Mobile IP

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Outline

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  - Mobile IPv4 Functionality
  - Mobile IPv4 Operation
- Mobile IPv6
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  - PMIPv6 Overview
  - PMIPv6 Operation Flow
  - PMIPv6 Features

Mobile IPv4

(IP Mobility Support for IPv4, RFC 3220)

Why Mobile IP

- Motivation for Mobile IP
  - TCP session needs to keep the same IP address for the life of the session
  - IP needs to change the IP address when mobile node moves to a new place
  - Consider the IP mobility problem as a routing problem
- Requirement for Mobile IP
  - Transparency
  - Compatibility
  - Efficiency and scalability

Mobile IPv4 basics

- Mobile IP Terminology
- Mobile IP Functionality
- Mobile IP Operation

Mobile IP Terminology

- Mobile Node
  - A host or router that changes its point of attachment from one network or sub network to another
- Home Agent
  - A router on a mobile node's home network which tunnels datagram for delivery to the mobile node when it is away from home, and maintains current location information for the mobile node.
- Foreign Agent
  - A router on a mobile node's visited network which provides routing services to the mobile node while registered

Mobile IP Terminology (Cont'd)

- Care-of Address
  - The termination point of a tunnel toward a mobile node, for datagram forwarded to the mobile node while it is away from home
- Correspondent Node
  - A peer with which a mobile node is communicating
- Foreign Network
  - Any network other than the mobile node's Home Network
- Home Address
  - An IP address that is assigned for an extended period of time to a mobile node

Mobile IP Terminology (Cont'd)

- Home Network
  - A network, possibly virtual, having a network prefix matching that of a mobile node's home address
- Mobility Binding
  - The association of a home address with a care-of address, along with the remaining lifetime of that association
- Mobility Agent
  - Either a home agent or a foreign agent
- Tunnel
  - The path followed by a datagram while it is encapsulated

Mobile IP Functionality

- Combination of 3 separable mechanisms:
  - Discovering the care-of address
  - Registering the care-of address
  - Tunneling to the care-of address

Discovering the care-of address

- Discovery process built on top of an existing standard protocol: router advertisement (RFC 1256)
- Router advertisements extended to carry available care-of addresses called: agent advertisements
- Foreign agents (and home agents) send agent advertisements periodically
- A mobile host can choose not to wait for an advertisement, and issue a solicitation message
- Foreign agents send advertisements to advertise available care-of addresses

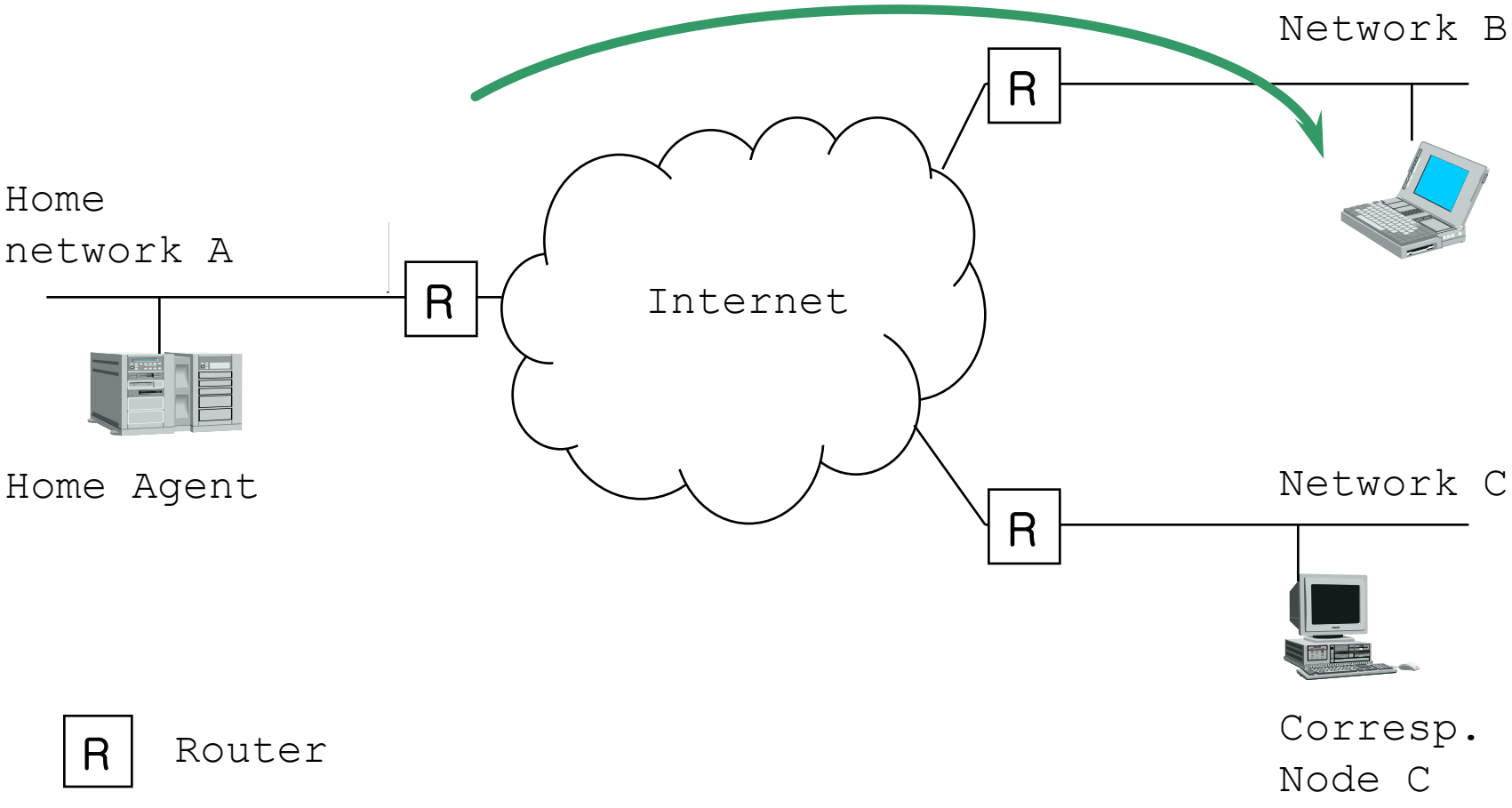
Registering the care-of address

- Once mobile host receives care-of address, it registers it with the home agent
- A registration request is first sent to the home agent (through the foreign agent)
- Home agent then approves the request and sends a registration reply back to the mobile host

Tunneling to the care-of address

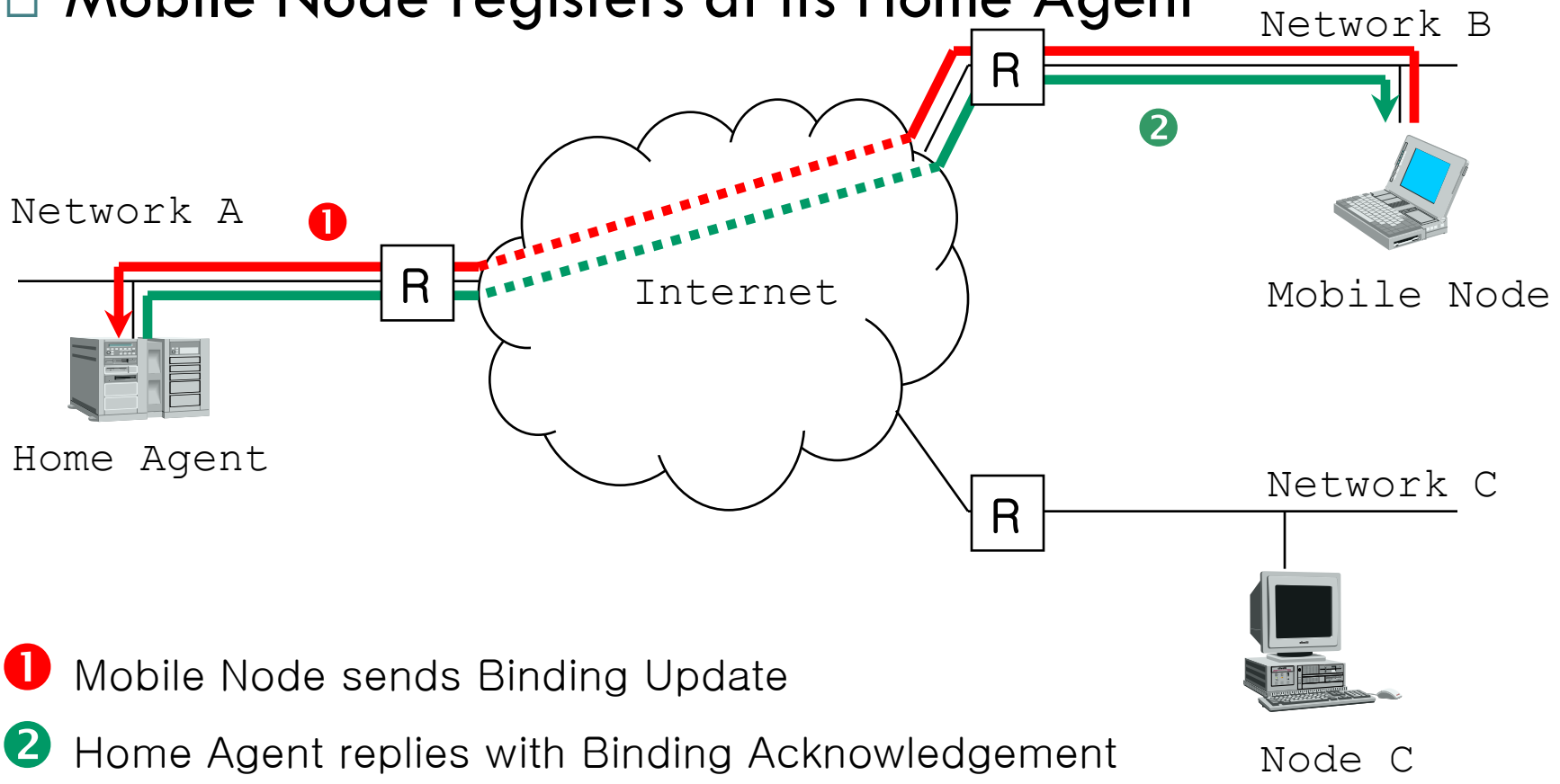
- Forward Tunnel:
  - Starts at the home agent, and ends at the mobile node's care-of-address.
- Reverse Tunnel:
  - Starts at the mobile node's care-of address and terminates at the home agent.

Mobile IP Operation



Mobile IP Operation

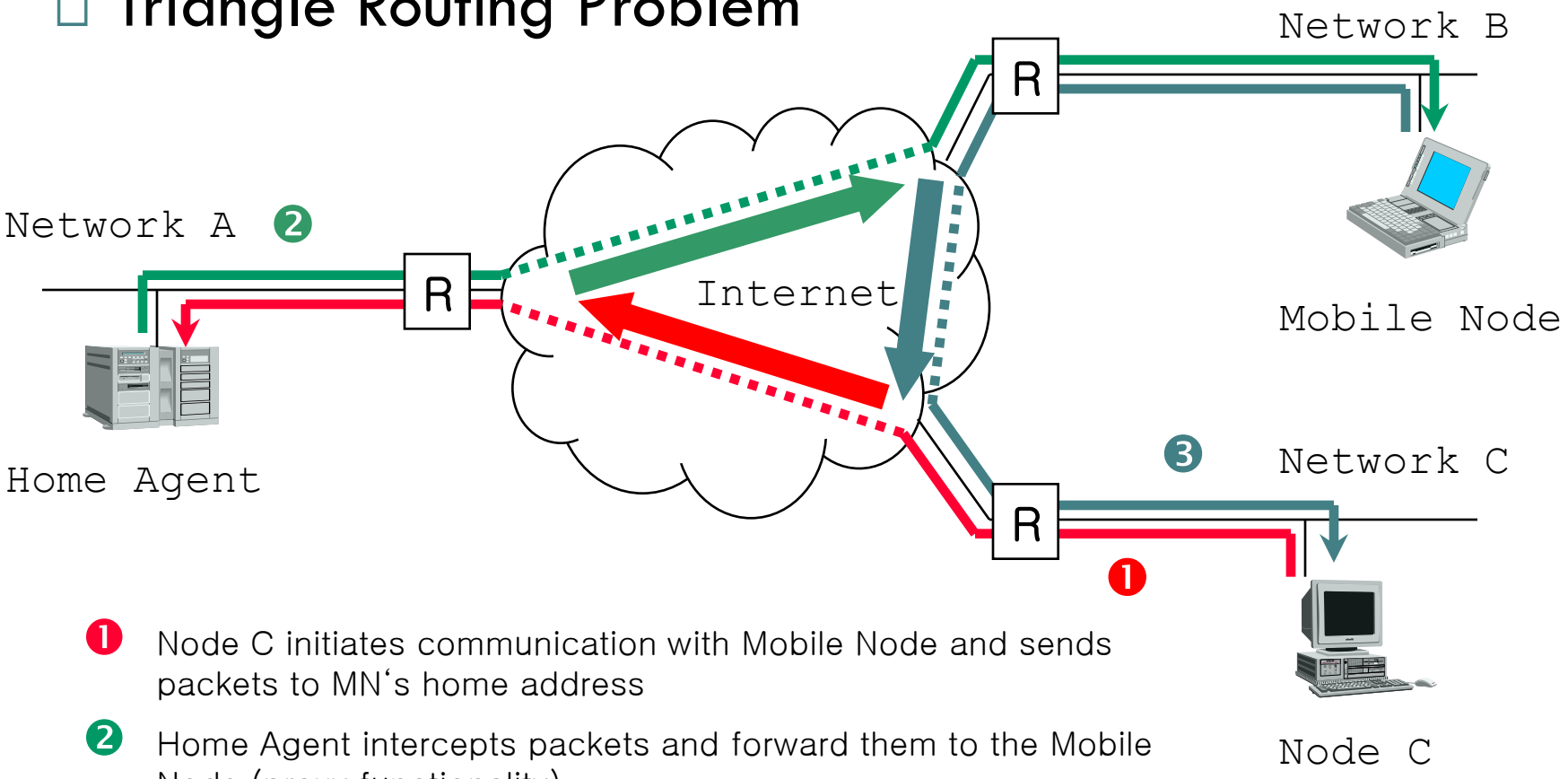
- Mobile Node registers at its Home Agent



1. Mobile Node sends Binding Update
2. Home Agent replies with Binding Acknowledgement

Mobile IP Operation

- Triangle Routing Problem



1. Node C initiates communication with Mobile Node and sends packets to MN's home address
2. Home Agent intercepts packets and forward them to the Mobile Node (proxy functionality)
3. Mobile Node replies directly to Node C

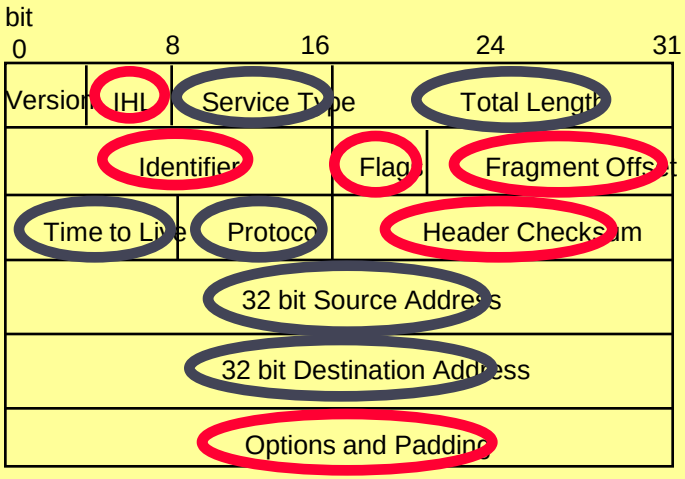
Mobile IPv6

(Mobility Support in IPv6, RFC 3775)

IPv6

- Sufficient Address Space
- IPv6:128 bits, IPv4: 32bits
- Fixed IP Header + Extension Header
- faster processing by routers
- Address Auto-configuration
- Address Renumbering

IPv6 Header Comparison with IPv4

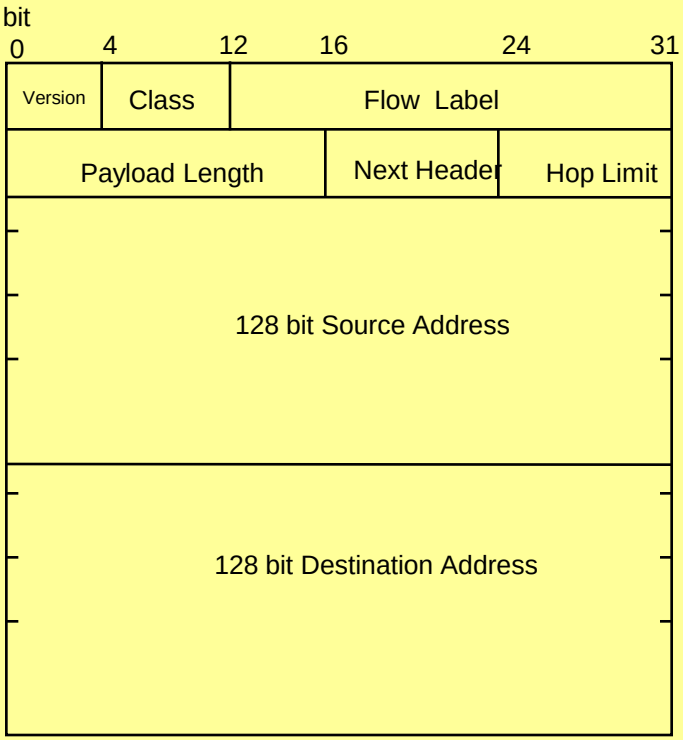


IPv4 Header

20 octets, 12 fields, including 3 flag bits
+ fixed max number of options

Changed

Removed



IPv6 Header

40 octets, 8 fields
+ Unlimited Chained Extension (options) Header

Introduction to Mobile IPv6

- C. Perkins et al., "Mobility Support in IPv6", RFC 3775, June 2004.
- Mobile IPv6 is intended to enable IPv6 nodes to move from one IP network to another
- Mobile Node can be contacted using it's home address regardless of it's current point of attachment to the internet

Mobile IP Terminology

- Home Address
  - A unicast routable 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.
- care-of address
  - A unicast routable address associated with a mobile node while visiting a foreign link; the subnet prefix of this IP address is a foreign subnet prefix.
- Home Agent
  - 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.

Mobile IP Terminology

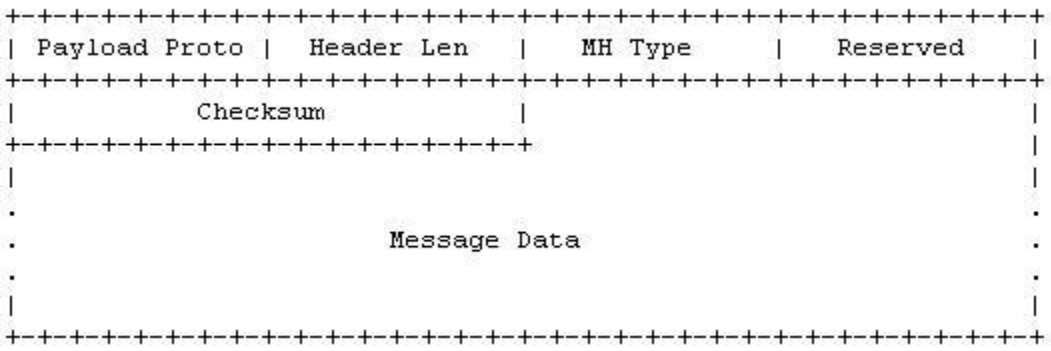
- Binding
  - The association of the home address of a mobile node with a care-of address for that mobile node, along with the remaining lifetime of that association.
- registration
  - The process during which a mobile node sends a Binding Update to its home agent or a correspondent node, causing a binding for the mobile node to be registered
- Return routability procedure
  - The return routability procedure authorizes registrations by the use of a cryptographic token exchange.

Basic Mobile IPv6 Messages

- All messages used in MIPv6 are defined as IPv6 options
  - Binding update:
    - used by MN to inform HA or CN about its CoA
  - BU acknowledge:
    - ACK of BU, if been requested
  - Binding request:
    - used by any node to request a MN to send BU

Basic Mobile IPv6 Messages

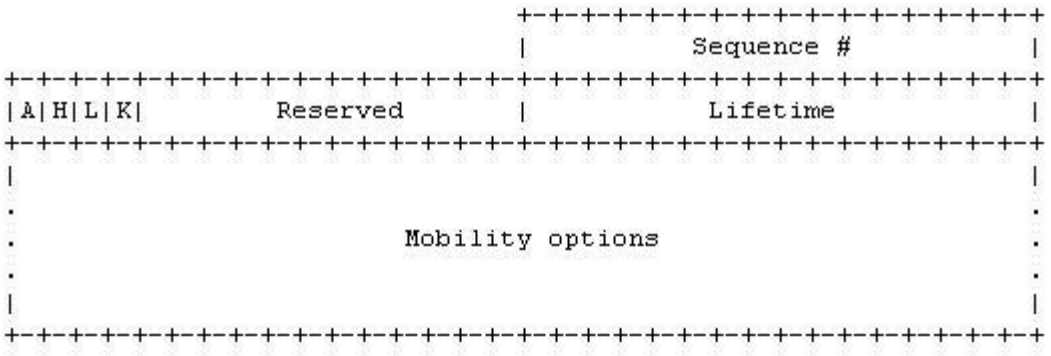
- Mobility Header Format



  - Next Header value: 135
  - Payload Proto: uses the same values as the IPv6 Next Header field
  - MH Type: identifies the particular mobility message

Basic Mobile IPv6 Messages

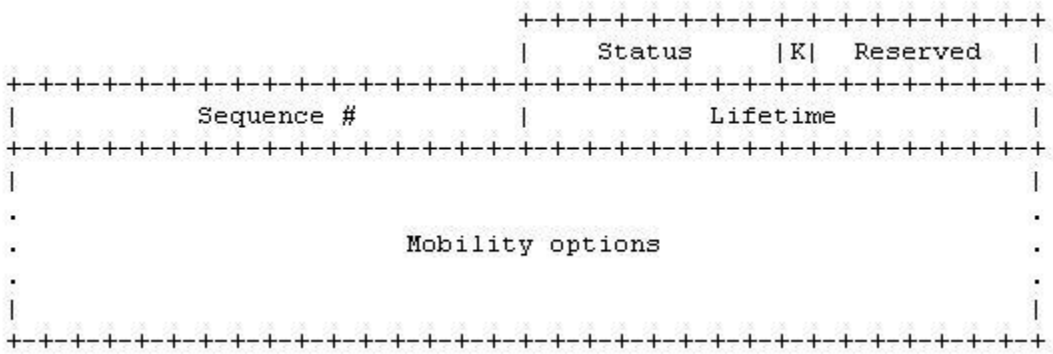
- Binding Update Format



- MH type value : 5
- A: The Acknowledge (A) bit is set by the sending mobile node to request a Binding Acknowledgement
- H: The Home Registration (H) bit s set by the sending mobile node to request that the receiving node should act as this node's home agent
- L: The Link-Local Address Compatibility (L) bit is set when the home address reported by the mobile node has the same interface identifier as the mobile node's link-local address
- K: If this bit is cleared, the protocol used for establishing the IPsec security associations between the mobile node and the home agent does not survive movements

Basic Mobile IPv6 Messages

- Binding Acknowledgement Format



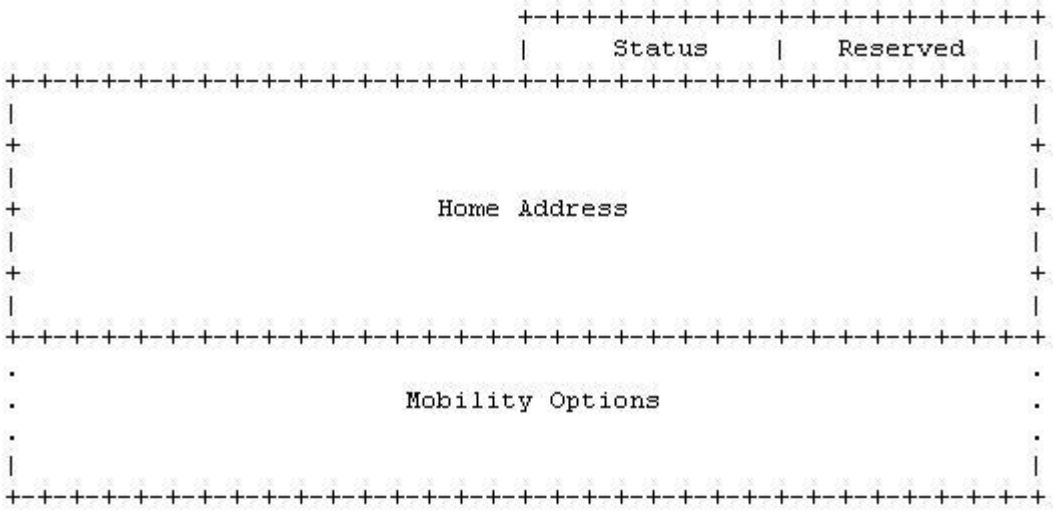
  - MH type value : 6
  - Key Management Mobility Capability (K)
    - If this bit is cleared, the protocol used by the home agent for establishing the IPsec security associations between the mobile node and the home agent does not survive movements.
  - Correspondent nodes MUST set the K bit to 0.

Basic Mobile IPv6 Messages

- Binding Acknowledgement Format
  - Status : 8-bit unsigned integer indicating the disposition of the Binding Update
    - 0 : Binding Update accepted
    - 1: Accepted but prefix discovery necessary
    - 128: Reason unspecified
    - 129 : Administratively prohibited
    - 130: Insufficient resources
    - 131: Home registration not supported
    - 132: Not home subnet
    - 133: Not home agent for this mobile node
    - 134: Duplicate Address Detection failed
    - 135 : Sequence number out of window
    - 136: Expired home nonce index
    - 137: Expired care-of nonce index
    - 139: Registration type change disallowed

Basic Mobile IPv6 Messages

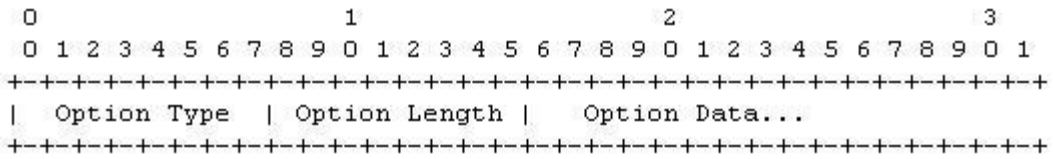
- Binding Error Format



  - MH type value : 7
  - status
    - 8-bit unsigned integer indicating the reason for this message
    - 1: Unknown binding for Home Address destination option
    - 2 :Unrecognized MH Type value

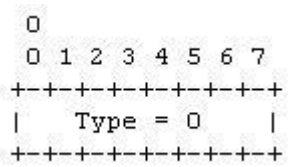
Mobility Option

- Mobility messages can include zero or more mobility options. This allows optional fields that may not be needed in every use of a particular Mobility Header, as well as future extensions to the format of the messages
- Format

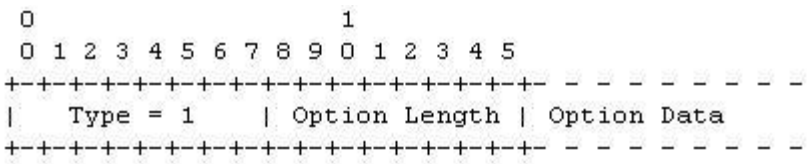


Mobility Option

- Pad1 option
  - The Pad1 option is used to insert one octet of padding in the Mobility Options area of a Mobility Header
  - Format

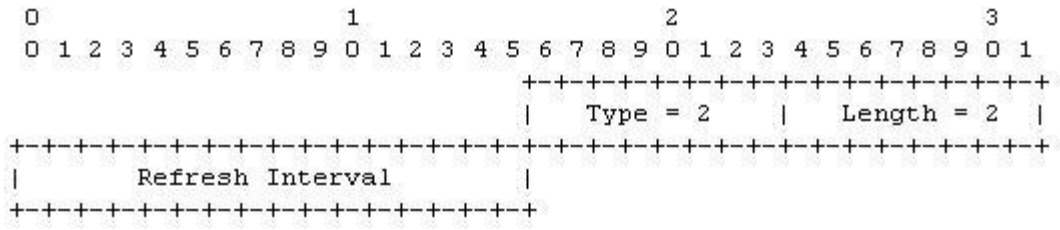


- PadN option
  - The PadN option is used to insert two or more octets of padding in the Mobility Options area of a mobility message



Mobility Option

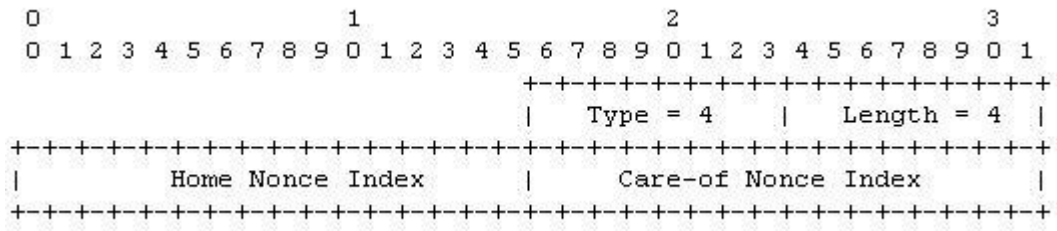
- Binding Refresh Advice



  - The Binding Refresh Advice option is only valid in the Binding Acknowledgement, and only on Binding Acknowledgements sent from the mobile node's home agent in reply to a home registration. The Refresh Interval is measured in units of four seconds, and indicates remaining time until the mobile node SHOULD send a new home registration to the home agent. The Refresh Interval MUST be set to indicate a smaller time interval than the Lifetime value of the Binding Acknowledgement.

Mobility Option

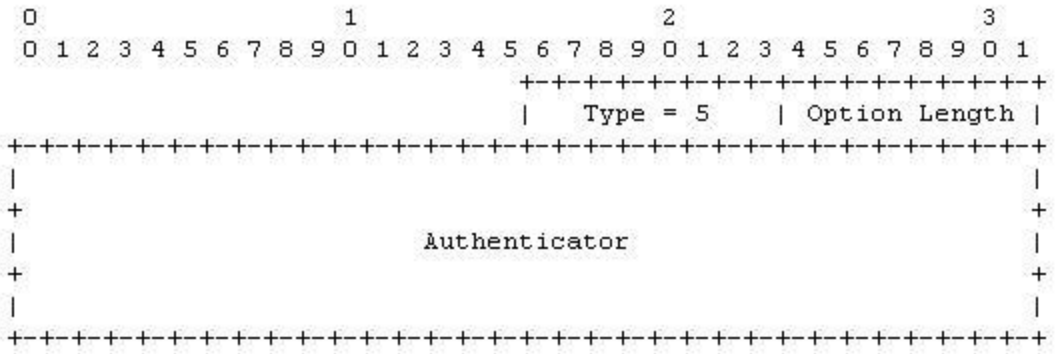
- Nonce Indices



- The Nonce Indices option is valid only in the Binding Update message sent to a correspondent node, and only when present together with a Binding Authorization Data option. When the correspondent node authorizes the Binding Update, it needs to produce home and care-of keygen tokens from its stored random nonce values
- The Home Nonce Index field tells the correspondent node which nonce value to use when producing the home keygen token.
- The Care-of Nonce Index field is ignored in requests to delete a binding. Otherwise, it tells the correspondent node which nonce value to use when producing the care-of keygen token.

Mobility Option

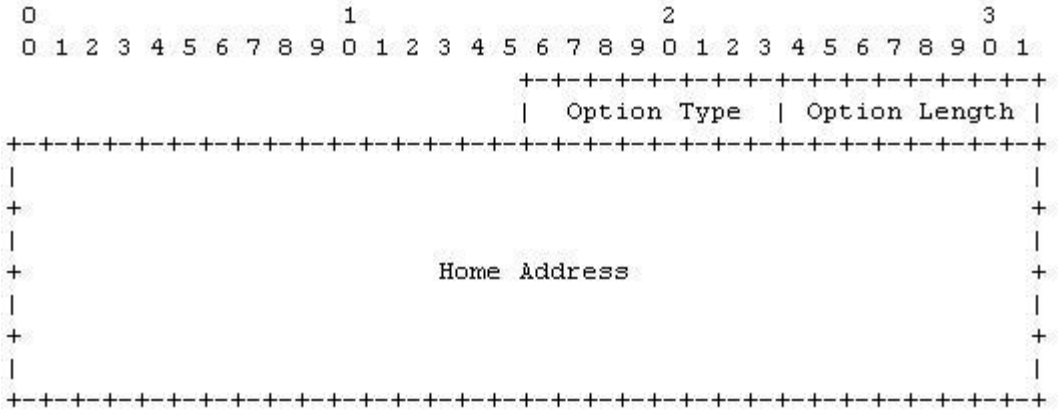
- Binding Authorization Data



- The Binding Authorization Data option is valid in the Binding Update and Binding Acknowledgement.
- The Authenticator field contains a cryptographic value which can be used to determine that the message in question comes from the right authority. Rules for calculating this value depends on the used authorization procedure.

Mobility Option

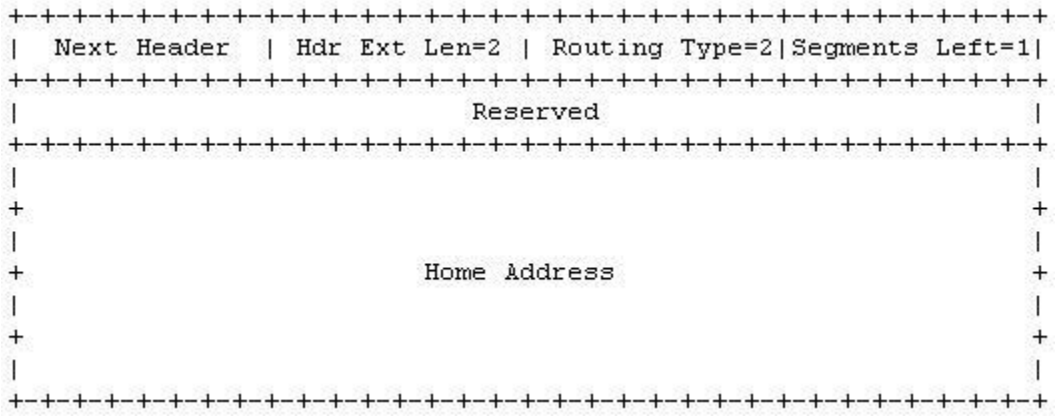
- Home Address Option



  - The Home Address option is carried by the Destination Option extension header (Next Header value = 60). It is used in a packet sent by a mobile node while away from home, to inform the recipient of the mobile node's home address.
  - Home Address
    - The home address of the mobile node sending the packet. This address MUST be a unicast routable address.

Mobility Option

- Type 2 Routing Header



  - The type 2 routing header, to allow the packet to be routed directly from a correspondent to the mobile node's care-of address
  - The mobile node's care-of address is inserted into the IPv6 Destination Address field. Once the packet arrives at the care-of address, the mobile node retrieves its home address from the routing header, and this is used as the final destination address for the packet.

Data Structure

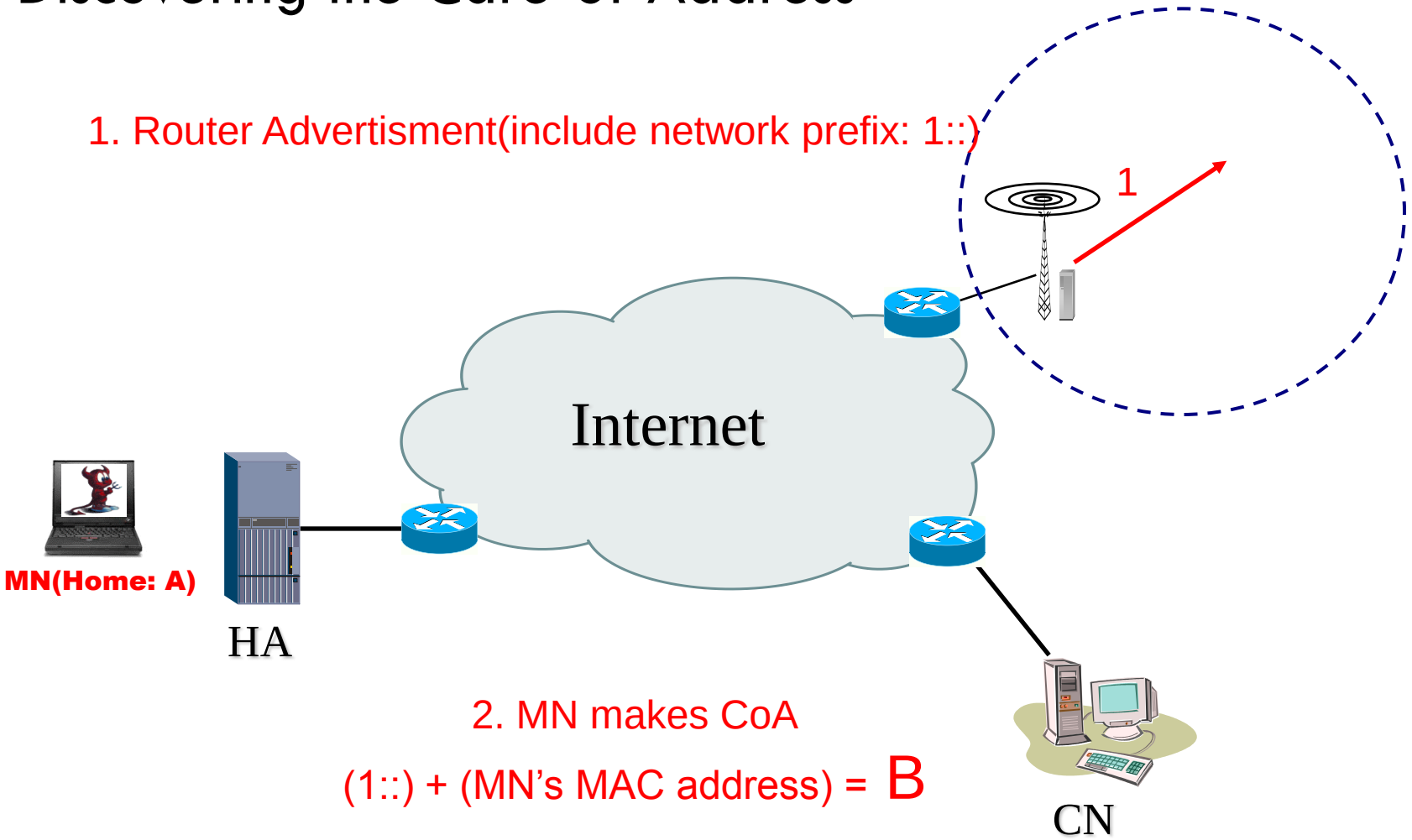
- Three conceptual data structures
  - Binding Cache:
    - used by any node to hold bindings for other nodes
  - Binding Update list:
    - used by MN to store Binding Updates sent by itself
  - Home Agent List:
    - maintained by HAs and the information is learn from Router Advertisement sent by all HAs on the home link using Dynamic Home Agent Address Discovery

Mobile IPv6 Operation

- Mobile IPv6 operation can be divided in to 3 parts
  - Discovering the Care-of Address
  - Registering the Care-of Address
  - Tunneling to the Care-of Address

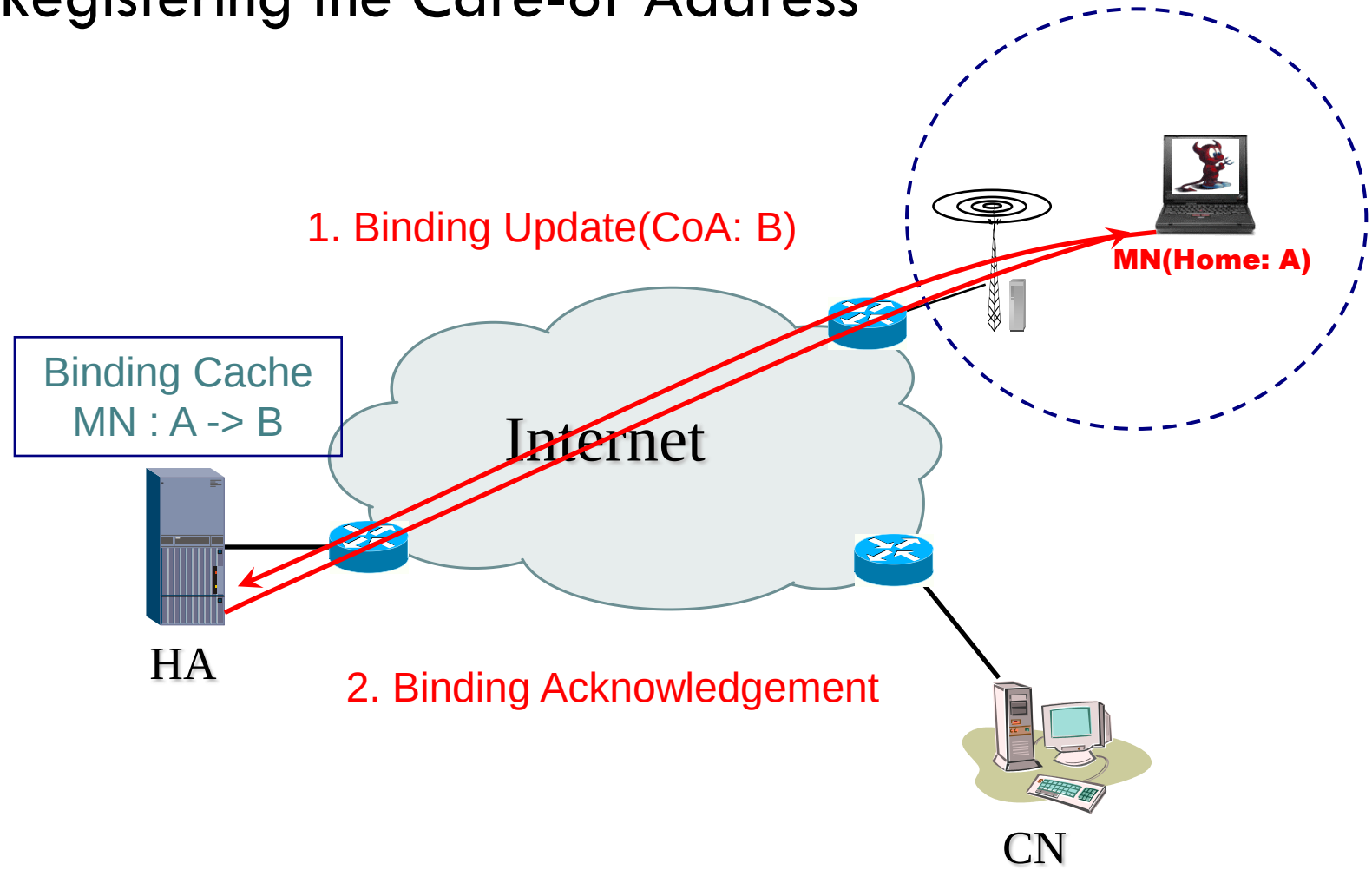
Mobile IPv6 Operation

- Discovering the Care-of Address



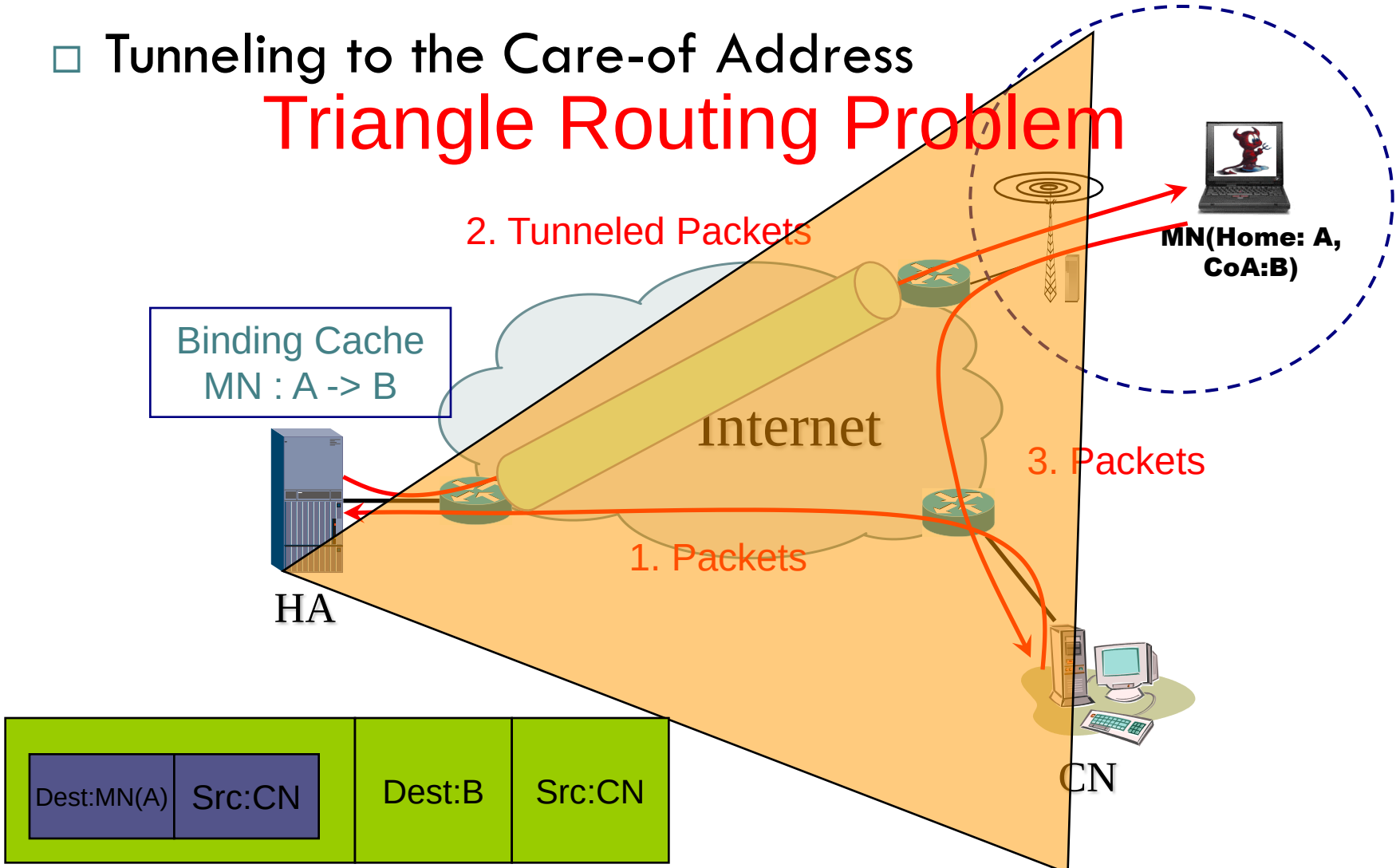
Mobile IPv6 Operation

- Registering the Care-of Address



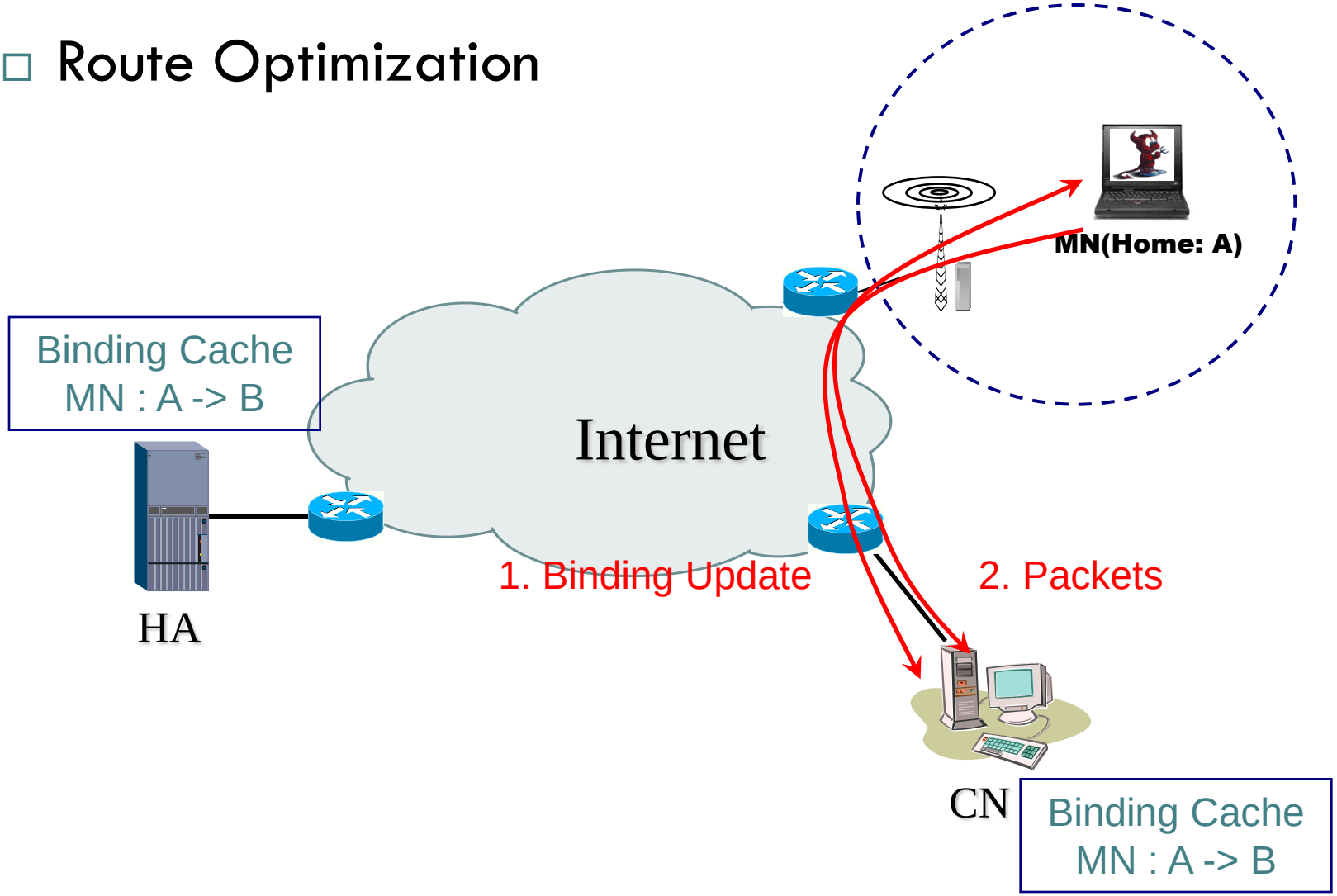
Mobile IPv6 Operation

- Tunneling to the Care-of Address



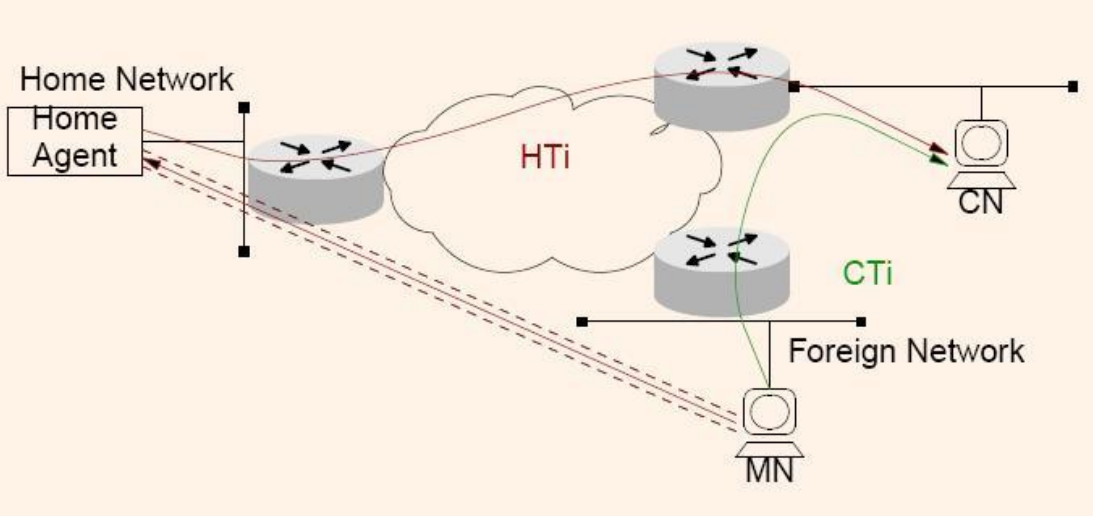
Mobile IPv6 Operation

- Route Optimization



Mobile IPv6 Operation

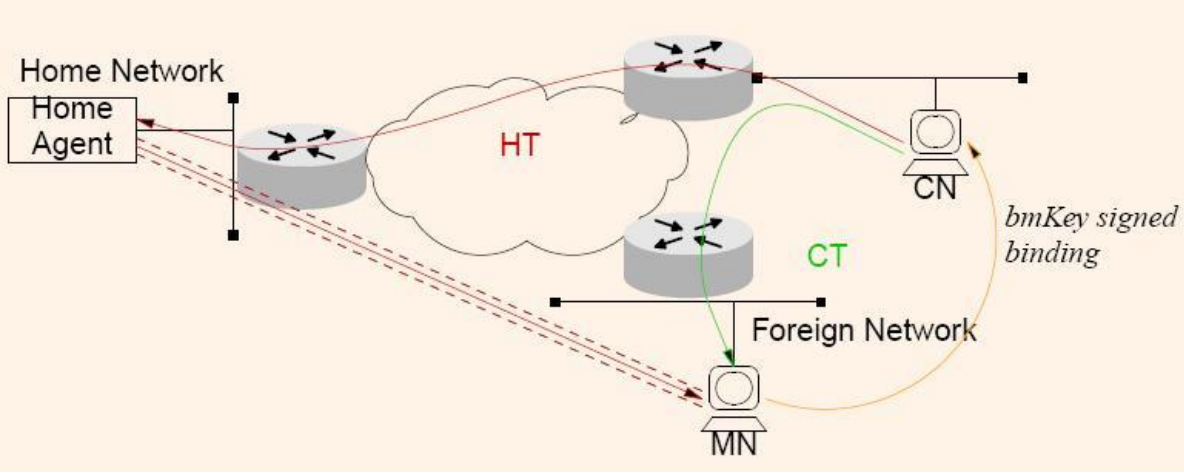
Return Routability Procedure (1)



- MN sends two messages with a cookie to CN
  - Home Test init(Hti) is send via HA
  - Care-of Test init(Cti) is send directly to CN
- CN uses pre-generated key and nonce to build two keygen tokens(Key: random number of 20 octests, Nonce: random octet string of any length)
  - Home keygentok := FIRST (64, HMAC_SHA1 (key, (HoA | nonce | “0”)))
  - Care-of keygentok := FIRST (64, HMAC_SHA1 (key, (CoA | nonce | “1”)))

Mobile IPv6 Operation

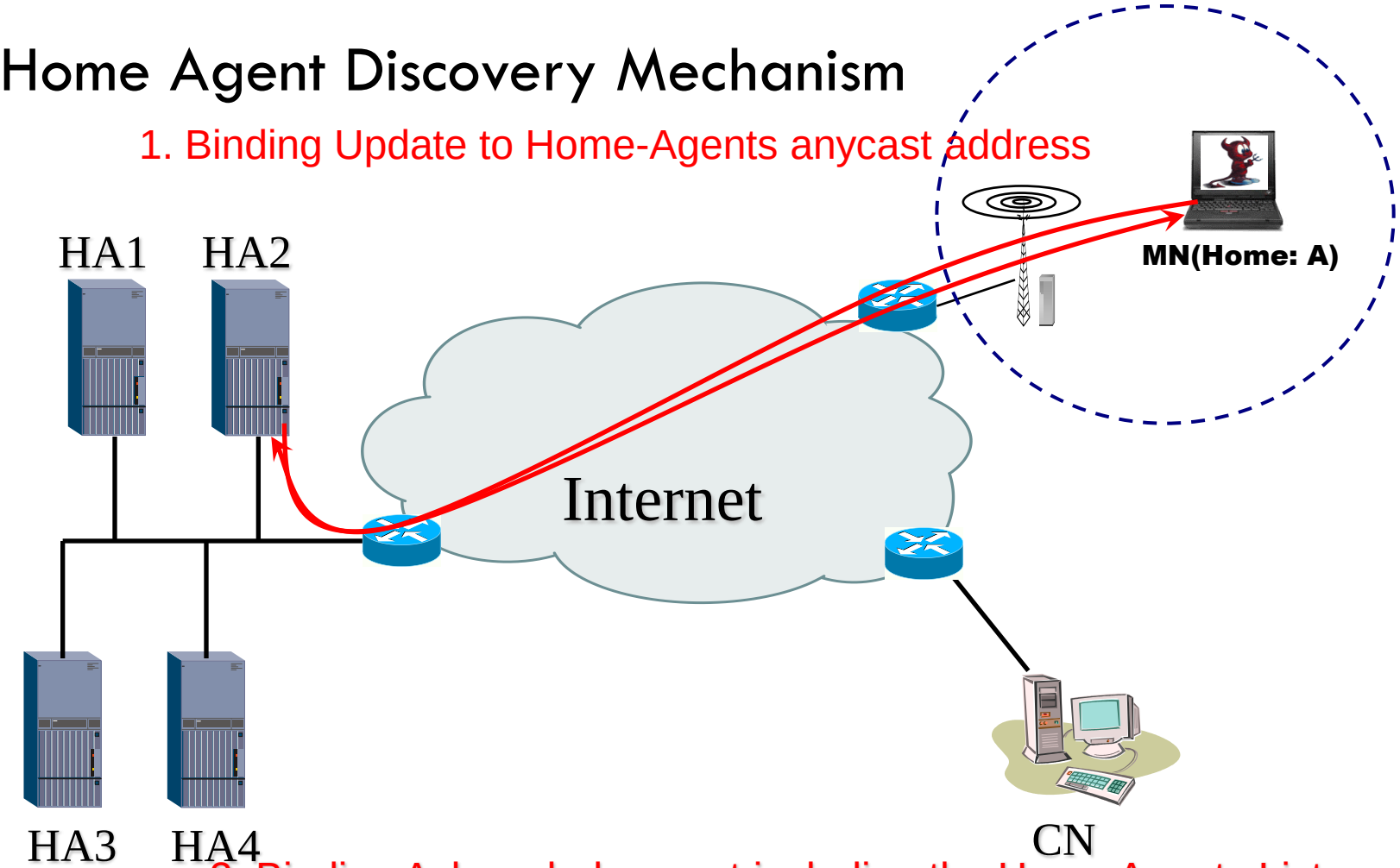
Return Routability Procedure (2)



- CN sends keygen tokens and cookies back to MN
  - Home Test(HT) and Care-of Test(CT) messages
- MN builds binding message key
  - bmKey := SHA (home keygen token|care-of keygen token)
- MN sends binding update message signed with bmKey
- CN can proof that the MN is reachable via both paths

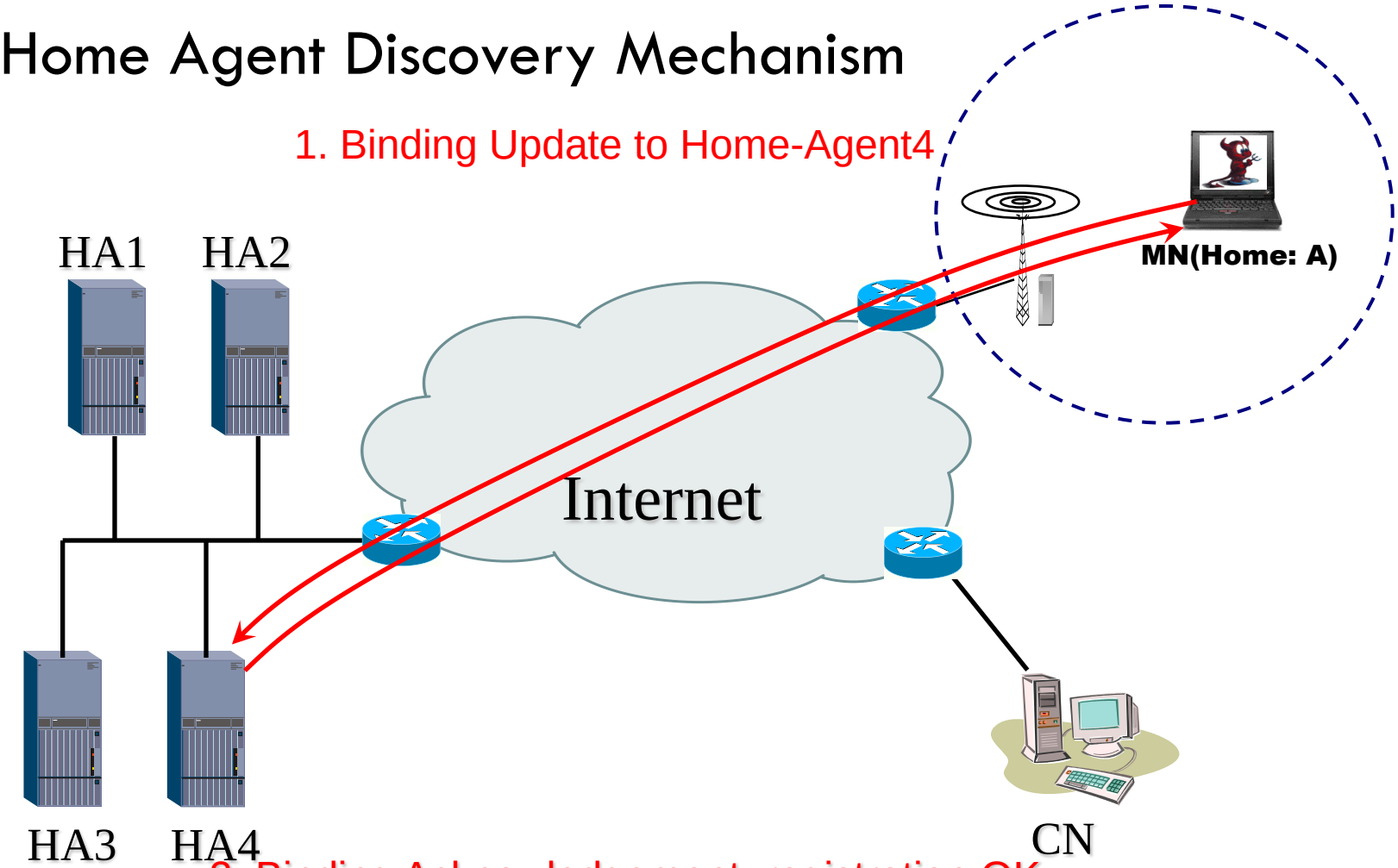
Mobile IPv6 Operation

- Home Agent Discovery Mechanism



Mobile IPv6 Operation

- Home Agent Discovery Mechanism



Mobile IPv6 Handover

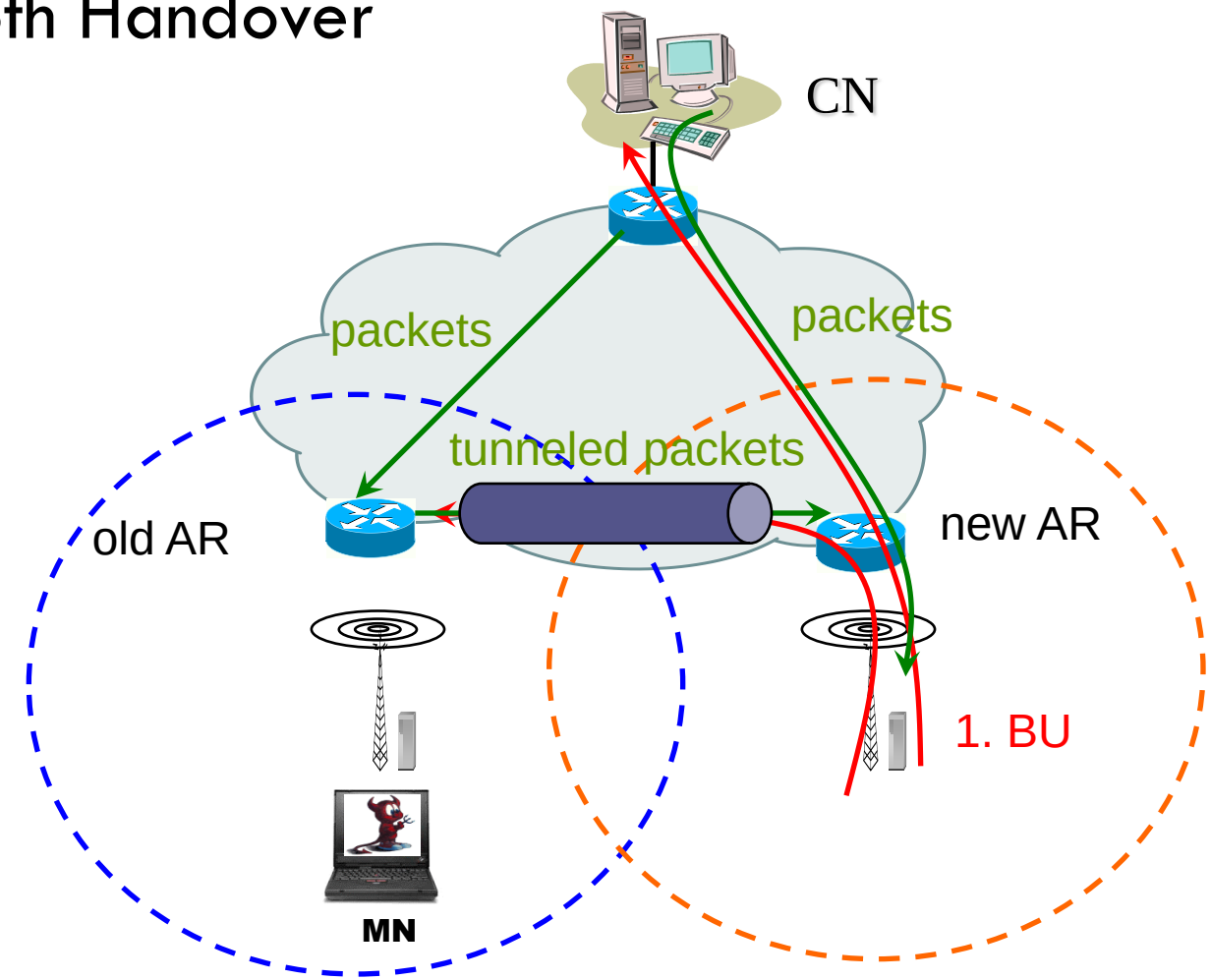
- What is a Handover?
  - Handover is the mechanism by which an ongoing connection between a Mobile Host and corresponding Access Point is transferred from Access Point to another
- When does handover occur?
  - Cell boundary crossing.
  - Weak Signal Reception.
  - Deteriorated QoS in the current cell.

Mobile IPv6 Handover

- Three kinds of handover operations
  - Smooth Handover
    - low loss
  - Fast Handover, Hierarchical Mobile IPv6
    - low delay
  - Seamless Handover
    - Both Hierarchical and Fast Handover

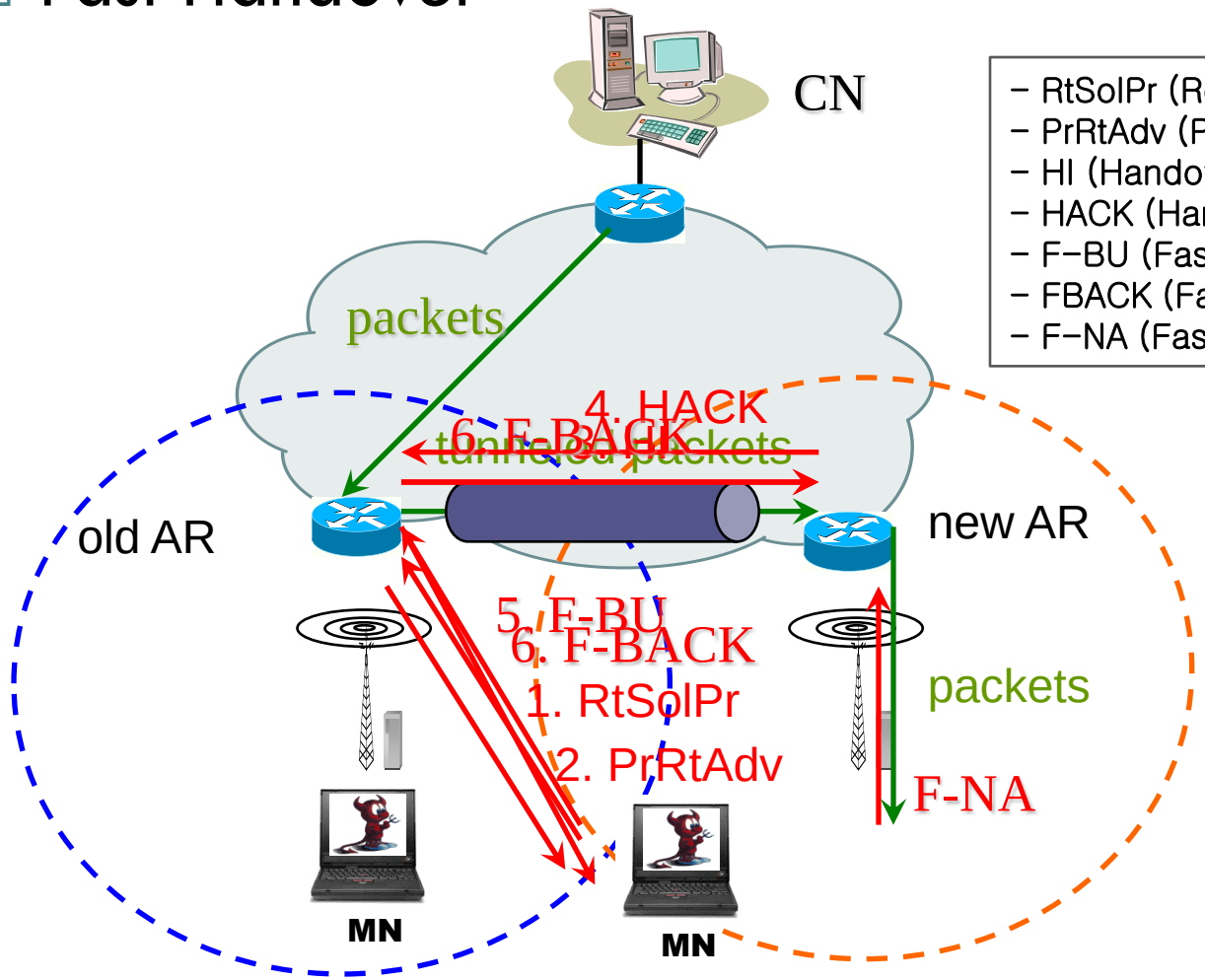
Mobile IPv6 Handover

- Smooth Handover



Mobile IPv6 Handover

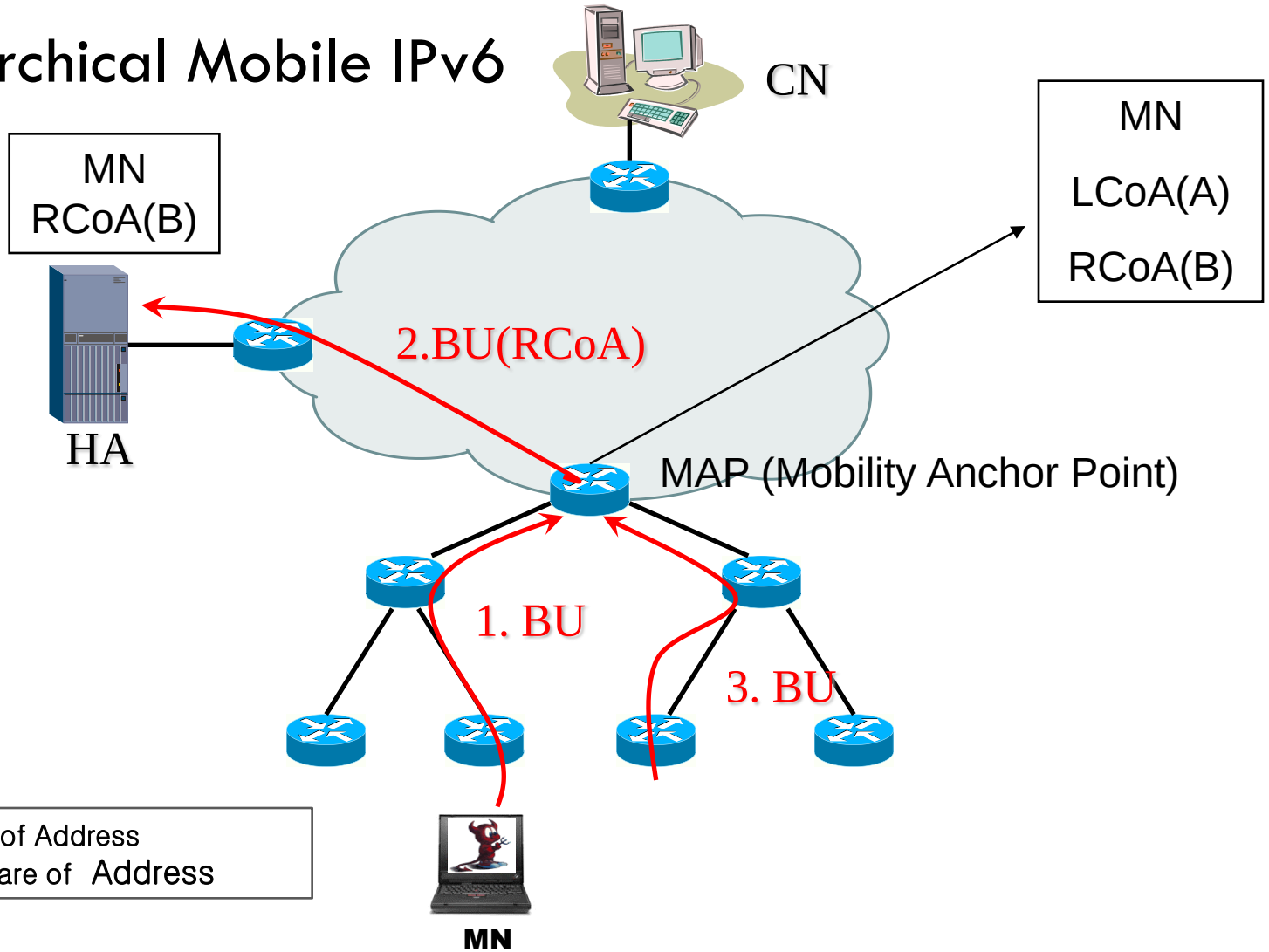
- Fast Handover



- RtSolPr (Router Solicitation for Proxy
- PrRtAdv (Proxy Router Advertisement)
- HI (Handoff Initiate)
- HACK (Handoff Acknowledgment)
- F-BU (Fast Binding Update)
- FBACK (Fast Binding Acknowledgement)
- F-NA (Fast Neighbor Advertisement)

Mobile IPv6 Handover

- Hierarchical Mobile IPv6

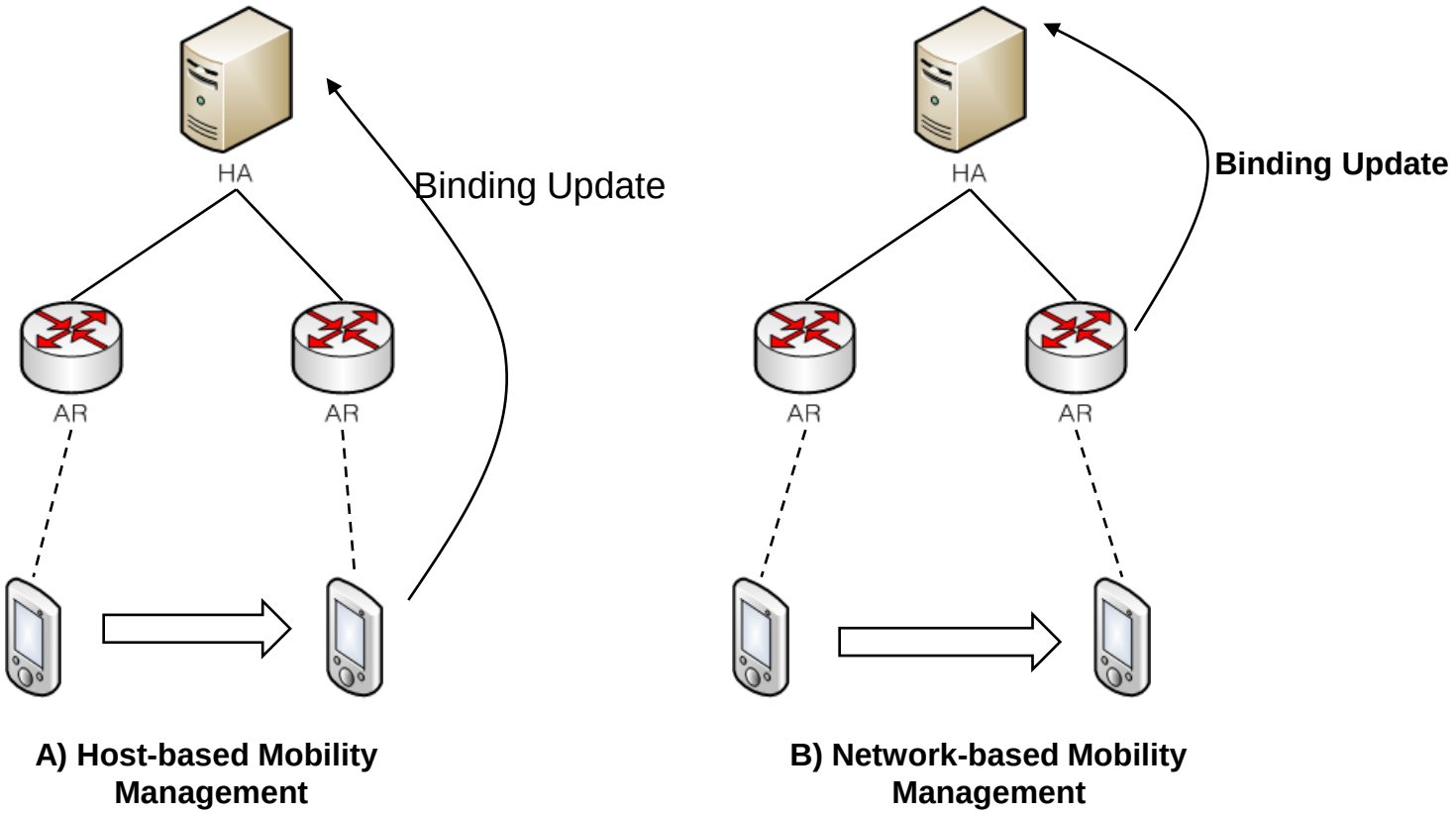


-LCoA: Local Care of Address
-RCoA: Regional Care of Address

Proxy Mobile IPV6 (PMIPv6)

- IETF NetLMM WG History
- Internet Drafts of PMIPv6
- Goal of PMIPv6
- PMIPv6 Overview
- PMIPv6 Operation Flow
- PMIPv6 Features

Background



A) Host-based Mobility Management

B) Network-based Mobility Management

Background

- Host-based Mobile IPv4/v6 (RFC 3344/3775) has not been yet deployed that much.
  - Why host-based MIP is not deployed yet?
    - Too heavy specification to be implemented at a small terminal
      - RFC 3344 (MIPv4): 99 pages
      - RFC 3775 (MIPv6): 165 pages
    - Battery problem
    - Waste of air resource
  - No Stable MIPv4/v6 stack executed in Microsoft Windows OS
- 3GPP, 3GPP2 and WiMAX operators are now showing their STRONG interests for network-based IP mobility solution
  - They are even now deploying their non-standardized network-based IP mobility solution (not Mobile IPv4/v6!).

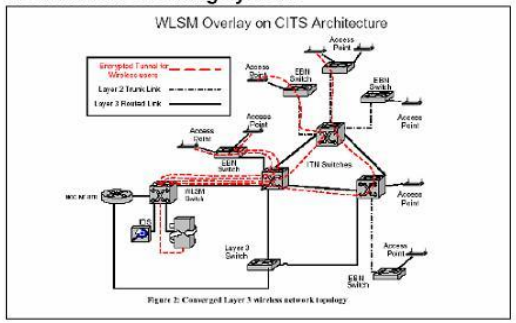
Background

- WLAN switch device starts to provide link specific and proprietary solution for IP handover.
  - No change in MN protocol stack required!

Telos Secure Wireless

Layer 3 Roaming Solution

Telos' Wireless LAN Services Module (WLSM) Solution provides the industry's fastest secure network-wide roaming system.



The demand for a converged Layer 3 wireless network has grown for enterprise wide wireless network configurations, and Telos has responded with the Telos Layer 3 Roaming Solution. The solution consists of a Wireless LAN Services Module (WLSM) hardware bundle that includes a Cisco 6503 chassis, power supplies, and Supervisor Engine 720. The WLSM supports up to 6,000 users and 300 access points unifying wireless and wireline networks.

Now transitioning to a Layer 3 core is easier than ever. The Telos Layer 3 Roaming Solution includes the installation services to get your Layer 3 wireless network up and running and the documentation to maintain it. Cisco-certified Telos engineers will install and configure the components to allow your clients to transparently roam from one access point to another without losing connectivity. The solution works by tunneling traffic from the access point to the WLSM through your Layer 3 core network. No changes to the client devices or the underlying infrastructure are required.

Telos Layer 3 Roaming Solution allows wireless clients to roam seamlessly between subnets

Some of the first wireless network implementations were architected with dedicated Layer 2 trunking to provide roaming across multi-subnets. As backbone wired network technology evolved, the core system architecture migrated from Layer 2 trunking to Layer 3 routing in order to improve speed and efficiency of the wired network. This migration has prevented the successful implementation of new secure wireless networks and caused fielded Layer 2 wireless networks to no longer function seamlessly.

The demand for a converged Layer 3 wireless network has grown for enterprise wide wireless network configurations, and Telos has responded with the Telos Layer 3 Roaming Solution, which offers:

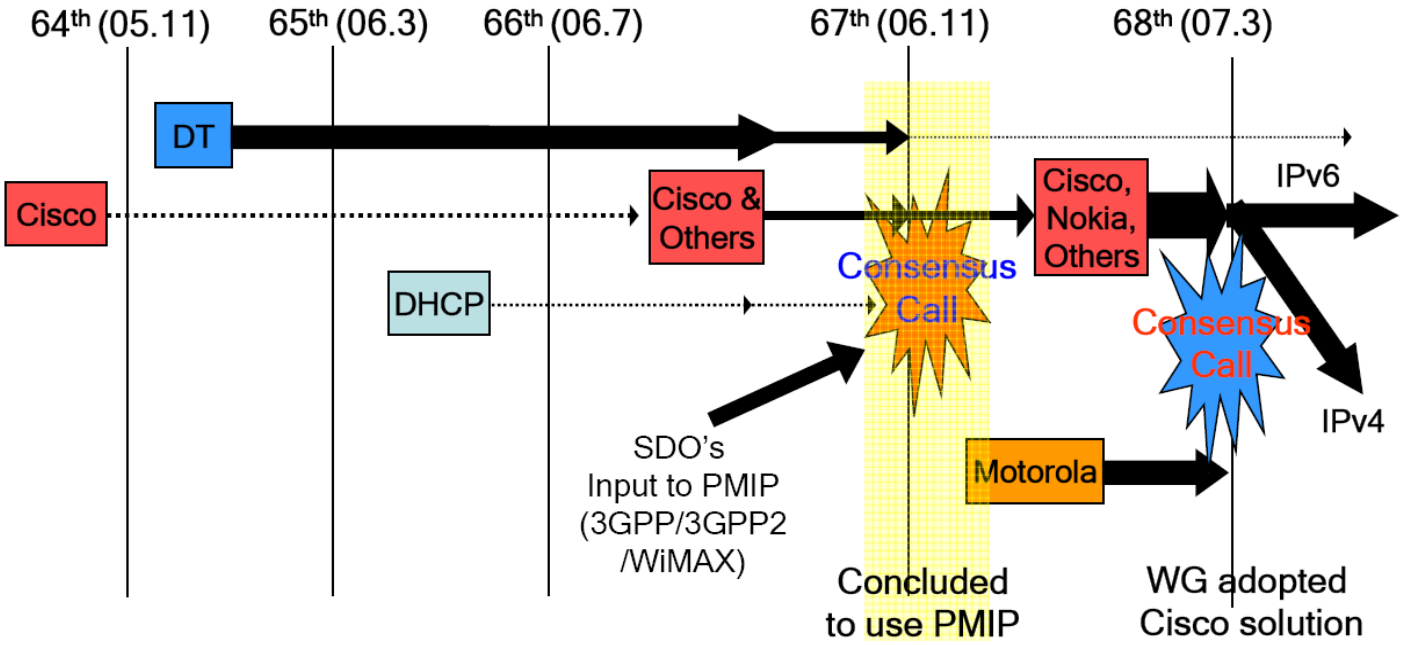
- Secure, seamless roaming throughout your coverage area without worrying about dropped connections
- Single sign-on for laptops, scanners, handhelds, PDAs, and other client devices
- Assured identity of APs verifies the identity of all users and equipment within the wireless enclave
- Solid security from the access point to the network core
- Extension of secure wireless network capabilities anywhere within your enterprise
- Management of all APs from a central application

The solution works by tunneling traffic from the access point to the WLSM through your Layer 3 core network. No changes to the client devices or the underlying infrastructure are required

Background

- IETF NetLMM WG started to standardize a network-based mobility management protocol.
  - 63th IETF (2005.7)
    - The first NetLMM BoF
  - 64th IETF (2005.11)
    - The second NetLMM BoF
  - 65th IETF (2006.03)
    - The first NetLMM WG
  - 66th,67th,68th IETF (2006.07, 2006.11, 2007.03)
    - The one of very active WGs in IETF meetings
    - Almost 150~200 persons usually participates in the NetLMM WG
    - Proxy Mobile IPv6 (PMIPv6) adopted as WG item
  - 69th IETF (2007.07)
    - PMIPv6-01 introduced
    - Other issues brought up
      - Route optimization, Fast Handover, MIPv6 interaction, Multi-homing, etc.

IETF NetLMM WG History



- NetLMM DT solution (draft-giaretta-netlmm-dt-protocol) : designed from the scratch
- Cisco's solution (draft-ietf-netlmm-proxymip6) : Proxy Mobile IPv6 (leverage MIPv6)
- Motorola's solution (draft-singh-netlmm-protocol)
- WG Chair (James Kempf, NTT) resigned after 67th meeting → Vidya Narayanan (Qualcomm)
- WG Chair (Phil Roberts, Motorola) resigned after 68th meeting → Jonne Soininen (Nokia)

Internet Drafts of PMIPv6

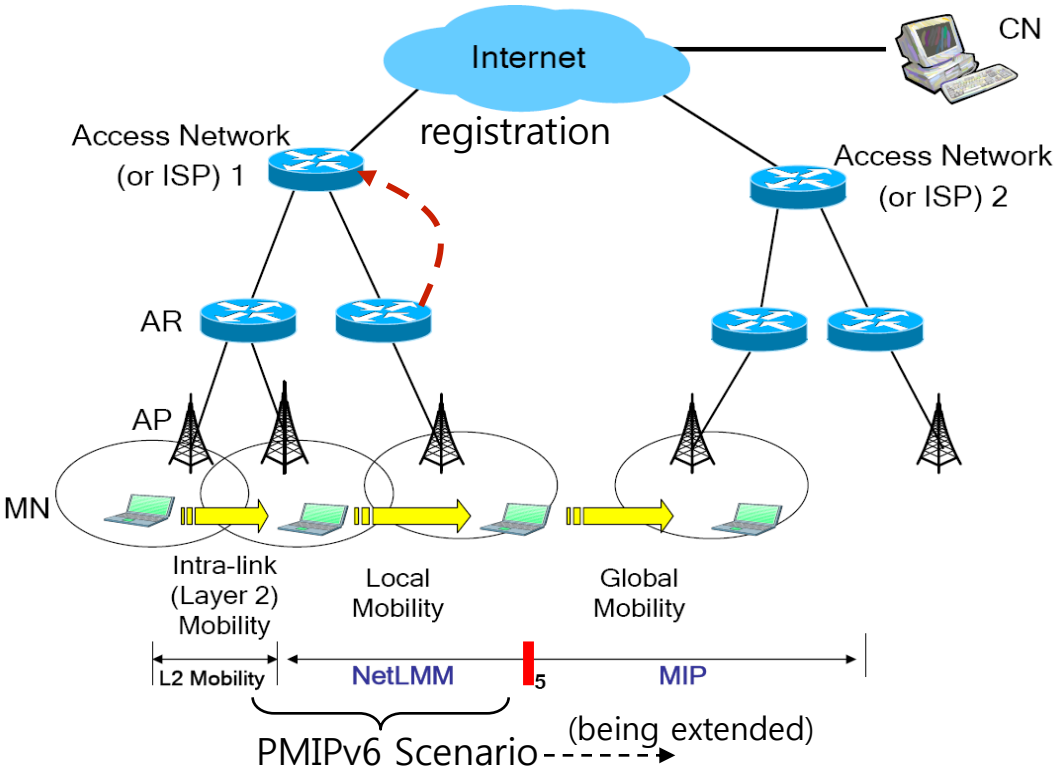
- IETF PMIPv6 Drafts History
  - Individual
    - S. Gundavelli (CISCO), K. Leung (CISCO), and V. Devarapalli (Azaire Networks), "Proxy Mobile IPv6," draft-sgundave-mipv6-proxymipv6-00, October 16, 2006.
    - S. Gundavelli (CISCO), K. Leung (CISCO), and V. Devarapalli (Azaire Networks), K. Chowdhury (Starent Networks), "Proxy Mobile IPv6," draft-sgundave-mipv6-proxymipv6-01, January 5, 2007.
    - S. Gundavelli (CISCO), K. Leung (CISCO), and V. Devarapalli (Azaire Networks), K. Chowdhury (Starent Networks), B. Patil (Nokia), "Proxy Mobile IPv6," draft-sgundave-mipv6-proxymipv6-02, March 5, 2007.

Internet Drafts of PMIPv6

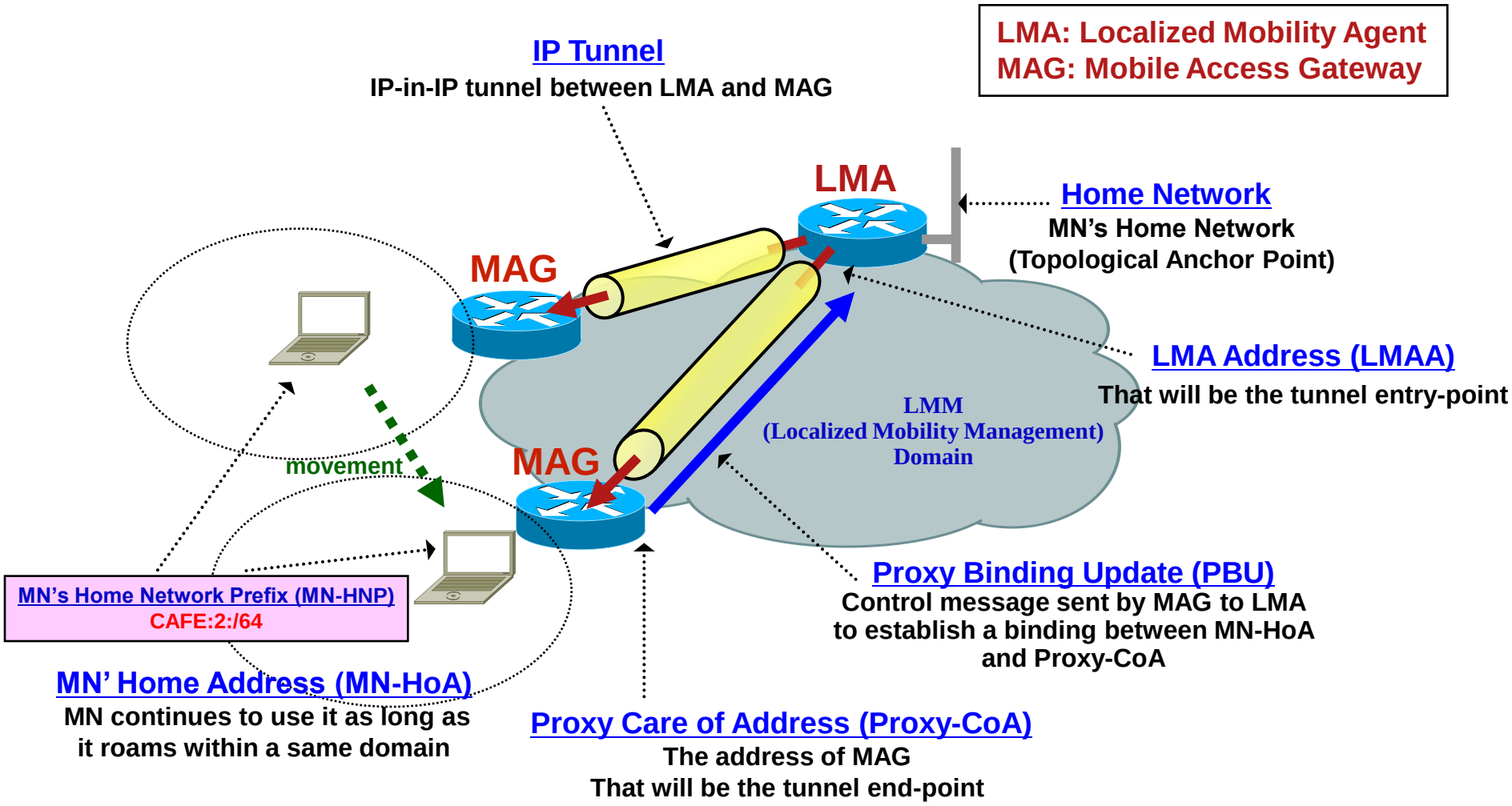
- IETF PMIPv6 Drafts History
  - Official WG Item
    - S. Gundavelli (CISCO), K. Leung (CISCO), and V. Devarapalli (Azaire Networks), K. Chowdhury (Starent Networks), B. Patil (Nokia), "Proxy Mobile IPv6," draft-ietf-netlmm-proxymip6-00.txt, April 8, 2007.
    - S. Gundavelli (CISCO), K. Leung (CISCO), and V. Devarapalli (Azaire Networks), K. Chowdhury (Starent Networks), B. Patil (Nokia), "Proxy Mobile IPv6," draft-ietf-netlmm-proxymip6-01.txt, June 18, 2007.

Goal of PMIPv6

- Goal
  - This protocol is for providing mobility support to any IPv6 host within a restricted and topologically localized portion of the network and without requiring the host to participate in any mobility related signaling.



PMIPv6 Overview



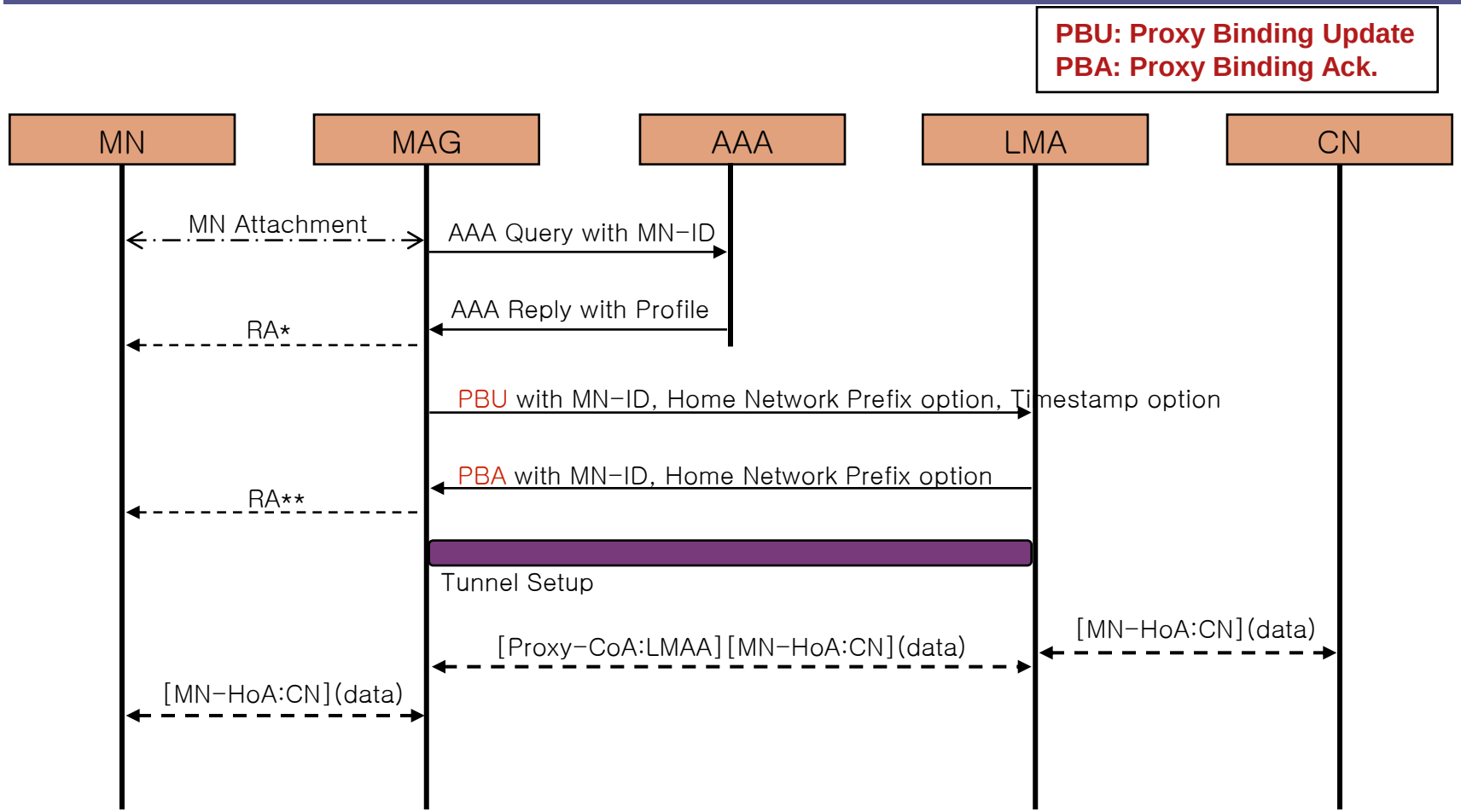
PMIPv6 Overview

- New entities
  - LMA (Local Mobility Anchor)
    - Home Agent for the mobile node in the PMIPv6 domain
    - Assigns MN's home prefix and manages the MN's reachability state
  - MAG (Mobile Access Gateway)
    - Manages the mobility related signaling for a mobile node
    - Tracking the mobile node's attachment to the link and for signaling the MN's LMA

PMIPv6 Overview

- Assumptions (or Restrictions)
  - Link between MN and MAG is a point-to-point link (not shared link)
    - Logically exclusive layer 3 link between MN and MAG
  - Per-MN Prefix model
    - unique home network prefix is assigned to MN
  - Support both Steteless and Stateful address configuration modes

PMIPv6 Operation Flow



RA*: Router Advertisement in case of receiving MN's Home Prefix from AAA
RA**: Router Advertisement in case of receiving MN's Home Prefix from LMA

PMIPv6 Features

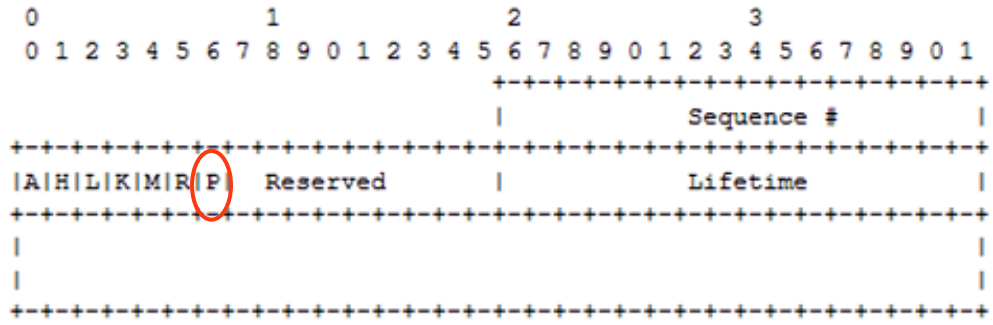
- Home in Any Place
  - Network Entry (or Handover) Procedures
    - After MN attachment, MAG gets MN's profile
      - LMA address and other configuration parameters
    - Obtain MN's home network prefix information
      - Static Scheme ➔ Get it from Profile
      - Dynamic Scheme ➔ Get it from LMA via PBU/PBA
    - Now MAG has enough information to emulate MN's home link
    - Send the RA (Router Advertisement) messages advertising MN's home network prefix and other parameters

PMIPv6 Features

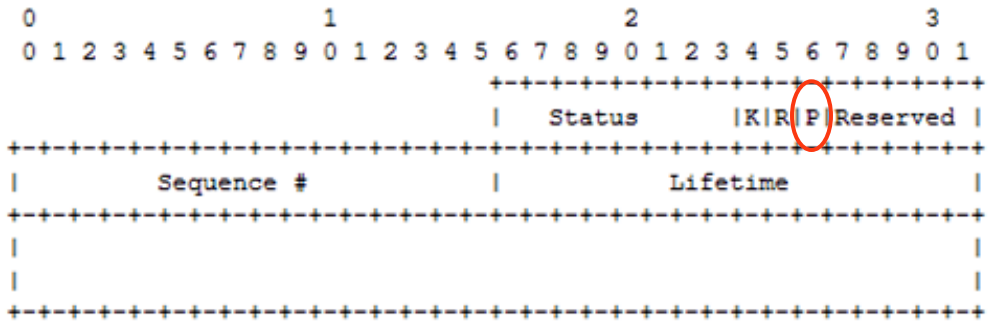
- Home in Any Place
  - MAG running as the access router will emulate the home link on MN's access link.
    - MN always obtain its "home network prefix", any where in the network.
    - It will ensure that MN believes it is at its home.

PMIPv6 Features

- Proxy Registration
  - LMA needs to understand the Proxy Registration
  - RFC 3775 MIPv6 BU/BAck Reuse



PBU (Proxy Binding Update)



PBA (Proxy Binding Acknowledgement)

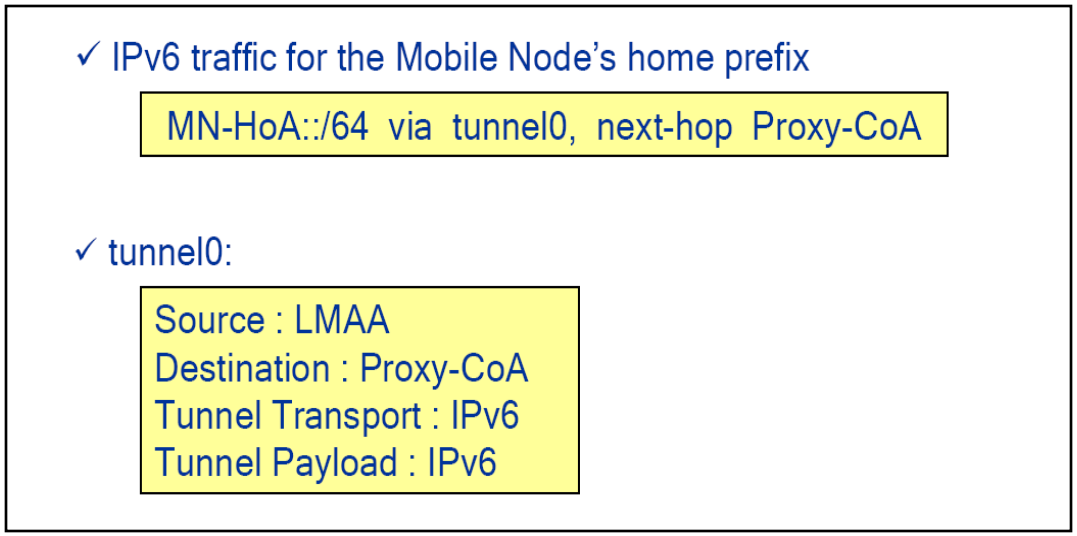
PMIPv6 Features

- M:1 Tunnel
  - LMA-MAG tunnel is a shared tunnel among many MNs.
    - m:1 relation
    - One tunnel is associated to multiple MNs' Binding Caches.

- RA (Router Advertisement) should be UNICASTed to an MN
  - It will contain MN's Home Network Prefix

PMIPv6 Features

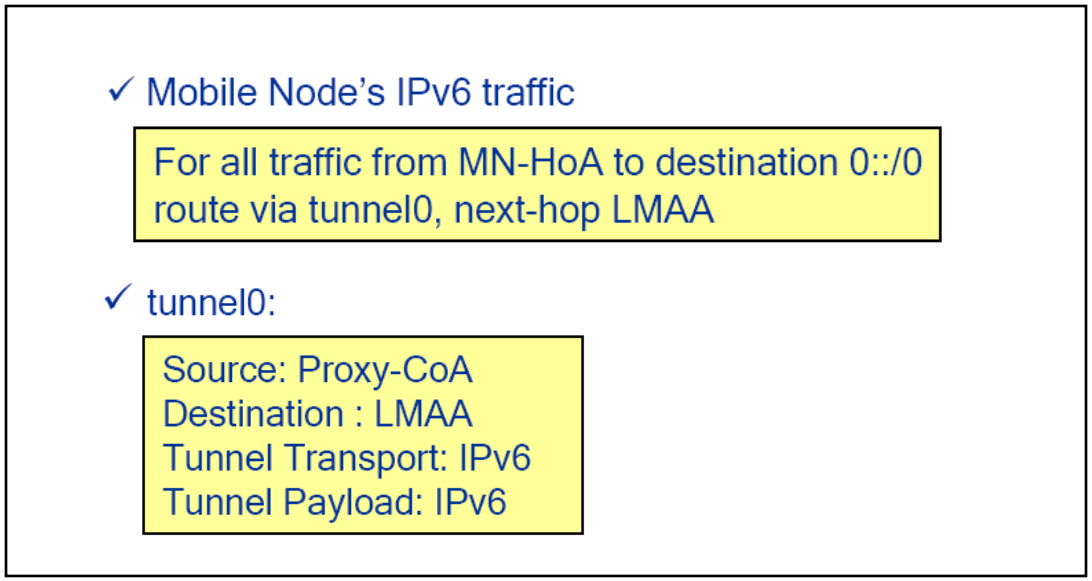
- LMA's Prefix-based Routing
  - LMA will add prefix routes to MN's home network prefix over the tunnel.



Routing State for a MN stored in LMA

PMIPv6 Features

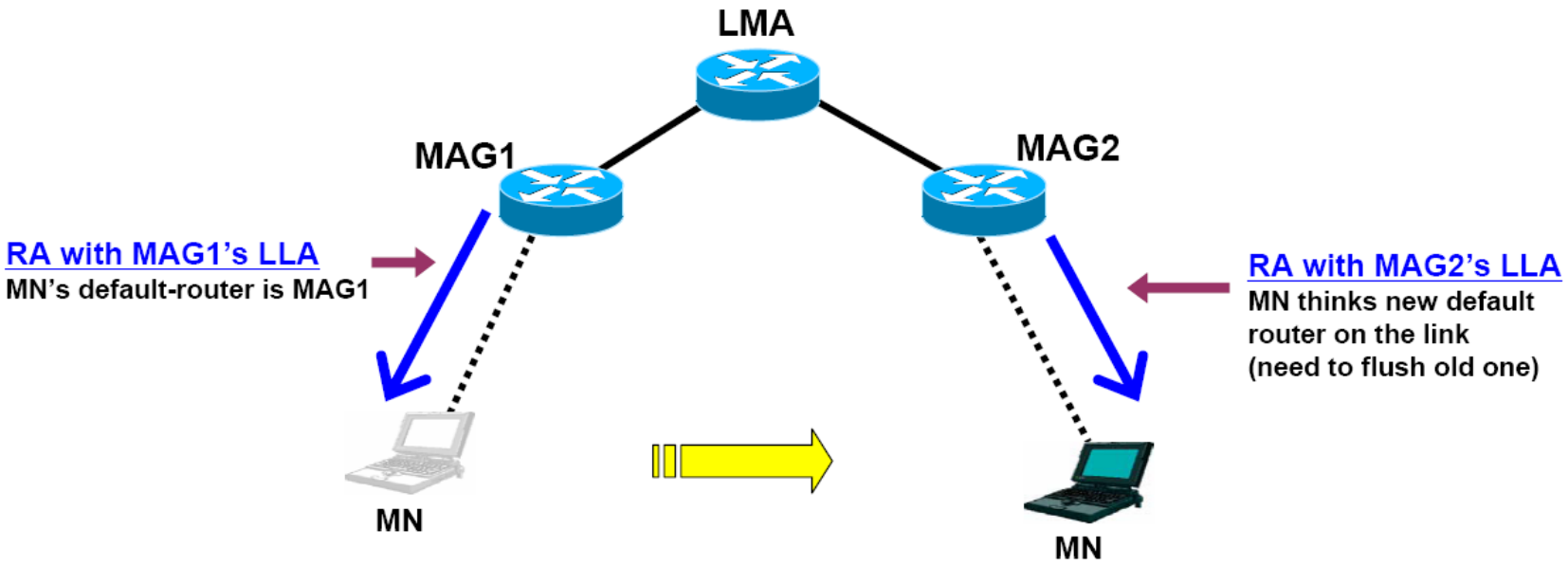
- MAG establishes IPv6 in IPv6 tunnel with LMA



Routing State for a MN stored in MAG

PMIPv6 Features

- Any MN is just a IPv6 host
  - Any MN is just a IPv6 host with its protocol operation consistent with the base IPv6 specification.
  - All aspects of Neighbor Discovery Protocol will not change.



LLA: Link Local Address (e.g., MAC Address)

Thank You!