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A Tunnel Reduction Technique to Reduce Delay in Nested Mobile Networks Using Hierarchical and Source Routing

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ABSTRACT

NEMO BSP was standardized by Internet Engineering Task Force (IETF) to provide Network Mobility mechanisms in order to provide ubiquitous communications to the Mobile Networks. Nested Mobile network is the multiple Mobile networks connected together with its Mobile Routers (MR's) in a hierarchical way with one top level mobile router (TMR). Even though the Nested Mobile Network attains optimal and ubiquitous communication it still suffers from certain limitations like pinball routing as the levels of nesting increases. In order to overcome this limitation in Nested Mobile Networks this paper provides an efficient Route Optimization by Tunnel Reduction Technique. This work reduces the Total Transmission Time (TTT) and hence achieves optimal Routing. At the end a comparison is made with NEMO BSP and Tunnel Free Scheme to evaluate the performance of the proposed work.

Keywords: NEMO, Nested Mobile Networks, Pinball Routing,DeSMERO,SIP,Tunnel Reduction Technique,Total Transmission Time

1. INTRODUCTION

The internet is a rapidly growing technology which provides ubiquitous communication. A traditional wired networking technology serves only the stationary computers. In the recent years, advancements in wireless and the invention of portable computing gadgets lead to the development of the mobile computing environment. When these devices move together as a unit it forms a mobile network. If a smaller network is contained in a larger network, it is known as Nested Mobile Networks.

Many works have been made by IETF on host mobility. Mobile IPV6 provides the solution for the Host Mobility support mechanisms. NEMO BSP was standardized by IETF to provide Network Mobility mechanisms. NEMO BSP inherits the benefits of MIPV6 and works on the IP layer and provides the solution to maintain the session continuity by establishing the bidirectional tunnel between the mobile routers and Home agents. The Existing works like NEMOBSP,NERON has some performance limits like transmission delay ,packet overhead, increased handoff latency since it does not support route optimization. The real time applications like video transmission are not sustained due to packet loss. Unlike Mobile Networks, however in a Nested Mobile Network, a NEMO enabled Mobile Router (MR) acts as an ingress interface, so that other ipv6 enabled devices can attach to it. When the mobile routers interconnect in this manner they form a hierarchical network topology called Nested NEMO as shown in Figure 1.

Whenever the CN communicates with MNN, the packets travel through the various MR-HA tunnels as shown in Figure 2. As the Nested Mobile network moves the MR has to inform the new location to its Home Agent. This

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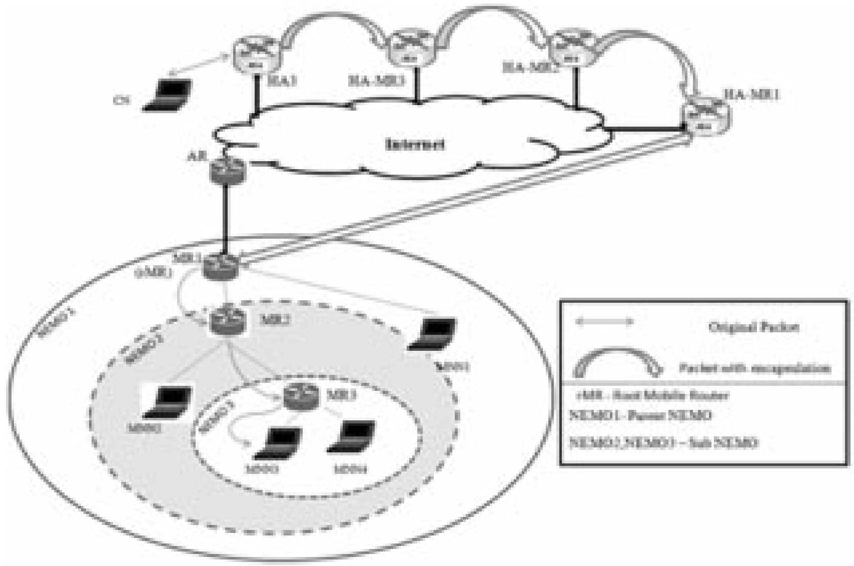

Figure 1: Nested Mobile Network Architecture

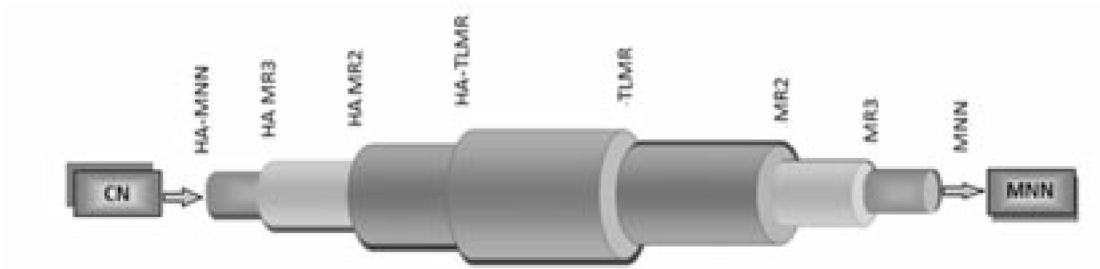

Figure 2: Tunnel structure in Nest architecture

Binding Update (BU), its corresponding Binding Acknowledgement (BAck) and messages have to travel through these tunnels. This problem is called pin ball routing.

In Case of Nested Mobile Networks while providing a solution to session continuity the NEMO BSP leads to suboptimal paths and encapsulation overhead. NEMO BSP which is a currently deployed lead to increased Total Transmission Time due to inefficient End to End path.

In this paper, the Tunnel Reduction Technique a new Route Optimization scheme based on hierarchical structure is introduced. It provides an efficient NEMO solution with optimal route. This paper provides a solution to improve the Total Transmission Time by optimal path detection when compared to the existing works. The rest of the paper is organized as follows. Section 2 presents some existing related works and the motivations to write this paper. Section 3 presents the proposed work TRT (Tunnel Reduction Technique). Section 4 reveals the research findings. Section 5 lists the important outcomes and concludes the paper.

2. RELATED WORKS

In order to provide the transparent access to the nested mobile network all the MR s have to support MIPV6 [1]. The Several Route Optimization Schemes [2] that have been proposed so far can be classified as

- Delegation
- Hierarchical
- Source routing

The rest of the section presents the basic principles and the related work in each category.

2.1. Delegation

In this scheme the prefix of the foreign network is delegated inside the network. The CN receives the CoA from the prefix and in turn send the BU to the HAs This scheme is simple and provides the RO with a low packet over head, but sending the BU to CN brings the signaling overhead.

Simple Prefix Delegation: Lee et al.,[3] proposed a simple Prefix delegation, Jeong et al., [4] proposed ND –Proxy where a network prefix can sent to the MRs. The MRs advertises this network prefix by using the delegated prefix option. Packet forwarding is based on the network prefix. However it requires the additional overhead to perform the prefix delegation. This scheme does not provide the Complete RO.

Optimal routing for network mobility (Optinet): This scheme proposed by Perera et al., [5] is similar to the prefix delegation but uses the different procedure for delegation. An extended Optinet (xOptinet) was proposed by Petander et al.[6] which reduces signaling overhead.

Mobile IPv6 Route Optimization for NEMO (MIRON): Calderon et al., proposed MIRON [7] where the CN obtain the CoA from the foreign network prefix. A DHCP request is sent by the CN to get the CoA .After getting the CoA, the MR notifies the attached MCNs to obtain CoA. This procedure is repeated at each handoff.

2.2. Hierarchical Scheme

In this Scheme the packet does not travel through all the HAs rather it travels only through the Top level MR (TMR) and the MNN's HA. The Mobile Routers does not send its CoA to CN's, rather it sends the TMRs CoA to it's HA which reduces the pinball routing.

Route Optimization using Tree Information Option: Cho et al., [8] proposed ROTIO where the HoA of TLMR and the CoA of the MR are conveyed to MR using the RA Messages that contains the tree information option which increases the packet overhead and Signal overhead at TMR.

Tunnel Free Scheme: Sunghong Wie et al.,[9] proposed the Tunnel Free Scheme that reduces the tunneling overhead. It forwards the data packets with the Routing table without any tunnel. It establishes the direct tunnel between the MAG and LMA. This scheme removes all the intermediate nested tunnels, but increases the Router overhead and it does not show the significant performance for intra nest architecture.

2.3. Source Routing Scheme

In this Scheme the route is optimized by sending the CoA of MR to CN through the packet header. Routing in the wireless section is done through the packet header which reflects the nested structure.

Session Initiation Protocol: (SIP) Huang et al.,[10] proposed a RO scheme which uses the SIP procedure to find an optimized route before initiating the data transfer. The major drawback here is sending the SIP leads to signaling overhead to track all the SIP sessions.

DeSMERO: Calduwel et al., [11] proposed Delay-Sensitive Mechanism to Establish Route Optimization. NEMO route optimization may require some nodes to be changed or upgraded before the initiation of route optimization, in order to verify that the node supports the route optimization or not.

The comparison of the above schemes reveals the differences among the schemes in more depth. Hence the performance has to be evaluated with a variation in level of nesting.

3. TUNNEL REDUCTION TECHNIQUE: A PROPOSED WORK

In the proposed work TRT, the message transmission from CN to MNN can be considered in two paths. 1. Fixed infrastructure 2. Mobile infrastructure. In the fixed infrastructure data packets travel from the CN to TMR through Access Router and several HA's. In the mobile infrastructure the packets move from TMR to the destination MNN as shown in Figure 3. In the proposed work the RO is carried in two phases

1. Path Identification in the fixed infrastructure
2. Next Node Identification in the infrastructure.

3.1. Phase I – Path Identification

The identification of path is essential to optimize the route in the fixed infrastructure of the network. This section proposes an algorithm to optimize the route from CN to TMR by continual updating and verification of the CNs Binding cache.

Algorithm

Let IMR be the intermediate MRs in the Nested mobile network, that is MR1,MR2, MR3 are the three IMRs . When a CN wishes to communicate with MNN,

Step 1. CN sends a root

request to HA-IMR

Step 2. The HA-IMR searches the Binding cache for the Binding information (IMR,T-MR).

If it finds a match it establishes a bidirectional tunnel between the HA-IMR and T-MR

Otherwise go to step 3

Step 3. HA-IMR encapsulates and sends the root request to HA-TMR.

Step 4. HA-TMR then encapsulates and sends the request to TMR

Step 5. TMR sends its new BU to HA-IMR.

Step 6. Append the Binding Cache of the HA-IMR with new binding information of the TMR.

Step 7. HA-IMR finds a match of the destination nodes MR in its Binding Cache. Now the HA-IMR Binding Cache has an optimized route to T-MR.

The CN establishes the optimized path from HA-IMR to the TMR by reducing the size of the tunnel. In the Tunnel Reduction Technique, the pinball routing is eliminated by sending the T-MR's CoA as Binding update to the HA of all the nodes in the Nested Mobile Network.

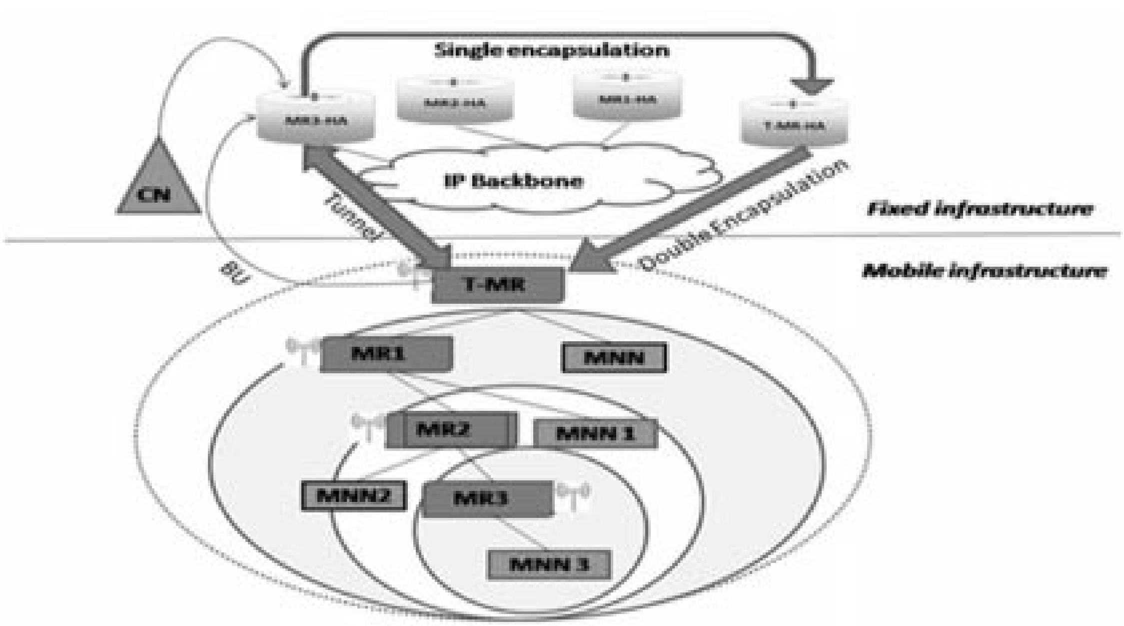

Figure 3: Message flow in TRT

3.2. Phase II Next Node identification

The identification of Next node to which the packet has to be transmitted is essential to optimize the route in the Wireless part. The nodes inside the Nested NEMO are organized in a hierarchical order the Source Routing algorithm is used to reduce the path inside the network. Figure 3. Shows an abstract view of the Tunnel Reduction Technique. Each Mobile Router maintains its own routing table as shown in Table 1 which contains the Binding Update information for the optimized path to the destination.

Table 1
Routing Table for the Mobile Routers in Figure 3

Node	*Binding Update information in Routing table*	*HNP of its Sub tree*
MR3	HoA_MNN3 - CoA_MNN3	HNP MR3
MR2	HoA_MNN2 – CoA_MNN2 HoA_MR3 – CoA_MR3 HoA_MNN3 – CoA_MNN3	
MR1	HoA-MNN1 – CoA_MNN1 HoA_MR2 – CoA_MR2 HoA_MNN2 – CoA_MNN2 HoA_MR3 – CoA_MR3 HoA_MNN3 – CoA_MNN3	HNP MR3 HNP MR2
TMR	HoA-MNN – CoA_MNN HoA_MR1 – CoA_MR1 HoA-MNN1 – CoA_MNN1 HoA_MR2 – CoA_MR2 HoA_MNN2 – CoA_MNN2 HoA_MR3 – CoA_MR3 HoA_MNN3 – CoA_MNN3	HNP MR3 HNP MR2 HNP MR1

The TRT technique stores the HNP of each sub tree which is used for source routing the packets when it arrives at the t-MR. When a packet arrives at the TMR, the packets are decapculated and the next destination will be the MNN's MR. Instead of forwarding the packet to the Immediate Mobile Router the TMR searches for the corresponding MR's Home Network Prefix and routes the packet to the MR of the destination MNN.

5. SIMULATION RESULTS AND DISCUSSIONS

The data path from CN to MNN3 in NEMO BSP is CN-> HA-MR3-> HA-MR2-> HA-MR1-> HA-TMR-> TMR->MR1->MR2->MR3->MNN3, where the number of hops from the source to destination is 9.

In case of TFS the path from CN to MNN3 is CN ->TMR->MR1->MR2-> MR3->MNN where the number of hops from the source to destination is 5.

In the proposed work Tunnel Reduction Technique the data path from the CN to MNN3 inside the Nested NEMO is CN --> HA-MR3 -> TMR-> MR3->MNN where the number of hops from the source to destination is 4.

In the proposed work the size of the tunnel is reduced and hence the Route is optimized which minimizes processing time for each node in the and hence the Total transmission Time is Reduced considerably.

In order to evaluate the performance of the proposed scheme the TRT with the Existing NEMO BSP and Tunnel Free Scheme in a network simulator. The Nested mobile Network is simulated by using OPNET simulator with the following parameters. The topology, configuration of node properties, protocol type, simulation time, and the transmission mode are set for simulation. To evaluate the total transmission time in an End to End path in a Nested Mobile Network the topology size 1000m x 800 m ,10 wireless nodes with a maximum moving speed of 10 m/s ,and the simulation time of 1000 sec with UDP traffic are used.

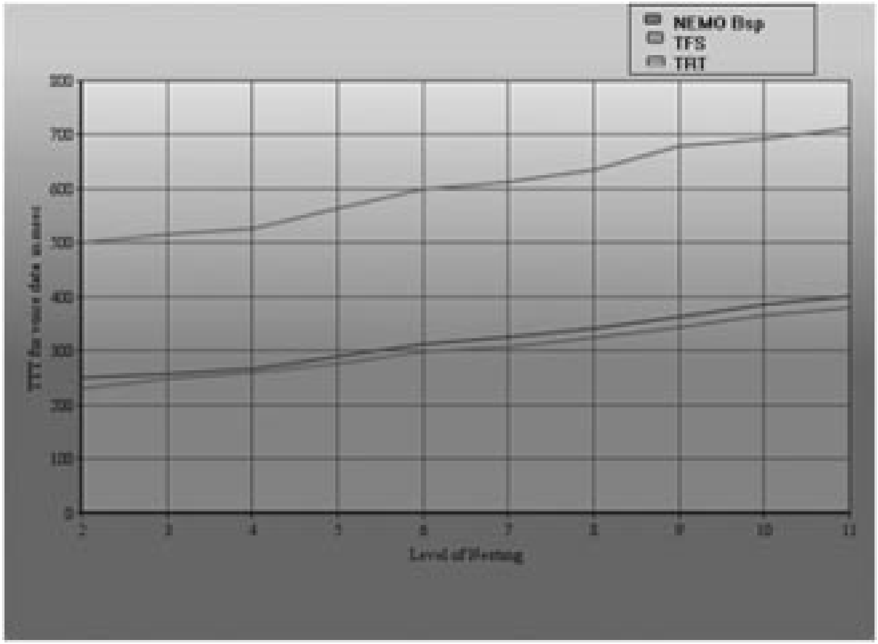

Figure 4: TTT for Voice Data transfer

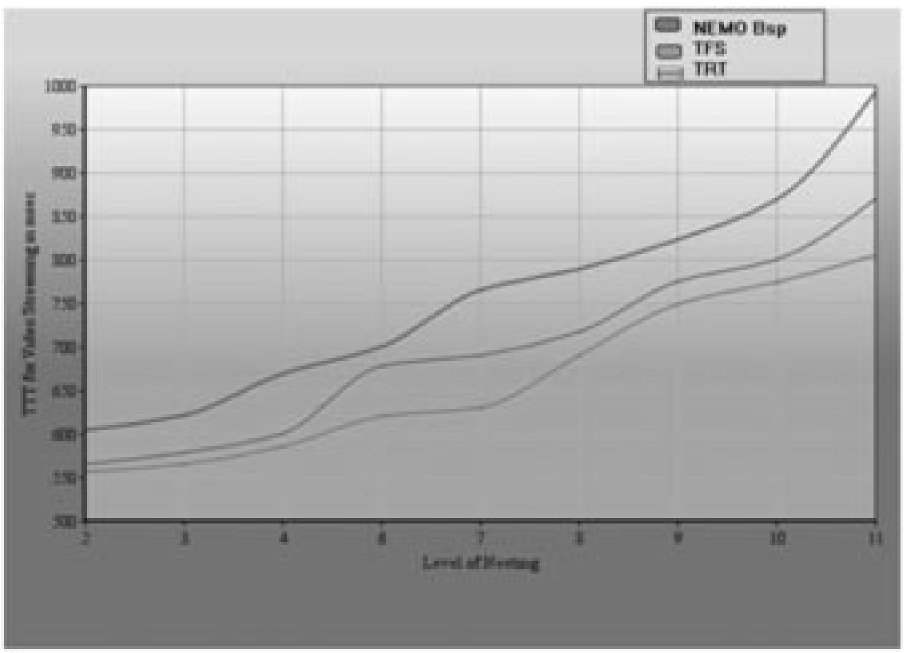

Figure 5: TTT for Video Data transfer

The comparison has been made with the existing NEMO BSP, the Tunnel Free Scheme and the proposed Tunnel Reduction Technique. The voice packet and the low resolution video packets are used to evaluate the Total Transmission Time in the Simulated Nested NEMO. The Total Transmission Time for the Voice and video packet is presented in Figure 4 and Figure 5. The TTT for the voice packets increases from 223 ms to384 ms with the increase in the number of level of nesting. The Total Transmission Time is reduced and the proposed scheme is slightly having less TTT than the other two. NEMO BSP has 502-705 ms and in TFS the TTT varies between 250-400 ms.

The TTT for the video packets increases from 553 ms to 802 ms with the increase in the number of level of nesting. It is considerably less when compared to the Existing work. From the performance study, results are concluded that the proposed work TRT minimizes the TTT by reducing the tunnel size.

6. CONCLUSION AND FUTURE WORK

This paper has proposed a technique to find the optimized path from the source to destination and compared it with the existing works. The result shows that the proposed work eliminates the pinball routing and has an optimized route from End to End. It greatly reduces the Total Transmission Time and the processing Delay at each link. The outcome of this paper increases the Mobility of the network by identifying the efficient route. It has been simulated using OPNET. Although this paper has better solution to reduce the TTT, it also has weekness. That is, a considerable amount of memory is needed for routing table. In future, it may be implemented to study the behavior in intra nest Mobile networks.

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