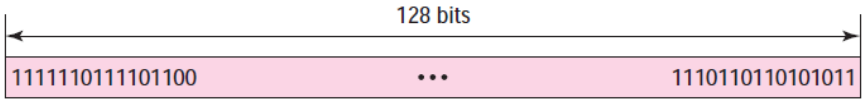
EE981 Network Switching and Routing

Kashif Sharif

Internet Protocol v6



- Dotted Decimal Notation

  221.14.65.11.105.45.170.34.12.234.18.0.14.0.115.255

- Hexadecimal Notation

  FDEC : BA98 : 7654 : 3210 : ADBF : BBFF : 2922 : FFFF

2

IP v6

Zero Compression

Mixed Representation

FDEC:14AB:2311:BBFE:AAAA:BBBB:130.24.24.18

::130.24.24.18

3

IP v6

CIDR Notation

FDEC :: BBFF : 0 : FFFF/60

- IPv6 is hierarchal

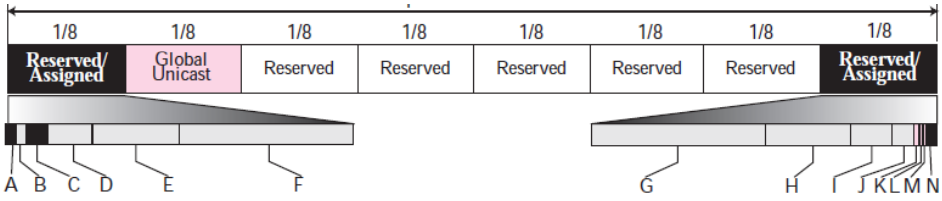
4

IPv6: Types of Addresses

- Unicast Address
- Anycast Address
- Multicast Address
  - Broadcast is a special case of multicast

5

IPv6 Address Space Allocation



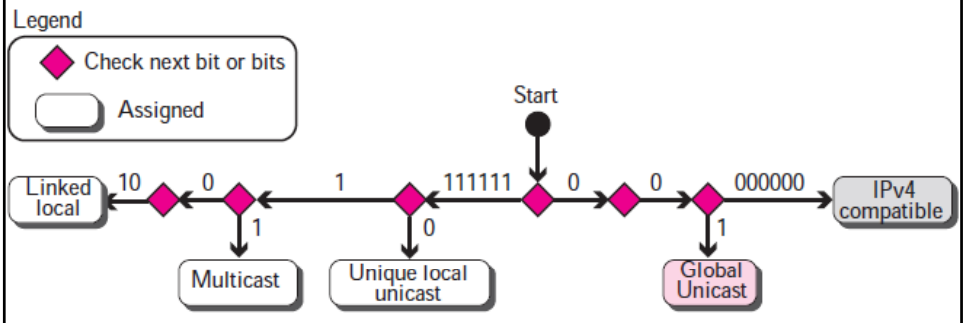
A: 1/256 IPv4 Compatible
B: 1/256 Reserverd
C: 1/128 Reserved
D: 1/64 Reserved
E: 1/32 Reserved
F: 1/16 Reserved
G: 1/16 Reserved
H: 1/32 Reserved
I: 1/64 Reserved
J: 1/128 Unique Local Unicast
K: 1/512 Reserved
L: 1/1024 Link Local
M: 1/256 Reserved
N: 1/256 Multicast

6

IPv6 Address Space Allocation

	Block Prefix	*CIDR*	*Block Assignment*	*Fraction*
1	0000 0000	0000::/8	Reserved (IPv4 compatible)	1/256
	0000 0001	0100::/8	Reserved	1/256
	0000 001	0200::/7	Reserved	1/128
	0000 01	0400::/6	Reserved	1/64
	0000 1	0800::/5	Reserved	1/32
	0001	1000::/4	Reserved	1/16
2	**001**	**2000::/3**	**Global unicast**	**1/8**
3	010	4000::/3	Reserved	1/8
4	011	6000::/3	Reserved	1/8
5	100	8000::/3	Reserved	1/8
6	101	A000::/3	Reserved	1/8
7	110	C000::/3	Reserved	1/8
8	1110	E000::/4	Reserved	1/16
	1111 0	F000::/5	Reserved	1/32
	1111 10	F800::/6	Reserved	1/64
	1111 110	FC00::/7	Unique local unicast	1/128
	1111 1110 0	FE00::/9	Reserved	1/512
	1111 1110 10	FE80::/10	Link local addresses	1/1024
	1111 1110 11	FEC0::/10	Reserved	1/1024
	1111 1111	FF00::/8	Multicast addresses	1/256

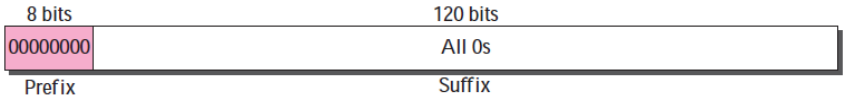
IPv6 Address Space Allocation: Algorithm



8

IPv4 Compatible Addresses

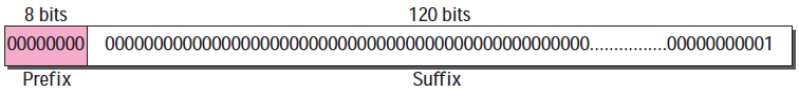
- Prefix: 00000000
- 2^{120} address available
- 0000::/8
  - Unspecified Address
    - All Zeros ::/128
    - Used in bootstrapping, when own IP is not known.



9

IPv4 Compatible Addresses

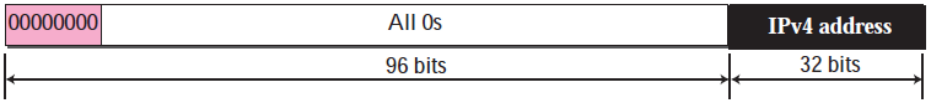
- Loopback Addresses
  - ::1/128



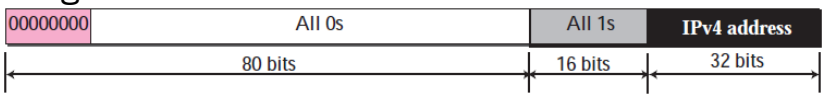
10

Embedded IPv4 Addresses

- Compatible Address
  - IPv6 to IPv6 communication, but intermediate region is IPv4 compliant
  - CIDR Notation ::/96

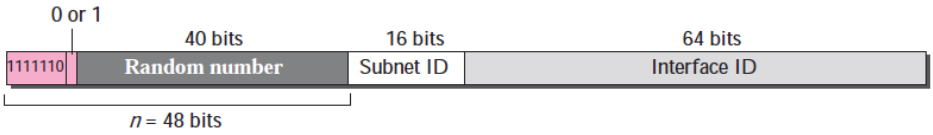


- Mapped Address
  - IPv6 sending to IPv4 machine
  - e.g. 0::FFFF:2.13.17.14



Unique Local Unicast Block

- Site Level (Unique Local Address)
  - Block Identifier 11111110
    - FC00::/8
    - FD00::/8
  - Random bits decrease the chance of duplication
  - This block is not routed into the internet

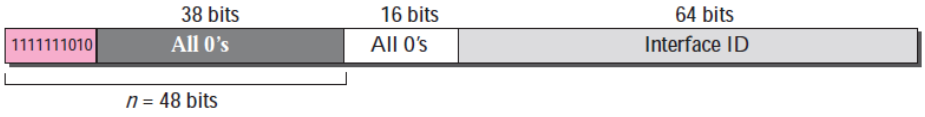


  - 0 or 1: Locally assigned or by some authority

12

Link Local Unicast Block

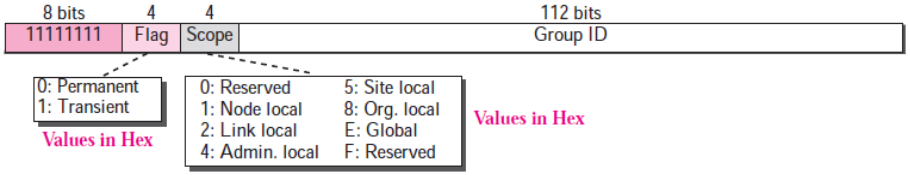
- Link Level Block
  - Every interface has 1 for management purposes
  - Not routable
  - Block Identifier: 1111111010 FE80::/10
  - Next 54 bits are All Zeros



13

Multicast Block

- 1 address for a group of machines
- IP packet is replicated to reach all
- Block Identifier: 11111111 FF00:/8

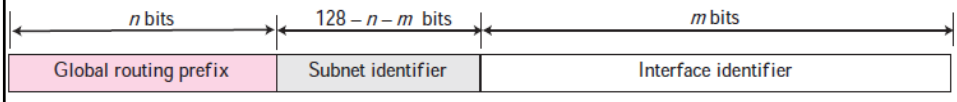


14

Global Unicast Address

- Block Identifier: 001 2000::/3
- 2^{125} available addresses

Three levels of hierarchy

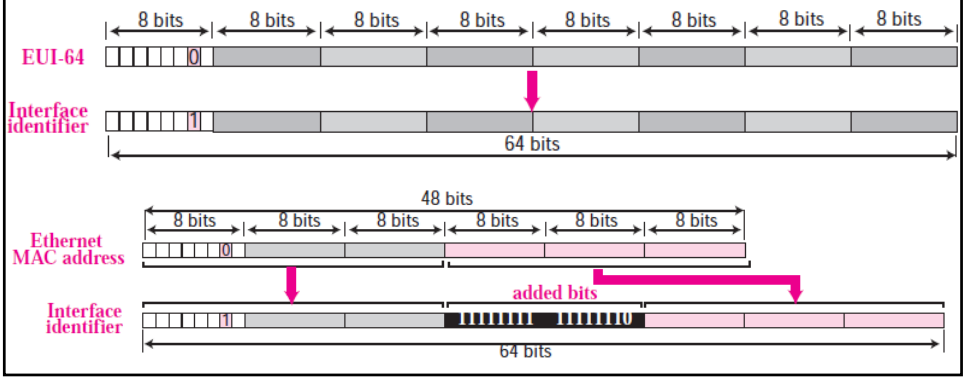


Block Assignment	*Length*
Global routing prefix (*n*)	48 bits
Subnet identifier (128 – *n* – *m*)	16 bits
Interface identifier (*m*)	64 bits

15

Global Unicast Address

- Interface Identifier
  - 2^{64} possibilities
  - May also contain MAC mapping

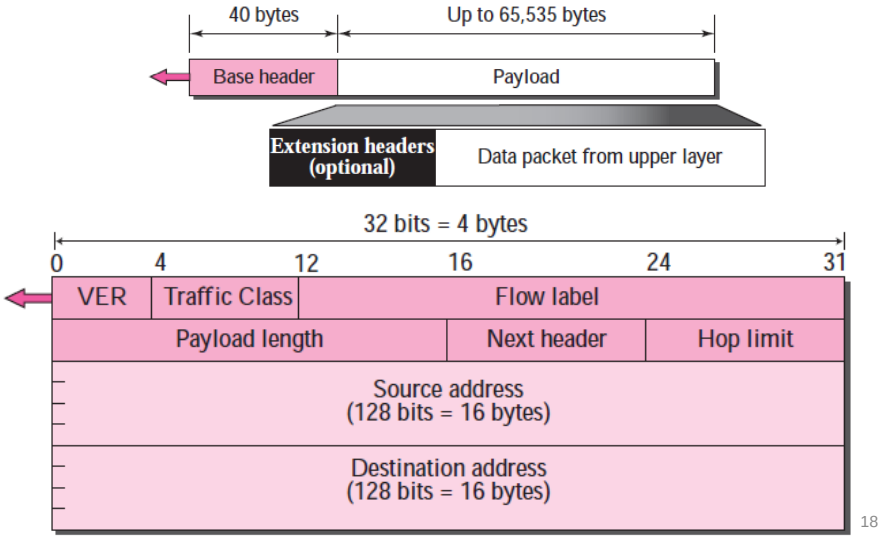


IP v6 Autoconfiguration

- In addition to DHCP IP assignment, host can assign an IP to itself
  - Create a Link Local Address: 1111111010 followed by 54 zeros, followed by 64 bit Interface Identifier
  - Test uniqueness: Neighbor Solicitation Message
    - ICMP v6
    - Neighbors advertise themselves in response
  - If uniqueness passes, build Global Unicast Address
    - Router Solicitation Message
    - Obtain unicast prefix and subnet prefix
  - If any of the above fails, wait for other means of allocation

17

IP v6 Datagram



18

IP v6 Datagram

- Version: 6
- Traffic Class: Same as ToS in IPv4
- Flow Label: Identifies different data flows
- Payload Length: Payload only. Base header not included
- Next Header: Transport layer protocol in use or the optional headers

Code	*Next Header*	*Code*	*Next Header*
0	Hop-by-hop option	44	Fragmentation
2	ICMP	50	Encrypted security payload
6	TCP	51	Authentication
17	UDP	59	Null (No next header)
43	Source routing	60	Destination option

19

IP v6 Datagram

- Hop Limit: TTL Field
- Source Address: Address of originator
- Destination Address:
  - Final destination, or
  - If source routing is used, then address of next router

20

Flow Label

- IP was designed to be connectionless
  - Technologies like MPLS encapsulate IP into a Flow header and use flow labels for forwarding
- Flow:
  - A sequence of packets that share same characteristics: same path, same resources, same level of security, etc.
  - Identified by a flow ID
- Flow tables are used rather than routing
- Beneficial when recourse allocation is done prior to data forwarding

21

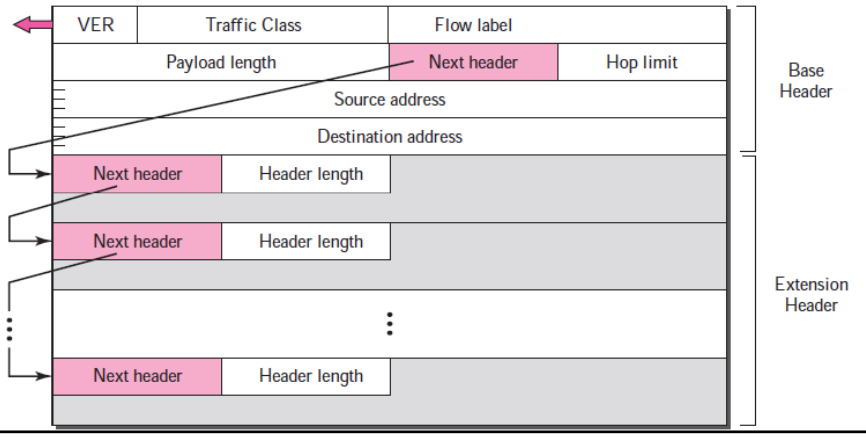
Flow Label

- Flow label rules in IPv6
  - Flow labels are assigned by source
  - Field is set to 0, if flows are not supported
    - If routers don't support it, they ignore the label
  - All packets with same flow label, have same source, same destination, same priority, and same options.

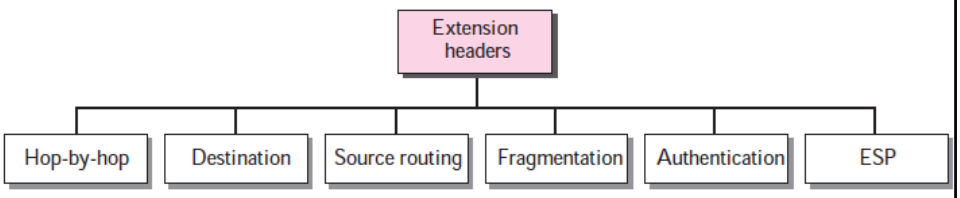
22

Extensions

Base header can be followed by up to 6 extension headers



Extensions



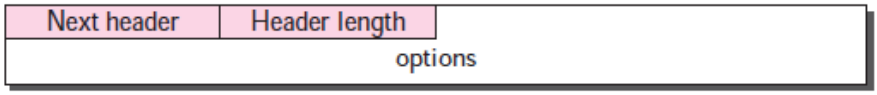
24

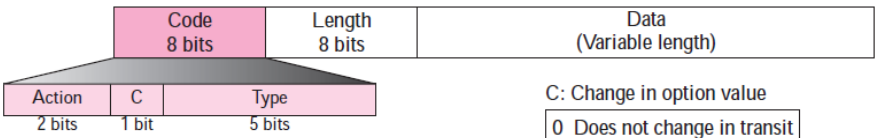
Extensions: Hop-by-Hop Option

- Used when special information has to be passed to each router in the path
- Also used, when payload size is more than 65535 bytes
- Options:
  - Pad1
  - PadN
  - Jumbo payload

25

Extensions: Hop-by-Hop Option





C: Change in option value

0 Does not change in transit
1 May be changed in transit

Action: if the option not recognized

00 Skip this option
01 Discard datagram, no more action
10 Discard datagram and send ICMP message
11 Discard datagram send ICMP message if not multicast

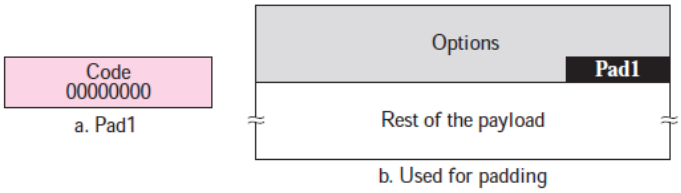
Type

00000 Pad1
00001 PadN
00010 Jumbo payload

26

Extensions: Hop-by-Hop Option

- Pad1
  - 1 byte option (Option Code Field ONLY)
  - For Alignment with 32-bit words using 1 byte only. e.g. Jumbo payload
  - Action is 00; Change bit is 0; Type is 00000



27

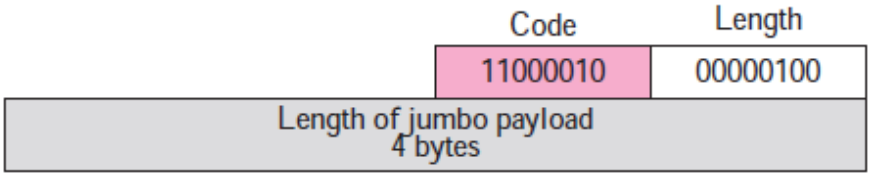
Extensions: Hop-by-Hop Option

- PadN
  - Used when 2 or more bytes are needed for padding
  - Action is 00; Change bit is 0; Type is 00001

28

Extensions: Hop-by-Hop Option

- Jumbo Payload
  - If length of payload in IP datagram is beyond 65535, Jumbo Payload option can be used to define it
  - Jumbo payload option starts at 4n+2 byte



29

Extensions: Destination

- When source needs to pass information to final destination ONLY
- Similar to Hop-by-Hop Extension
- Only Pad1 and PadN defined for it

30

Extensions: Source Routing

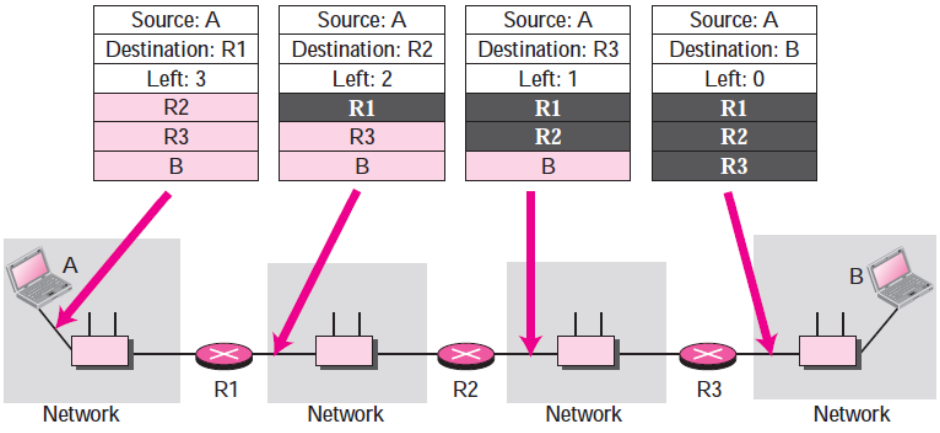
Next header	Header length	Type	Addresses left
Reserved	Strict/loose mask		
First address			
Second address			
⋮			
Last address			

- Type: Type of routing
  - 0: Similar to Loose source
- Addresses Left: Number of hops still needed to reach destination

31

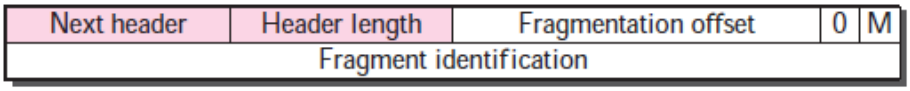
Extensions: Source Routing

Destination Address in IP base header contains next hop address, if this extension is used



Extensions: Fragmentation

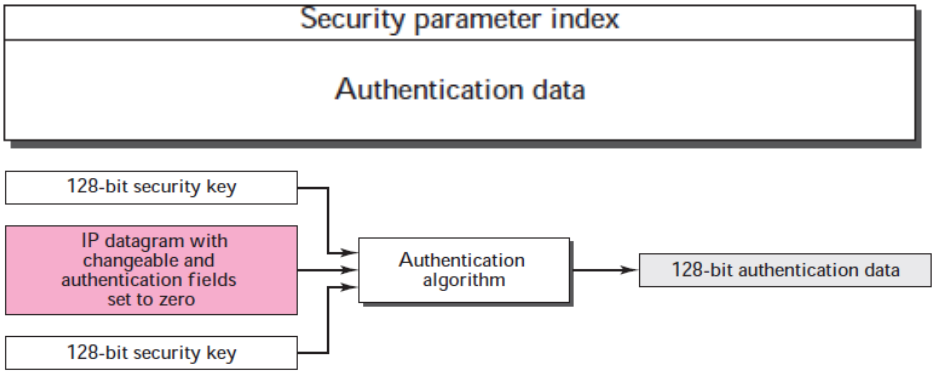
- Only source is allowed to fragment
- Path MTU Discovery Technique is used to determine the smallest MTU along the path
  - If not used, then datagram is fragmented into 1280 bytes or smaller



33

Extensions: Authentication

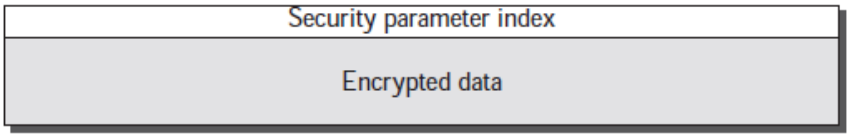
- Extension Header
  - Validates the message sender
  - Ensures integrity of data



34

Extensions: Encrypted Security Payload

- Guards against eves dropping
- Ensures confidentiality



35

Recommended Extension Order

Extension Header	Description
IPv6 Hop-by-Hop Option	All path nodes options
Destination Options for IPv6	Destination node-only options
Routing Header for IPv6	To specify a route (ex : mobile IPv6)
Fragment Header for IPv6	Parameters for datagrams fragmentation
Authentication Header	AH (IPSEC)
Encapsulating Security Payload	ESP (IPSEC)
Destination Options for IPv6	Destination node-only options
Mobility Extension Header for IPv6	Mobile IPv6 Parameters

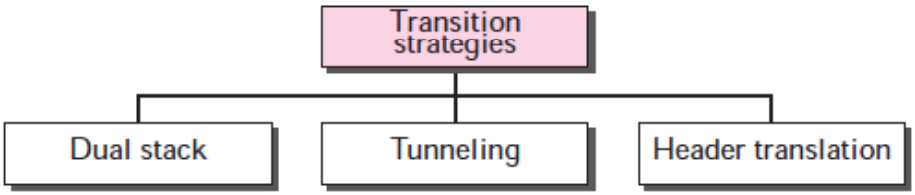
36

IPv4 vs IPv6

- No-op & End-of-option
- Record Route
- Time stamp
- Source Route Option
- Frag. Field
- No Authentication
- No Encryption
- Pad1 & PadN
- No route recording
- No Time stamping
- Source Route Extension
- Frag. Extension
- Authentication Extension
- ESP Extension

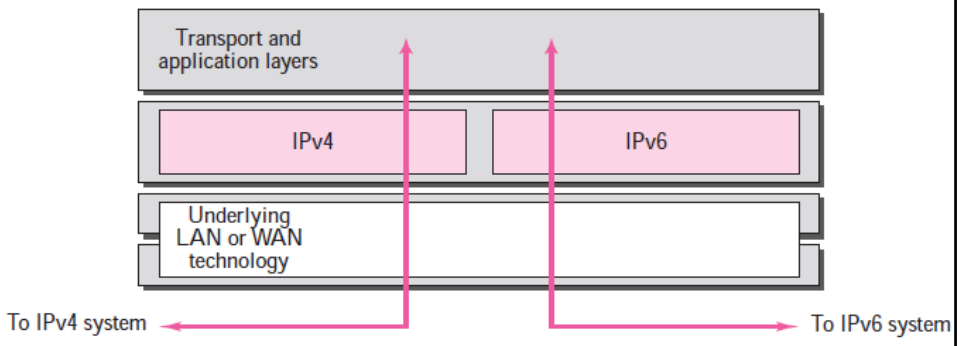
37

Transition IPv4 → IPv6



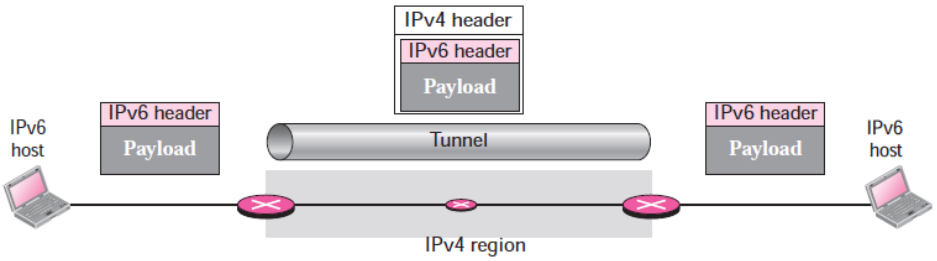
38

Transition IPv4 → IPv6
Dual Stack



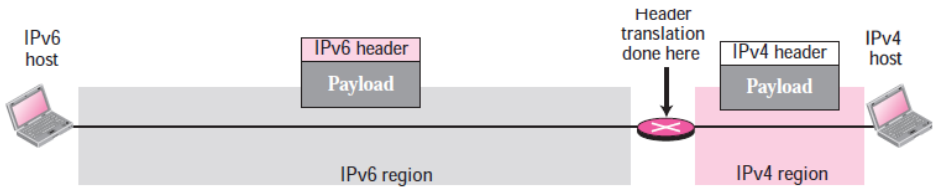
39

Transition IPv4 → IPv6
Tunneling Strategy



40

Transition IPv4 → IPv6
Header Translation



41