



INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

Y.1281

(09/2003)

SERIES Y: GLOBAL INFORMATION
INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS
AND NEXT GENERATION NETWORKS

Internet protocol aspects – Architecture, access, network
capabilities and resource management

Mobile IP services over MPLS

ITU-T Recommendation Y.1281

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ITU-T Recommendation Y.1281

Mobile IP services over MPLS

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Summary

This Recommendation defines service definition and requirements to support mobile IP services through the MPLS network. It also describes the service architecture and application procedures to provide the mobility service over the MPLS network.

Source

ITU-T Recommendation Y.1281 was approved by ITU-T Study Group 13 (2001-2004) under the ITU-T Recommendation A.8 procedure on 13 September 2003.

Keywords

CR-LDP, Home Agent (HA), Foreign Agent (FA), IP-in-IP Tunnel, Label Edge Router (LER), Label Switched Path (LSP), Label Switched Router (LSR), LDP, mobile IPv4, mobile IPv6, MPLS, Quality of Service (QoS), route optimization, RSVP-TE, Smooth Handover, Virtual Private Network (VPN).

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Introduction

This Recommendation defines service definition and requirements to support mobile IP services through the MPLS network. It also describes the service architecture and application procedures to provide the mobility service over the MPLS network.

In the mobile IP network, a node's IP address uniquely identifies the node's point of attachment. Therefore, a mobile node must be located on the network indicated by its IP address in order to receive packets destined to it. Otherwise, packets destined to the mobile node would be undeliverable. In order not to lose its ability to communicate whenever it changes its point of attachment, the mobile node must change its IP address. The IP address of mobile node must be advertised through the entire Internet to receive packets whenever it moves. The link by which a mobile node is directly attached to the Internet may often be a wireless link [7].

Mobile IP is intended to enable nodes to move from one IP subnet to another. This makes mobile IP suitable for mobility across heterogeneous media. If the mobile node moves from one LAN segment to another (e.g., a wireless LAN), the mobile node's IP address remains the same after such a movement in order to receive packets from other nodes. In fact, a mobile node is given a long-term IP address on a home network, the "home" address. This home address is administered in the same way that a "permanent" IP address is provided to a fixed host.

When away from its home network, a "care-of address" is associated with the mobile node and reflects the mobile node's current point of attachment. When away from home, mobile IP uses protocol tunnelling to hide a mobile node's home address to routers between its home network and its current location. The tunnel terminates at the mobile node's care-of address [8]. The care-of address must be an address to which packets can be delivered via conventional IP routing. At the point of care-of address, the original packet is extracted from the tunnel and is delivered to the mobile node.

In the basic mobile IPv4 protocol, there is no direct routing from any correspondent node to any mobile node. Packets need to pass through the mobile node's home network and be forwarded by its home agent, which is called the problem of "triangle routing". To solve this problem, the route optimization capability allows direct routing from any correspondent node to any mobile node [19]. In IPv6 network, IPv6 node caches the binding of a mobile node's home address with its care-of address, and then sends any packets destined to the mobile node directly to this care-of address. To support this operation, mobile IPv6 defines an IPv6 protocol and a destination option [29]. All IPv6 nodes, whether mobile or stationary, support communications with mobile nodes.

From the network provider's point of view, future networks are designed to support network operation and maintenance by guaranteeing acceptable quality of service (QoS) levels and satisfying various service level agreements (SLAs) negotiated with customers. To support future business models, the IP network has to be upgraded to meet the demands placed by real-time and multimedia applications. It then provides various features such as fault tolerance, traffic prioritization, and QoS classes. To meet these requirements over future mobile services, first, the end-to-end performance would be manageable and predictable regardless of whether end users are moving or not. Second, for the mobile IP service, the functions of home agent and foreign agent are positioned after consideration of architectural consequences. Third, the existing and future transport technologies, including an optical one, would be able to support a future mobile world.

In the MPLS network, once a packet is classified according to quality of service, no further header analysis is done by subsequent routers: all forwarding is driven by the labels. This has a number of advantages over conventional IP layer forwarding. The MPLS forwarding can be done by switches which are capable of doing label lookup and replacement at adequate speed and QoS. There is no need to analyze the IP layer headers. Sometimes it is desirable to force a packet to follow a particular route which is explicitly chosen at or before the time the packet enters the network, rather than being chosen by the normal dynamic routing algorithm as the packet travels through the

network. This may be done as a matter of policy, or supporting MPLS traffic engineering. In MPLS, a label can be used to represent this explicit route, which is called a traffic engineered tunnel.

For mobile IP service, the home agent intercepts packets on the home link destined to the mobile IP node's home address, encapsulates them, and tunnels them to the mobile node's registered care-of address via the foreign agent. The foreign agent decapsulates and delivers packets to the mobile IP node.

By combining tunnelling functions of a home agent and a foreign agent into the MPLS forwarding paradigm, the MPLS node is capable of handling the mobile IP node by assigning labels for a tunnel between a home agent and a foreign agent. In this case, the home agent and the foreign agent can be located or attached at a MPLS node, the tunnelling between the home agent and the foreign agent being provided at the MPLS layer. To avoid the problem of triangle routing, the MPLS nodes can allow a direct binding, which is the same with routing optimization of IP layer, from any correspondent node to any mobile IP node by assigning a label.

As far as the support of the MPLS network is concerned, the MPLS network can provide the QoS-enabled and reliable tunnels for mobile IP service for the various sets of service requirements. The MPLS tunnelling capabilities can be implemented at the layer 2 level rather than the layer 3 mobile IP protocol level, then achieving higher service rate and lower overhead during tunnelling operation. Specifically, the MPLS network supporting the mobile IP services has the following features:

- The flow concept of MPLS network provides the connection-oriented virtual channel capability with acceptable quality of service (QoS) levels for transfer delay and loss.
- A direct cut-through tunnel between the mobile node and the correspondent node may be established while the mobile IPv4 protocol does not support it. This can save overall resource consumption and reduce the processing overhead of home agent.
- The binding cache information of the mobile IPv6 protocol can be mapped one-to-one to the MPLS label information table in each MPLS node, without requiring any complex interworking feature.
- If the home agents and/or the foreign agents can be located at the MPLS node, the L3 tunnels between the home agents and the foreign agents can be mapped into the L2 tunnels of the MPLS layer.
- The mobile agents and mobile nodes do not need any knowledge of the MPLS backbone network. This means that the mobile IPv4 and mobile IPv6 nodes do not need to modify their tunnelling procedures through the MPLS backbone network.
- The MPLS network can provide seamless end-to-end connectivity without any performance degradation during handover operations (smooth handover).

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ITU-T Recommendation Y.1281

Mobile IP services over MPLS

1 Scope

The scope of this Recommendation covers:

- Service requirements and definitions for mobile IPv4 and mobile IPv6 services over MPLS;
- Service architecture to support mobile IP service over MPLS;
- LSP tunnelling scenarios to support the mobile IP services over MPLS;
- Application procedures to support the mobile IP services over MPLS.

However, this Recommendation does not cover:

- The detailed signalling protocol and packet formats for tunnel establishment;
- The detailed interworking procedures between the external mobile IP network and the MPLS network including traffic and QoS parameters;
- The mapping and conversion procedures between the IP-in-IP tunnels inside the mobile IP network and the LSP tunnels of the MPLS network;
- Coverage of more than one MPLS administrative domain;
- QoS negotiation procedures between mobile IP nodes and the MPLS network;
- Routing algorithms of MPLS network with mobility support.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

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3 Terms and Definitions

In relation to mobile IPv4, mobile IPv6 and MPLS nodes, this Recommendation defines the following terms.

3.1 agent discovery: Home agents and foreign agents may advertise their availability on each link for which they provide service (that is, Agent Advertisement). A newly arrived mobile node can send a solicitation on the link to learn if any prospective agents are present (that is, Agent Solicitation) [9].

3.2 anchor node: An MPLS node capable of changing the routing path when a better next hop becomes available at some LSR along the LSP during handover time of the mobile node. The anchor node provides the cross-over location from old LSP to new LSP between the correspondent node and the new mobile node's location.

3.3 binding acknowledgement: A binding acknowledgement message is used to acknowledge receipt of a binding update [29].

3.4 binding cache: A cache of mobility bindings of mobile nodes, maintained by a node for use in tunnelling packets to those mobile nodes [29].

3.5 binding update: A message indicating a mobile node's current mobility binding, and in particular its care-of address [22].

3.6 Correspondent Node (CN): A peer with which a mobile node is communicating. A correspondent node may be either mobile or stationary [9].

3.7 Care-of Address (CoA): The termination point of a tunnel toward a mobile node for packets forwarded to the mobile node while it is away from home. The protocol can use two different types of care-of address: a "foreign agent care-of address" is an address of a foreign agent with which the mobile node is registered, and a "colocated care-of address" is an externally obtained local address which the mobile node has associated with one of its own network interfaces [9]. In IPv6, among the multiple care-of addresses that a mobile node may have at any given time (e.g., with different subnet prefixes), the one registered with the mobile node's home agent is called its "primary" care-of address [29].

3.8 Foreign Agent (FA): A router on a mobile node's visited network which provides routing services to the mobile node while registered. The foreign agent detunnels and delivers packets to the mobile node that were tunneled by the mobile node's home agent [9].

3.9 Forwarding Equivalence Class (FEC): A group of IP packets which are forwarded in the same manner (e.g., over the same path, with the same forwarding treatment) [12].

3.10 Gateway Foreign Agent (GFA): Foreign Agent which has a publicly routable IP address [32].

3.11 gateway LER/HA: One or more LER/HAs responsible for a specific administrative domain (defined by network operator), in which the mobile nodes register the current care-of address.

3.12 gateway LER/FA: One or more LER/FAs responsible for a specific administrative domain (defined by network operator).

- 3.13 home address:** An IP address assigned to a mobile node, used as the permanent address of the mobile node. This address is within the mobile node's home link. Standard IP routing mechanisms will deliver packets destined for a mobile node's home address to its home link [29].
- 3.14 Home Agent (HA):** A router on a mobile node's home link with which the mobile node has registered its current care-of address. While the mobile node is away from home, the home agent intercepts packets on the home link destined to the mobile node's home address, encapsulates them, and tunnels them to the mobile node's registered care-of address [29].
- 3.15 IP-in-IP encapsulation:** To encapsulate an IP datagram using IP-in-IP encapsulation, an outer IP header is inserted before the datagram's existing IP header [10], [11].
- 3.16 Layer 2 (L2):** The protocol layer under layer 3 (which therefore offers the services used by layer 3). Forwarding, when done by the swapping of short fixed length labels, occurs at layer 2 regardless of whether the label being examined is an ATM VPI/VCI, a frame relay DLCI, or an MPLS label [12].
- 3.17 Layer 3 (L3):** The protocol layer at which IP and its associated routing protocols operate link layer synonymous with layer 2 [12].
- 3.18 Label Edge Router (LER):** An MPLS node that connects an MPLS domain with a node which is outside of the domain, either because it does not run MPLS, and/or because it is in a different domain [12].
- 3.19 Label Edge Router/Foreign Agent (LER/FA):** An MPLS edge node with functions of foreign agent. It notes that there is no need of foreign agent in IPv6 [LER in IPv6].
- 3.20 Label Edge Router/Home Agent (LER/HA):** An MPLS edge node with functions of home agent.
- 3.21 Label Switched Path (LSP):** The path through one or more LERs/LSRs at one level of the hierarchy followed by packets in a particular FEC [12].
- 3.22 Label Switching Router (LSR):** An MPLS node which is capable of forwarding native L3 packets [12].
- 3.23 Mobility Agent:** Either a home agent or a foreign agent [9].
- 3.24 mobility binding:** The association of a home address with a care-of address, along with the remaining lifetime of that association [9].
- 3.25 MPLS domain:** A contiguous set of nodes which operate MPLS routing and forwarding and which are also in one Routing or Administrative Domain [12].
- 3.26 Mobile Node (MN):** A node that can change its point of attachment from one link to another, while still being reachable via its home address [29].
- 3.27 MPLS egress node or egress LER:** An MPLS edge node in its role of handling traffic as it leaves an MPLS domain [12].
- 3.28 MPLS ingress node or ingress LER:** An MPLS edge node in its role of handling traffic as it enters an MPLS domain [12].
- 3.29 MPLS node:** A node which is running MPLS (e.g., LER and LSR). An MPLS node will be aware of MPLS control protocols, will operate one or more L3 routing protocols, and will be capable of forwarding packets based on labels. An MPLS node may optionally be also capable of forwarding native L3 packets [12].
- 3.30 path extension:** When a mobile node moves and registers with a new foreign agent, IP datagrams for old foreign agent are tunnelled to the mobile node's new care-of-address [29].