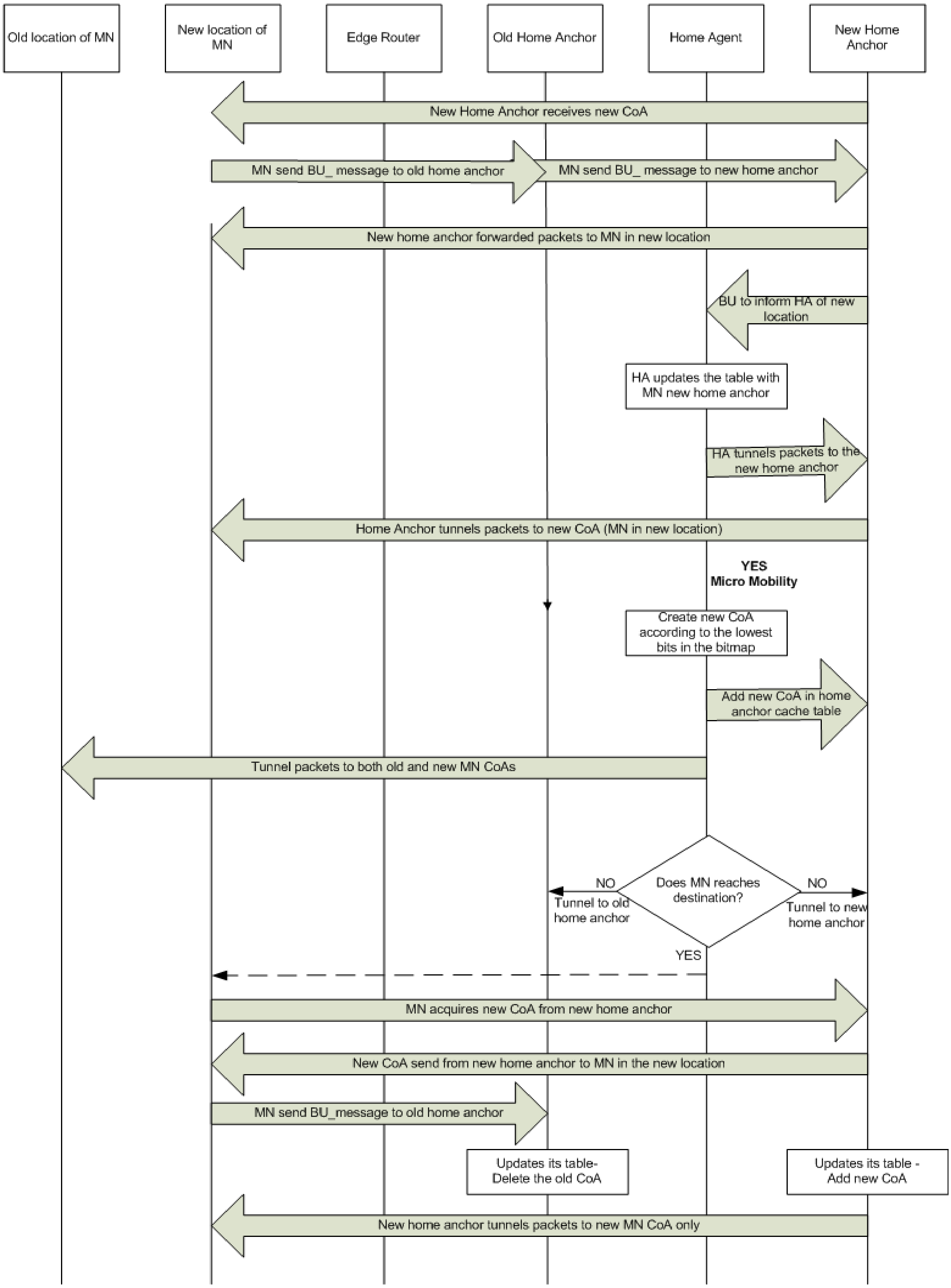

Figure 1 (b): Flow Control of Micro and Macro Mobility Process (part 2)

Some of the most important key points in this paper:

- Adding a bitmap which is a number of binary bits proposed to be used instead of the subnet prefix to specify the subnet.

- Propose to update the binding update message to include a bitmap field; this field is occupied by a lowest part which refers to the router's prefix and a highest part which refers to the home anchor's address, the proposed message can be called binding update request which should be sent as soon as the MN initiates the movement to the anticipated foreign network.
- The mobile node has the ability to measure the beacon strength in order to decide which anchor point to join as the future home agent.
- Binding Update message: it is mentioned in HMIPv6 standard [6, 7], this message is sent by the mobile node to the home anchor or the home agent (in some cases it is sent to correspondent node), it is used to register the MN's Care of Address in its home anchor or its home agent, but this message is sent after the MN acquires a CoA in its foreign network.
- Binding cache Table: it is a mapping table that resides in the Enterprise Gateway (home agent) and home anchor points to translate the value of the bitmap to its equivalent prefix. Also it is used to track the MN's movement.
- The proposed solution contributes to both inter-domain (macro-mobility) and intra-domain (micro-mobility) in terms of handover delay. This will improves multimedia applications.

1. The New Operation of Micro and Macro-mobility:

a) Operation of Micro Mobility: As shown in Figure 1, the proposed solution suggested sending a binding update request (BU req.) when the MN initiates its movement to the foreign network. The MN will sense the strong signal from the foreign network router. It translates this to the bitmap field by setting up the corresponding bit. The contributed bitmap in this paper requires updating the present binding update message by using the reserved bits already exist for future use.

Then the MN sends the updated BU req. message to the upstream Home Anchor. When the home anchor receives the updated BU req., it will check the highest bits in the bitmap, as we can see in the decision box (Figure 1), if these bits refers to the home anchor itself, the home anchor will learn that this is a micro-mobility and create a new address (CoA) for the MN according to the lowest bits of the bitmap.

Now, the Home Anchor cache table has two CoAs for a particular MN one for the previous MN's location and the other for the new location. It starts to tunnel the packets to both CoAs for a while till the handover preparation is finalized. Therefore the MN will have a seamless mobility and continuous communication, even before obtaining the new CoA from the future foreign router.

When the MN reaches the foreign router area and obtains the CoA, it will send a Binding update message which includes the HoA and the CoA to the upstream Home Anchor, then the Home Anchor will refresh its binding cache and delete the old CoA.

Finally, the Home Anchor will tunnel the packets only to the new CoA.

b) Operation of Macro Mobility

This section explains the mobility between two routers each of them belongs to different Home Anchor or different domains. The process flow is shown in Figure 1.

Assume the MN initiates the movement to a router that is connected to different home Anchor. The MN receives the beacon from the foreign router and recognizes it as different from the old one from the prefix. It reflects this in the higher bits of the bit map. It updates the BU request message accordingly with the new bitmap then sends the message to the upstream Home Anchor. When the Home Anchor receives the BU req., it will check the highest bits in the bitmap, in this case it will recognize that these bits refers to another Anchor, therefore it forwards the BU req. to the Enterprise Gateway (home agent). At the same time, the home anchor translates the lowest part of the bitmap to its prefix and adds it to the MAC address to form the new CoA. The Home Anchor will tunnel the packets to the current CoA and the new CoA at the same time. On the other hand, the Enterprise Gateway receives the BU req. and translates the highest bits of the bitmap to the equivalent Home Anchor address. Besides, it refreshes the cache table with this new value and starts to tunnel the packets to the current Home Anchor and the new Home Anchor. But the traffic which is destined to the new Anchor will not be forwarded to the MN till the MN reaches the particular foreign router and obtained a new CoA. At this time the MN will send a BU message to the Enterprise Gateway. As a result, the Home Agent refreshes its cache table to delete the previous Anchor and includes the updated one then tunnels the traffic to the new Home Anchor. The new home anchor in turn will tunnel the packets to the new CoA of the mobile node in the new location.

2. Binding update message format

The main contribution in this work is based on the idea of using the reserved bits in the BU message shown in Figure 2.

As can be seen in Figure 2 the binding update message has reserved bits starting from bit 5 up to bit 15, so some or all of these bits can be used to implement the proposed mechanism in this paper. For example, if 6 bits are used, the highest 2- bits can be assigned to the Home Anchors with possibilities of (00, 01, 10, 11), the lowest 4-bits can be assigned to the access routers (ARs) which can handle 2^4 or 16 routers starting from 0000 to 1111.

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  0                   1                   2                   3
  0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
                                 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                                 |          Sequence #           |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |A|H|L|K|M|      Reserved       |          Lifetime             |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                                                               |
 |                                                               |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
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Figure 2: Binding update message format [3]

Figure 3 shows the system architecture for the proposed mechanism, here are some abbreviations:

CN: Correspondent Node.

MN: Mobile Node.

BU req.: Binding Update request message.

ACK: Acknowledgement message

HoA: MN's Home Address.

CoA: MN's Care of Address in the foreign network.

Based on the architecture, the MN initiates its movement from the home network to Home Anchor-1. As shown in Figure 3, MN receives the beacon from R2 in Home Anchor1's coverage area and it translates this signal to the bitmap by setting the correspondent bit. The MN will send a BU request message which contains the bitmap to the Home Anchor1. Home Anchor1 builds its bitmap mapping table by translating the received bitmap to CoA2, then it replies back an acknowledgment message to MN. The MN receives the acknowledgment and sends another BU request message to the Enterprise Gateway (home Agent). The Enterprise Gateway receives the BU req. and checks the highest bits in the bitmap field and translates it to the equivalent home Anchor's addresses. In this architecture, the highest bits refer to the Home Anchor-1, then the Home Agent refreshes its bitmap mapping table to add the Home Anchor's addresses in the table.

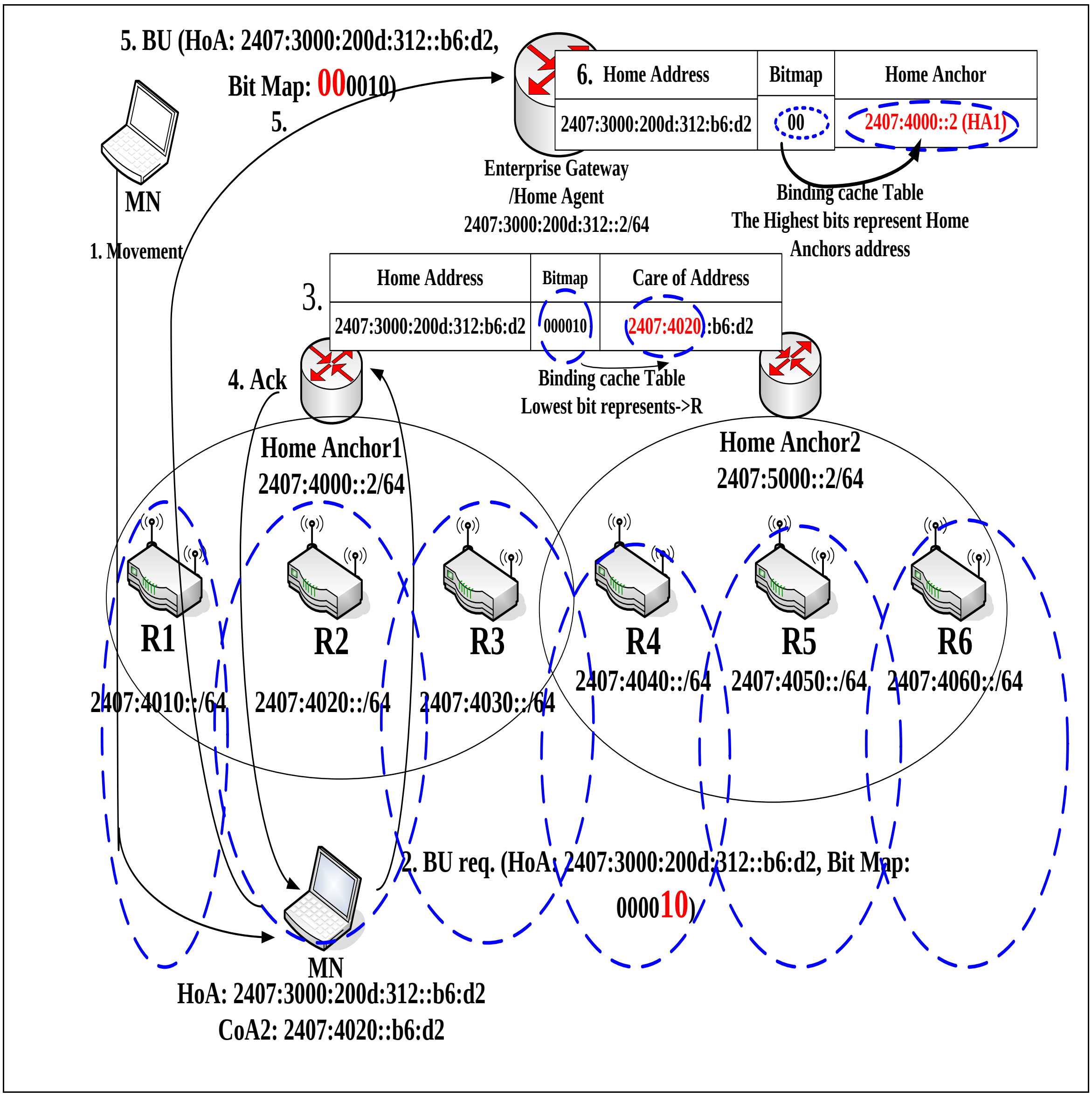

Figure 3: MN moves from Home Network to the R2's Network

Assume there is a correspondent node (CN) in the Home Network vicinity as shown in Figure 4, the CN will send the packets to the home agent address (HoA), and the Home Agent receives the traffic and checks the binding cache table. It will find out the HoA refers to the Home Anchor-1, therefore the Home Agent tunnels the packets to Home Anchor-1, and the Home Anchor-1 in turn tunnels the packets to CoA2 according to its cache table. Finally the MN receives the packets from R2 as shown in Figure 4.

Figure 5 shows the Micro-mobility scenario in the proposed mechanism, where MN indicates the augmentation of the signal received from R3 while it initiates its movement towards R3, thus it translates the beacon received from R3 to the equivalent bitmap. Then, MN sends a BU req. message including the bitmap field to the Home Anchor-1 which checks the highest bits of the received bitmap, the highest bits refers to the same Home Anchor-1. Therefore Home Anchor-1 translates the received bitmap to the equivalent Care of Address which is CoA3 (new CoA) in this case, and it adds it to the Home Anchor-1's binding cache table.

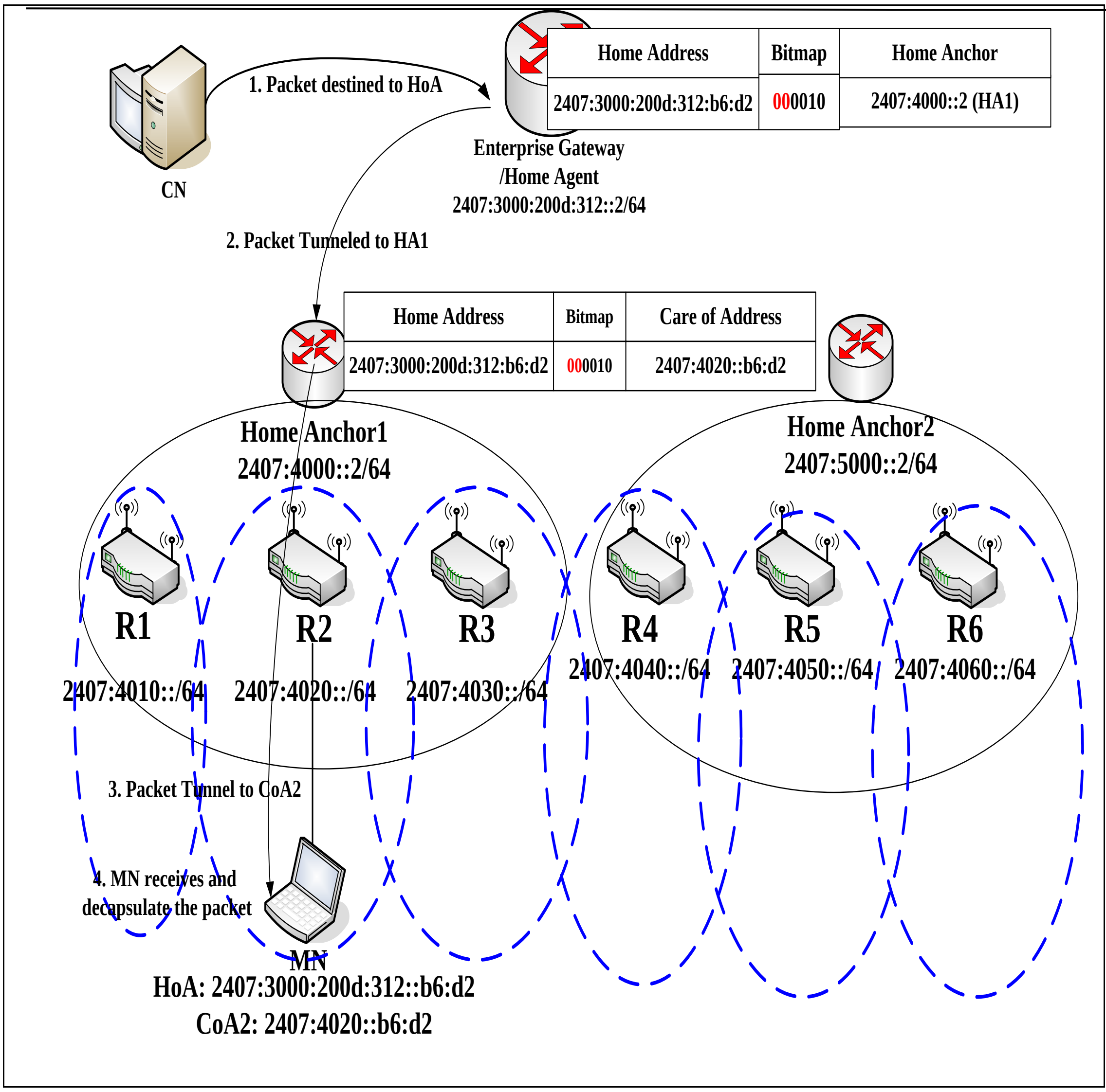

Figure 4: CN sends Packets to the MN in its Foreign Network (R2)

So far, the Home Anchor-1 tunnels the packets to both CoA2 and CoA3 at the same time, this will provide a continuous communication between CN and MN. MN still can receive the traffic even before sending a BU message to Home Anchor-1 through R3.

Figure 6 shows that when MN obtains CoA3 from R3, it will send a BU message to Home Anchor-1 through R3, then Home Anchor-1 checks the Binding cache table again and refreshes it. It will exclude CoA2 from the table and tunnels the packet only to CoA3 according to the new address of MN.

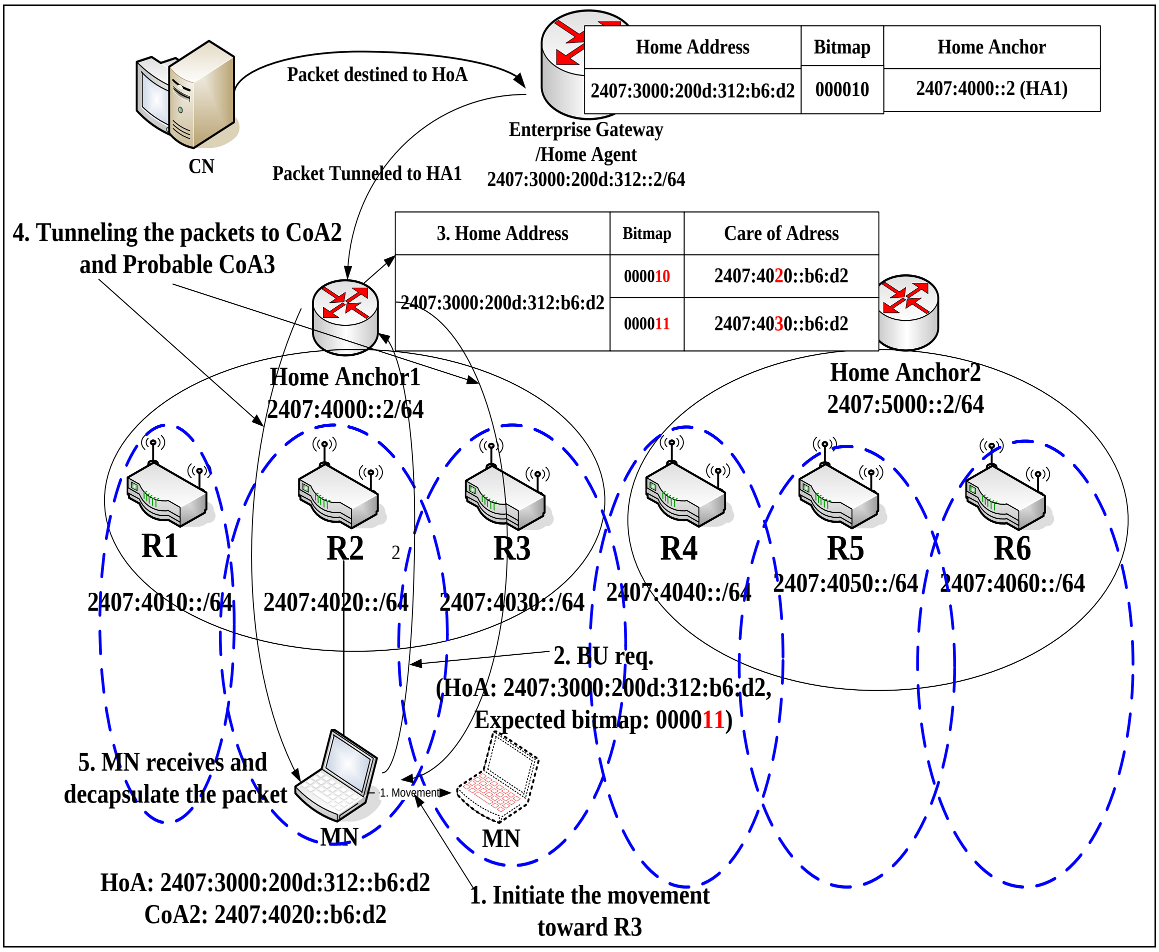

Figure 5: MN starts to move to R3

Figure 7 shows the macro-mobility between two different home anchors. MN initiates its movement toward R4, the same procedure previously explained will be followed, and MN will decry the augmentation of R4's signal and translate it to the equivalent bitmap.

MN sends a BU req. message to Home Anchor-1; here the difference is that the Home Anchor checks the received bitmap, it finds out that the highest bits of bitmap refers to another home anchor. Therefore, Home Anchor-1 will forward the BU req. to the upstream Enterprise Gateway (Home Agent) and at the same time it translates the lowest bits to the equivalent CoA (in this case CoA4).

Now, Home Anchor-1 tunnels the packets to CoA3 and CoA4 as shown in Figure 7, Enterprise gateway receives the BU req. from Home Anchor-1, and translates the highest bit to the equivalent home anchor's address, as shown in figure 7. The Enterprise gateway will add the address of Home Anchor-2, and then it will start to tunnel the packets to Home Anchor-2. Home Anchor-2 still does not have a record in its binding cache table to track the new MN's CoA.

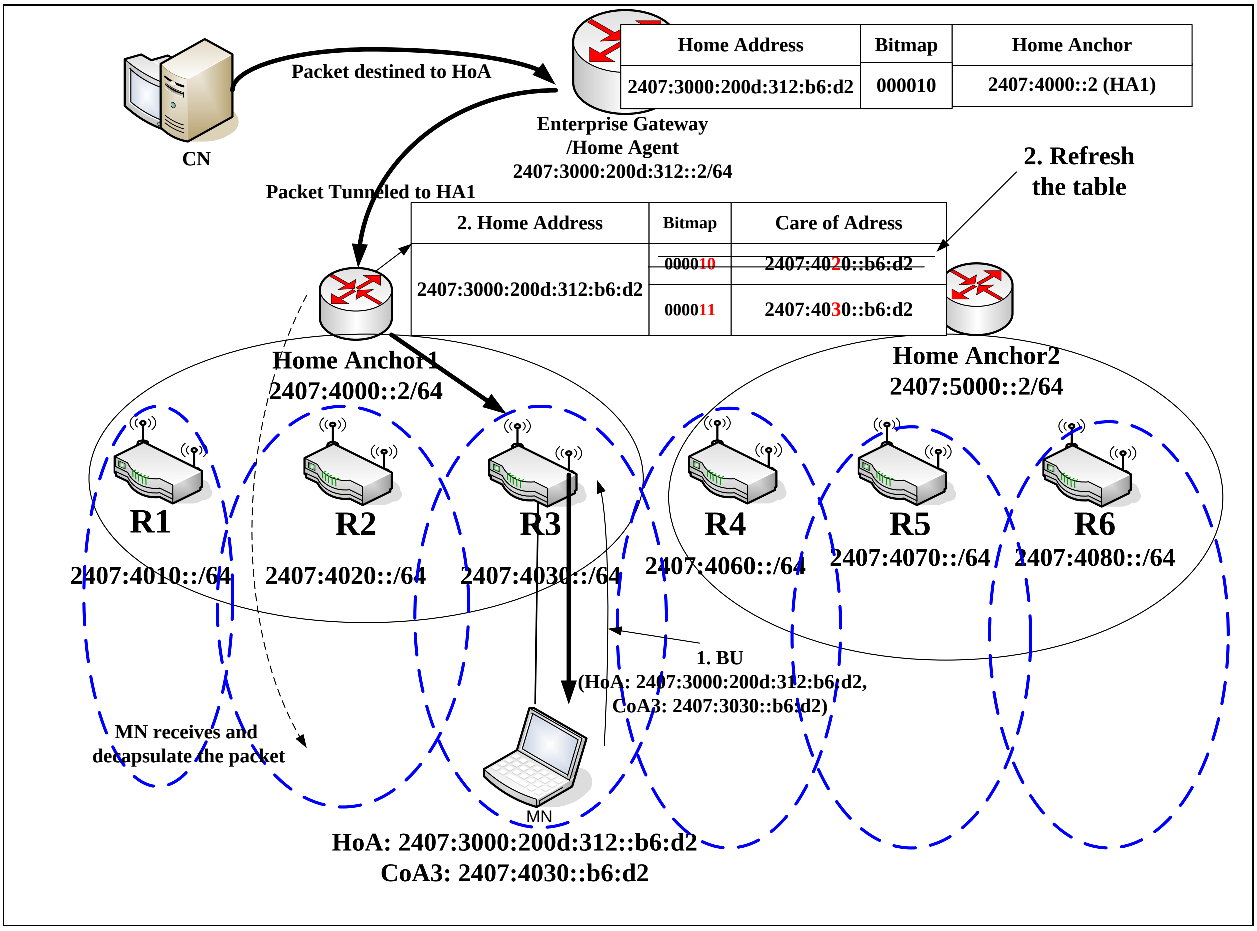

Figure 6: MN obtained CoA3 from R3

As shown in figure 8, MN acquired CoA4 and sends a BU message to Home Anchor-2 and Home Anchor-1 simultaneously.

Home Anchor-1 updates its table and sends packets to CoA4 only and at the same time Home Anchor-2 starts to forward the traffic to CoA4. The MN will send a BU message to the Enterprise Gateway (Home Agent) telling about CoA4.

Home Agent receives the BU message, checks the MN's CoA then excludes Home Anchor-1 from the table and sends the traffic to Home Anhcor-2 only which is the next hop to reach CoA4.

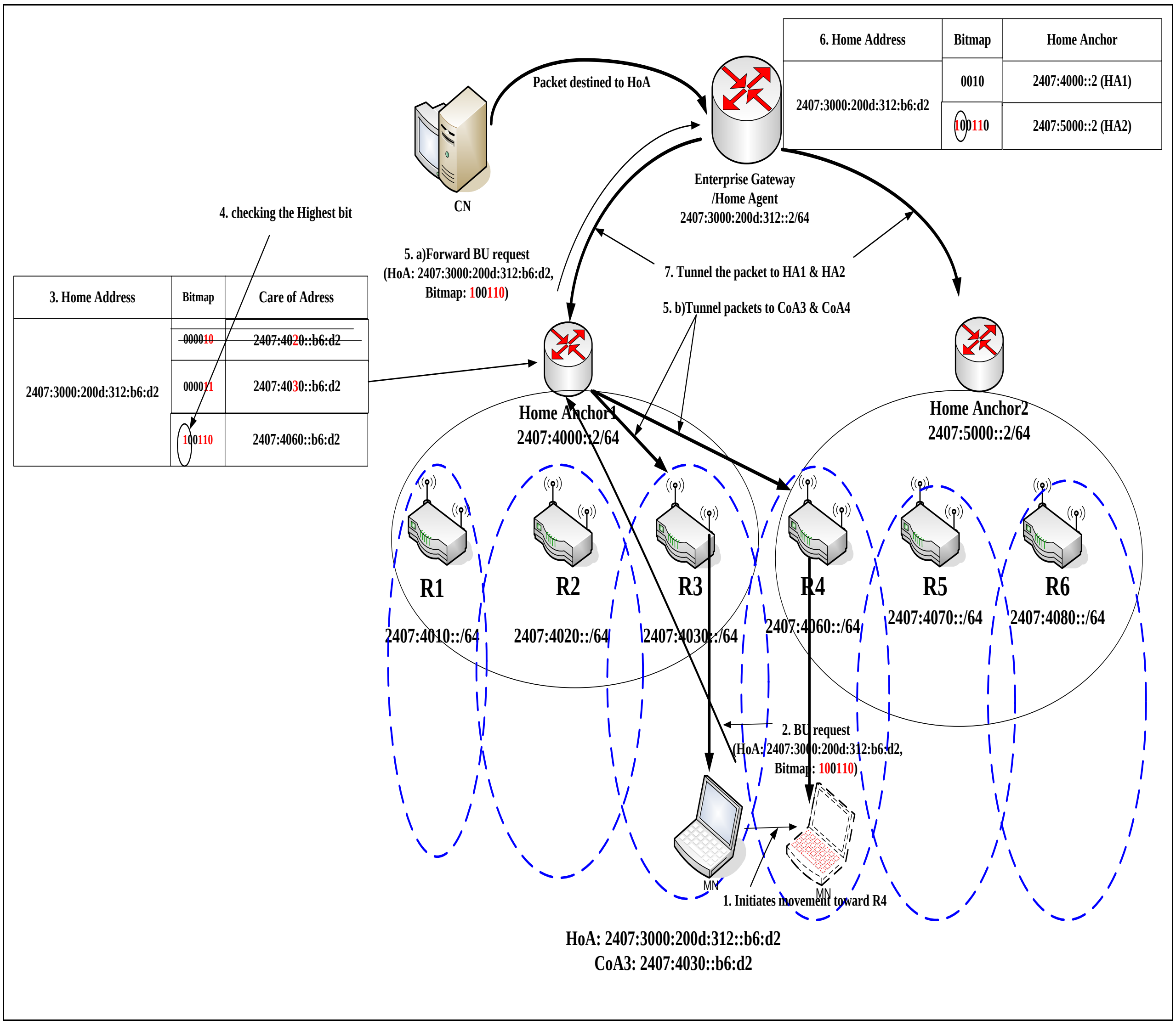

Figure 7: MN initiates movement to Home Anchor-2 (R4)

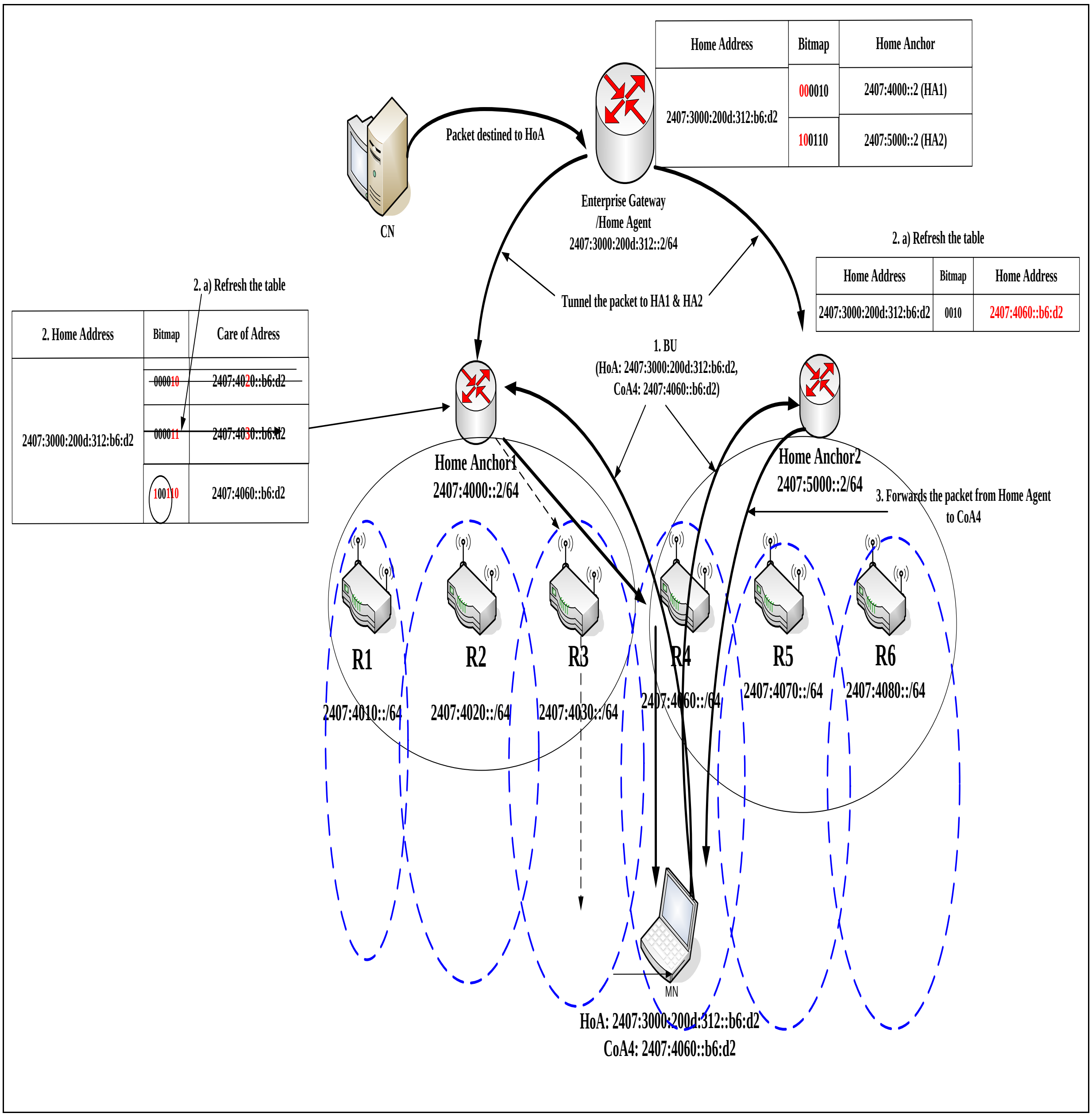

Figure 8: Home Anchor-2 forwards the traffic to CoA4

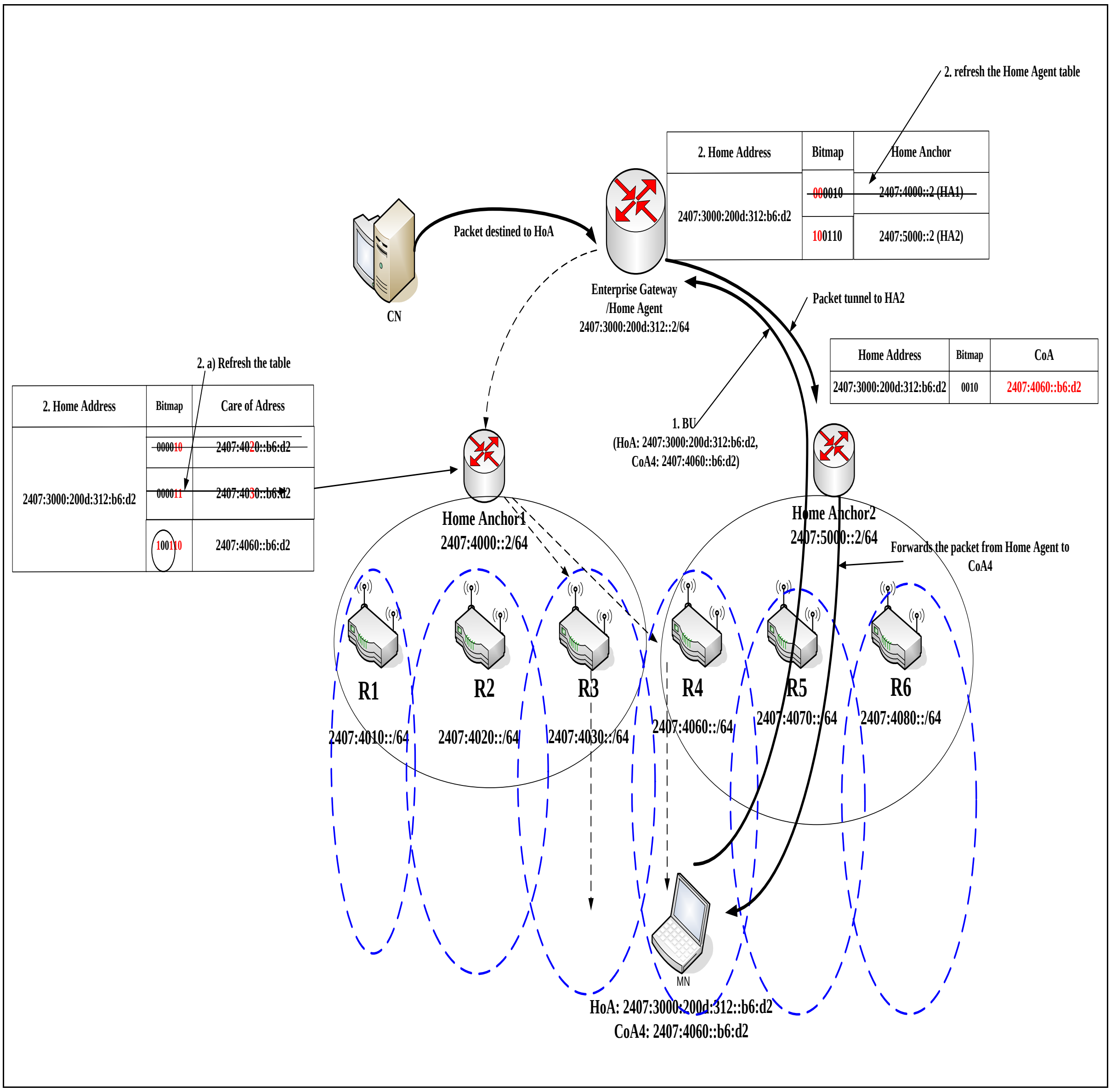

Figure 9: Updating the Home Agent Table

III. Conclusions And Future Work

From the proposed and explained scenarios, the MN will have a seamless mobility by anticipating the new location and new CoA and take some actions as soon as it initiates the movement. On the other hand, this mechanism will save the network resources by updating the cache table of the server. Which means the traffic will not keep multicasting to multi probable addresses but only to one probable address in each single movement. As a result, the real time (multimedia) applications will experience better service flow.

A future work will study how the multimedia applications are affected when applying the proposed mechanism.

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