University of Rochester

IPv6, Mobile IP & Mobile IPv6

Tolga Numanoglu

HARRIS

UNIVERSITY OF ROCHESTER WCNG

CEIS

Outline

- IPv6
  - Background
  - Features
  - Details
- Mobile IP
  - Mobile Node, Home Agent, Foreign Agent
- Mobile IPv6
  - What’s different?

IPv6 Background

- IP has been patched (subnets, supernets) but there is still the fundamental 32 bit address limitation
- IETF* started effort to specify new version of IP in 1991
  - New version would require change of header
  - Include all modifications in one new protocol
  - Solicitation of suggestions from community
  - Result was IPng which became IPv6
  - First version completed in '94
- Same architectural principles as v4 – only bigger

*IETF: Internet Engineering Task Force

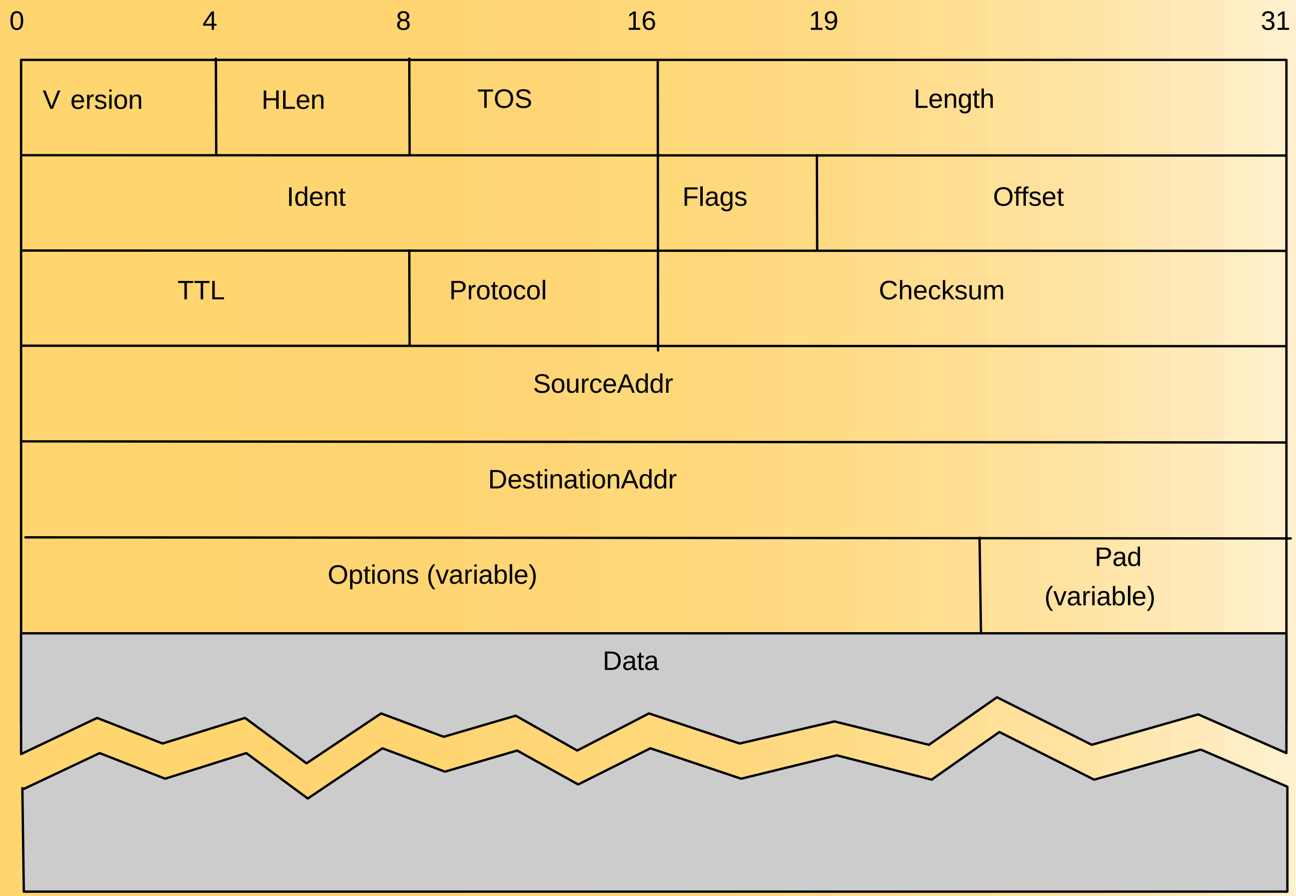
IPv6 features

- 128-bit address space
  - This is what it's all about…
- Real-time/QoS services
- Security and authentication
- Autoconfiguration
  - Hosts autoconfig with IP address and domain name
  - Idea is to try to make systems more plug-n-play
- Enhanced routing functionality eg. Mobile hosts
- Multicast
- Protocol extensions
- Smooth transition path from IPv4

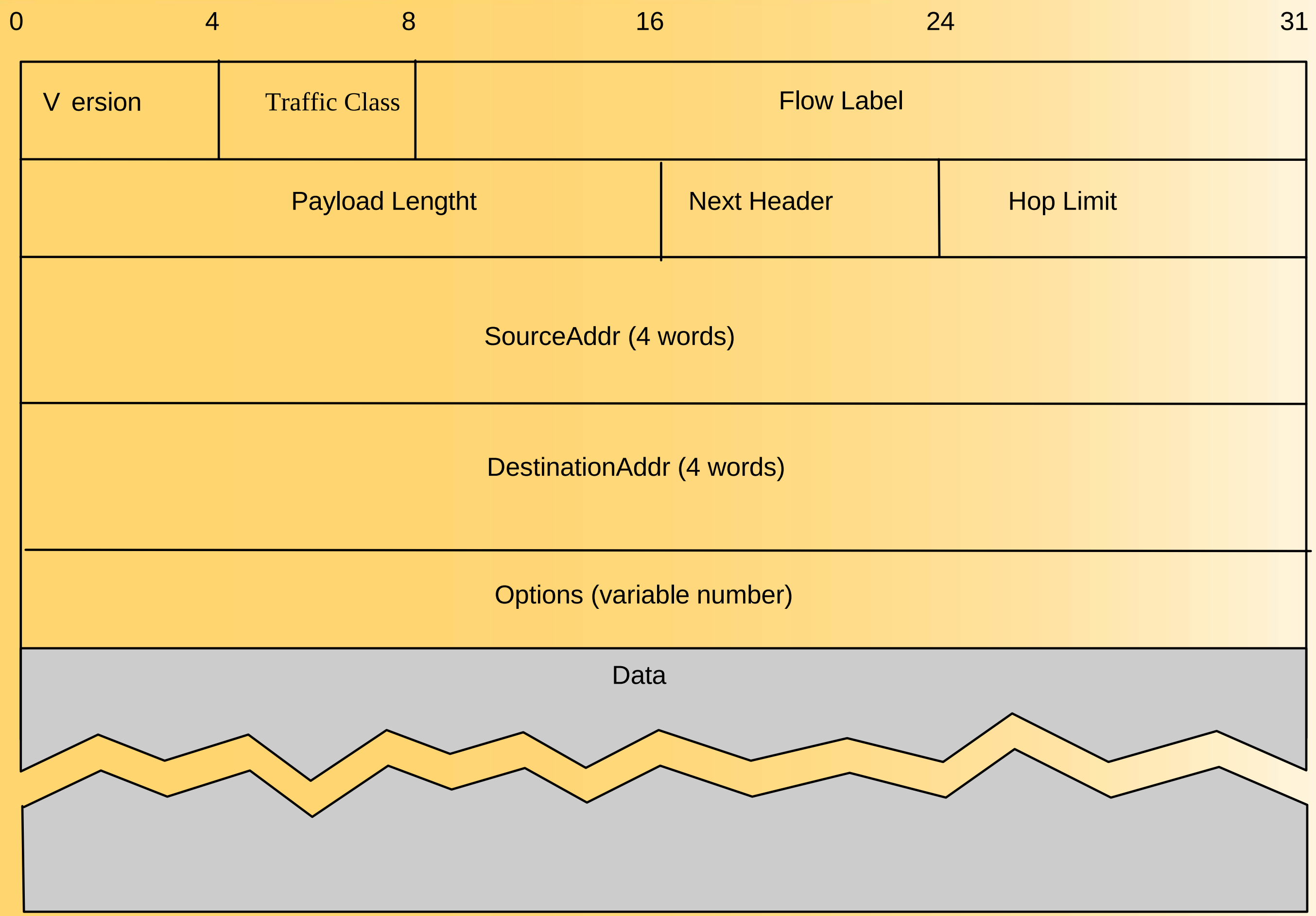
Address Space and Notation

- Allocation is classless
  - Prefixes specify different uses (unicast, multicast, anycast)
    - Anycast: send packets to nearest member of a group
  - Prefixes can be used to map v4 to v6 space and visa-versa
  - Lots of flexibility with 128 bits!
    - $\sim 5 \times 10^{28}$ addresses for each of the roughly 6.5 billion people alive today
- Standard representation is set of eight 16-bit values separated by colons
  - Eg. 47CD:1234:3200:0000:0000:4325:B792:0428
  - If there are large number of zeros, they can be omitted with series of colons
    - Eg. 47CD:1234:3200::4325:B792:0428
  - Address prefixes (slash notation) are the same as v4
    - Eg. FEDC:BA98:7600::/40 describes a 40 bit prefix

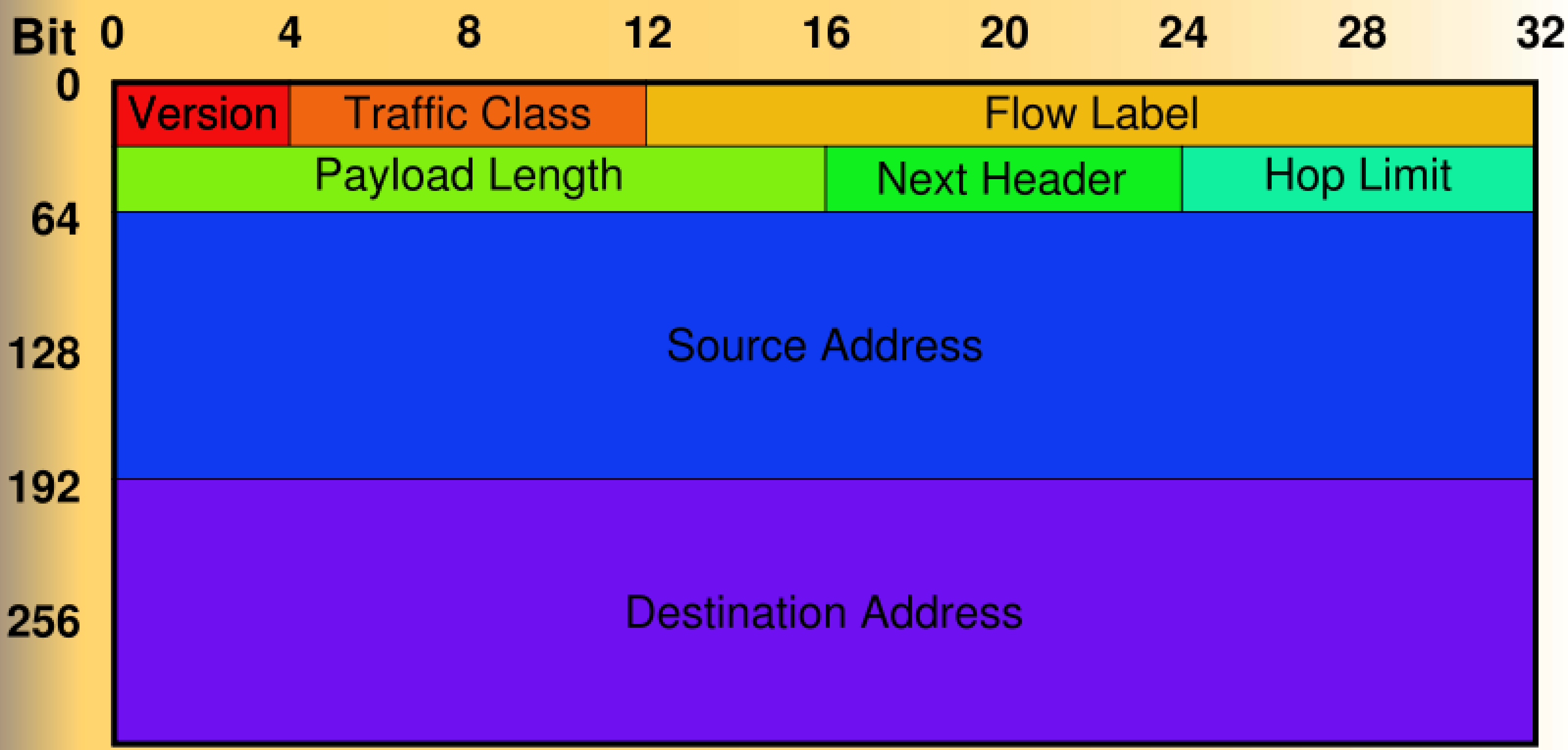
IPv4 Packet Format Details



IPv6 Packet Format



Header in detail…



Packet Format Details

- Simpler format than v4
- Version = 6
- Traffic class same as v4 ToS
- Treat all packets with the same Flow Label equally
  - Support QoS and fair bandwidth allocation
- Payload length does not include header –limits packets to 64KB
  - There is a “jumbogram option”
- Hop limit = TTL field
- Next header combines options and protocol
  - If there are no options then NextHeader is the protocol field
- Options → “extension header” that follow IP header
  - *Ordered* list of tuples – 6 common types
    - Quickly enable a router to tell if the options are meant for it
  - Eg. routing, fragmentation, authentication encryption…

Key differences in header

- No checksum
  - Bit level errors are checked for all over the place
- No length variability in header
  - Fixed format speeds processing
- No more fragmentation and reassembly in header
  - Incorrectly sized packets are dropped and message is sent to sender to reduce packet size

Transition from v4 to v6

- Flag day is not feasible
- Dual stack operation – v6 nodes run in both v4 and v6 modes and use version field to decide which stack to use
  - Nodes can be assigned a *v4 compatible v6 address*
    - Allows a host which supports v6 to talk v6 even if local routers only speak v4
    - Signals the need for tunneling
  - Nodes can be assigned a *v4 mapped v6 address*
    - Allows a host which supports both v6 and v4 to communicate with a v4 hosts
- Tunneling is used to deal with networks where v4 router(s) sit between two v6 routers
  - Simply encapsulate v6 packets and all of their information in v4 packets until you hit the next v6 router

Portable Networking Technology

- Cellular systems
  - Cellular Digital Packet Data (CDPD)
  - 3G
- Bluetooth
  - Low cost, short range radio links between mobile devices
- Wireless Ethernet (802.11)
  - Widely used wireless MAC layer technology

Mobility and Standard IP Routing

- IP assumes end hosts are in fixed physical locations
  - What happens if we move a host between networks?
- IP addresses enable IP routing algorithms to get packets to the correct network
  - Each IP address has network part and host part
    - This keeps host specific information out of routers
  - DHCP is used to get packets to end hosts in networks
    - This still assumes a fixed end host
- What if a user wants to roam between networks?
  - Mobile users don't want to know that they are moving between networks
  - Why can't mobile users change IP when running an application?

Mobile IP

- Mobile IP was developed as a means for transparently dealing with problems of mobile users
  - Enables hosts to stay connected to the Internet regardless of their location
  - Enables hosts to be tracked without needing to change their IP address
  - Requires no changes to software of non-mobile hosts/routers
  - Requires addition of some infrastructure
  - Has no geographical limitations
  - Requires no modifications to IP addresses or IP address format
  - Supports security
    - Could be even more important than physically connected routing

Mobile IP Entities

- Mobile Node (MN)
  - The entity that may change its point of attachment from network to network in the Internet
    - Detects it has moved and registers with “best” FA
  - Assigned a permanent IP called its *home address* to which other hosts send packets regardless of MN’s location
    - Since this IP doesn’t change it can be used by long-lived applications as MN’s location changes
- Home Agent (HA)
  - This is router with additional functionality
  - Located on home network of MN
  - Does mobility binding of MN’s IP with its CoA (Care of Address)
  - Forwards packets to appropriate network when MN is away
    - Does this through encapsulation

Mobile IP Entities contd.

- Foreign Agent (FA)
  - Another router with enhanced functionality
  - If MN is away from HA the it uses an FA to send/receive data to/from HA
  - Advertises itself periodically
  - Forward's MN's registration request
  - Decapsulates messages for delivery to MN
- Care-of-address (CoA)
  - Address which identifies MN's current location
  - Sent by FA to HA when MN attaches
  - Usually the IP address of the FA
- Correspondent Node (CN)
  - End host to which MN is corresponding (eg. a web server)

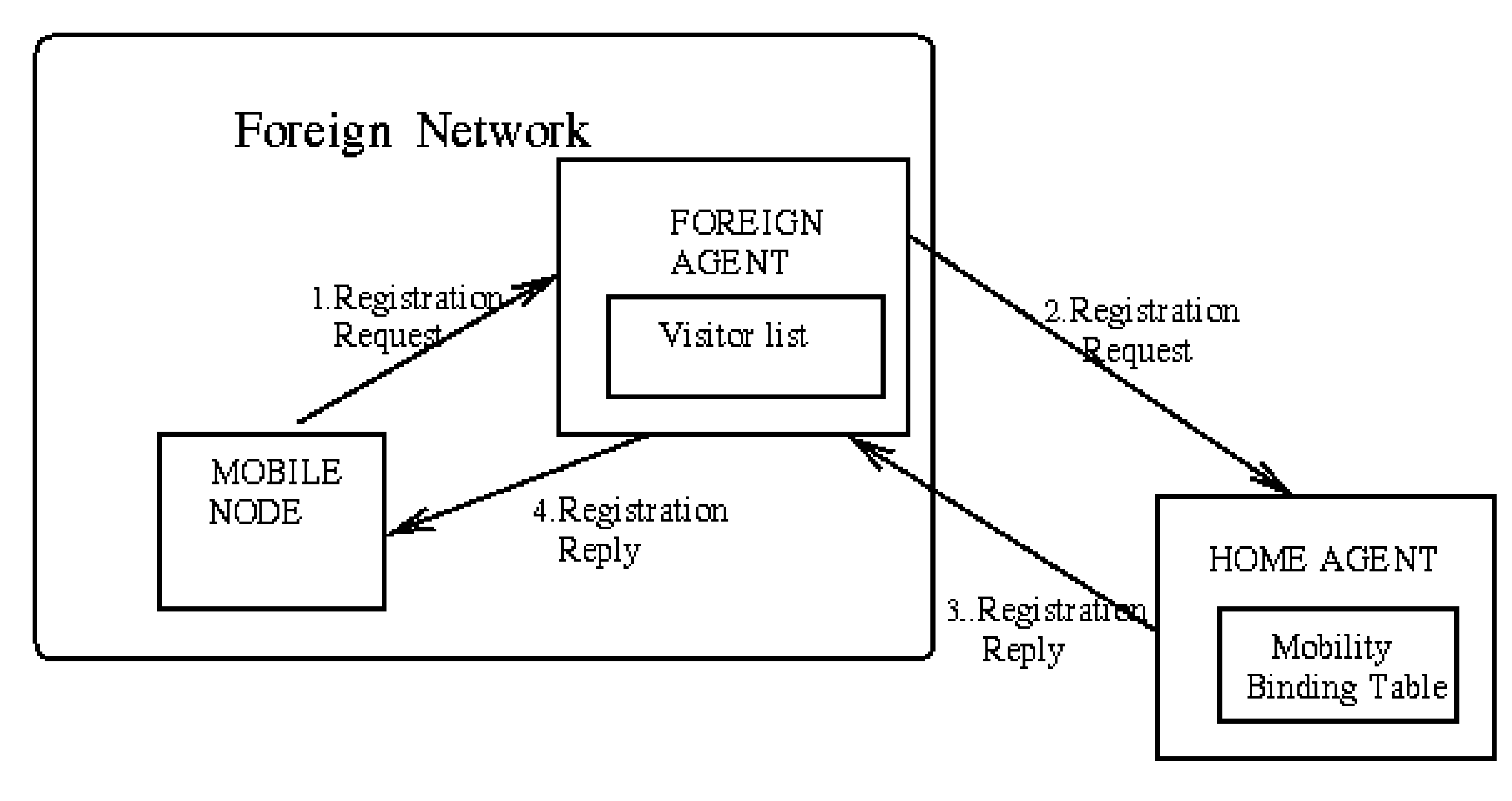
Mobile IP Support Services

- Agent Discovery
  - HA's and FA's broadcast their presence on each network to which they are attached
    - Beacon messages via ICMP Router Discovery Protocol (IRDP)
  - MN's listen for advertisement and then initiate registration
- Registration
  - When MN is away, it registers its CoA with its HA
    - Typically through the FA with strongest signal
  - Registration control messages are sent via UDP to well known port
- Encapsulation – just like standard IP only with CoA
- Decapsulation – again, just like standard IP

Mobile IP Operation

- A MN listens for agent advertisement and then initiates registration
  - If responding agent is the HA, then mobile IP is not necessary
- After receiving the registration request from a MN, the HA acknowledges and registration is complete
  - Registration happens as often as MN changes networks
- HA intercepts all packets destined for MN
  - This is simple unless sending application is on or near the same network as the MN
  - HA masquerades as MN
  - There is a specific lifetime for service before a MN must re-register
  - There is also a de-registration process with HA if an MN returns home

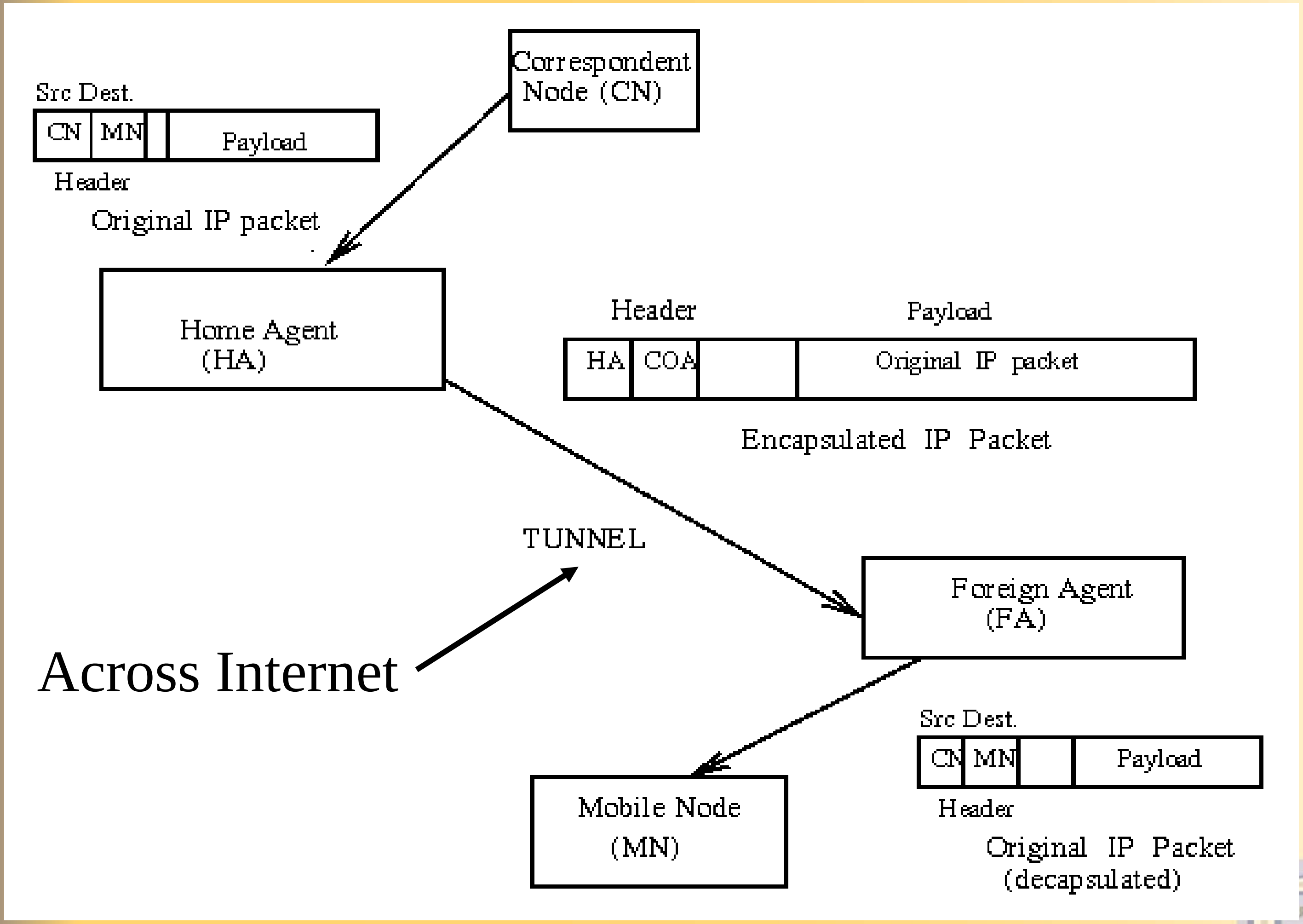
Registration Process



Mobile IP Operation contd.

- HA then encapsulates all packets addressed to MN and forwards them to FA
  - IP tunneling
- FA decapsulates all packets addressed to MN and forwards them via hardware address (learned as part of registration process)
- NOTE that the MN can perform FA functions if it acquires an IP address eg. via DHCP (Dynamic Host Configuration Protocol)
- Bidirectional communications require tunneling in each direction

Mobile IP Tunneling



Security in Mobile IP

- Authentication can be performed by all parties
  - Only authentication between MN and HA is required
  - Keyed MD5 is the default
- Replay protection
  - Timestamps are mandatory
  - Random numbers on request reply packets are optional
- HA and FA do not have to share any security information.

Mobility in IPv6

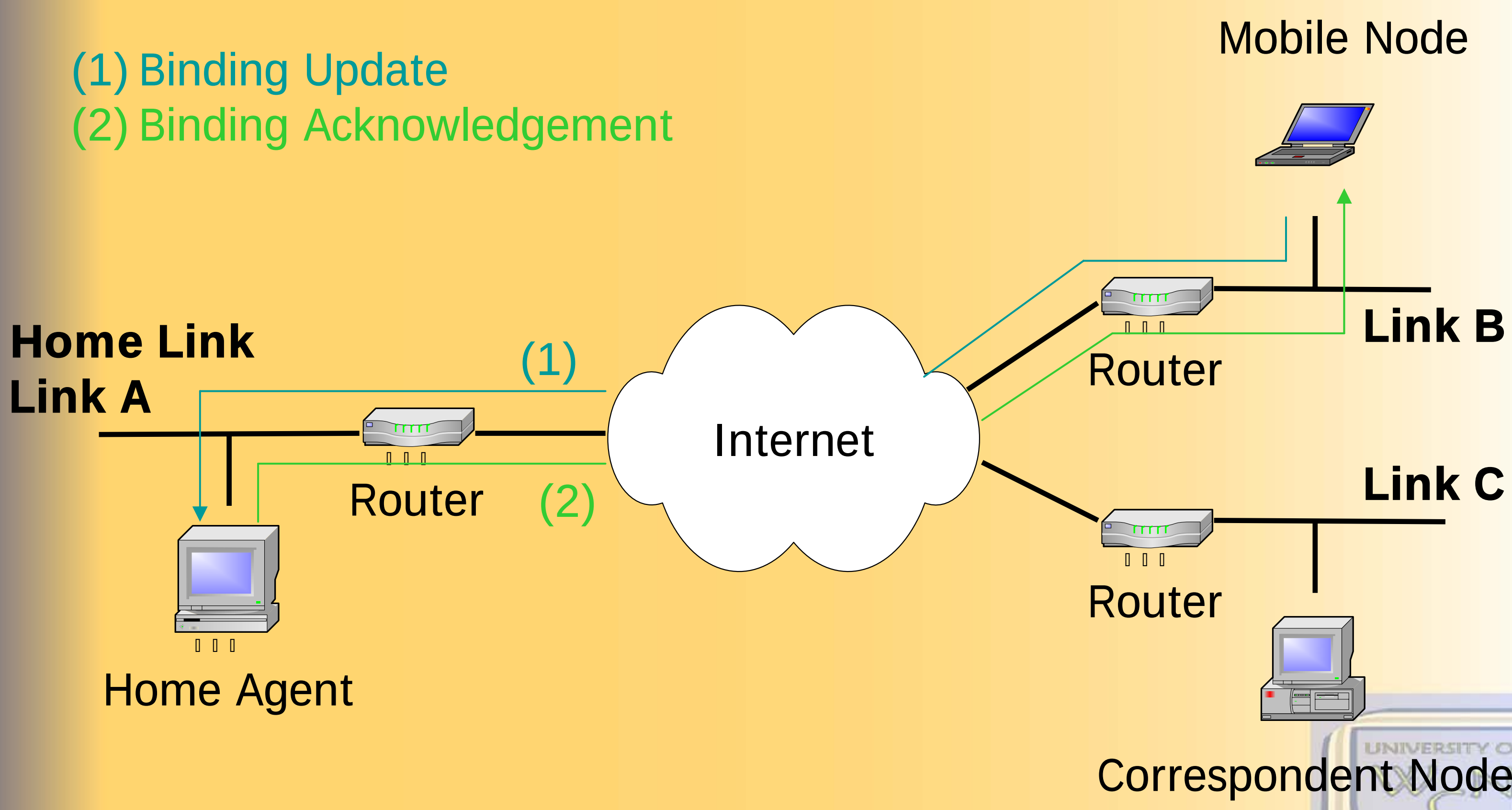
- Route Optimization is a fundamental part of Mobile IPv6
  - Mobile IPv4 it is an optional set of extensions that may not be supported by all nodes
- Foreign Agents are not needed in Mobile IPv6
  - MNs can function in any location without the services of any special router in that location
- Security
  - Nodes are expected to employ strong authentication and encryption

Mobile IPv6 Operation

- Home Agent Registration
  - An MN performs address auto-configuration to get its care-of address
  - The MN registers its care-of address with its home agent on the home link
    - Use “Binding Update” Destination Option
  - The HA uses proxy Neighbor Discovery and also replies to Neighbor Solicitations on behalf of the MN

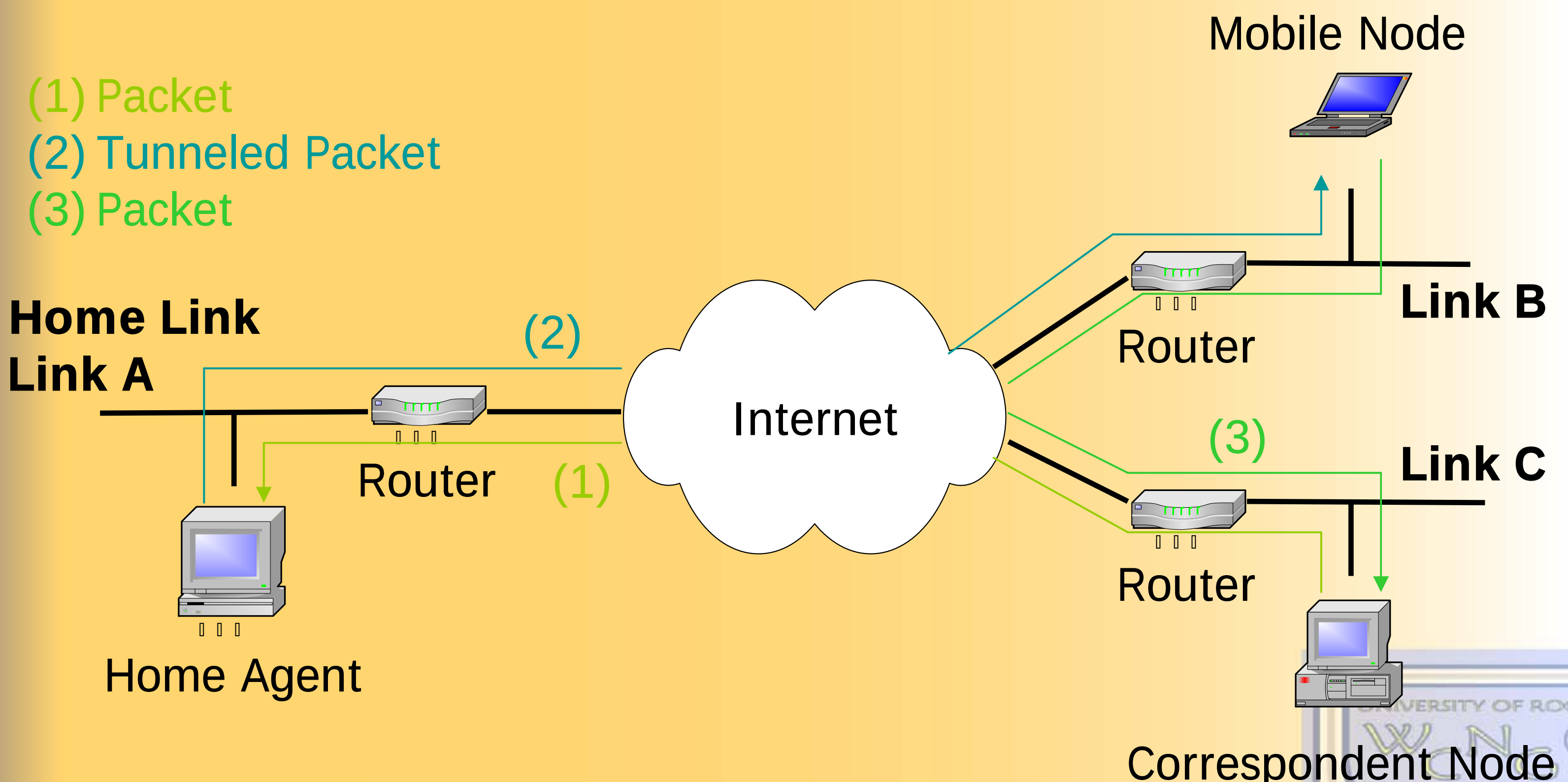
Mobile IPv6 Operation (cont.)

- Home Agent Registration



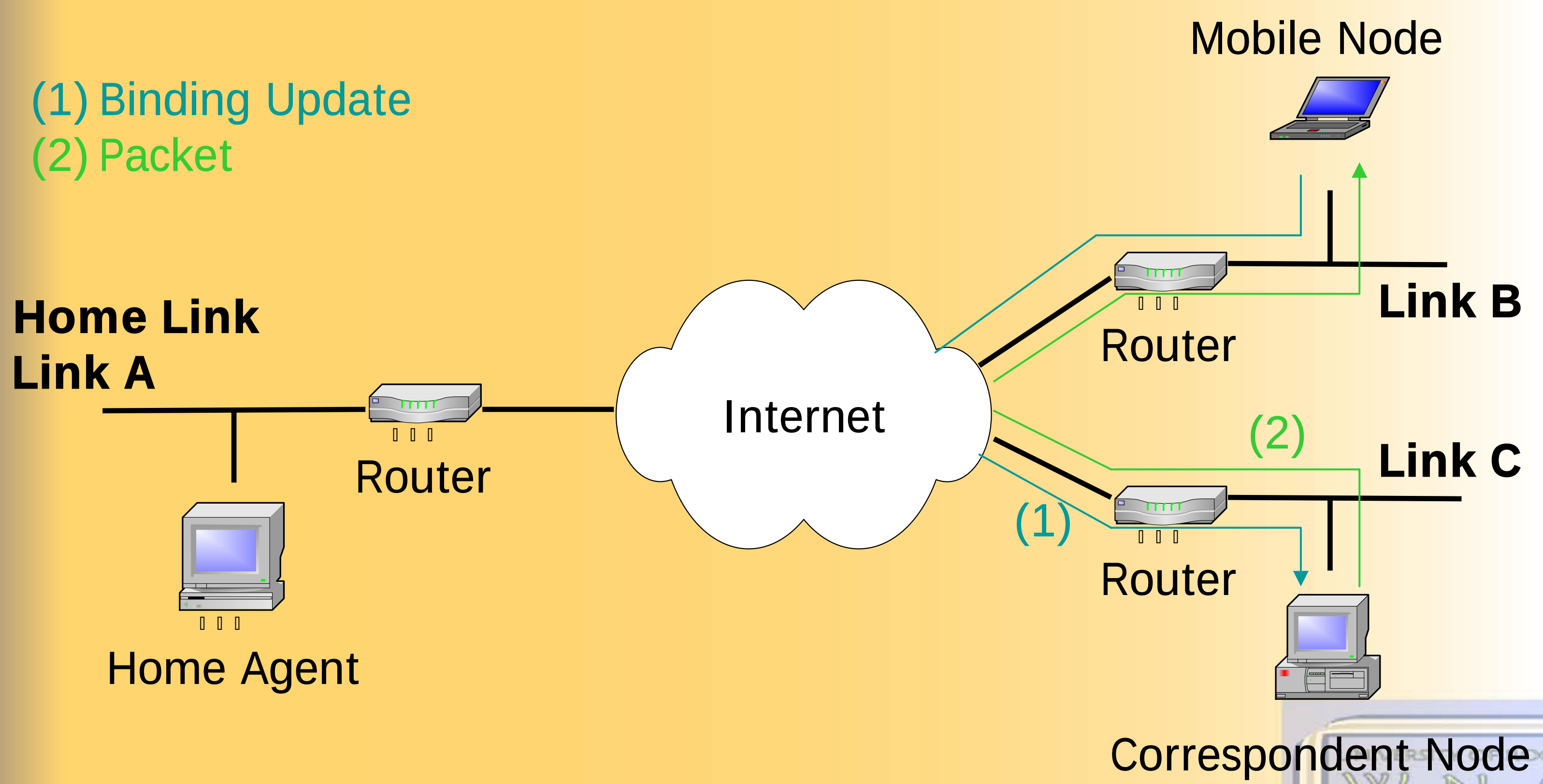
Mobile IPv6 Operation (cont.)

- Route Optimization
  - To avoid triangle routing



Mobile IPv6 Operation (cont.)

- Route Optimization



Mobile IPv6 Operation (cont.)

- Movement Detection
  - While away from home, an MN selects one router and one subnet prefix advertised by that router to use as the subnet prefix in its primary care-of address
  - To wait for the periodically sent Router Advertisements

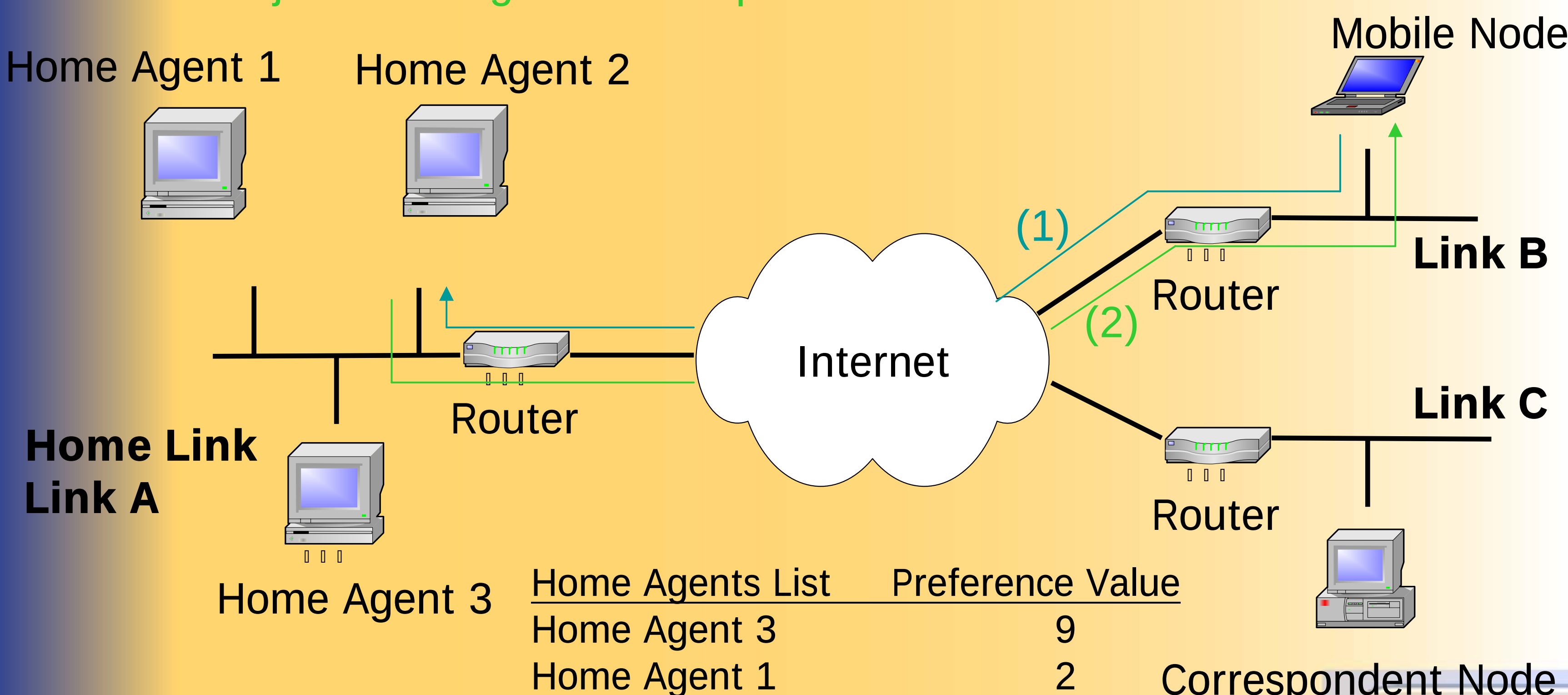
Mobile IPv6 Operation (cont.)

- Binding Management
  - To trigger Binding Acknowledgement, the MN sets the Acknowledge bit in the Binding Update
    - Retransmitting the Biding Update periodically until receipt of the acknowledgement
  - An MN MUST set the Acknowledge bit in Binding Updates addressed to an HA
  - The MN MAY also set the Acknowledge bit in Binding Updates sent to a CN

Home Agent Discovery Mechanism

(1) Binding Update to Home-Agents anycast address

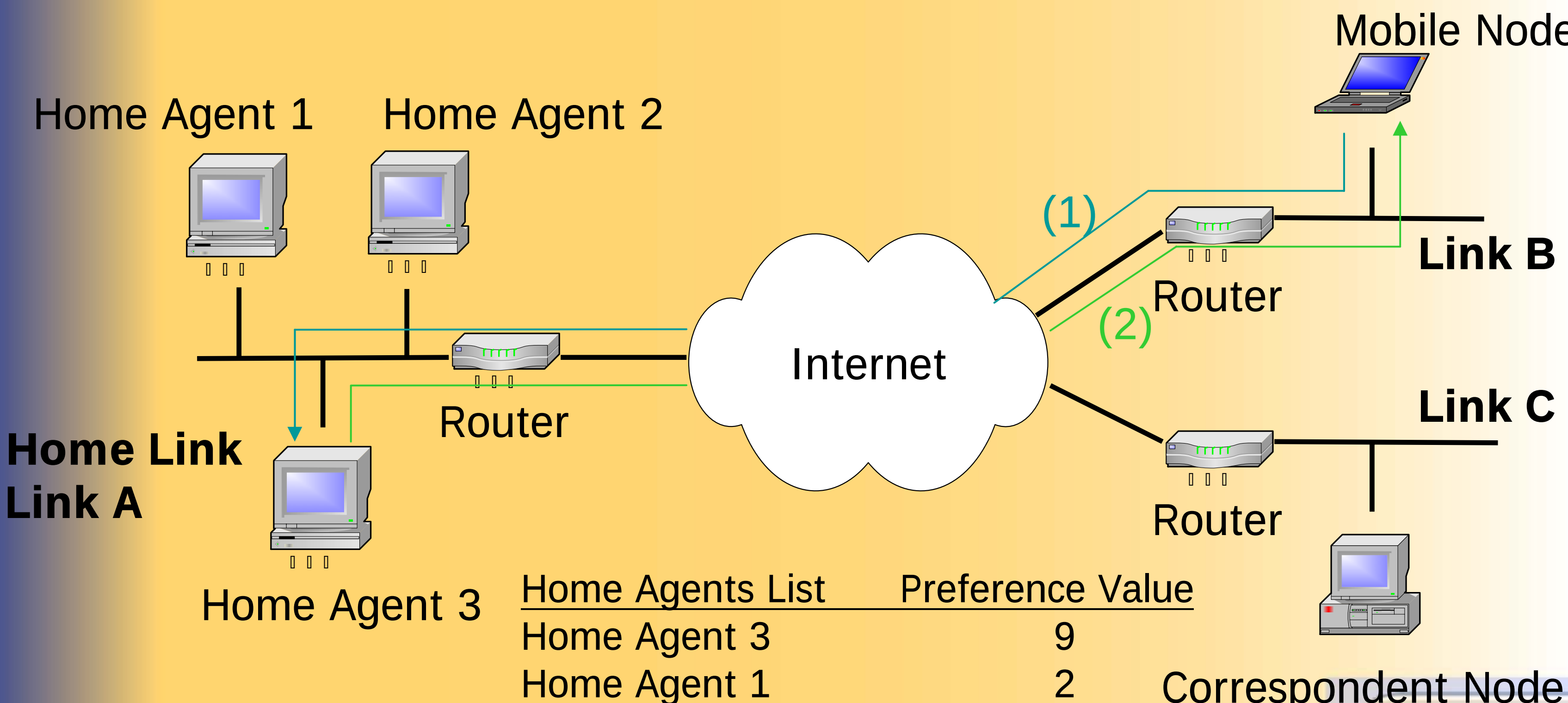
(2) Binding Acknowledgement including the Home Agents List; rejects the registration request



Home Agents List	Preference Value
Home Agent 3	9
Home Agent 1	2
Home Agent 2	-3

Home Agent Discovery Mechanism (cont.)

(1) Binding Update to Home Agents 3
(2) Binding Acknowledgement, registration OK



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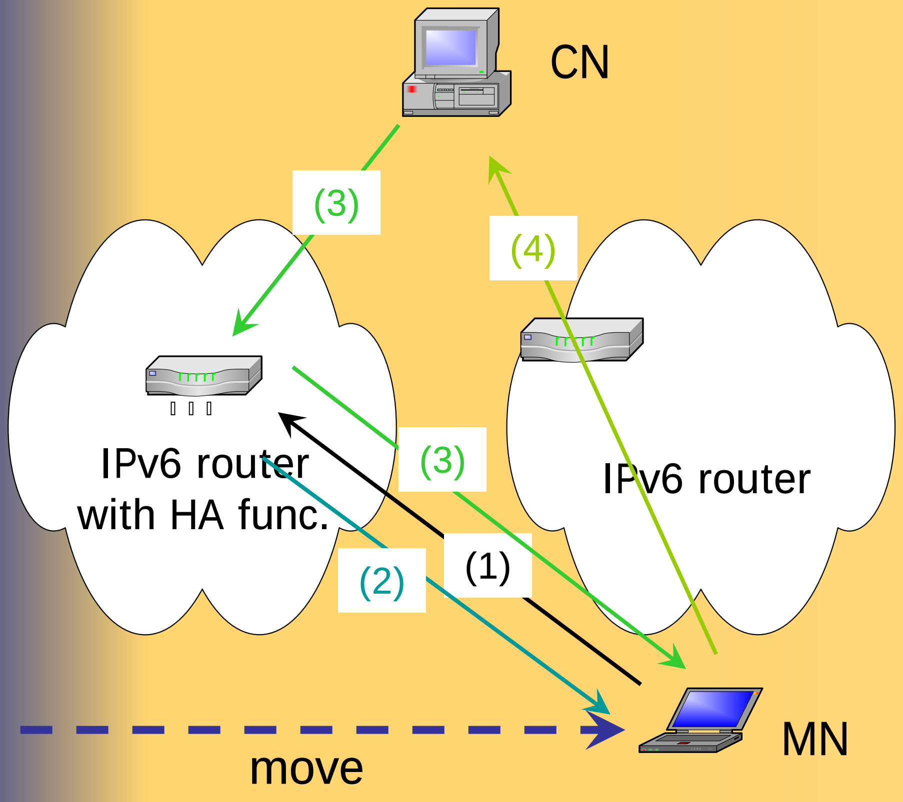
Home Agent 3	9
Home Agent 1	2
Home Agent 2	-3

Handover

- Router-Assisted Smooth Handovers



(1) MN sends a Binding Update to an HA on previous network

(2) HA returns a Binding Acknowledgement

(3) HA tunnels packets to MN

(4) MN sends a Binding Update to CN

Handover (cont.)

- Three kinds of handover operations
  - Smooth Handover
    - Minimizes data loss during the time that the MN is establishing its link to the new access point
  - Fast Handover
    - Minimizes or eliminates latency for establishing new communication paths to the MN at the new access router
  - Seamless Handover
    - Both Smooth and Fast Handover

Quality of Service

- IPv6 header has two QoS-related fields
  - 20-bit Flow Label
    - Used by a source to label sequences of packets for which it requests special handling by the IPv6 routers
    - Geared to IntServ and RSVP
  - 8-bit Traffic Class Indicator
    - Used by originating nodes and/or forwarding routers to identify and distinguish between different classes or priorities of IPv6 packets
    - Geared to DiffServ

Quality of Service (cont.)

- New IPv6 option – QoS Object
  - QoS Object describes QoS requirement, traffic volume and packet classification parameters for MN's packet stream
  - Included as a Destination Option in IPv6 packets carrying Binding Update and Biding Acknowledgment messages

Conclusions

- Mobile IPv6
  - An efficient and deployable protocol for handling mobility with IPv6
  - Lightweight protocol
- Neither MIP nor MIPv6 are widely deployed today
- Transition will take time

References

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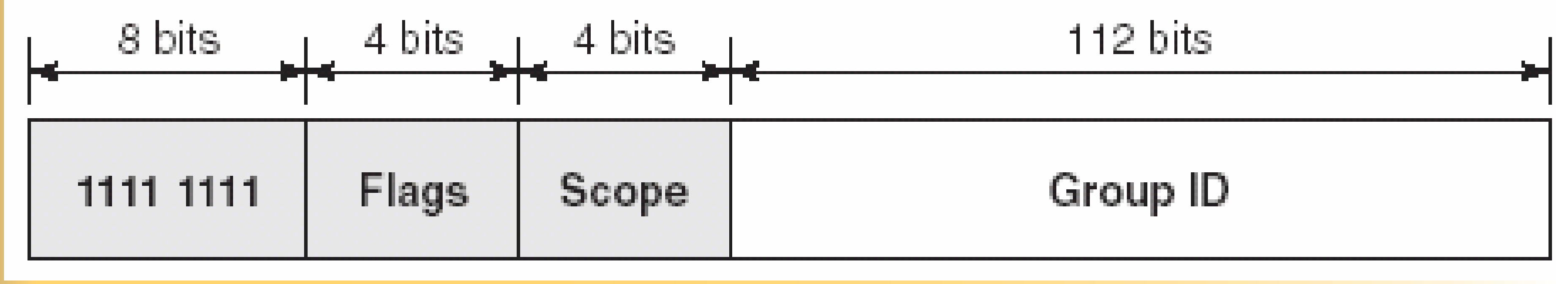
- K. Zhigang et al., “QoS in Mobile IPv6,” in *Proc. of International Conferences on Info-tech and Info-net 2001*, vol. 2, pp. 492 -497.
- N. Montavont and T. Noel, “Handover Management for Mobile Nodes in IPv6 Networks,” *IEEE Communication Magazine*, pp. 38-43, Aug. 2002.

Backup

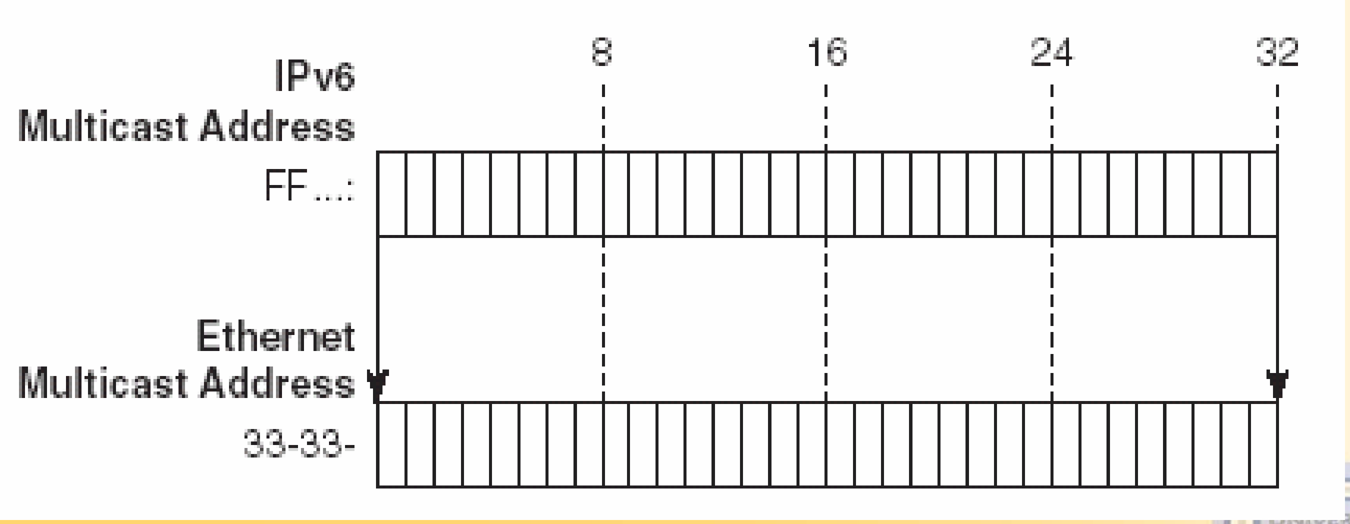
Slides

Multicast in IPv6

The structure of the IPv6 multicast address



The mapping of IPv6 multicast addresses to Ethernet multicast addresses



Unicast Assignment in v6

- Unicast address assignment is similar to CIDR
  - Unicast addresses start with 001
  - Host interfaces belong to subnets
  - Addresses are composed of a subnet prefix and a host identifier
  - Subnet prefix structure provides for aggregation into larger networks
- Provider-based plan
  - Idea is that the Internet is global hierarchy of network
  - Three levels of hierarchy – region, provider, subscriber
  - Goal is to provide route aggregation to reduce BGP overhead
    - A provider can advertise a single prefix for all of its subscribers
  - Region = 13 bits, Provider = 24 bits, Subscriber = 16 bits, Host = 80 bits
    - Eg. 001,regionID,providerID,subscriberID,subnetID,intefaceID
  - What about multi-homed subscribers?
    - No simple solution
- Anycase addresses are treated just like unicast addresses
  - It's up to the routing system to determine which server is "closest"

Problems with Mobile IP

- Suboptimal "triangle" routing
  - What if MN is in same subnetwork as the node to which it is communicating and HA is on the other side of the world?
    - It would be nice if we could directly route packets
  - Solution: Let the CN know the COA of MN
    - Then the CN can create its own tunnel to MN
    - CN must be equipped with software to enable it to learn the COA
    - Initiated by HA who notifies CN via "binding update"
    - Binding table can become stale