Survey on Route Optimization for Mobile IP

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Abstract— Mobile Internet Protocol is a recommended Internet protocol designed to sup- port the mobility of a user (host). Host mobility is becoming important because of the re- cent blossoming of laptop computers and the high desire to have continuous network connectivity anywhere the host happens to be. The development of Mobile IP makes this possible. The traditional Mobile IP specification forces all packets forwarded to the Mo- bile Node (MN), to be routed via Home Agent (HA), which often leads to Triangular Routing, which in turn causes data transmission delay and wastes network resources. This paper discusses means of resolving the Triangle Routing Problem; it introduces some of the recent Route Optimization schemes that have been used to solve that problem.

Key words: Mobile IP, Route Optimization

I. INTRODUCTION

Mobile IP is a standard communication protocol of Internet Engineering Task Force (IETF) standard that is designed to give the mobile device users the freedom to move from a home network to a foreign network while maintaining a permanent IP address. A mobile node can change its location and still access and communicate with and through the computer's home network. Assigning a different IP address to the mobile node is cumbersome. Thus, under the current Internet Protocol the mobile node loses routing if it moves without changing its address. If the mobile node does change the address, it loses connection. Mobile IP solves this problem by giving the mobile node the freedom to use two IP addresses, the first address, which is the fixed home address, gives the node a permanent home address and the second address, which is a care of address, change at each new point of attachment. Mobile IP enables a computer to roam freely on the internet or handles mobility. The following figure illustrates the general Mobile IP topology. Triangle Routing Problem is considered as one of the main problems facing the implementation of Mobile IP such as, when a Communicating Node (CN) sends traffic to the Mobile Node, packets first get to the Home Agent, which encapsulates these packets and tunnels them to the Foreign Agent. The Foreign Agent de-tunnels the packets and delivers them to the Mobile Node. The route taken by these packets is triangular in nature, and the most extreme case of routing can be observed when the Communicating Node and the Mobile Node are in the same subnet. In recent literature many proto- cols have been invented to solve the Triangle Routing Problem. In this paper we introduce some of recent Route Optimization Schemes that are used in solving the conventional Triangle Routing Problem in Mobile IP.

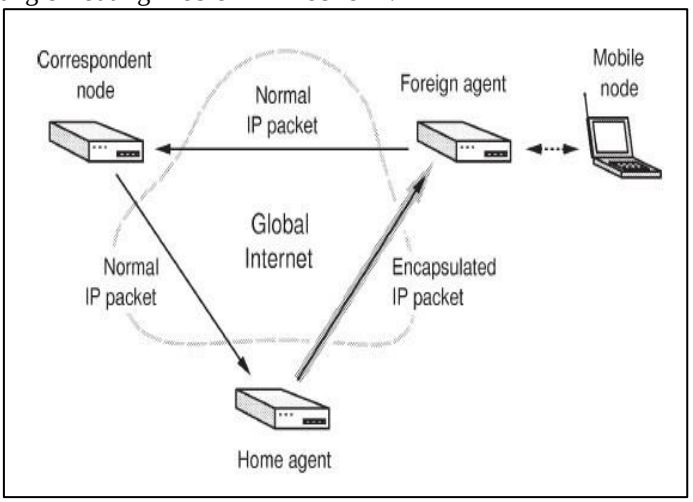

Fig. 1: Mobile IP protocol.

II. MAIN COMPONENTS OF MOBILE IP

Let us assume that a mobile node is connected to a mobile network. The network provided by the service provider is called the Home Network and the address of it is called as home address. The Networks other than this network at which mobile node can connect is called Foreign Network and the network to which the mobile node is currently connected is called Visited Network Mobile IP introduces the following new functional entities.

– Mobile Node–A host that changes its address frequently from one network to another without changing its IP addresses.

- Home agent– A router on the home network of a mobile node which delivers data packets to the departed mobile nodes and maintains present lo- cation information for each.
- Foreign agent–It stores information about mobile nodes visiting its network. For datagrams sent by a mobile network, the FA may serve as a de- fault router for registered Mobile networks. Mo- bile IP uses care-of-address which is advertised by the foreign agents. If there foreign agents available in the host network, the MN has to search for an address and advertising it.

III. BASIC OPERATION ON MOBILE IP

A. Mobile IP Is A Way of Performing Three Related Operations-

- Agent advertisement and discovery- The discovery process in Mobile IP is very similar to the router advertisement process defined in ICMP. For the purpose of discovery a router or other network node that can act as an agent periodically issues a router advertisement ICMP message with an advertisement extension. The router advertisement portion of the message includes the IP address of the router. The advertisement extension includes additional information about the router's role as an agent. A Mo- bile Node listens for these agent advertisement messages. The Mobile Node must compare the network portion of the router's IP address with the network portion of its own Home Network. If these network portions do not match, then the Mobile Node is on a Foreign.
- Registration- If the mobile node is not in its home network, it registers its care-of-address with its home agent. The mobile node initiates the registration process. It sends a Registration Request to the foreign network, which consist of the mobile node's home address, the care-of address, the home agent's address etc. Once a mobile node discovers a care of address, it sends the information to its home agent. The home agent will be then able to redirect appropriate traffic to the mobile node. The process by which the mobile node sends its care of address to the home agent is called registration.
- Tunnelling- Once the mobile node has reported its care of address to the home agent, the problem of supporting seamless connectivity is simplified to the problem of delivering all packets from the home address to the mobile node at its care-of address, unchanged its final form. The problem can be solved by tunnelling the packet i.e. The home agent has to tunnel the diagrams to the care-of address.

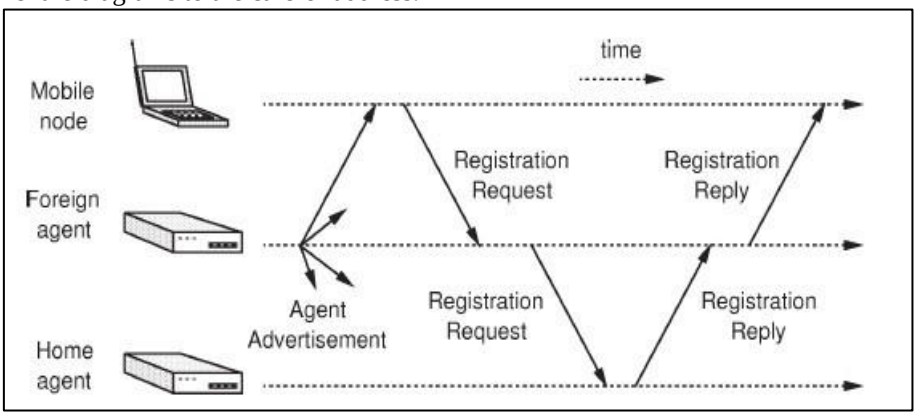

Fig. 2: Registration

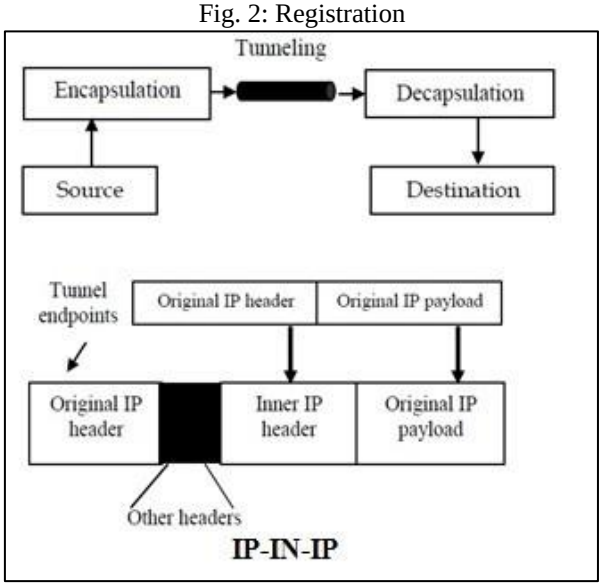

Fig. 3: Tunnelling and IP in IP

IV. MOBILE IP OPERATION SEQUENCE

- Mobility agents (Foreign Agents and Home Agents) advertise their presence via agent- advertisement messages. A Mobile Node may optionally solicit an agent advertisement message from any local mobility agents by using an agent solicitation message.
- A Mobile Node (MN) receives an agent advertisement and determines whether it is on its Home Network or a Foreign Network.
- When the Mobile Node detects that it is located on its Home Network, it operates without mobility services. If returning to its Home Net- work from being registered elsewhere, the Mobile Node deregisters with its Home Agent (HA) through a variation of the normal registration process.
- When a Mobile Node detects that it has moved to a Foreign Network, it obtains a Care-of- Ad- dress (CoA) on the Foreign Network. The Care- of-Address can either be a Foreign Agent (FA) Care-of- Address or a Co-located Care-of-Address.
- The Mobile Node, operating away from home, then registers its new Care-of- Address with its Home Agent through the exchange of a registration request and registration reply message, possibly by way of a Foreign Agent.
- Datagrams sent by the Correspondent Node (CN) to the Mobile Node's Home Network are intercepted by its Home Agent, tunnelled by the Home Agent to the Mobile Node's Care-of- Ad- dress, received at the tunnel endpoint (either at a Foreign Agent or at the Mobile Node itself), and finally delivered to the Mobile Node.
- In the reverse direction, datagrams sent by the Mobile Node may be delivered to their destination using standard IP routing mechanisms, without necessarily passing through the Home Agent.

V. ROUTE OPTIMIZATION OF MOBILE IP

Triangle Routing Problem is considered as one of the problems facing the implementation of Mobile IP. When a Correspondent Node (CN) sends traffics to Mobile Node (MN), the following sequence must be done:

- Packets first get the Home Agent (HA).
- Home Agent encapsulates these packets and tunnels them to the Foreign Agent (FA).
- The Foreign Agent de-tunnels the packets and delivers them to the Mobile Node.

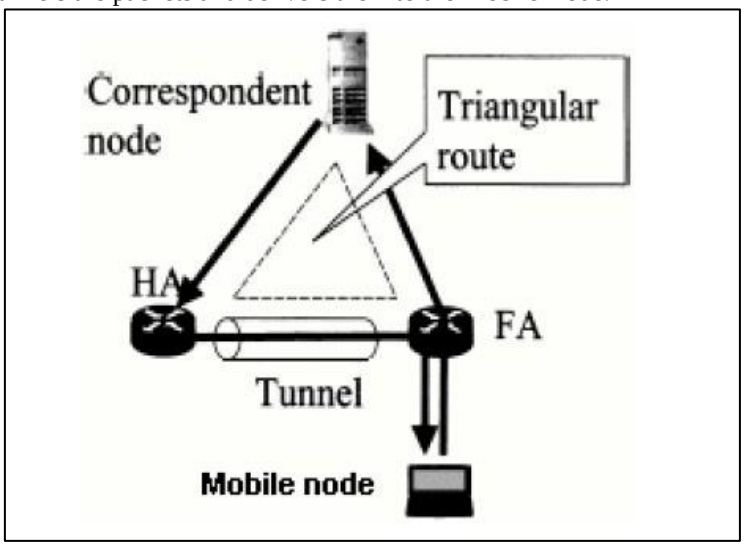

Fig. 4: Triangle Routing

As shown in figure , the route taken by these packets is triangle in nature, and the most extreme case of routing can be observed when the Correspondent Node and Mobile Node are in the same sub- net. Triangle routing drawbacks as follow:

- Increases the delays per packet in datagrams transferred to the Mobile Node.
- Waste of network resources.
- Home Agent bottle neck.
- Delimits the scalability of Mobile IP protocol.

For the correspondent node to eliminate triangle routing, it must have some information regarding the current location of the mobile node

A. Route Optimization by Forward Tunnelling and Binding Cache

Route Optimization Protocol in figure was developed to solve the Triangular Routing Problem, by allowing each host to maintain a binding cache for a mobile host wherever it is. When sending a packet to a Mo- bile Node, the following sequence must be taken

- If the sender has a binding cache containing the Care-of-Address of the Mobile Node (MN), it will deliver the packets directly towards the Mobile Node.

- If the sender has no binding information the first packets should be destined at first to the Home Agent (HA).
- Home Agent encapsulates the packets and sends them to the Foreign Agent (FA).

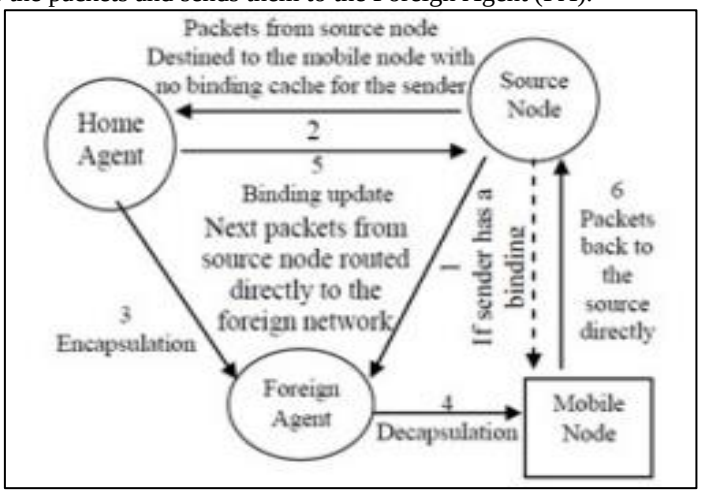

Fig. 5: Binding cache method

- Foreign Agent decapsulates the packets and send them to the Mobile Node.
- Binding information is transferred from the Home Agent to the source node for the further correspondences in the future, such that the next packets should be routed directly to the Foreign Network.
- If Mobile Node sends packets to the source node, the packets will be transferred directly from the Mobile Node to the source node.
  - In order to deliver bindings to the correspondent nodes of the mobile node, route optimization defines four new messages sent to the same port as the base Mobile IP.
- Binding warning-the foreign agent should send a Binding Warning message to the mobile node's home agent, advising it to send a Binding Up- date message to the node that tunnelled this packet.
- Binding request-Any node that wants to know the current location of an MN can send a binding request to the HA. The HA can check if the MN has allowed of its current location. If the HA is allowed to reveal the location it sends back a binding update.
- Binding update-This message sent by the HA to CNs reveals the current location of an MN. The message contains the fixed IP address of the MN and the COA. The binding update can request an acknowledgement
- Binding acknowledgement-If requested, a node returns this acknowledgement after receiving a binding update message.

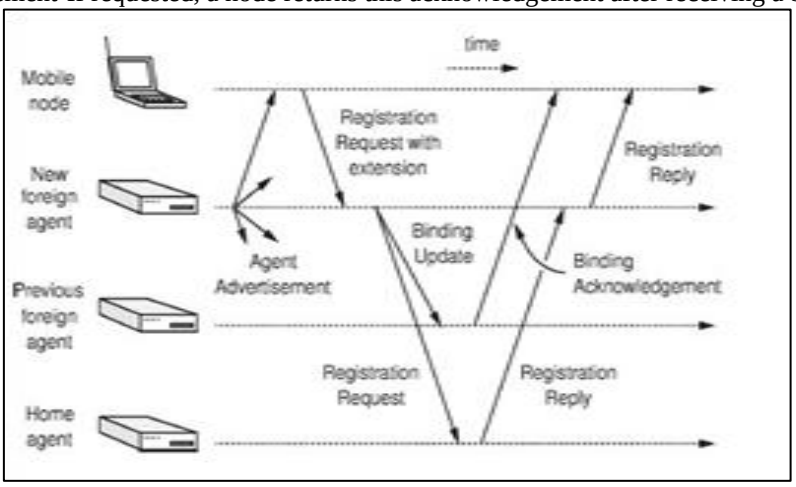

Fig. 6: Smooth handoff

This Route Optimization scheme provides a smooth handoff when the Mobile Node moves and registers with a new Foreign Agent. It provides a means for the previous Foreign Agent to be notified of the Mobile Node's new mobility binding allowing data grams in flight to the Mobile Node's Foreign Agent to be forwarded to its new Care-of-Address as shown in figure. As a result of simulation comparison between the original Mobile IP scheme and the improved scheme using Forward Tunnelling and Binding Cache. It has been proved that, the transmission time (delay) between the Correspondent Node and the Mobile Node is reduced because of the shortest path to reach the Mobile Node. The traffic and control signals over the network have been decreased

B. Route Optimization Using Dynamic Address Allocation in Mo- Bile IP

This technique proposes an extension to the Mobile IP architecture. In this scheme one Mobile Station (MS) is to handle two IP addresses between internet and intra-domain, one is called Current Address (CA) and another one is called Register

Address (RA). Lo- cation Agent (LA) is a router responsible for translating both addresses between internet and intra-domain. Register Address is used for packets routing in internet; Current Address is used for packets in intra-domain. Mobile Agent (MA) is router on a Mobile Station's current network which delivers packets to Mobile Station; it has functionality similar to FA and HA. Considering a packets routing scheme be- tween MS and CN, the packets downlink and uplink of the proposed architecture are described in figure as following

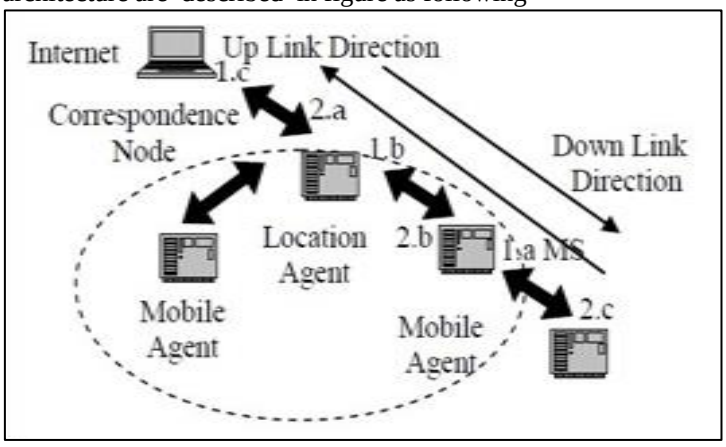

Fig. 7: Dynamic allocation mobile IP architecture

- When a MS sends a packet to CN, the packet routed first to LA by using Current Address. When LA receives packet, it will use the Current Address of MS to check relative address of MS. LA uses the Register Address instead of Current Address and retransmits the packet to CN. This sequence is called packet Up Link sequence.
- In case of packet Down Link, when a CN sends a packet to MS, the packet is routed to LA by using Register Address first. When LA receives the packet, it will use the Register Ad- dress of MS to check the relative Current Ad- dress of MS. LA uses the Current Address in- stead of Register Address and retransmits the packet to MS. Hard handoff scheme is proposed to be used with this technique. Also a "packet retransmission" scheme is used to avoid packet loss while hard handoff, in which every MA should have a buffer to store the downlink packets transmitted to MS. After MS handoff, old MA would retransmit packets which are stored in its buffer to new MA which delivers them to MS. By evaluating the performance comparison between the Mobile IP scheme and the dynamic address allocation scheme, it has been found that the transmission time taken between the CN and MS takes a longer Downlink path in case of Mobile IP scheme than the dynamic allocation scheme in which the transmission time equal to the time taken between the CN and MA plus the time taken between MA and MS. Also the traffic would increase obviously in the Mobile IP scheme. Comparatively, Dynamic Allocation Scheme would not increase any extra traffic.

C. Route Optimization Using Internet Service Provider Points of Presence ISP Pops

The basic idea in optimizing Triangle Routing is to get the HA as close as possible to the MN, when the MN no longer in its Home Network. This is achieved by shifting the Home Agent into the ISP's Domain. The ISP's network can be made Mobile IP "aware" by enhancing ISP Points of presence (PoPs) and by creating a virtual network composed of PoPs to dis- tribute the state information about the MN at the original HA to all PoPs. This ensures that no matter where the MN is, the HA is just a PoP away. Figure offers a simplistic view of a global network showing the position of CN, MN, PoP1. PoP2, PoP3 and ISP. The following paragraphs describe events that occur in order to set up the stage for successful CN to MN communication.

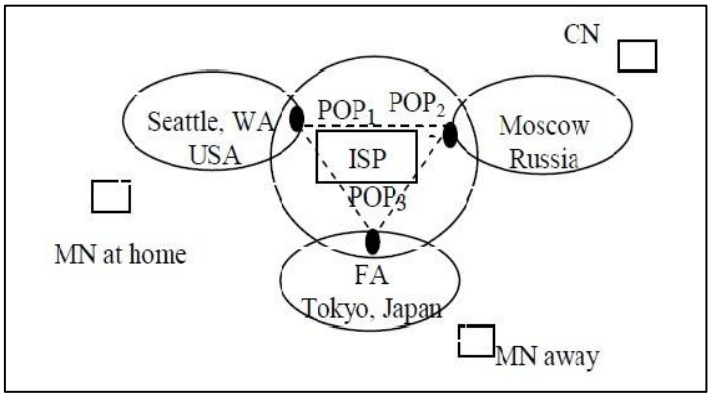

Fig. 8: view of a global network

- Registration with the HA;
- The MN registers with the closest HA, in this case, PoP1
- PoP1 informs PoP2 and PoP3 about MNs intent to be mobile through the PoPs Virtual Network (PVN) as shown in figure.

- Registration with the FA;
- The MN registers with the FA, seeking mobile services in the new network.
- The FA gets in touch with the nearest HA, in this case PoP3 in order to authenticate the MN.
- PoP3 now knows that to reach the MN, it only needs to reach the FA. So it creates an explicit routing entry mapping the MN address with the FA address. PoP3 broadcasts this information to all other PoPs, so that they may also do the same as shown in figure.
- On receiving a successful reply for the MN authentication message, the FA creates an association between the original MN address and its current point of attachment in the subnet. It uses this association to replace the destination IP address in incoming packets with the cur- rent point of attachment address. Similarly, the source address in outgoing packets from the MN is replaced with the original MN address.

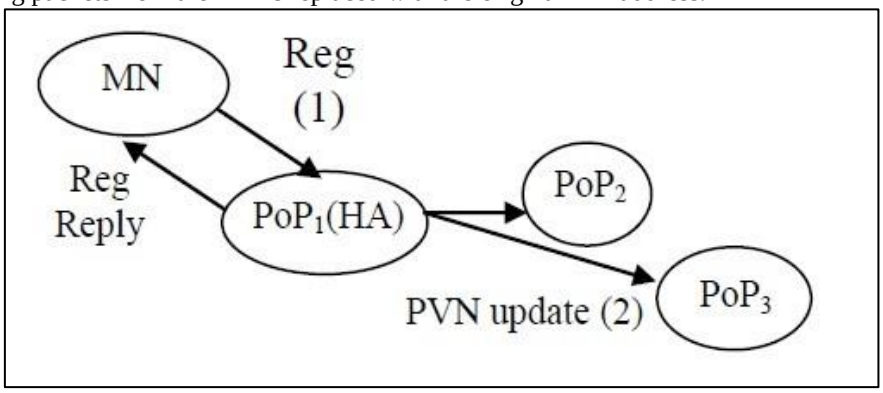

Fig. 9: HA registration

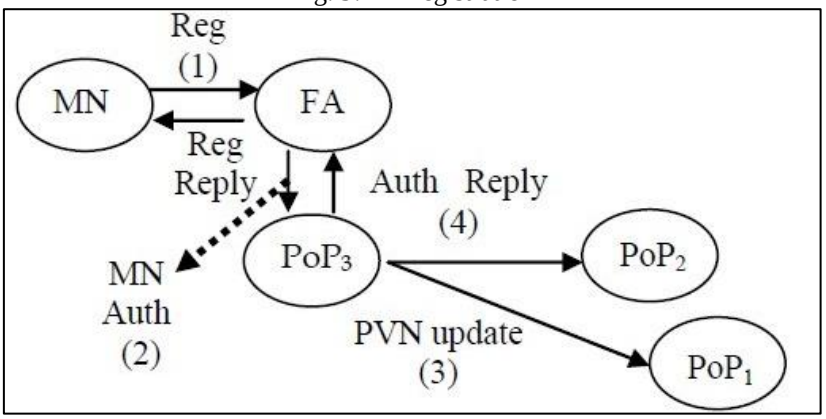

Fig. 10: FA registration

- CN needs to communicate with MN;
- Packets addressed to the MN's address can be routed by PoP3, since it has an explicit routing destination (FA) for such packets.
- Normal Internet routing gets these packets to the FA, where a destination address swapping occurs, in which the original MN address is swapped with its Current Address.
- The IP protocol stack at the MN can now receive the packets originally destined for the MN address.
- MN gets back to its Home Network;
- The MN de-registers with the closest HA, in this case PoP1.
- PoPl informs its peers, and all state information regarding the MN is purged.
- FAs purge their associations based on the life- time of the association. As the result of simulation comparison applied between the two approaches, the Conventional Mobile IP framework and the new proposed Mobile IP framework. It has been found that applying the new frame- work for Mobile IP is best suited to large ISPs with a large topological reach. It increases the TCP throughput to MN by almost double that in that traditional Triangle Routing case. Also the transmission time (delay) has been reduced through the new framework.

D. A Hierarchical Network

A hierarchical network is considered for the new technique, in which the routers and nodes are arranged logically in the form of parents and children .The network is divided into domains clubbed together to form higher level domains and so on till one reaches at the top, which is known as the root. The hierarchical network helps in organizing and managing the network. It represents an idealized Internet where optimal paths are used. Our hierarchical network consists of 4 levels contains the HA, FAs, MN, and standard IPv4 nodes without mobility support as illustrated in. The addressing system used in this network model consists of 3 levels of hierarchy: domain. Cluster. Node, according to NS2 simulator. In the proposed technique as the MN moves away from its HN, it registers a new CoA with the HA. The HA forwards the new CoA and all information related to the MN to a router that has the same functionality as a mobile agent and resides two levels

above the original HA, which we refer to as surrogate HA (SHA). The packets destined for MN is tunnelled at that router instead of the HA node, which saves the transmission time. These steps can be summarized as follows:

- Mobility agents (HA and FA) advertise their presence using its agent advertise messages.
- The MN receives an agent advertisement message and determines whether it is in the HN or in a FN
- When MN detects that it is in a FN, it requests a CoA from this FN.
- Then MN registers its CoA with its HA using the registration and replay messages.
- The HA forwards the MN's CoA to the SHA
- When packets are sent to the MN, they are intercepted by the SHA rather than the original HA, and then the SHA tunnels them to the MN current location.

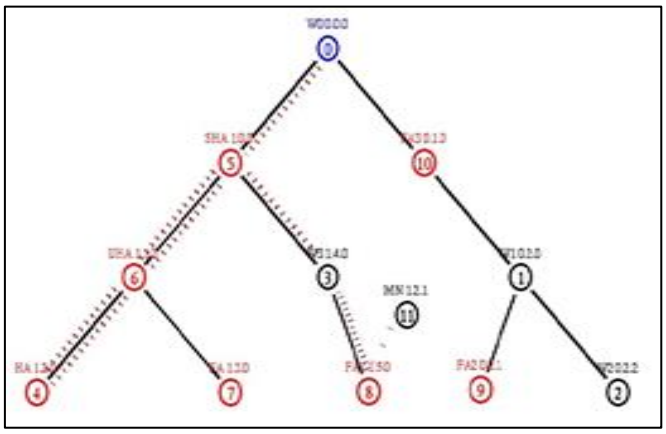

Fig. 11: Traffic data flow path for the original MIP

To illustrate the triangle problem and the proposed technique we consider the following example. Sup- pose that the MN will receive traffic from a correspondent node (W0) which is the root of the hierarchal tree with an address 0.0.0. If the MN (1.2.1) moves from its HA (1.2.0) to the FA (1.5.0), the original MIP path will be (0.0.0, 1.0.0, 1.1.0, 1.2.0, 1.1.0, 1.0.0, 1.4.0, 1.5.0) to the MN as illustrated in Fig. In the proposed technique, the new current location of the MN is forwarded to SHA (1.0.0), so the traffic data flow will take the path (0.0.0, 1.0.0, 1.4.0, 1.5.0), as illustrated in Figure. This overcomes the triangle routing problem of the original MIP and enhances the performance by reducing the delay, the packets loss and the registration time.

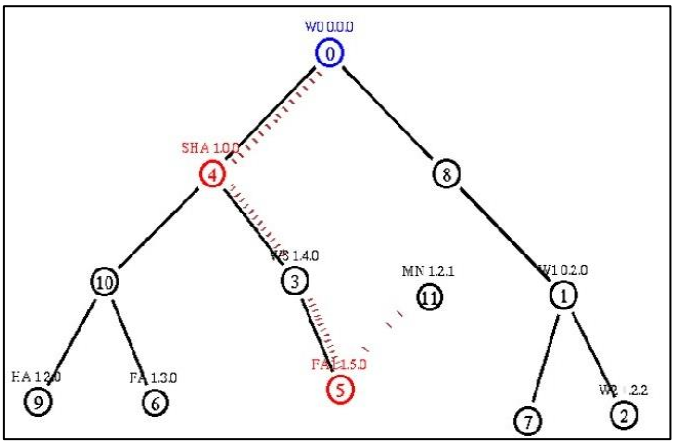

Fig. 12: Traffic data flow path for the proposed technique

VI. PREVIOUS ROUTE OPTIMIZATION SCHEMES DRAWBACKS IN MOBILE IP

The great effect of using the Route Optimization schemes is to minimize the transmission time (delay) between Correspondent Node (CN) and Mobile Node (MN) because of the shortest path to reach Mobile Node and also to reduce the traffic and control signals over the network. The drawbacks of the most Route Optimization techniques are classified as follows:

- Rigid requirements for an authentication of the clamed Care-of-Address especially when both of Mobile Node and Correspondent Node are in a different IP networks.
- Expensive hardware devices needed for the Route Optimization functions.
- Increase the amount of traffics over the network.
- Increase the rate of buffering and storage buffers.
- Increase the rate of blocking especially when the number of connections to Mobile Nodes is in- creased which results in increasing in the trans- mission time between Correspondent Node (CN) and Mobile Node (MN).

VII. CONCLUSIONS

This paper, we have presented the current proposed protocol definition for Route Optimization, by which is meant the elimination of triangle routing when- ever the correspondent node is able to perform the necessary protocol operations. The Route Optimization protocol definition is largely concerned with sup- plying a Binding Update to any correspondent node that needs one. The Binding Update message is also used in conjunction with the Previous Foreign Agent Notification extension to allow for smooth handoffs between foreign agents. Forward Tunnelling, Dynamic Agent Allocation, the Internet Service Providers Points-of-Presence (ISP PoPs), hierarchical network were proposed as recent researches that provide a solution for the Triangle Routing Problem in conventional Mobile IP Protocol.

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