A Delay-Sensitive Mechanism to Establish Route Optimization in Mobile Networks

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Abstract

Route Optimization (RO) is an emerging technique in the area of Mobile Networks (MN). Finding a best solution for the route optimization is still in research. The NEMO (NEtwork MObility) protocol provides network mobility and MIPv6 provides host mobility. A MN can have nodes with NEMO or MIPv6. The NEMO has more complexity in providing RO than MIPv6 in terms of throughput, payload, etc. Sometimes each and every node in the mobile network may not support RO. The nodes that do not support RO must be identified early in order to avoid excessive delay in setting up RO. In this paper, we have proposed a mechanism to reduce the delay in establishing RO by effectively maintaining a table that stores information about whether a node supports RO or not. In order to reduce the table size and search delay, information about RO support is stored in binary value. The outcome of this paper reduces time taken for fall back procedure that in turn reduces excessive delay in establishing RO. In general, it helps to offer better Quality of Services to the customers.

Keywords: *Mobile Network, NEMO, MIPv6, Host Mobility, Route Optimization, Delay*

I. Introduction

The technology, protocols and mechanisms used in mobile wireless networks keep changing rapidly. It makes the service provider to do many changes and improvements in their service mechanisms. Mobile IPv6 [1] supports host mobility which enables the mobile hosts to move within the mobile wireless network regardless of its home location address. The mobile nodes in the MIPv6 are identified by its home address regardless of its current location. When a mobile is away from its home location it is associated with the care-of-address. The care-of-address provides the information about the current location. When an IPv6 packet is transferred to a mobile node's home address that packet will be routed to the care-of-address which is the current location of the mobile node. The mechanism for binding the home address and care-of-address will enable the mobile nodes to connect directly. Then, the packets will be transferred between the mobile nodes directly. Thus, the MIPv6 supports the Route Optimization (RO). Figure 1 shows the general structure of the MIPv6 with the route optimization tunnel.

The NEMO that is Network Mobility protocol enables a whole network to move into another network. In other words, NEMO supports network mobility that is movement of an entire network. The NEMO Basic Support protocol [6] allows a group of nodes as a network to roam around Internet [2]. While roaming into another network all the nodes of the visiting network connected under a single router. The visiting network router will be connected to the foreign network router. Now, all the communications between the foreign network and the visiting network are possible.

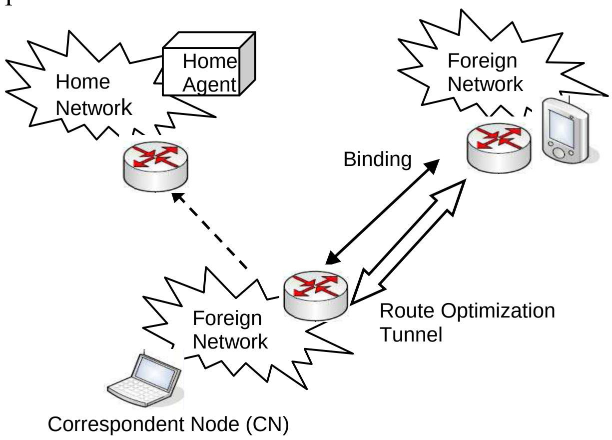

Figure 1. RO in MIPv6

Figure 2 shows the basic structure of the NEMO. In the NEMO, the Mobile Router (MR) which acts as the access router is called an Upstream MR or parent-MR [7]. The MR which is acquiring access is called downstream MR or sub-MR. The top-most MR in a nested mobile network is called root-MR. The mobile network containing all the other mobile networks is called root-NEMO. All the other mobile networks nested inside root-NEMO are called sub-NEMOs. A MR has a unique IP address called home address. The home agent HA takes care of all the data traffic of the MR when MR is away from home. When the MR is in a foreign network, it will get a care-of-address and then the MR will bind the care-of-address with the home address.

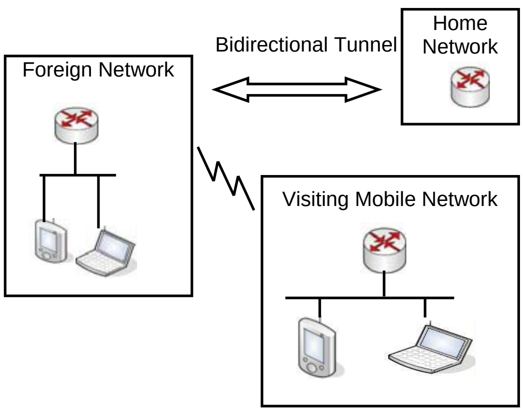

Figure 2. NEMO Basic Structure

After a successful completion of this binding process, a bi-directional tunnel is setup between MR and HA. All future packets will be intercepted by the HA and then encapsulated with an extra IP header [3] whose destination address is the care-of-address of the MR. The packets will be sent through the MR-HA tunnel.

In the MIPv6, all the mobile nodes will communicate with the Correspondent Node (CN) directly without the help of the home network. Route optimization feature in MIPv6 makes data transfer faster. The mobile node may be in any of the foreign network which may be far away from the home location and there may be several routers needed to be passed through. In this case, a normal connection and routing may cause time delay. But, by the support of the route optimization in the MIPv6, the time delay is avoided by establishing a direct connection between the Mobile Node and the Correspondent Node (CN).

The NEMO supports network mobility so that an entire network can move to another network. Assume MIPv6 network has 100 mobile nodes then each node has to manage on its own to maintain connection and data transfer with outside the network. It will be a heavy load if the number of nodes is increased. This problem is comparatively reduced in NEMO. That is, NEMO has a mobile router for each network and all the signals of the mobile nodes will be maintained only by the MR of that network. All the nodes inside the mobile network send the signals to its MR. This MR will take care of maintaining a connection with outside network. So, the heavy load of signals that cause the outside network to be overloaded is reduced. In other words, it reduces signaling storm.

This paper is organized as follows. Section II shows the related works and motivations to write this paper. Section III explains the proposed mechanism to reduce the delay in setting up RO. Section IV discusses research findings with an example and shows the results in a graphical form. Section V concludes our research findings. Finally, references are listed.

2. Related work

This section describes the related works and motivations to write this paper. Sahibzada Ahmed Noor et. al analyzed the NEMO route optimization [2]. They targeted network mobility issues from the scope of route optimization. Their aim was to explore route optimization schemes in NEMO. After discussing the need of route optimization in NEMO, available solutions are discussed and a quantitative analysis is provided.

Thomas Clausen et.al [4] discussed that the NEMO working group has developed a protocol suite, extending the notion of edge-mobility on the Internet to include that of network mobility. This implies that a set of nodes, along with their mobile router, changes their point of attachment and that traffic to these nodes is tunneled to be delivered through their new point of attachment. This mechanism is transparent to applications in that existing traffic to a node is being encapsulated and tunneled, regardless of where the network containing the destination node is attached.

Thierry Ernst et.al addressed some of the problems in the MIPv6 [5]. V.Devarapalli et.al describe the Network Mobility (NEMO) Basic Support protocol that enables Mobile Networks to attach to different points in the Internet [6]. The protocol is an extension of Mobile IPv6 and allows session continuity for every node in the Mobile Network as the network moves. It also allows every node in the Mobile Network to be reachable while moving around. Young Beom Kim et. al. explained that, in nested mobile networks, the undesirable effects due to non-optimal routing tends to get aggravated, leading to excessively long packet sizes and transfer delays. In his paper [8], in order to resolve the non-optimal routing problem, also known as ‘pinball routing problem’ in the literature, he proposes a new route optimization scheme where the care-of address in each binding update message is recursively substituted by the intermediate mobile routers in the mobile network.

Jongkeun Na et. al. proposed a unified route optimization scheme [9] that can solve several types of RO problems by using Path Control Header (PCH). In his scheme, Home Agent (HA) does piggyback the PCH on the packet which is reversely forwarded from Mobile Router (MR). That enables any PCH-aware routing facility on the route to make a RO tunnel with MR using the Care-of address of MR contained in the PCH. By applying to some already known NEMO RO problems, he shows that his scheme can incrementally optimize the routes via default HA-MR tunnel through the simple PCH interpretation.

The goal of the network mobility (NEMO) management is to effectively reduce the complexity of handoff procedure and keep the mobile devices connected to the Internet. The customers not only need mobility but also quality. It is a great challenge for the service providers to offer Quality of Service (QoS) [11]. Vehicle is moving so fast that it may cause the handoff and packet loss problems. Both of the problems will lower down the throughput of the network. To overcome these problems, Yuh-Shyan Chen et. al. propose a novel NEMO protocol for vehicular ad hoc network (VANET) [12]. There are different types of Internet applications and mobile network interfaces. The Internet applications are file transfer, telephony, video conferencing, etc. The QoS requirements will vary from one application to another application [13, 14]. From the above discussions, we find that there is a need to reduce time taken to set up RO which in turn helps delay-sensitive applications to increase the Quality of Service of the mobile network.

3. Desmero: A proposed approach

This section explains proposed approach in detail. The DeSMERO is an acronym for **De**lay-**S**ensitive **M**echanism to **E**stablish **R**oute **O**ptimization. NEMO route optimization may require some nodes to be changed or upgraded [2]. Before the initiation of route optimization, there is a need to check the functionalities of the mobile nodes in order to verify that the node supports the route optimization or not. If a node doesn't support route optimization, then a fall back procedure has to be done. It is better to take some measures before initiating the route optimization. Before sending any packets to the mobile node, it is necessary to ensure that the mobile node supports the route optimization or not. Assume that a packet is sent to a mobile node and found that MN doesn't support the route optimization then there will be a fall back procedure. This process wastes time and creates unnecessary traffic as it has to find a node again that supports RO. It will give a bitter experience for a customer and also to the service provider. The proposed mechanism enables to reduce above shortcomings and avoid fall back procedure. The process of checking a mobile node that supports RO or not, must be done during a mobile node enters into the NEMO. In other words, at the time of registration, the MN is checked for RO. The various steps in proposed mechanism to effectively establish a RO is as follows.

Various steps in DeSMERO

1. Identify the available functionalities in the mobile node
2. Check whether the mobile node supports route optimization
    a. If it doesn't support then it is identified as RO-not-supported
    b. Otherwise, it is identified as RO-supported.
    c. Information about RO supported or not supported can be stored in Visiting Location Register (VLR).
3. If route optimization request arrives,

```
Then
        If RO = 0 (check with the VLR)
        Then
            Drop RO with that node
        Else
            Establish RO with that node
        Endif
    Endif
```

The VLR is a database which stores information about the mobile node such as the IMEI No., IP address, etc. VLR database can have one binary attribute called as RO which stores

"1", if RO is supported and "0", is stored if RO is not supported. The modified VLR database is shown in Table1.

Table 1. VLR Database with RO support

Node	…	IP address	…	RO
Node A	…	69.251.23.25	…	1
..	…	..	…	0
..	…	..	…	0
..	…	..	…	1

Figure 3 shows the NEMO with mobile nodes. It also shows that new Visiting Network (VN) is entering into the network. When the VN enters into the network, the registration process will be done. During this process of registration, the router has to find whether the new VN-MR supports RO or not.

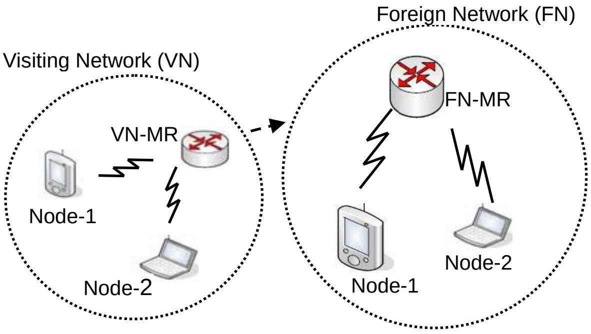

Figure 3. NEMO nodes registration

4. Research findings

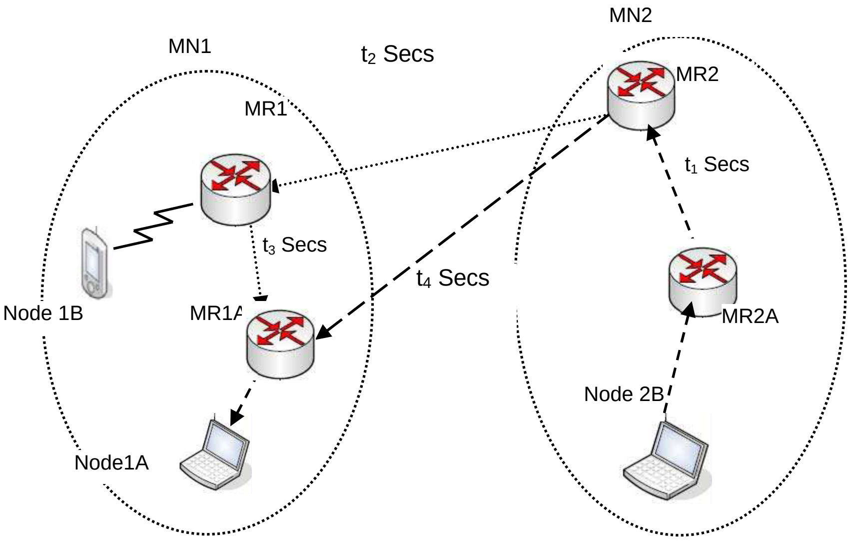

Figure 4. Example Network

At the time of RO initiation process, the destination mobile node will be checked with the VLR table whether RO is supported or not. If it finds that it doesn't support RO then immediately the traditional way of data transfer will be established. Otherwise, RO is established. This RO solution will reduce the time delay in the data transfer. The RO support is identified at the registration time itself.

Figure 4 shows two mobile networks (MN1, MN2) and the path through which the data transfer will take place. The node 2A which is in the MN2 wants to send a data to the node 1A which belongs to MN1. The MR2A that is in the MN2 has to initiate the RO. The actual route of the data transfer in the traditional way is Node2A → MR2A → MR2 → MR1 → MR1A → Node1A.

The actual times taken for communication between each node in the MN1 and MN2 are as follows:

Table 2. Possible Routes and their Delays

Routes		**Delay (Secs.)**
Source	***Destination***	
MR2A	MR2	t_1
MR2	MR1	t_2
MR1	MR1A	t_3
MR2	MR1A	t_4

In the traditional way of data transfer, the MR2A starts the RO. The request for RO goes through MR2, MR1 and MR1A and the time taken to reach each node in that path are t1, t2 and t3 respectively. If the node MR1A doesn't support RO then backward routing will take place to inform that there is no support for RO in the MR1A. Here, RO request falls back to MR2A which consumes $t_3 + t_2 + t_1$.

If RO is not-supported, total delay-time

$= 2t_1+2t_2+2t_3 = 2(t_1+t_2+t_3)$ …….(1)

In proposed approach, the RO request will pass from MR2A – MR2 - MR1. At MR1, the RO support for MR1A is checked with the VLR. If MR1A supports RO, then RO will be setup. Otherwise, RO is cancelled. Here, the time taken to reach MR1 is t_1+t_2. Hence, the total time taken for round trip is $2(t_1+t_2)$. Even if MR1 identifies that MR1A does not support RO, the total time needed to reach MR2A is $t_1+t_2+t_2+t_1$ or $2(t_1+t_2)$. The time, t3 is not needed because RO is checked in MR1 itself. The proposed approach saves time as follows.

If RO is supported, total delay-time

$= 2(t_1 + t_2)$ *($2t_3$ is not needed)* …....(2)

If RO is not supported, total delay-time

$= 2(t_1+t_2)$ *($2t_3$ is not needed)* ….(3)

Time taken for data transfer after establishing RO = t_1+t_4

From (1) and (2), we can infer that proposed approach gives better results. In other words, $2t_3$ is not needed to establish RO. Once RO is established, data transfer takes t_1+t_4. In the existing approach, the time delay (α) is $2(t_1 + t_2 + t_3)$ and in proposed approach, the time delay (β) is $2(t_1+t_2)$ to identify whether RO is supported or not.

The time that is saved (£) = total time taken for existing approach (α) - time taken for proposed approach (β)

£ $= 2(t_1 + t_2 + t_3) – 2(t_1 + t_2)$

£ $= 2t_3$

So, £ time is saved. In other words, $2t_3$ time is not needed.

The advantages of DeSMERO are: minimum delay and binary data stored in VLR table will increase the speed of search. It also helps to reduce packet overload because of minimum number headers to be encapsulated. In other words, when a node sends data it should travel through different intermediate nodes. If number of intermediate nodes increase then number of headers to be encapsulated also increases. But, DeSMERO contributes to establish RO with minimum number of intermediate nodes that reduces number of packets to be encapsulated.

Consider the following assumptions.

Let t_1=3 secs, t_2=5 secs, t_3=3 secs

From (1),

$\alpha = 2(3+5+3) = 22$ secs

From (2),

$\beta = 2(3+5) = 16$ secs

$£ = \alpha - \beta = 6$ secs

From the above calculations, proposed approach shows better results. That is 6 secs are saved to establish RO.

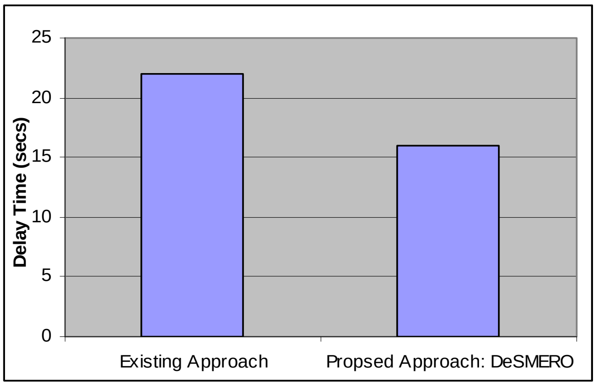

Figure 5. Existing Approach Vs Proposed Approach

Figure 5 shows proposed approach results in graphical form. The X-axis shows the approaches and Y-axis shows the delay time. The existing approach takes 22 secs. But, the proposed approach takes only 16 secs.

V. Conclusion and Future work

This paper has proposed a mechanism to detect and integrate the nodes in existing internet infrastructure with better RO solution. It has also described a table that stores information about RO support. It stores '1', if RO is supported. Otherwise, '0' is stored. This table is searched whenever RO request arrives. The result shows that the proposed mechanism gives better RO solution. In other words, the time taken to establish RO is comparatively reduced than the traditional way. The results clearly show that the DeSMERO takes less time to establish RO. In particular, the outcome of the proposed mechanism reduces the time needed for fall back procedure that in turn reduces excessive delay in establishing RO. In general, DeSMERO helps to increase the Quality of Service (QoS) with respect to delay. The service providers can implement our idea to provide better QoSs to the customers for delay-sensitive applications like video conferencing, telephony, etc. Although this paper has better RO solution, it also has few weaknesses. That is, considerable amount of time is needed to search the table for RO support. The mechanism that identifies the new functionalities like RO is out of the scope of this paper and can be taken into account in future.

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