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Study of Network and Transport Layer Protocols to Exploit the Potential of Higher Layers in Mobility Management

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Abstract: ***A brief survey of existing protocols for providing seamless mobility in IP based network is carried out with an emphasis on mobility management in IPv6. The paper covers evolving mobility protocols at network layer, their improvements over the predecessor. Apart from this various transport layer mobility protocols have also been studied so that the role of higher layers in mobility management can be exploited to make the process of mobility simpler and less prone to infrastructural change.***

Keywords: Network layer protocols, Transport layer protocols, Mobility Management, Care of Address(CoA),Handoff.

1. Introduction

When a mobile node or a subnet changes its home network, uninterrupted communication is ensured by mobility management. Host Mobility refers to mobility of a node [2] and Network Mobility refers to change of subnet [24]. In addition to this, Personal Mobility also exists [12], which helps users to access services regardless of the terminal or networking they are using, focus is on the movement of users instead of devices, Session Mobility, refers to the mobility between two terminals, involving tracking of the communication sessions between two nodes as they move [12].

Based on how and where the node moves, mobility can be termed as Micro-Mobility [25] i.e. the localized mobility between Pico-cells (probably heterogeneous cells) in the same subnet and the mobility between subnets in a domain and Macro-Mobility [25] the mobility between the domains in wide-area wireless networks. Most access networks provide mobility at link layer by having an access router keeping track of the specific access point a Mobile Node (MN) is attached to. Mobile IP can provide support for macro-mobility. But it is not suitable for micro-mobility because of signaling overhead, transient packet loss and handover latency.

In order to achieve mobility, both seamless connectivity and consistent reach ability should be supported. IP addresses being location specific cannot provide support for mobility. IETF proposed Mobile IP in IP networks as mobility solution. Mobile IP used concept of indirection point to decouple the binding between the host identifier and topology location. Although Mobile IP supports mobility, it still has some limitations due to which it is not suitable for all movement patterns of MNs. Specially in the coming generation of wireless networks like Adhoc, Vehicular, Sensor and Opportunistic Networks [11].

2. Mobility of IP-based Wireless Networks

Mobility management in wireless network deals with change in the point of attachment and hence thereby the IP address, of a MN. Following section focuses on the basic requirements and issues of mobility and introduces current solutions for mobility.

2.1 Categories of Mobility

Efficient handoff, routing and reduced packet loss are foremost requirement of any mobility scheme, following are few prominent scenarios of mobility.

2.1.1 Host Mobility and Network Mobility

Change in point of attachment by the end node with its network while maintaining communication between the host node and its correspondent node is referred to as host mobility.

Change in the mobile IP subnet's point of attachment to an IP backbone leads to network mobility. In a simple scenario of network mobility, a network contains a mobile router and a set of mobile nodes and the internal structure of a mobile network is a relatively stable internal topology. While in a complex mobility scenario, various mobile nodes or other mobile networks visit a mobile network [2].

2.1.2 Macro-mobility and Micro-mobility

The inter-domain movement refers to as Macro-Mobility. A number of well-known proposals like Mobile IP is well suited for macro-mobility due to their mechanisms for achieving handoff efficiency, reduced packet loss, delivery and routing of packets, etc. However, these proposals suffer from relatively large overhead. When, mobility solutions for macro-mobility are adopted for micro-mobility, as it introduces significant network overhead in terms of delay, packet loss and signaling. For example, wireless applications such as Voice IP (VoIP) which requires real time service would suffer degradation of service due to frequent handoff. Micro-mobility solutions are proposed for localized mobility in a domain. These proposals focus on reducing the handoff latency by inducing those additional overheads due to control traffic as they have to maintain routing information and address space issues at the local network [2 & 6].

2.2 Requirements of Mobility

The mobility solutions should posses the following properties.

A. Efficient Handoff: The performance of a mobility scheme mainly depends on the type of handoffs it uses. There are two types of handoffs: soft handoff and hard handoff affecting the performance of mobility schemes. In ***Soft handoff*** *a new connection is made before disconnecting the existing connection*. It allows the mobile node to communicate with multiple interfaces during handoff and when the signal strength between the old access point drops below a certain threshold the communication with the old interface is dropped. In case of ***hard handoff*** *the previous connection is dropped before making a new connection*. They are more prone to packet loss and packet delay thus should be handled efficiently to keep the losses bare minimum [5 & 29].

B. Location Management: Mobile host must be reachable by other nodes availing it's services, it must be able to be located by these nodes as it moves as well as maintaining location transparency [29].

C. Efficient Routing: Route optimization needs to be performed so that Packets can be routed with the latency as low as possible, by following the shortest path provided by IP routing [26]

D. Security: Security is a crucial issue in a wireless environment involving authentication of the newly visited node in the external network imposing overhead during handover. Mobility management schemes should not introduce additional security issues to the network [26&27]

E. Scalability: A mobility scheme should be flexible enough to accommodate the visiting mobile nodes and their corresponding nodes without performance degradation [2].

F. Fault Tolerance: A mobility scheme should make the communication between mobile nodes as much tolerant to fault as the communication between stationary nodes. Scheme should be able to identify the performance bottlenecks so that it can be robust even in case of failures by providing additional backup resource for communication (may be through distributed mobility management schemes) [2].

G. Simultaneous Mobility: Sender and receiver mobile nodes may move simultaneously and should be able to communicate without any interruption [28].

H. Link Layer Independence: In spite of the fact that not all of link layer support the same mobility scheme, still user should be able to seamlessly operate across heterogeneous link layer technologies.

I. Compatibility with IP Routing: Includes acquiring a new topologically correct IP address of the mobile host upon moving, since Internet does not deal with propagation of full host routes [2].

J. Transparency: The mobility scheme need to ensure transparency , to avoid modification to the applications, so that they remain unaware of the handoff taking place . [26]

K. Quality of Service: QoS should be retained during movement of mobile Host and handoff [29].

3. Existing Solutions for Host Mobility

Most current solutions revolve around the notion of indirection points which gives independency to the correspondent node from topology location of the Mobile node and the correspondent node is just concerned with sending packets to the indirection points. Such solutions require changing the underlying network layer working. Other solutions at higher layer (transport layer) do not require change in the IP substrate rather offer end-to-end architecture. Following are some existing mobility solutions which are prevalent and fulfilling the requisite mobility support.

3.1 Mobile IP

Mobile IP (MIP) was developed by Internet Engineering Task Force (IETF) to support mobility in the Internet. It is supported by network layer and gives independence to higher layers, which makes them unaware of node movement and the mobile node maintains a continuous communication with the correspondent node.

3.1.1 Working of MIPv4

When an MN visits a foreign network it performs the following steps a shown in Figure 1.

Step 1: The foreign agent advertises router advertisement message periodically, on receiving this message the node generates Care of Address (CoA) based on the information in the Router Advertisement RA message.

Step 2: After generating CoA visitor node registers itself with Foreign Agent FA sharing its permanent home address and link layer address.

Step 3: Foreign agent acknowledges the visitor node after retaining the visitor nodes information.

Step 4: Visitor node receives the acknowledgement and sends Binding update message, comprising of newly obtained CoA and a tentative time to live of the CoA, to its Home Agent.

Step 5: On receipt of Binding Update (BU) from the mobile node the Home Agent stores it in the database and send binding update acknowledgement (BACK) message to the MN.

Step 6: The process of handover is marked completed when the MN receives BACK from the HA, after this MN receives packets the new location.

In mobile IP, HA resides in MN's Home network and act as indirection point, also intercepts and tunnels packets to the Mobile Node. The temporary CoA obtained by MN helps in routing in foreign network. Every time the mobile

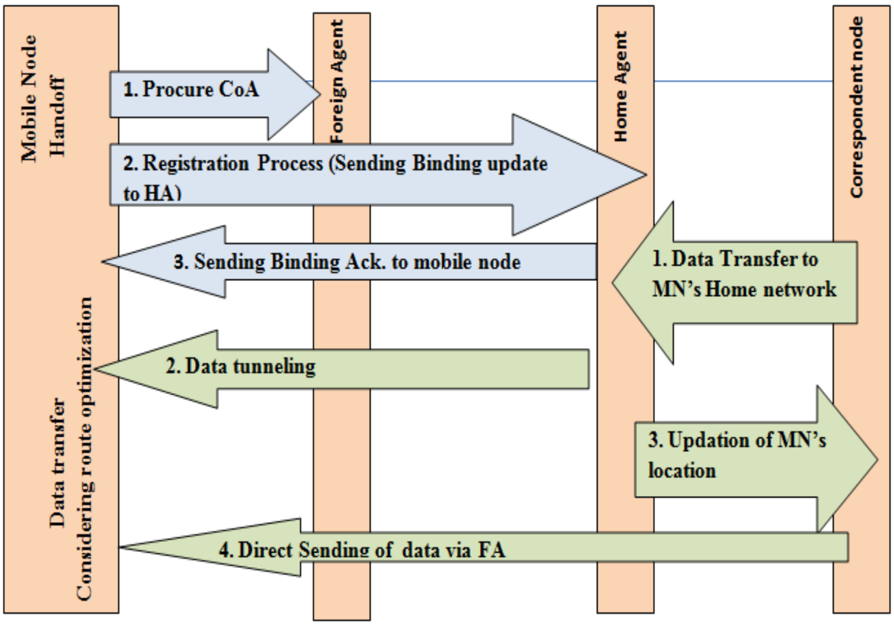

Figure 1: Message passing in MIPv4 [2, 4&6]

Node obtains CoA it registers it to its Home Agent and this process is called registration. The permanent address is used by the MN to maintain the transport and higher-level communication when moving unlike CoA used for routing in foreign network. Through the process of binding the two addresses are linked and help in communication between MN and HA [2, 4, 6 & 9].

3.1.2 MIPv4 shortcomings

Though MIPv4 is most widely deployed Internet Protocol connecting devices on the Internet still it suffers from the following mentioned drawbacks.

I) IPv4 addresses on the verge: The prime reason for exhaustion of IPv4 addresses is insufficient design capacity of the basic Internet infrastructure apart from this deployment of new and advanced devices for network are few factors that have raised the demands for IPv4 addresses. IPv4 has 32 bit capacity and hence some organizations are forced to use NAT (Network Address Translation) in order to map multiple private addresses into a single public IP address [9].

II) **Complexity of configuration:** As more and more Computer and devices use IP , It generates a need for an easier and higher automatic Configuration of address which avoids the complex administration of DHCP Infrastructure .[30]

III) Flat Routing Infrastructure: In the initial Internet, to create a hierarchical routing infrastructure individual access prefixes were allocated, rather than assigning address prefixes. Each address prefix became a new route in the routing tables due to which Internet backbone routers are required to maintain irrationally large number of routing tables. The large routing tables have over voluminous specified routes. Current IPv4 infrastructure support both flat and hierarchical routing.[31]

IV) Security: Internet supports private communication over a public medium. Hence, security demands for encryption services that should protect the data that is being sent from being viewed or being modified in the transmission. The rapidly increasing intimidating environment on the Internet demands built in security.[9]

V) Quality of Service (QoS): Presently, Internet users are not confined to web browsing and searching data text, voice and video chat features; online video libraries and video conferences are also prevalent. This type of communication requires real time data transfer support. These services require TCP (Transmission Control Protocol) or UDP (User Data-gram Protocol). [3&31]

VI) Problem of Triangle Routing: Each time when a packet is received in the home network for the MN, the HA will intercept the packet and then encapsulate it inside a packet and send it to the COA of the MN. Thereafter packets sent from the MN addressed to the CN may either be routed directly from the foreign network to the CN, known as triangle routing or be tunneled back to the HA and routed from HA to CN, which is known as reverse tunneling [30]. Security issues does might not allow triangle routing in Foreign Network.

Although Mobile IP is appropriate in handling node mobility, including hosts and routers, it does not explicitly support network mobility.

3.2 MIPv6

Incorporation of mobility in IPv6 leads to development of MIPv6 i.e. it enables mobile device to be reachable and maintains continuous communication during the movement of mobile node from one network to another. The protocol also allows for optimal routing between mobile nodes and other nodes they are communicating with. MIPv6 allows a mobile node to communicate with another peer using shortest possible path provided by IPv6 routing [1]. Figure 2 depicts message passing in MIPv6. One of the functional entity is replaced i.e. foreign agent of MIPv4 is replaced by Access Router in MIPv6.

3.2.1 Advantages of IPv6

I) Voluminous addressing Space: IPv6 has 128 bit long addresses which serve to provide sufficient future anticipated address space. It avoids use of NAT supporting all kinds of devices to connect to the Internet extending support for Internet of Things (IoT) concept. It renders transparent end-to-end security. It gives a provision for assigning address space internationally. [5]

II) Flexible Addressing Configuration: Supports address representation including any cast, multicast, uncast. When a packet is sent to any cast group, data flooding will be limited as packet will be delivered to the nearest interface (one of the group members). Unlike any cast, when a packet is sent to the multicast group, it will be delivered to all the addresses given by that address. Hence, there is transmission of a single data packet to multiple receivers [31]. Such transmission can be advantageous to Multimedia applications.

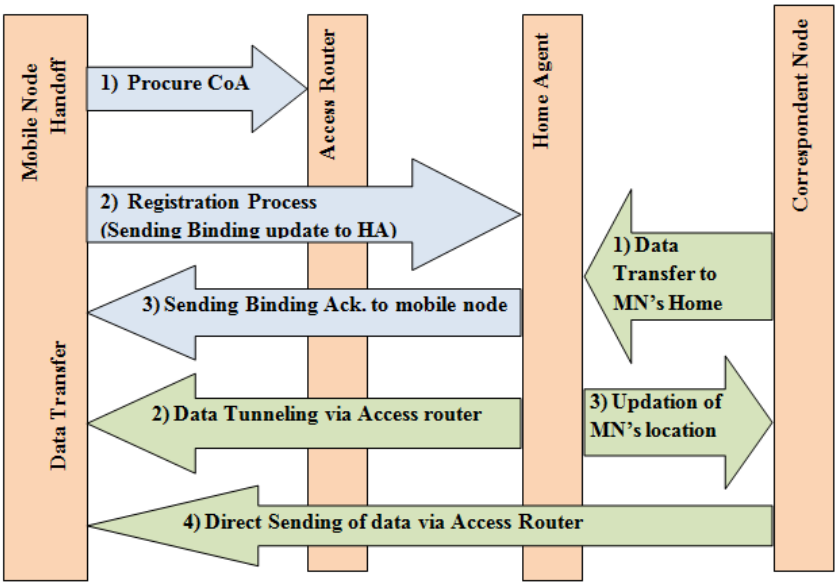

Figure 2: Message Passing in MIPv6 [1&6]

III) Hierarchical organization of routing infrastructure: Involves organization of routing tables according to hierarchical infrastructure leading to faster routing and relatively less routing entries [30]. The concept of hierarchical routing also supports the anticipated large address space in the massively grown Internet space.

IV) Address Auto-Configuration: Two configurations are supported by IPv6, stateless address configuration (without DHCP automatic configuration) and the state full address configuration (with DHCP). Hence, IPv6 hosts can configure themselves automatically in the absence of an address configuration infrastructure using stateless address configuration. In Mobile IPv6, since it offers address auto-configuration capabilities, there is no need to deploy FAs in foreign networks unlike IPv4 networks. [1&5]

V) Improved Security: IPv6 requires support for IPsec which is a framework of open standards developed by the Internet Engineering Task Force and functions at a low-level in the layers between the physical wire and a software application. Interoperability is promoted with the routing between MN and CN. With route optimization, the MN informs the CN of its COA using a Binding Update (BU), and then an IPv6 routing header will be used to send packets directly from the CN to the COA of the MN. However location privacy is compromised as the CoA gets exposed to the CN.

VI) Dynamic HA/Neighbor discovery: Mobile IPv4 uses a broadcasting mechanism to dynamically discover the HA in the home network, whereas Mobile IPv6 uses the IPv6 Neighbor Discovery Protocol. . [30] MIPv6 provides a dynamic home agent address discovery mechanism that allows a MN to dynamically discover the IP address of a HA in its home location

3.3 Hierarchical MIPv6

MIPv6 does not:

1. Categorize movement of node as local or global. This leads to same signaling load during the movement of mobile node in both the scenarios regardless of its movement to adjoining cell or to distantly located cell. This makes MIPv6 less scalable and the signaling load may increase tremendously when the number of mobile nodes increases. [5]
2. Deal with Optimal path during nested mobility.

HMIPv6 is the extension of MIPv6 by introducing new entity called **Mobile Anchor Point (MAP).** All the architectural entities of MIPv6 are also available in HMIPv6.

Mobile Anchor Point (MAP): The MAP is basically a server maintained in the network that keeps track of all the MN that currently visiting that site. The MAP limits the amount of MIPv6 signaling outside the local domain [5, 9 &14]

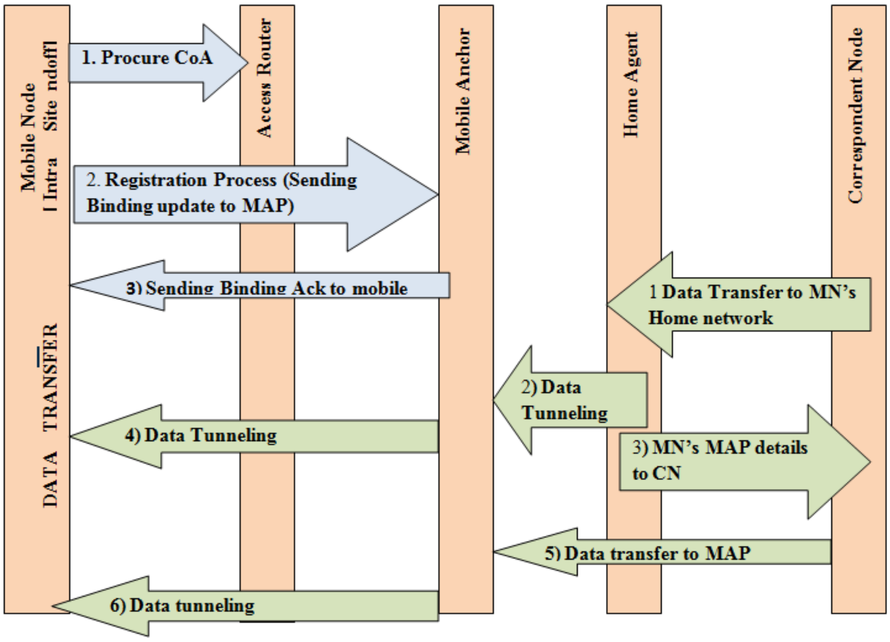

Figure 3: Message Passing in HMIPv6 Intra Site Mobility [9&14]

Hierarchical Mobile IPv6 (HMIPv6)

1. Differentiate movement of MNs as local and global mobility and handles both the movement separately and introduces both the mobility by different hierarchically arranged agents. [5]
2. Handles standalone mobile network[14], which implies that a visiting node in a mobile network should be reachable by the other nodes in the same mobile network even when the mobile network is not attached to the IP infrastructure.
3. Support of dynamic addressing and routing mechanisms, which means that the MR should be able to take part in routing and network management operations with its home network.

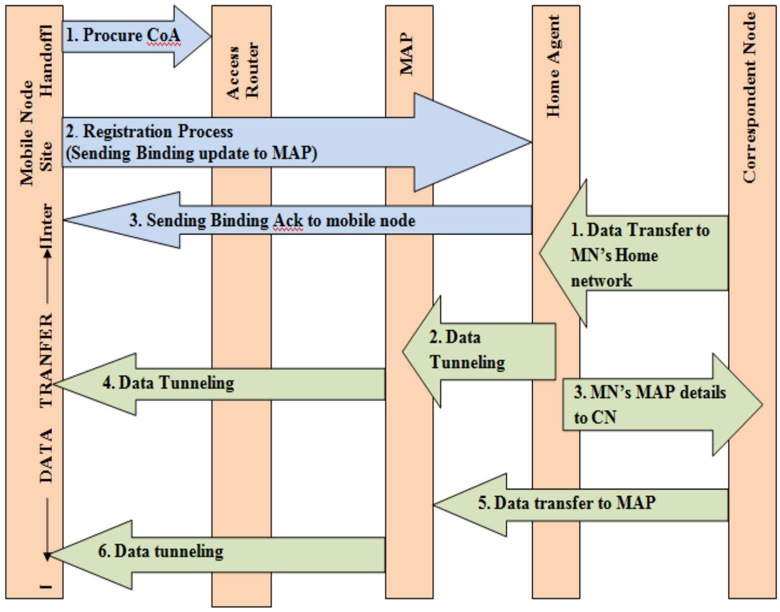

Figure 4: Message passing in HMIPv6-Inter Site Mobility [5&9]

Inter-site and Intra-site movement has two main advantages.

First, it improves Handoff latency since local handoffs are managed locally.

Second, it significantly minimizes the signaling load due to handoff management because signaling messages corresponding to movement within the local site do not cross the whole Internet but stay confined to the site. With hierarchical arrangements the Intra-site mobility of MNs are completely hidden to CN. [9 &14]

In HMIPv6, Provision of MAP as shown in Figure 3 and Figure 4, solves many issues, specially the security issue where the MN sends binding update related messages to MAP rather than sending it to HA and CNs which allows MN to hide their location from CN and HA. HMIPv6 imbibes the route optimization provided by MIPv6 thereby leading to performance enhancement. [5]

3.4 Fast Handover for MIPv6

The underlying principle of Fast Handover is to make a MN acquire new CoA before it enters a new access area i.e. make before break. In such a case as shown in Figure 5, when the MN is attached to the New Access Router (NAR), it can continue its communications with its new already assigned address. While constructing the new CoA before the actual handover, the protocol takes help of the signal strength of the used signal and newly received signal during the movement of MN. In case of anticipated registration failed (i.e., temporary address obtained prior to handoff could not be used) MN can always proceed with normal handoff. During Fast Handover messages are exchanges between OAR/NAR and MN, based on the information obtained from MAC layer. Proper packet forwarding mechanism between OAR and NAR is adopted. The message flow diagram for FMIPv6 is depicted in Figure 5.

3.4.1 Steps involved in Fast Handover

1. Either the MN or the Old Access Router (OAR) may initiate the fast handover, based on the link layer information.
2. The MN sends a Router Solicitation for Proxy (RtSolPr) message to the OAR to trigger handover process.
3. The OAR then sends a Proxy Router Advertisement (PrRtAdv) message to the MN.
4. The MN procures a new CoA (NCoA) and is also connected to the OAR.
5. The OAR validates the MN's new CoA, sends Handover Initiation (HI) message to the NAR thereby initiating the process of establishing a bidirectional tunnel between the OAR and the NAR.
6. In response to the HI message, the NAR sets up a host route for the MN's previous Care of Address (PCoA) and responds with a Handover Acknowledge (HACK) message.
7. When the MN receives a PrRtAdv message, it sends a Fast Binding Update (FBU) message. When the OAR receives an FBU message, it must verify that the requested handover is accepted by the NAR as indicated in the HACK message.
8. Then, it begins forwarding packets intended for old CoA to the NAR and sends a Fast Binding acknowledgement (F-BACK) message to the MN.
9. The NAR stores all the packets received from the OAR till the actual arrival of the new MN in its coverage area.
10. On arrival of the MN under the coverage of the NAR, it initiates a Fast-Neighbor Advertisement (F-NA) to inform its arrival in the new cell. When the NAR receives the F-NA message it forwards all the packets which are being waiting for the visitor MN [1, 5 & 9]

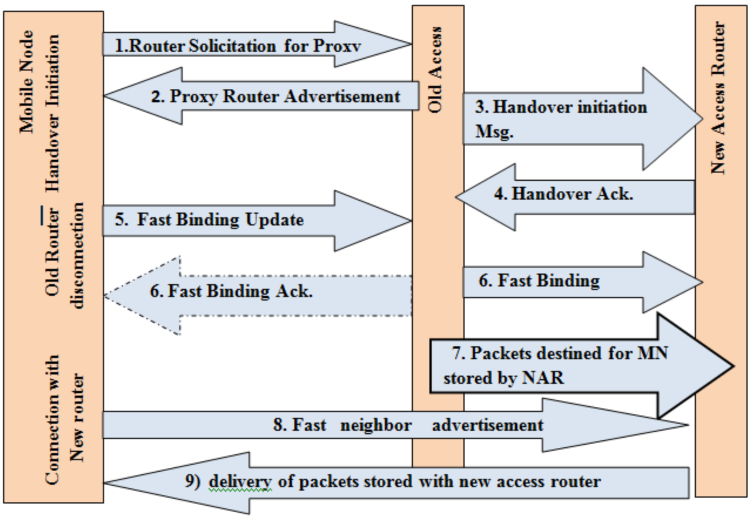

Figure 5: Message Passing in FMIPv6 [5&9]

4. Transport Layer Protocols for Mobility Management

Though mobile IP is a network layer scheme and renders transparency to upper layers but result in infrastructural overheads. Transport layer scheme which are based on end-to-end approach to handle mobility tends to keep the Internet infrastructure unchanged and passes the responsibility of mobility to end hosts.

4.1 Evaluation criteria for Transport layer protocols

The following evaluation criteria has already been discussed in IP based network Protocols

- Handoff Process
- Scalability and Fault Tolerance
- Application Transparency
- Packet Loss/ Delay
- Security

Others criteria for protocol evaluation include:

I) **Path Diversity/IP Diversity:** Increasing number of mobile devices nowadays come with multiple communication interfaces. During handoff, an MH may be able to take advantage of multiple IP addresses (called IP diversity), obtained from separate subnets, and associated with the multiple interfaces [28].

II) **Change in Infrastructure:** A mobility management scheme may require additional software agents (such as Home/Foreign agents in the case of MIP) or hardware to be deployed in the existing network infrastructure. Such additional agents/hardware may result in scalability and deployment issues for the scheme to be implemented in the real world [8].

III) Change in protocol: Mobility management at transport layer may require change in the transport protocol, or may require application to use a new Transport protocol or API. [27]

Based on the above mentioned criteria transport layer protocols supporting mobility (either handoff or location management or both, can be classified in four major categories as depicted in Figure 6.

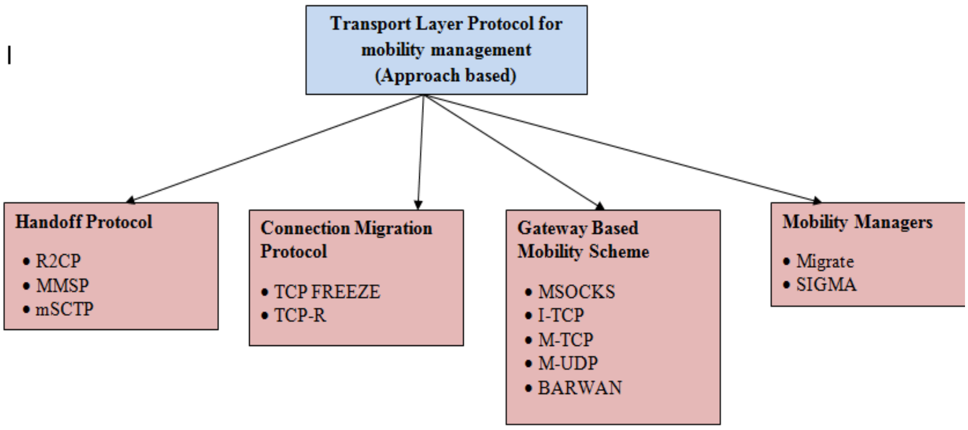

Figure 6: Categories of Transport Layer protocols supporting mobility [2, 8, 16, 19&21]

4.2 Existing Transport Layer Protocols Supporting Mobility

I) MSOCKS Maltz et al. [23] propose TCP Splice to split a TCP connection at a proxy by dividing the host-to-host communication into host-proxy and proxy-host communications. MSOCKS [2] uses TCP Splice for connection migration and supports multiple IP addresses for multiple interfaces. During Handoff when a MH disconnects itself from a subnet, it obtains a new IP address from the new subnet using DHCP, and establishes a new connection with the proxy using its second interface. There is no change in communication between proxy and CN. The data flow between MH and CN thus continues, with the CN being unaware of the mobility. Location management is done through the proxy who is always aware of the location of the MH; this limits the mobility within the coverage of the proxy. [2]

II) Seamless IP diversity based Generalized Mobility Architecture (SIGMA) is a complete mobility management scheme implemented at the transport layer, and can be used with any transport protocol that supports IP diversity. SIGMA supports IP diversity-based soft handoff. The MH obtains a new IP address from the new subnet when it enters an overlapping region of two neighboring subnets and is still having the old address as its primary address.

When, the received signal from the old subnet below a certain threshold, the MH changes its primary address to the new one. When it leaves the overlapping area, it releases the old address and continues communicating with the new address thus achieving a smooth handoff across subnets. Location management in SIGMA is done using DNS as almost every Internet connection starts with a name lookup[16]. Whenever there is change in MH's address, the DNS entry is updated so that subsequent requests can be served with the new IP address.

III) Migrate Migrate is a transparent mobility management scheme which is based on connection migration using Migrate TCP, and DNS is used for location management.[15] In Migrate TCP, when an MH initiates a connection with a CN, the end nodes exchange a token to identify the particular connection. A hard handoff takes place when the MH reestablishes a previously established connection using the token, followed by migration of the connection. Similar to SIGMA, this scheme proposes to use DNS for location management.

IV) Freeze-TCP Freeze-TCP is a connection migration scheme that lets the MH 'freeze' or stop an existing TCP connection during handoff by advertising a zero window size to the CN, and unfreezes the connection after handoff. This scheme reduces packet losses during handoff at the cost of higher delay. Although it provides transparency to applications, Freeze TCP requires changes to the transport layer at the end nodes. Freeze-TCP only deals with connection migration, but does not consider handoff or location management.[17] It can be employed with some other schemes like Migrate to implement a complete mobility management scheme.

V) R2CP Radial Reception Control Protocol (R2CP) is based on Reception Control Protocol (RCP), a TCP clone in its general behavior but moves the congestion control and reliability issues from sender to receiver on the assumption that the MH is the receiver and should be responsible for the network parameters. R2CP has some added features over RCP like the support of accessing heterogeneous wireless connections and IP diversity that enables a soft handoff and bandwidth aggregation using multiple interfaces. A location management scheme might be integrated with R2CP to deploy a complete scheme. [32]

VI) MMSP Mobile Multimedia Streaming Protocol (MMSP) supports transparent soft handoff through IP diversity and uses bi-casting (a technique to duplicate a flow simultaneously) to prevent losses during the handoff [8]. The following table summarizes various categories of protocol at Transport layer and their characteristic feature.

Table 1: Features of Transport layer Protocols supporting Mobility[2,8,16,18,19,20&21]

Category	*Features*
Handoff Protocol • **R2CP** • **MMSP** • **MSCTP**	• Prime aim of protocols under this scheme is to improve the performance • Supports seamless Handoff and IP Diversity • Not complete mobility management schemes(i.e. lack of location management) • Supports soft handoff • Fault tolerant • Supports transparency • No packet loss or delay • Supports IP diversity • No Change in Infrastructure required
Connection Migration Protocols • **TCP FREEZE** • **TCP-R**	• The protocols under this category are based on migrating connections which have been put under wait state may be due to handoff • Do not deal with handoff issues • Help in connection management i.e. stopping and resuming during handoff initiation and completion • Fault tolerant, not at MN • Freeze TCP prevents losses • No support for IP diversity • No Change in Infrastructure required
Gateway Based mobility Scheme • **MSOCKS** • **I-TCP** • **M-TCP** • **M-UDP** • **BARWAN**	• The Connection between CN and MN is split at the gateway • Connection between gateway and CN remains fixed and varying with the mobile node • Requires special entity that split connection between MN and CN • Does not offer complete mobility management • Usually support hard handoff • Fails on the failure of infrastructure • Usually maintains transparency • Packets during handoff lost except for BARWAN • Less secure • No Support for IP diversity except BARWAN
Mobility managers • **MIGRATE** • **SIGMA**	• Provide complete end to end mobility management schemes • Supports both handoff and location management • Usually support soft handoff, hard in case of migrate • Depends on location management , fails on non performance • Usually maintains transparency , except migrate • No packets loss or delay, Migrate stop transmission • Supports IP diversity, except Migrate • No change in infrastructure required

VII) I-TCP Indirect TCP (I-TCP) is a mobility scheme that requires a gateway between the communication path of the CN and MH to enable mobility. In this scheme, a TCP connection between CN and gateway and a I-TCP connection between the gateway and MH is established to provide CN to MH communication. The TCP part remains unchanged during the lifetime of the communication and remains unaware of the mobility of MH. In the I-TCP portion, when the MH moves from one subnet to another one, a new connection between MH and the gateway is established and the old one is replaced by the new one. There is a need to modify transport layer of the MH but applications enjoy a transparent view of the mobility at both the ends. I-TCP does not support IP diversity and soft handoff. Location management is not supported by this Scheme.[18]

VIII)M-TCP Mobile TCP (M-TCP), an enhanced version of ITCP is implemented at MH which works like a link layer one hop protocol that connects to the gateway via wireless. The gateway maintains a regular TCP connection with the CN and redirects all packets coming from CN to MH. This redirection is unnoticed by both the MH and CN [19]. The enhancement of M-TCP over I-TCP is in requiring less complexity in the wireless part of the connection. Similar to I-TCP, M-TCP does not support IP diversity or location management but ensures application transparency.

IX) M-UDP Mobile UDP (M-UDP) is an implementation of UDP protocol with mobility support similar to I-TCP and M-TCP, Like M-TCP, M-UDP uses a gateway to split the connections between MH and CN to ensure one unbroken gateway to CN connection and continuously changing MN to gateway connection. This also does not include IP diversity or location management. [8]

X) BARWAN The Bay Area Research Wireless Access Network (BARWAN is a solution to heterogeneous wireless overlay network. It architecture is gateway centric based on an assumption that the wireless networks are built around the gateways. Diverse overlapping networks are integrated through software that operates between the MH and the network. MH is supported to move among multiple wireless networks - whenever MH moves out of a lower coverage network (e.g. WLAN) it moves into a higher coverage network (e.g. WWAN) and MH changes its connection from lower to higher one [20]. This scheme supports IP diversity for the MH hence enables seamless handoff across different networks. BARWAN requires the application to be aware of mobility as the decision to make a handoff is taken by the application. Location management is not specified by the scheme.

XI) **TCP Redirection (TCP-R)** is a connection migration scheme that maintains active TCP connections during handoff pairs. Whenever MH gets a new IP address, TCP-R updates the address at CN and the already existent connection continues with the new address. TCP-R does not implement connection timeout to support long disconnection. Transport layer at both the ends needs modification for this support, yet it gives application transparency. Like Migrate, TCP-R proposes to use DNS as location manager. Combined with a handoff management scheme, this scheme might be deployed as a complete mobility scheme.[21]

XII) **Mobile SCTP (mSCTP)** supports IP diversity and soft handoff. The handoff is similar to the one of SIGMA. mSCTP can maintain application transparency but it does not support location management.[7&8]

4.3 Advantages to transport layer mobility include inherent route optimization (triangle routes never occur), no dependence
on the concept of a home network or additional infrastructure beyond DHCP and DNS, the possibility of smooth handovers if the mobile node has multiple interfaces, and the ability to pause transmissions in expectation of a mobility-induced temporary disconnection. Since most common applications use TCP, a mobility support extension to TCP has most of the benefit of inheritability that Mobile IP does. [21]

4.4 Problem with a transport layer approach is:

1) The dependence on other layers for location management. For example, if dynamic DNS is employed, it may take quite some time to globally converge to a host's current address, by which time it may be ready for new location to move. [10]
2) Another problem is that if binding update is to be implemented by individual transport protocol, then each one requires an authentication scheme to prevent spoofing. Ensuring the security of each individual authentication scheme could be tedious and error-prone if they are significantly different between transport protocols.

5. At What Layer Does Mobility Belong?

Traditionally the responsibilities for communication have been split amongst various layers in network model but these responsibilities seem to be ill-defined in current scenario of wireless communication [10]. A modification or an added feature in lower layer may cause problem in higher layer. Mobility is one such feature which was not incorporated in the classical protocol stack. If a link layer hands over between two heterogeneous networks, a network layer protocol will likely need to acquire a new address. Similarly when mobility is implemented at the network layer, through Mobile IP, then transport layer protocols deal with problems (new congestion control mechanisms, Security policies etc. In current scenario when heterogeneous network environment exists and the mobile host demands support for multiple interfaces and switching between heterogeneous networks, support for an efficient supportive feature in protocol stack is need of the hour.

6. Conclusion

A significant point is single layer approach to mobility doesn't seems to be adequate specially in the era where concept like Internet of things is being introduced which will connect physical infrastructure get connected over the network adding new dimension to the field of information and communication paradigms[13]. Thus, multilayer cooperation for mobility can be an effective solution. Link layer support is mandatory in any case, but can do very little to either preserve higher layer connections or provide location management when movement is across administrative domains. The common network layer solution is Mobile IP, which while effective, has several limitations in practice. Most of Mobile IP's problems can be tackled by a higher transport or session layer approach. The transport layer approaches to mobility are likely the strongest, despite requiring modifications to well-established protocols like TCP. By deploying mobility-enabled TCP implementations, applications that use TCP may transparently gain mobility support just as they do with Mobile IP, with less potential problems. Although the question of what layer mobility should properly be provided at is largely an open question and many cross layer mobility management techniques [22] are being devised to meet the expectations of end user.

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