Complete Handoff Tactics for the Integrated 3G and NEMO Network

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Abstract: This paper aims to revise the handoff method for integrated 3G and NEMO network. The method includes horizontal handoff in NEMO and vertical handoff in 3G for the heterogeneous wireless network. This paper took advantage of the NEMO’s characteristics to propose a novel horizontal handoff method. We adopt the conception of hierarchical network to design a vertical handoff method. Our method decreases handoff latency and control packets for handoff. The simulated results demonstrate our method is better than the traditional NEMO.

Key-Words: NEtwork Mobile (NEMO), Horizontal Handoff, Vertical Handoff, Heterogeneous Wireless Network, Hierarchical Network

1. Introduction

Third Generation (3G) mobile communication system is the most popular system. However, 3G mobile communication system does not satisfy high-speed mobile users. Consequently, one burgeoning issue is extensively discussed— NEtwork MOBILE (NEMO). Popular issues include hierarchical Mobile Router (MR), Router Optimization, Multihoming and so on for the NEMO network. There is little research spread out into such topics as bandwidth management, security and authentication, authorization and accounting (AAA), etc. [1]

As for handoff, the theses already put forward mostly focus on handoff for a single system. However, heterogeneous wireless network is the trend of the future. The handoff methods for a single system are not enough for the heterogeneous wireless network. Those methods have considerable overhead and handoff latency in the heterogeneous wireless network.

So, this paper focuses on the handoff issue for integrated NEMO into the 3G network. We designed a comprehensive handoff method that includes horizontal handoff in NEMO network and vertical handoff in heterogeneous wireless network.

The rest of this paper is structured as follows. The existing methods are described and discussed in section 2. Section 3 describes in detail the proposed method. The introduction of handoff tactics is divided into two parts: horizontal handoff and vertical handoff. Finally, we provide conclusions and future work in Section 5.

2. Background [2][3][4][5][6]

This section introduces the NEMO network and handoff method in NEMO. Subsection 2.1 is a summary of the NEMO Network. Subsection 2.2 is the horizontal handoff in NEMO. Subsection 2.3 is the vertical handoff in integrated 3G and NEMO system.

2.1. NEMO Network

Fig. 1: NEMO Network
Figure 1 shows the conception of what the NEMO is like. Each Mobile Host (MH) and MR has their Home Agent (HA). MR updates new Care-of address (CoA) with its’ HA, that is the so-called Binding Update (BU), when it left the old Base Station (BS) to go to a new BS. After it entered a scope of new MR and successfully registered with the MR, MH updates BU, too. No matter how the MR moves, MH does not update BU when MH does not leave MR. Thus each movement only updates MR’s CoA if the MR serves a lot of MH. So, the NEMO system decreases a large number of registered and BU packets. Besides, the NEMO system also decreases packet latency and packets lost as a result of a short registration time.

2.2. Horizontal Handoff in NEMO
When MR moves in new Base Station (BS), MR will register itself at a new BS, as shown in Figure 2. Then, the new BS confirms the registered messages with the MR’s HA. The registered messages include authentication, authorization and accounting (AAA). BS assigns a CoA for MR after a confirmable MR and executes BU to the MR’s HA. The BU is to update the MR’s CoA. MR’s HA will send the data packet to this CoA, when Correspond Node (CN) wants to send data packet to MH in MR.

MH provides MR with registered message, when MH moves off 3G and moves into the range of MR. (Shown as the dark-line in Figure 3 (b)) MR confirms the registered messages with the MH’s HA through BS. MR becomes the MH’s New Access Router (NAR) after confirmable MH. MR assigns CoA and bandwidth for MH. Then, MR executes BU to the MH’s HA. The BU is to update the Home Address of MH at this time. MH’s HA notifies CN of MR’s home address. (Blue line in Figure 3 (b)) CN tunnels a route from CN to MR’s HA. CN sends data packet by the tunnel. MR’s HA redirects the packet to BS that MR stayed at and BS redirects the packet to MR. Lastly MR redirects the packet to MH. (Red lines in Figure 3 (b)).

2.3. Vertical Handoff in Integrated 3G and NEMO System
There are two cases of vertical handoff in integrated 3G and NEMO. The first one is when MH moves from NEMO to 3G, the other one is when MH moves from 3G to NEMO. Figure 3 shows the message driftage of vertical handoff. MH provides BS with a registered message, and when MH moves off NEMO and moves in the range of BS. (It is shown as the dark-line in Figure 3 (a)) BS confirms the registered messages with the MH’s HA. BS becomes the MH’s Foreign Agent (FA) after confirmable MH. BS assigns CoA and bandwidth for MH. Then, BS executes BU to the MH’s HA. HA notifies CN of CoA. (Blue line in Figure 3 (a)) CN tunnels a route from CN to BS. CN sends a data packet by tunnel. Then, BS redirects the packet to MH. (It is the red line in Figure 3 (a)).

MH requests the BS or MR to resend the lost data packet when the MH moves in the BS or MR. BS or MR will request CN to resend the lost packet by the above-mentioned tunnel. Then, the packet is redirected to MH from BS or MR.

The above-mentioned handoff tactic is a mode that MH is a new user of new service provider. However, this tactic causes grave handoff latency. If connected services are broken by the length of time that it takes to start the system and search the service provider, the user will endure it no longer. We make a description of our handoff tactic in the next section. We emphasize that this paper focuses on the integrated 3G and NEMO network.

3. The Handoff Method for Integrated 3G and NEMO
3.1. Horizontal Handoff
NEMO was devised for public transportation such
as buses, trains, rapid transit and passenger trains, etc. Most public transportation has the characteristic that they move in a fixed route. We can utilize this characteristic to revise the horizontal handoff for the NEMO network.

When public transportation moves in a new BS, MH cannot receive data packets until MH is finished with registration and tunnel. As for a train carriage, the number of passengers is about 40 in a carriage. As for rapid transit, the number of passengers is about 20–60. As for high-speed rail, the number of passengers is about 100. There is a great quantity of packets that MHs demand to send when the public transportation pulls up to a station. So, NEMO will confront the problem that the system has insufficient bandwidth or a crowded internet.

We revised the above horizontal handoff. There are a great number of registered packets to be sent between MR’s HA and BS when the public transportation pulls up to a station. The new BS will very busy, if it is still sending data packets for MH. We propose the idea that CN sends data packet in advance because the public transportation moves in a fixed route. CN starts the bi-cast to send the data packet for MH according to the schedule of public transportation. (Shown in Figure 4)

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\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{fig4}
\caption{Horizontal handoff of NEMO}
\end{figure}

Figure 5 shows the data packet is sent in advance and the message driftage of horizontal handoff. MH receives the data packet immediately from MR after completing registration. This method does not wait for the CN to redirect the data packet. We not only increase the used rate of idle bandwidth in the new BS but also decrease the deliverable packet latency for handoff. We call this method as “send packets in advance machine”.

As far as unfixed routes of public transportation are concerned, this type of public transportation has a characteristic that there are fewer passengers than a fixed route of public transportation. We can utilize the Candidate Access Router Set (CAR-set) in Multicast-based Mobility (M&M) system that was proposed by Ahmed Helmy etc. [7][8] A handoff can predict a new BS, as AR5 shown in Figure 6. Before the handoff, the CN starts bi-cast transmission (AR1 and AR5). If the handoff cannot predict a new AR, the CAR-set is AR1.4.5.6.8.9 and 10. Before the handoff, the CN starts multicast transmission (AR1.4.5.6.8.9 and 10). The number of data packets is less than the fixed route of public transportation due to the lack of passengers. So, multicast transmission will not consume too much bandwidth in this system.

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\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{fig6}
\caption{CAR-set in M&M system}
\end{figure}

3.2. Vertical Handoff in Integrated 3G and NEMO

We utilize the idea of the hierarchical network, and propose a HandOff table (HO-table) to decrease the handoff latency. Each MR and BS will maintain an HO-table. The table records the MHs that are about to handoff, and all the information for those MH. MR and BS will exchange the HO-table that is maintained by them when the public transportation pulls up to a station. The table informs the other side that MHs will move out itself and move to the other system. New service provider assigns a CoA to MH and delivers the unsent
data packet. MH moves out of NEMO and moves into 3G, as shown in Figure 7. MR exchanges HO-table with BS, as shown by the line 1 in Figure 7. BS assigns a CoA for MH, as shown by the line 2 in Figure 7. BS updates BU to MH’s HA, and redirects the data packet to MH (as shown by the line 3 in Figure 7). MH decreases the time of registration through the assistance of MR.

Figure 7: Concept of vertical handoff from NEMO to 3G

Figure 8 shows the process to vertical handoff in integrated 3G and NEMO. The blue MH will move out of NEMO and move into the 3G system. The MH’s data packet is delivered from BS to MR before starting handoff. Then, MR redirects the data packet to MH, as shown by the blue line in Figure 8. BS assigns a CoA for MH after MR exchange HO-table with BS. (Dotted line 2 is shown in Figure 8.) BS delivers unsent data packet to MH directly instead of MR after finishing registration. (Blue line 3 is shown in Figure 8.) MH is still staying in the scope of MR in this moment, it receives data packet from both MR and BS. If MH moves out of NEMO, it will request BS to resend the scarce data packet.

The green MH will move out of 3G and move into the NEMO system. The MH’s data packet is delivered to MH from BS before handoff begins. When handoff starts, BS redirects the data packet to MR, as the green line shows in Figure 8. MR assigns a CoA for MH after BS exchange HO-table with MR. (Dotted line 2 is shown in Figure 8.) BS delivers unsent data packet to MR instead of delivering to MH directly after finishing registration. (Green line 3 is shown in Figure 8) MH is still staying in the scope of BS in this moment, it receives a data packet from both BS and MR. If MH moves out of 3G, it will request MR to resend the scarce data packet.

MR and BS reserve cache to storage data packet for every MH communication. When the MH requests to resend the losing packet, MR (or BS) looks for the packet in the cache first. The size of the cache for every communication is allotted according to the type of communication. The cache will be released when the MH move out the scope of MR (or BS).

Compared with the original handoff method, this vertical handoff method decreases much registered packet. Serious packet loss was due to the MH moving out the former scope or the bandwidth be used to register. The cache machine decreases the route of resending losing data packet, especially for vertical handoff.

3.3. Contents and Establishing of HO Table

This subsection will introduce the proposed HO table. Little subsection 3.3.1 describes the contents of HO table. The usage and establishment of the HO table is described in subsection 3.3.2.

3.3.1 Example and Illustration for HO Table

BS and MR establish a table for possible MHs that are about to vertically handoff, respectively. We called this table HO Table. HO table includes information that AAA, HoA, the state of MH, and requested statement of MH. (Shown as Table 1) This table helps to comprehend the demand of bandwidth, QoS level and MH’s state for new service system. This information is necessary for the new service system, so as to complete the continued request. The new service system will update CoA with
According to the HoA of MH in the HO table.

Table 1: An example of HO Table

<table>
<thead>
<tr>
<th>AAA of MH</th>
<th>The HoA of MH</th>
<th>State</th>
<th>Type of performing application</th>
<th>QoS of performing application</th>
<th>Time of performing application</th>
</tr>
</thead>
<tbody>
<tr>
<td>MH A</td>
<td>AAA data IPv6 address</td>
<td>Active</td>
<td>1.TCP/IP: Audio 2.UDP: message</td>
<td>1.Good 2.Basic</td>
<td>1.00:20 1:30 2.00:10 00</td>
</tr>
</tbody>
</table>

In Table 1, state shows the present state of MH. State includes Idle, Active and Sleep. QoS of performing application shows the QoS level for MH’s request. QoS level includes Excellent, Good and Basic. Time of performing application shows surplus time of MH’s request. The format of the time is Hour: Minute: Second.

The Application of HO table regards BS and MR as the hierarchical framework. When MH completed registration with upper strata, upper strata notified lower strata to finish local registration. MH does not need to register as the new call with new service system in this method. So, both registered time and handoff latency can be decreased by hierarchical framework.

3.2.2 Establishing and Using of HO Table

This subsection introduces the system how to determine the MH that it is about to leave old system. We use Figure 9 to simplify the interpretation. The green circle represents the region of the 3G network, and the network contains a platform at a railway station. The blue circle with an oblique line represents the region of NEMO network, and the network contains a carriage. Two black circles represent the doors of the carriage, and they represent the region that MH will leave its network when MH moves in the circuit. The MH’s information will be added to the HO table when it moves into the black circuit. In Figure 9, BS adds the information of MH1 into BS’s HO table and MR adds the information of MH2 into MR’s HO table. We know which one circuit is sphere of action in advance, because the public transportation moves in a fixed route and just one door of the carriage will be open.

Travelers move to the door when the public transportation is about to reach the station. MR and BS update its’ HO table according to the reachable schedule for public transportation. The update will start ahead of time when MH moves in a large station or when the time is rush hour.

MR exchanges HO table with BS when the public transportation stops at a station. When MR and BS detect MHs entering his region and the public transportation moves out from the station, MR and BS start the handoff process respectively. MR and BS delete the data in HO table when MR and BS cannot detect MHs enter his region and the public transportation moves out of the station. MR and BS start the original handoff process when the HO table does not contain the MH’s information.

4. Simulation

4.1. Simulated Environment

In this section, an operational example for our
proposed method can be displayed in Figure 10. [9] MHs move at random (for number between 10~100). The MR moves in a fixed route. So, HA of MR will notify CN the bi-cast address before horizontal handoff start. The service provider supplies horizontal or vertical handoff according to MHs move. We compare the handoff latency in the horizontal handoff. We compare the total number of control packets in the vertical handoff. [10][11]

4.2. Simulated Results

Figure 11 shows the handoff latency for horizontal handoff in NEMO. It shows that our method is much better than the traditional NEMO method, because our proposed method delivers data packets in advance and NEMO uses soft handoff. The handoff latency is 4~15 ms for our method and 2500~3500 ms for the traditional NEMO method. The handoff latency increases according to increased MH.

There are many control packets to be delivered for handoff in the traditional method. (Shown in Fig. 3) We used HO table and local registration to reduce costs for handoff. Figure 12 shows the total number of control packets for vertical handoff. Our method reduces the control packets between BS and HA. The great amount of MH makes obvious impression on our method. Our method is better than the traditional method by about 47.4% when the number of MH is 100. The average result of our method is better than the traditional method by about 47.3%.

5. Conclusion and Future Work

Both the integrated heterogeneous wireless network and NEMO are the trends of the future. This paper considers both trends and proposes suitable handoff schema. This schema includes not only vertical handoff for the heterogeneous network but also improved horizontal handoff for the NEMO network. We utilize just the NEMO character and idle bandwidth. So, the original system does not need much revision. Our method reduces the number of control packets, and handoff latency. Our method decreases 47.3 percent of control packets.

System, which can effectively utilize bandwidth, are an important issue in the heterogeneous wireless network. We will develop a bandwidth reserved method for MH in 3G and NEMO heterogeneous network in the future.

Reference