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Avoiding Pin Ball Routing Problem in Network Mobility Hand-Off Management

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Abstract**—**With the demand of mobility by users, wireless technologies have become the hotspot developing arena. Internet Engineering Task Force (IETF) working group has developed Mobile IP to support node mobility. The concept of node mobility indicates that in spite of the movement of the node, it is still connected to the internet and all the data transactions are preserved. It provides location-independent access to Internet. After the incorporation of host mobility, network mobility has undergone intense research. There are several intricacies faced in the real world implementation of network mobility significantly the problem of nested networks and their consequences. This article is concerned regarding a problem of nested network called pinball route problem and proposes a solution to eliminate the above problem. The proposed mechanism is implemented using NS2 simulation tool and it is found that the proposed mechanism efficiently reduces the overload caused by the pinball route problem.

Keywords**—**Mobile IP, Pinball routing problem, NEMO

I. Introduction

IN the recent years, laptops and notebook computers have taken an edge over the usual desktop computers. Most users have turned their attention towards the usage of wireless devices available such as cellular phones, Personal Digital Assistance and so on. These trends have demanded the ability of mobile wireless computers to get connected to the Internet. However the complexity is that the wireless computers have to remain connected to Internet even when the devices move from one point of attachment to another. This switching from one access network to another access network is termed as handoff. Mobile IP is the solution proposed for this mobile wireless connectivity issue [1]. Let us consider a scenario of people accessing Internet through their mobile devices while moving in train. In this case several connections have to be established since Mobile IP requires individual connection for each of the mobile node. This causes traffic in the network. IETF proposed a solution for this problem by establishing a protocol standard named NEMO (NEtwork MObility) Basic Support Protocol [2]. NEMO is used for managing the mobility of the entire network which changes its point of attachment to the internet. The mobile network includes one or more mobile routers which connect it to global Internet.

NEMO Basic Support Protocol: In NEMO only the Mobile Router (MR) will be aware of the movement of the network. Thus the nodes, which are unaware of the movement of the network, are accommodated under MR. Each MR must have a Home Agent (HA); this is the basic requirement for supporting network mobility. A bidirectional tunneling between MR and HA helps in preserving the continuity of the session while the MR moves [2]. The MR will acquire a Care-of-Address (CoA) from its attachment point i.e. the Foreign Agent (FA). Each MR will appear to its attachment point as a single node; this approach allows nesting of mobile networks.NEMO model supports the connectivity of one entire mobile network through another mobile network resulting in topologies known as Nested NEMO networks. Mobile networks get benefit from the ability to directly inter-connect and send packets toward the Internet via one another or communicate directly with each other. The Nested NEMO scenarios quickly become extremely inefficient and are not suitable for real life deployment solutions. Consider Fig. 1, when we illustrate Nested NEMO Network it becomes inefficient. Even a simple Nested NEMO scenario where only two mobile networks are connected together, packet transfer will follow a highly suboptimal path.

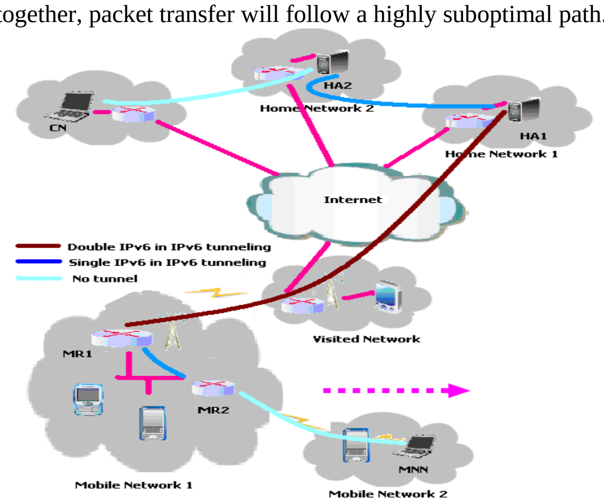

Fig. 1 Nested NEMO

The inefficient routing model that occurs in Nested NEMO Networks is commonly referred to as “Pinball Routing” [6]. This example also illustrates how using NEMO BS to support these scenarios requires the HAs to be permanently reachable, even if a direct connection between the two mobile networks exists. Again this is another fundamental flaw that many use case scenarios cannot accommodate.

In more complicated scenarios, such as vehicle communication where the number of inter-connecting networks is potentially much higher, the resulting network topologies that would arise if NEMO BS were relied upon would ultimately be massively more complex. Consider a vehicle inter-communication scenario that allows vehicles to access the Internet via the mobile networks of other vehicles.

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This type of scenario would increase the availability of the Internet by allowing vehicles to mesh together and access the Internet indirectly via other vehicles when they are unable to form their own direct Internet connection. This kind of scenario would result in many mobile networks connecting to each other and could therefore be expected to generate Nested NEMOs that were many layers deep, further exacerbating the inefficiencies of the NEMO BS model.

II. Pin Ball Problem

In case of nested NEMO network, several tunneling occurs and this leads to several intricacies. One of the significant problems regarding the nested NEMO is the pinball routing problem. Both inbound and outbound packets will flow via the Home Agents of all the Mobile Routers on their paths within the mobile network, with increased latency, less resilience, and more bandwidth usage [4]. When a mobile node sends a message to a distant corresponding node, it may pass through several MRs. On reaching each MR, a tunnel has to be established with the HA of the corresponding MR. Thus for a single data transmission, the packet has to traverse through various MRs and their corresponding HAs. When the mobile network moves to a new location, the new location has to be informed to the home agent of the mobile network. This binding update (BU) [3] and binding acknowledgement (BAck) has to pass through several MR-HA tunnels [4]. This process is called as pinball routing. This mechanism can be well described by considering a scenario. In this example Fig. 2 three mobile networks are considered MN1, MN2, and MN3. These are managed by the routers MR, oMR (old mobile router) and nMR (new Mobile Router) respectively. MN1 is directly connected to its home network through internet and the Access router AR. MN2 and MN3 access their home network through MN1. MN1, MN2 and MN3 are forming a two level nested mobile network. The packets sent in the network undergo tunneling process. Fig. 2, shows the routing path between VMN to its home agent HA4.

When VMN present in mobile network 3 wants to send a data packet to it's HA, the packet is sent to NMR then the packet is forwarded to MR, HA of MR followed by HA of NMR and finally to HA of the mobile node. Thus, when the router in the network receives a data packet, it is first forwarded to its home agent and then the data packets are forwarded to the destination node.

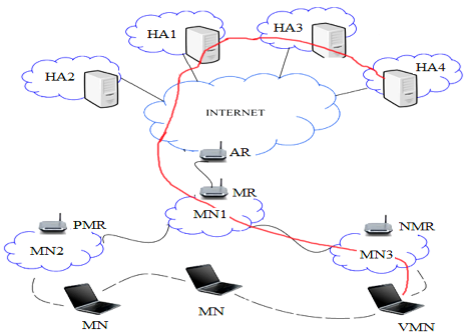

Fig. 2 Pinball routing problem

This process of tunneling increases with the increase in the number of nest levels in the network [9]. The various problems that occur due to pinball routing are as follows.

Increased Processing Delay: The encapsulation of packets in the MRHA tunnel also results in increased processing delay at the points of encapsulation and decapsulation [5]. Such increased processing may include encryption/ decryption, topological correctness verifications, MTU computation, fragmentation, and reassembly.

Increased Chances of Packet Fragmentation: The augmentation in packet size due to packet encapsulation may increase the chances of the packet being fragmented along the MRHA tunnel [6]. This can occur if there is no prior path MTU discovery conducted, or if the MTU discovery mechanism did not take into account the encapsulation of packets. Packet fragmentation will result in a further increase in packet delays and further reduction of bandwidth efficiency [7].

Increased Susceptibility to Link Failure: Under the assumption that each link has the same probability of link failure, a longer routing path would be more susceptible to link failure [8]. Thus, packets routed through the MRHA tunnel may be subjected to a higher probability of being lost or delayed due to link failure, compared to packets that traverse directly between the Mobile Network Node and its Correspondent Node.

Increased Packet Size: An extra IPv6 header is added per level of nesting to all the packets. The header compression cannot be applied because both the source and destination (the intermediate Mobile Router and its Home Agent) are different hop to hop. Nesting also amplifies the probability of congestion at the Home Networks of the upstream Mobile Routers [7]. In addition, the Home Link of each upstream Mobile Router will also be a single point of failure for the nested Mobile Router.

III. Proposed Architecture

In pinball routing when the data packets pass through several MR-HA tunnel, which results in latency. When the mobile network starts moving, binding update is delayed and the HA of mobile network is unaware of the new location and transfers the data packet to the previous location. The motivation behind the research in this topic is to reduce the binding update and binding acknowledgement delay, which occurs during the handoff. The proposed mechanism states that when a mobile network moves to a new location, the previous mobile router sends a handoff initiation to the new mobile router. This handoff initiation message passes through several MR-HA tunnels [11]. The message must pass through the HA of old mobile router then the HA of new mobile router. When handoff initiation message reaches the HA of new MR, a binding update is sent to the HA of the mobile network. Then the handoff initiation message reaches the new MR and it replies with a handoff acknowledgement message that passes through several MR-HA tunnels. The major advantage of the proposed mechanism is that the burden of sending BU and receiving BA by MN is taken care by the HA of new MR. Hence the time taken for handoff registration is reduced and the ongoing data transaction takes place uninterrupted.Let us consider a scenario where a mobile network moves from old mobile router to a new mobile router. The hand-off initiation message is sent from previous mobile router to the next mobile router. During this process the message reaches the home agent of the next mobile router before reaching it. Here the home agent of the next mobile router registers the new location of the mobile node to the mobile node's home agent. This information about the new location of the mobile node is sent along with the hand-off initiation message. The hand-off initiation message sent by previous mobile router is received by next mobile router. Now, next mobile router sends an acknowledgement message to the previous mobile router. So when the mobile network reaches the new MR, the mobile network is already registered with its HA and the handoff latency is greatly reduced.

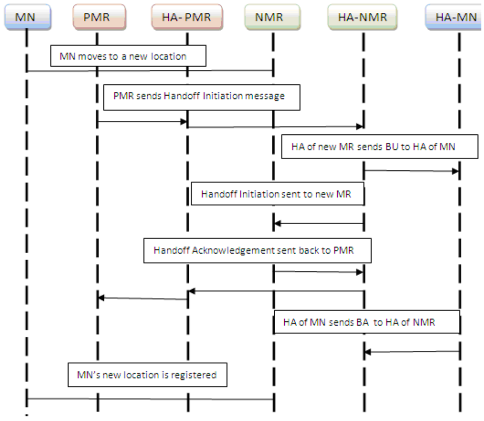

Fig. 3 Sequence diagram

The above sequence diagram (Fig. 3) shows the sequence of events that occurs during the handoff initiation and handoff acknowledgement. However the overall process that occurs during handoff registration can be depicted in the form of block diagram Fig. 4 as follows.

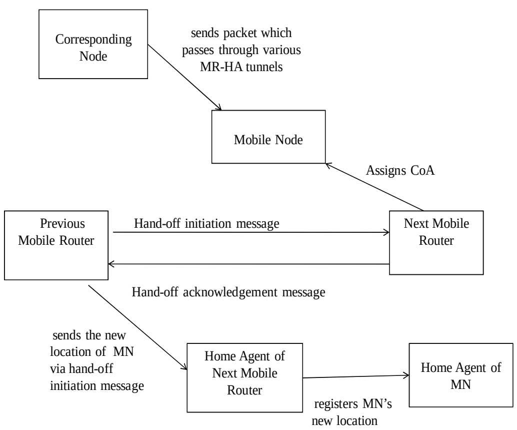

Fig. 4 Proposed architecture

Advantages Of The Proposed System: The proposed system gives an efficient mechanism to reduce the handoff latency in the pinball routing problem. The various merits concerning the proposed systen are as follows.

- Handoff latency is greatly reduced. The burden of Binding update and binding acknowledgement is taken care by the HA of new MR and when MN reaches a new network, it is already updated to HA.
- The packet loss percentage in the proposed mechanism is greatly reduced. This is because the latency that occurs during handoff is reduced and so the ongoing data sessions remain uninterrupted.

IV. Performance Analysis

The proposed system and the existing mechanism are simulated using NS2 simulation tool in linux environment [10] and the following results were observed. Handoff latency and packet loss are the two parameters considered to evaluate the efficiency of the systems. On comparing the existing system trace files with the proposed system trace file it is evident that the proposed system is far better than the existing system.

Handoff Latency: When a mobile network moves out of the coverage area of one access router and reaches the coverage of another access router, it is called as handoff or handover. Once the mobile network reaches a new location, the HA of MN has to be updated by sending a BU message and HA has to respond back with a binding acknowledgement message. The amount of time that is consumed for sending BU and receiving BAck is called as handoff latency [13]. When latency has a larger value it means the delay is longer. Thus the ongoing data transactions are temporarily paused. A mechanism that provides lower latency value is considered as efficient mechanism.

A scenario that implements the existing nested NEMO architecture was created using NS2 simulation tool and the handoff latency that occurs during the movement of MN is generated by the tool. The graph depicting the handoff latency for existing mechanism is shown in Fig. 5.

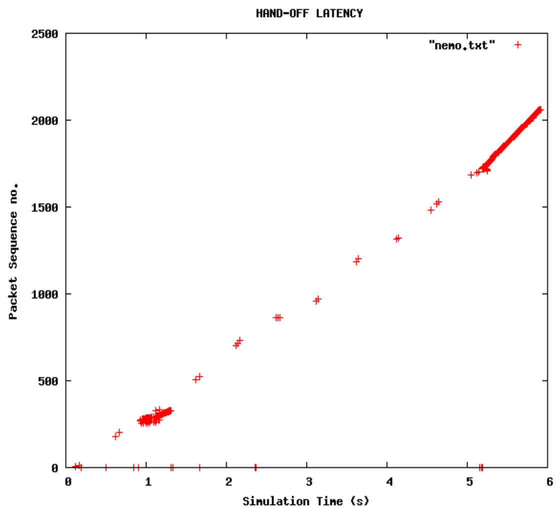

Fig. 5 Hand off latency of existing system

A scenario that implements the proposed mechanism where the BU is sent by HA of new MR was also created and the handoff latency graph for proposed mechanism is as follows.

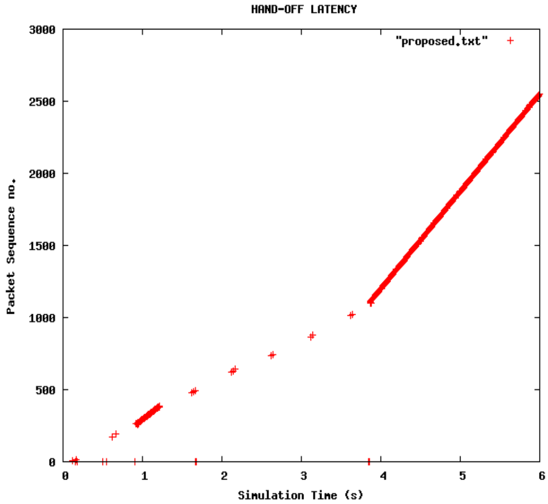

Fig. 6 Hand off latency of proposed system

The above Fig. 6 shows the hand off latency of the proposed system. The empty space in the graph between the packet flows indicates the handoff delay. It is evident that the proposed mechanism shows lower delay compared to the existing mechanism. The average handoff delay values were calculated using the trace files [10] that were generated during simulation and these values are tabulated in TABLE1.

TABLE I
HANDOFF LATENCY

System	Hand-off latency (seconds)
Existing System	3.87
Proposed System	2.64

Packet Loss: The total number of packets that were dropped during the data communication denotes the packet loss. A mechanism that results in higher packet loss becomes inefficient because these packets are not delivered to the destination and the ongoing data transactions are highly interrupted. An efficient mechanism must reduces the packet loss. Packet loss is identified for a simulation using the tr file generated. The dropped packets are mentioned by –d in the trace file. Those lines are alienated and counted. The overall simulation of existing system and the proposed system are same so as to make the comparison easier. The packets dropped at particular time interval is marked and connected. The existing system has more packet loss whereas the proposed system has fewer packet losses. The following Fig.s 7 and 8 and TABLE 2 are illustrates the same.

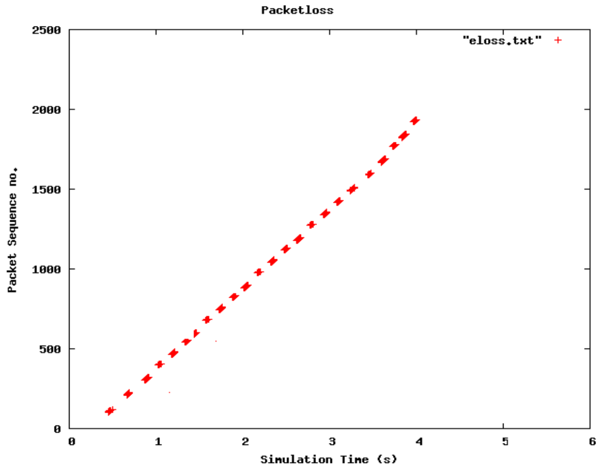

Fig. 7 Packet loss of existing system

TABLE II
PACKET LOSS OF EXISTING AND PROPOSED SYSTEM

System	Total Packet Transferred	Total Packet Loss	Packet loss percentage
Existing System	2049	57	2.78
Proposed System	2548	48	1.88

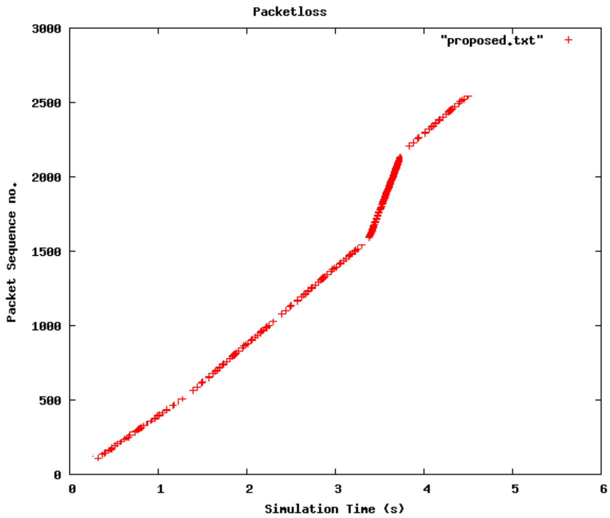

Fig. 8 Packet loss of proposed system

The obtained simulation results prove that the handoff latency value and the number of packet drops in the proposed mechanism are very low compared to the existing mechanism. The bar graph (Fig. 9) displays overall comparative results of

Packet loss and Hand-off Latency in both systems.

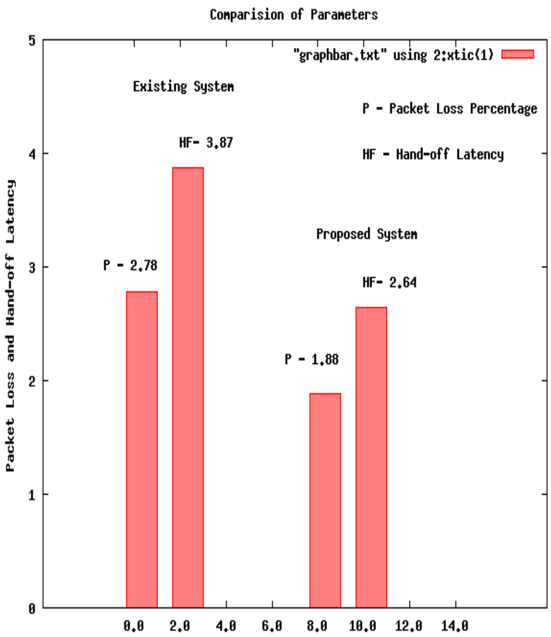

Fig. 9 Overall comparison results

V. Conclusion

One of the major concerns in Network Mobility is providing seamless data transfer for mobile users. This seamless connectivity is very much affected by Pinball problem and Hand-off delays that occur in the mobile networks. The solution proposed is effective in reducing the hand-off delays in the wireless scenario. The packet loss in the system also shows a considerable difference when compared to NEMO. The proposed system can be enhanced by adding a security support for preventing the attacks that happens in the networks. For instance the attacker can redirect the mobile user's traffic to another node by changing the Care of Address field [12]. Many such attacks are possible in the networks. These types of problems can be resolved to provide secure data transfer in the mobile networks.

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