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Seamless Ubiquitous Data Migration through Route Optimization in Mobile IP

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Abstract

The Mobile IP (MIP) [1] for IPV4 [2] is being standardized by the Internet community, IETF [3] provides continuous internet connectivity to mobile hosts, without requiring any changes to existing routers.MIP aims at maintaining internet connectivity with location registers closer to the service node used in PSTN [4] while a host is moving. The MIP uses tunnelling of IP packets from Home Agent to Foreign Agent [5] [6] to make the mobility transparent to the higher layers. In this paper, we propose to use mobility support protocol, MIP, applicable to support real time communication in a more efficient way.

Keywords: Correspondent Node, Foreign Agent, Home Agent, Mobile Node, Mobile IP.

Introduction

To provide mobility between homogeneous or heterogeneous networks, IETF [3] devised an protocol for Internet users, called Mobile IP (MIP) [1].The MIP, mobility support for IP, enables a mobile node, the MN to send packets to the correspondent node, CN[6] directly routed by its respective agents, home agents, HA and foreign agent, FA. But, packets from CN to MN have to be routed through three different subnets: the CN's subnet, the HA's subnet and the FA's subnet where the MN is currently located. This redundant routing in MIP, taking longer than optimal routing [7] is known as "triangular routing" [8] as stated in (Figure-1)

In MIP, a MN has two IP addresses. The first one identifies the MN's identity at home network as Home Address, HOA, while the second one identifies MN's current location as Care –Of – Address (COA). The MN is always reachable through its HOA while it changes its COA according to its present location. An agent called Home Agent (HA), placed at the MN's home network, and maintains bindings between the MN's HOA and COA for forwarding IP packets.

A correspondent node(CN) when transmits IP packets destined to MN, the internet not having information on the current location of MN routes the packets to the HOA of MN. The HA of MN now encapsulates & tunnels [9][10] the packet to the COA of MN, hiding the movement of MN, which causes triangle routing [8]. The triangle is made of the three segments, CN to HOA, HOA to COA of MN and MN back to CN.

One way to optimize the route is to inform CN of the current location of MN by caching at CN, known as Binding cache [11].

Component Overview

Mobile IP uses some basic entities and terminologies for its core networking functions.

Mobile Node (MN)

A MN is an end system or router that can change its point of attachment to the internet using MIP.

Correspondent Node (CN)

At least one partner is needed for communication. CN is the partner for MN.CN can be fixed or mobile.

Home Agent (HA)

The agent that provides several services to the MN and is located in the home network. The tunnel for packets toward the MN starts at HA.

Foreign Agent (FA)

The agent that provides several services to the MN during its visit to the foreign network.

Home Address (HOA)

The IP address of MN at home network is HOA.

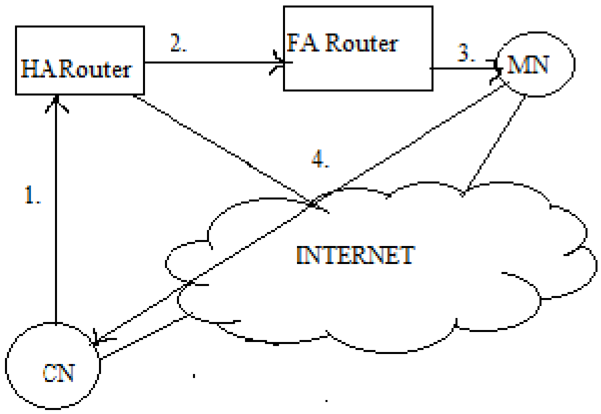

Figure 1: Triangular Routing in Packet delivery

Care of Address (COA)

The COA defines the current location of MN from an IP point of view. All IP packets sent to MN are delivered to the COA, not directly to the IP address of the MN. Packet delivery toward the MN is done using tunnel. There are two possibilities for the location of the COA:

Foreign agent COA: The COA is an IP address of the FA.

Co-located COA: The COA is co-located if the MN temporarily acquired an additional IP address.

Home Network

The subnet of the MN belongs to with respect to its IP address.

Foreign Network

The current subnet the MN visits.

Proposed Optimization in MIP

With the basic MIP all packets to the MN have to go through the HA. This can cause unnecessary overheads to the network between CN and HA, but also between HA and COA, depending on the current location of MN.

One way to optimize the route is to inform the CN of the current location MN. The CN can learn it by caching it in a binding cache. The appropriate entity to inform the CN of the location is the HA. The optimized MIP [1] needs four additional messages for binding cache:

Binding Request

Any node that wants to know the current location of MN can send a binding request to the HA of MN. The HA checks if the MN has allowed dissemination of its current location. If HA is allowed it sends back a binding update.

Binding Update

This message sent by HA to CN reveals the current location of MN. Binding update can request an acknowledgement.

Binding Acknowledgement

If requested, a node returns this acknowledgement after receiving a binding update message.

Binding Warning

If a node decapsulates [13] a packet for MN, but it is not the appropriate current FA of MN, this node returns a binding warning message.

The Figure-2, explains these optimization technique. The CN can request the current location from the HA. If allowed by the MN, the HA returns the COA of MN via an update message. CN acknowledges this update message and stores the mobility binding. Now CN can send its data directly to the current FA as FA $_{old}$.. FA $_{old}$ forwards the packet to the MN. This scenario shows a COA located at an FA. Encapsulation of data for tunneling to the COA is now done by the CN, not by the HA.

The MN might now change its location and register with the new FA, FA $_{new}$. This registration is also forwarded to the HA to update its location database. Also FA $_{new}$ informs FA $_{old}$ about the new registration of MN. MN's registration message contains the address of FA $_{old}$ for this purpose. Passing this information is achieved via an update message, which is acknowledged by FA $_{old}$. So FA $_{old}$ would now forward the packets to the new COA of MN, FA $_{new}$. This forwarding of packets is another optimization of the MIP which is known as smooth handover [9]. Without this all packets in transit would be lost while the MN moves from one FA to another.

To inform CN about the current foreign network of MN, FA $_{old}$ sends a binding warning [14] message to CN.CN then requests for a binding update .The HA sends an update to inform the CN about the new location of MN, which is acknowledged by binding acknowledgement. Now CN can send its packets directly to FA $_{new}$, avoiding triangular routing.

Smooth Handover

When MN makes a visit to a foreign network. FA_{new}, the CN does not know anything about the new location, so it still tunnels its packets for MN to the old FA, FA_{old}. This FA now notices packets with destination MN, but also knows that it is not the current FA of MN. FA_{old} might now forward these packets to the new COA of MN which is FA_{new}. This forwarding of packets is another optimization technique of MIP, which is smooth handover.

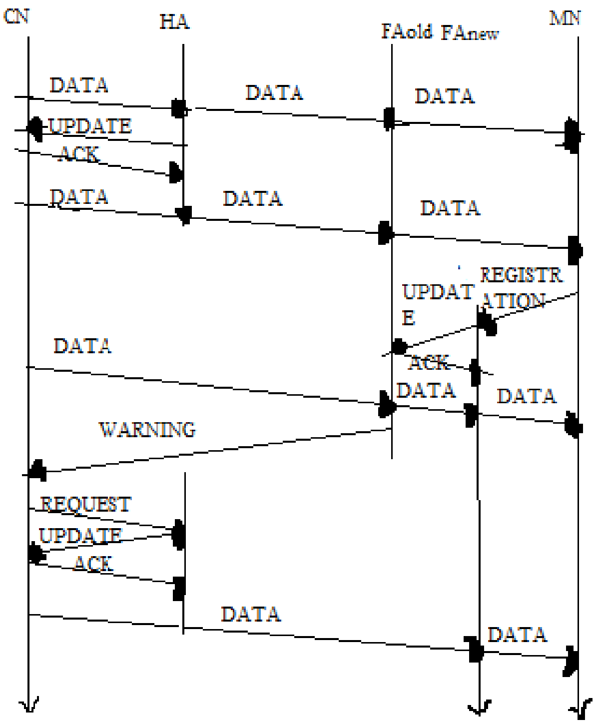

Figure 2: Optimized Mobile IP and Route Optimization

Performance Analysis

A criterion to measure the performance of a network and its protocols is throughput. The throughput is the amount of data transferred by a network in a time unit. Generally, it is expressed as Mbps (million bits per second).

The scenario that the mobile node moves into the same subnet as the correspondent node is the typical case for the investigation. To explore the performance under the impact of the network link between the foreign network and home network, two groups of experiments are done in terms of decrement of bandwidth and the increment of drop rate between FA and the HA. Table-1 and Table-2 show the various bandwidths and drop rates. Con. Int. is the abbreviation of confidence interval.

Table-1: MN and CN in the same Subnet (Throughput)

HA–FA Bandwidth		Plain IP	MIP	Optimized MIP
2 Mbps	Average	1.561	1.341	1.543
	Con. Int.	1.548,1.574	1.165,1.517	1.518,1.568
1.5 Mbps	Average	1.552	1.264	1.538
	Con. Int.	1.551,1.553	1.119,1.409	1.517,1.559
1 Mbps	Average	1.556	0.944	1.527
	Con. Int.	1.555,1.557	0.907,0.981	1.506,1.547

Table -2: MN and CN in the same Subnet (Drop Rate)

HA–FA Drop Rate		Plain IP	MIP	Optimized MIP
0%	Average	1.558	1.39	1.531
	Con. Int.	1.557,1.559	1.398,1.391	1.53,1.532
1.5 %	Average	1.556	1.184	1.53
	Con. Int.	1.555,1.557	1.183,1.184	1,529,1.531
5.0 %	Average	1.56	1.035	1.534
	Con. Int.	1.559,1.561	1.034,1.036	1.533,1.535

We can make several observations from the tables. First, as bandwidth becomes narrower from 2 Mbps to 1Mbps the throughput of Optimized MIP and Plain IP keeps unchanged. In contrast, the throughput of basic MIP degrades dramatically along with the available bandwidth between the foreign agent and the home agent. Especially, when the bandwidth decreases to 1 Mbps, Optimized MIP has nearly 17 times the throughput as compared to basic MIP. However, this is only 1.6% loss compared to Plain IP. Considering the impact of the drop rate, the throughput of basic MIP drops from 1.39 Mbps to 1.035 Mbps when it increases from 0% to 5%. When the drop rate reaches 5%, there is about 48% efficiency gains in Optimized IP compared to MIP, and only 1.7% loss in Optimized MIP compared to Plain IP. So it is clear that in the extreme case the advantage of Optimized MIP is obvious.

Second, with any bandwidth and at any drop rate, Optimized MIP has only 1.4% to 1.7% efficiency loss compared to Plain IP.

Conclusion

In this paper I have investigated the current optimized protocol MIP, for route optimization, by which the triangular routing problem is eliminated. The packets from CNs are directly- routed to MNs without causing delay unlike indirectly routed packets. Moreover the delay in packet delivery may result in performance degradation of network.

My study provides guidelines to adequate routing policies through binding caches and binding updates to maintain the end-to-end network communication intact. Moreover optimization can also be achieved through smooth handover between the old FA and new FA of MN, without which all packets in transit would be lost while the MN moves from one FA to another. The performance of route optimization using MIP is also analyzed in various network conditions.

Acknowledgement

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