CN-Basic
L29

IPv6 and IPSec

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IPv6 Resources

- http://www.ipv6forum.org/dl/books/the_second_internet.pdf
- http://www.ipv6forum.org/dl/books/ipv6forall.pdf http://www.6deploy.eu/e-learning/english/
- http://highered.mcgraw-hill.com/sites/0073376221/student_view0/chapter22/java_applets.html

IPv6 - Why New IP/Motivation

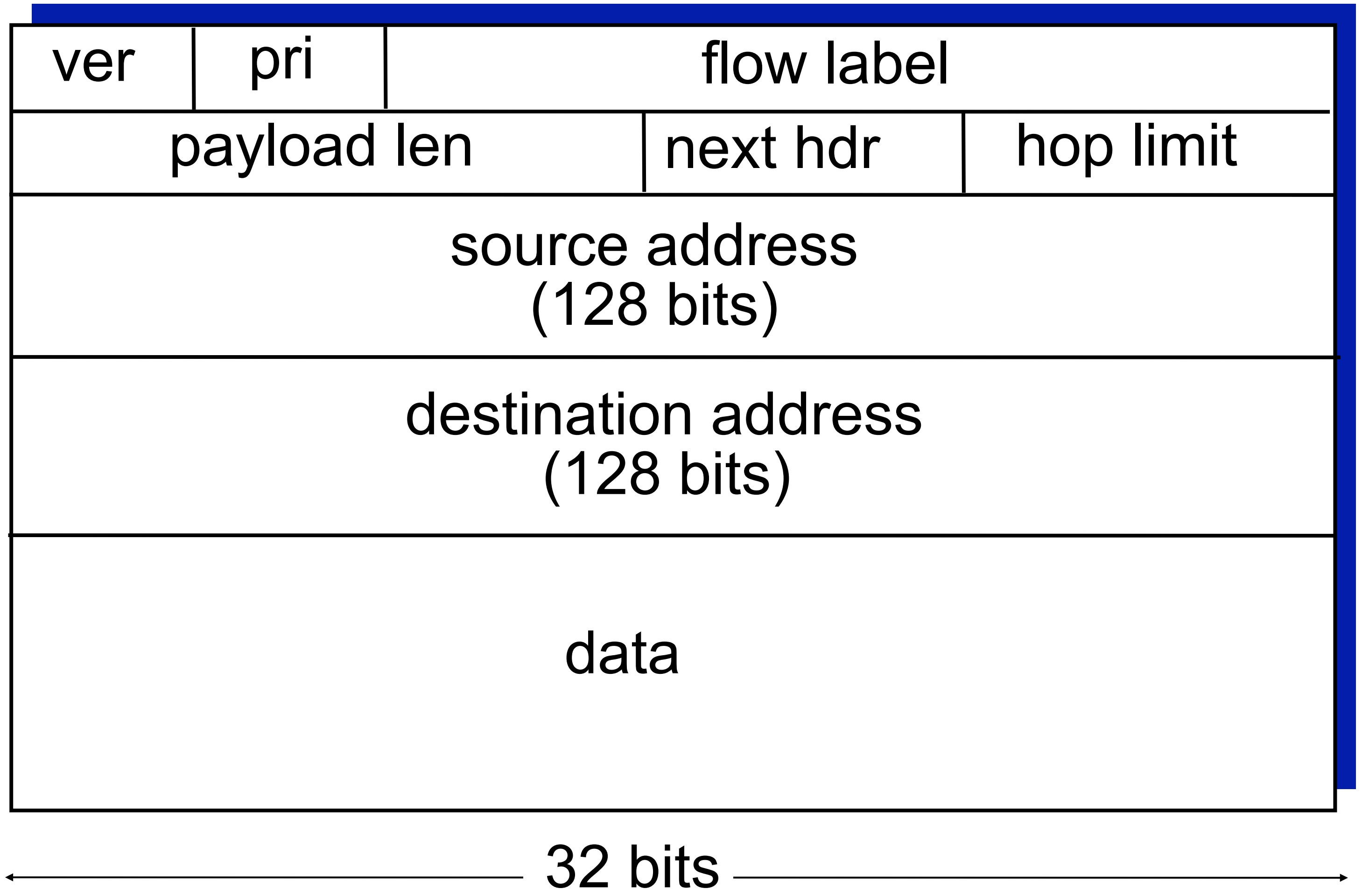
- More addresses needed
- Billion of new devices
  - May explode by 100 times
  - Pervasive computing (internet of devices, things)
- Billions of new users: India, China etc
- Ability to do end to IPSec
  - NAT not needed
- additional motivation:
  - header format helps speed processing/forwarding
  - header changes to facilitate QoS
  - fixed-length 40 byte header
  - no fragmentation allowed

IPv6 datagram format

priority: identify priority among datagrams in flow

flow Label: identify datagrams in same “flow.”
(concept of“flow” not well defined).

next header: identify upper layer protocol for data



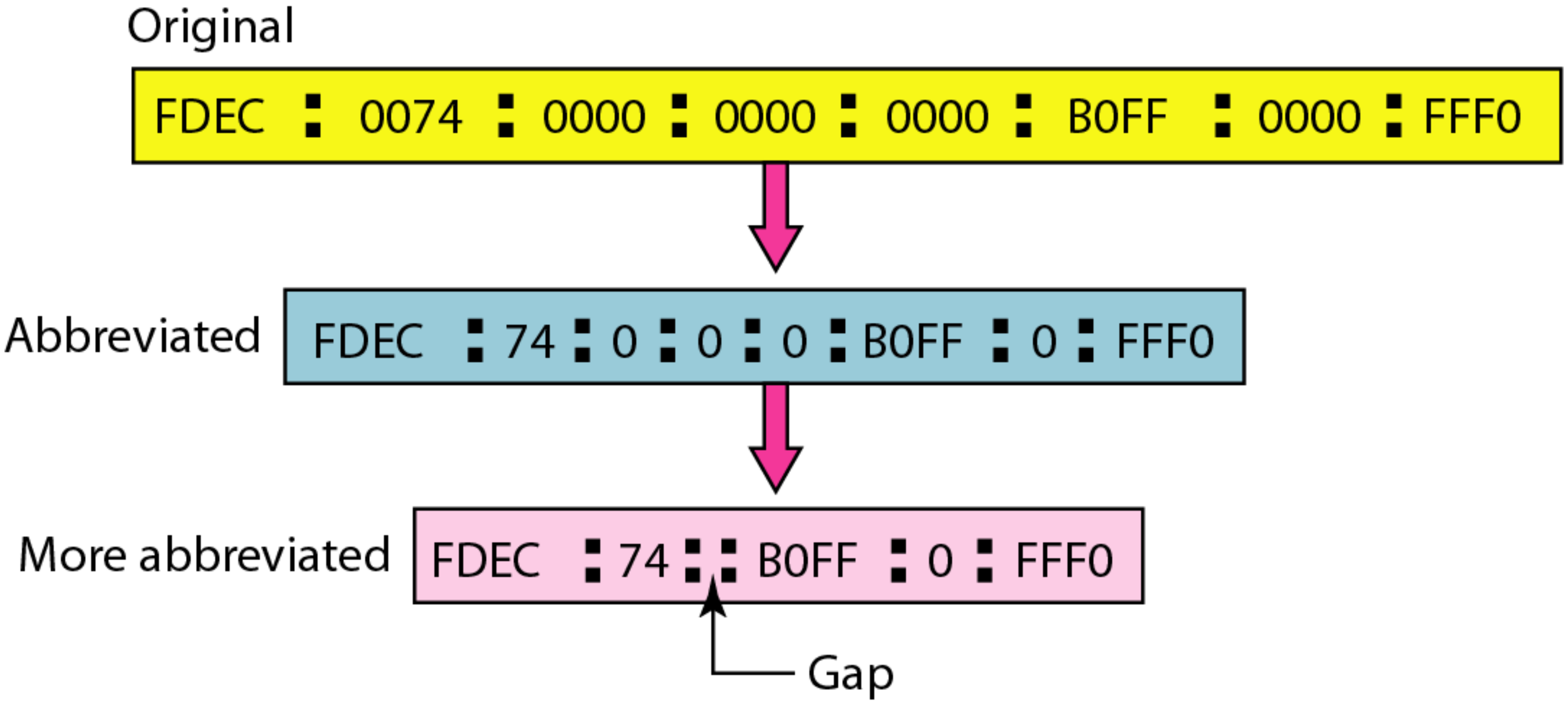
ver
pri
flow label
payload len
next hdr
hop limit
source address
(128 bits)
destination address
(128 bits)
data
32 bits

Other changes from IPv4

- *checksum:* removed entirely to reduce processing time at each hop
  - better header format
- *options:* allowed, but outside of header, indicated by "Next Header" field
- *ICMPv6:* new version of ICMP
  - additional message types, e.g. "Packet Too Big"
  - multicast group management functions
  - allows for extension of protocols
- Security & Mobility support

IPv6 Addresses

- 128 bits address
  - 16 bytes = 32 hex digits
- Written in hexadecimal colon notation
  - preferred form - x:x:x:x:x:x:x:x


Original
FDEC : 0074 : 0000 : 0000 : 0000 : B0FF : 0000 : FFF0
Abbreviated
FDEC : 74 : 0 : 0 : 0 : B0FF : 0 : FFF0
More abbreviated
FDEC : 74 :: B0FF : 0 : FFF0
Gap

❖ Src: Frozen Computer Networking

IPv6 Address Types

- Unicast
  - aggregatable with prefixes of arbitrary length
- Multicast
  - No broadcast in IPv6
  - Broadcast considered one special case of Multicast
  - uses special link local all nodes multicast group
    - FF02::1 - Analogous to 224.0.0.1
    - FF02::2 - link local scope all routers
- Anycast
  - packets delivered to one member of group

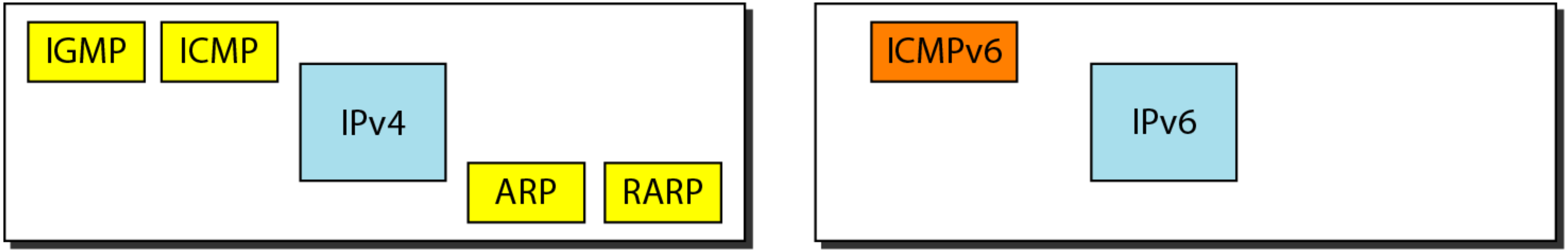
IPv6 Address Allocation

- Unicast
  - Global Unicast (First 3 bits are `001`)
  - Site-local unicast (deprecated) (0xFEC0)
  - Link-local unicast (0xFE80)
  - Unique local (`(0xFC)`
    - like `192.168.x.x, 172.16.x.x-172.31.x.x, 10.x.x.x`
- Global Unicast
  - For one to one communication between hosts
    - global routing prefix
    - subnet identifier
    - interface identifier
      - similar to hostid in IPv4

IPv6 Address - Special Addresses

- The Unspecified Address
  - 0:0:0:0:0:0:0:0
  - can be written as ::
- The loopback address
  - 0:0:0:0:0:0:0:1
  - can be written as ::1
  - similar to 127.0.0.1 in IPv4

ICMPv6



Network layer in version 4

Network layer in version 6

- ICMPv6 is more complicated than ICMPv4
  - ARP and IGMP are combined into ICMPv6
  - More messages have been added
- ICMPv6 Message categories
  - Error Messages
  - Informational Messages
  - Neighbor Discovery Messages
    - ND (Neighbor Discovery) protocol
  - Group Membership messages
    - MLD (Multicast Listener Delivery) protocol

ICMPv6 Messages

- Stateless Autoconfiguration
  - RFC 2462
  - allows a host to generate its own address
  - uses local information and router advertisement info
  - routers advertise the prefix identifying the subnets
  - host generates the interface id within the subnet
  - when router is absent
    - host generates link local address
    - permits communication on same link
  - applies only to hosts and not to routers
    - routers need to be configured by some other means

Transition from IPv4 to IPv6

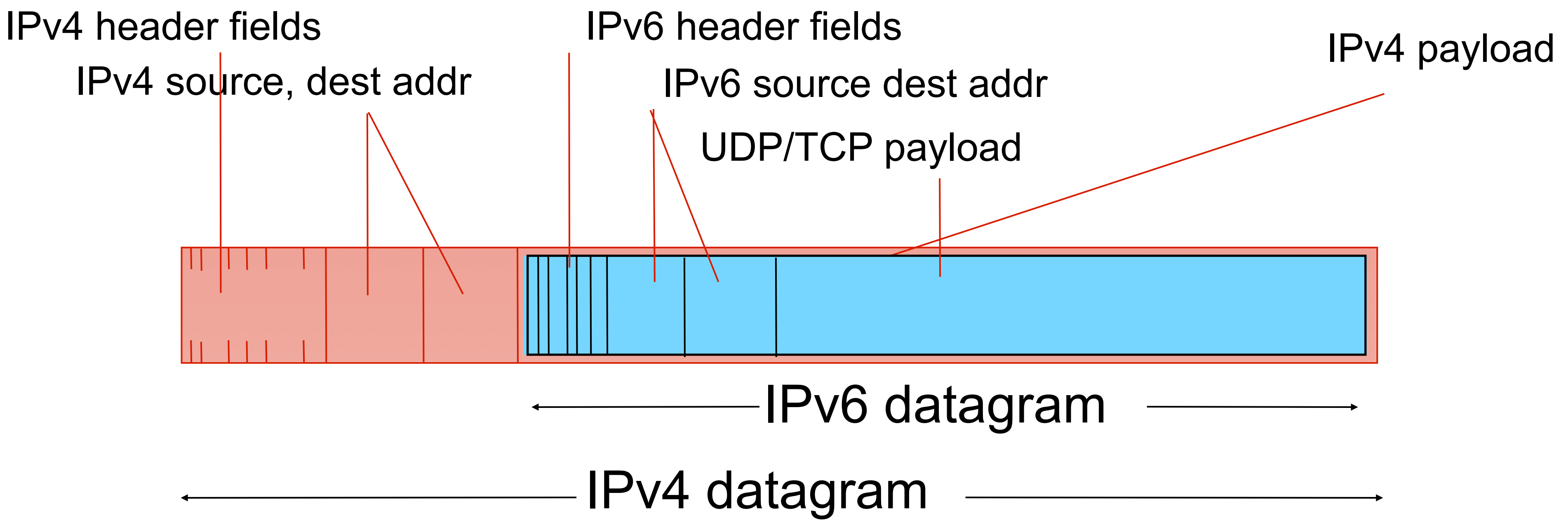
- Not all routers can be upgraded simultaneously
  - no "flag days"
  - how will network operate with mixed IPv4 and IPv6 routers?
- Transition Strategies
  - Dual Stack
  - Tunneling
  - Address Translation

Transition from IPv4 to IPv6

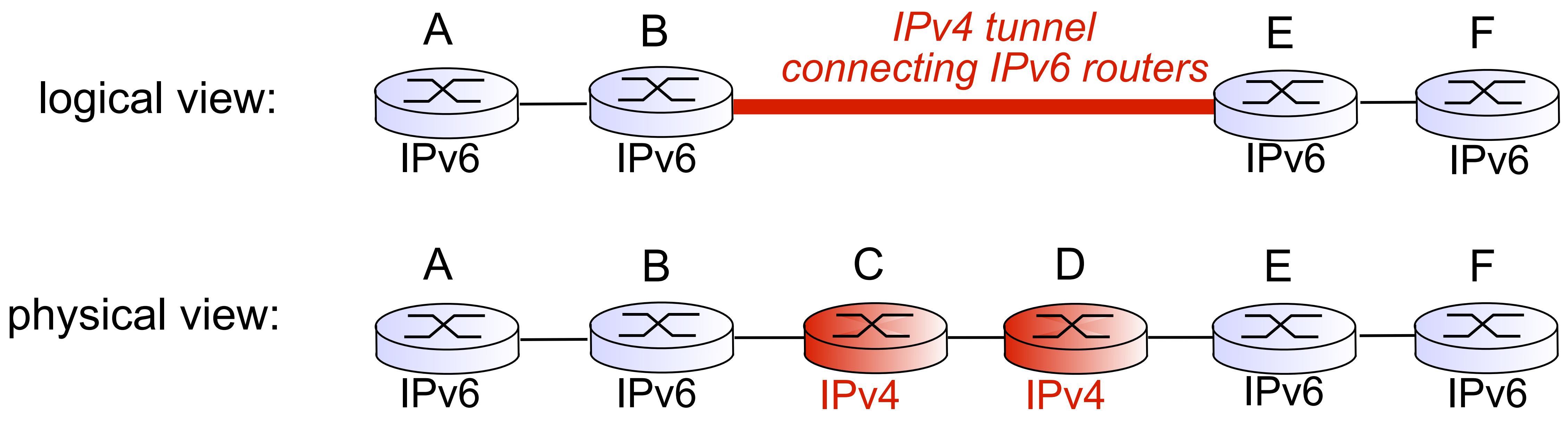
- Dual Stack
  - at network layer, both IPv4 and IPv6 present
  - DNS response determines which stack to use
    - response can IPv4 or IPv6 or both
      - If IPv6 is present, use IPv6
      - Else use IPv4
  - Two stacks co-exist indefinitely
  - Bundled with OS, no extra add on software/cost
    - Linux, Mac, Windows (including Windows XP)
  - No change in Datalink layer/Transport layer

Transition from IPv4 to IPv6

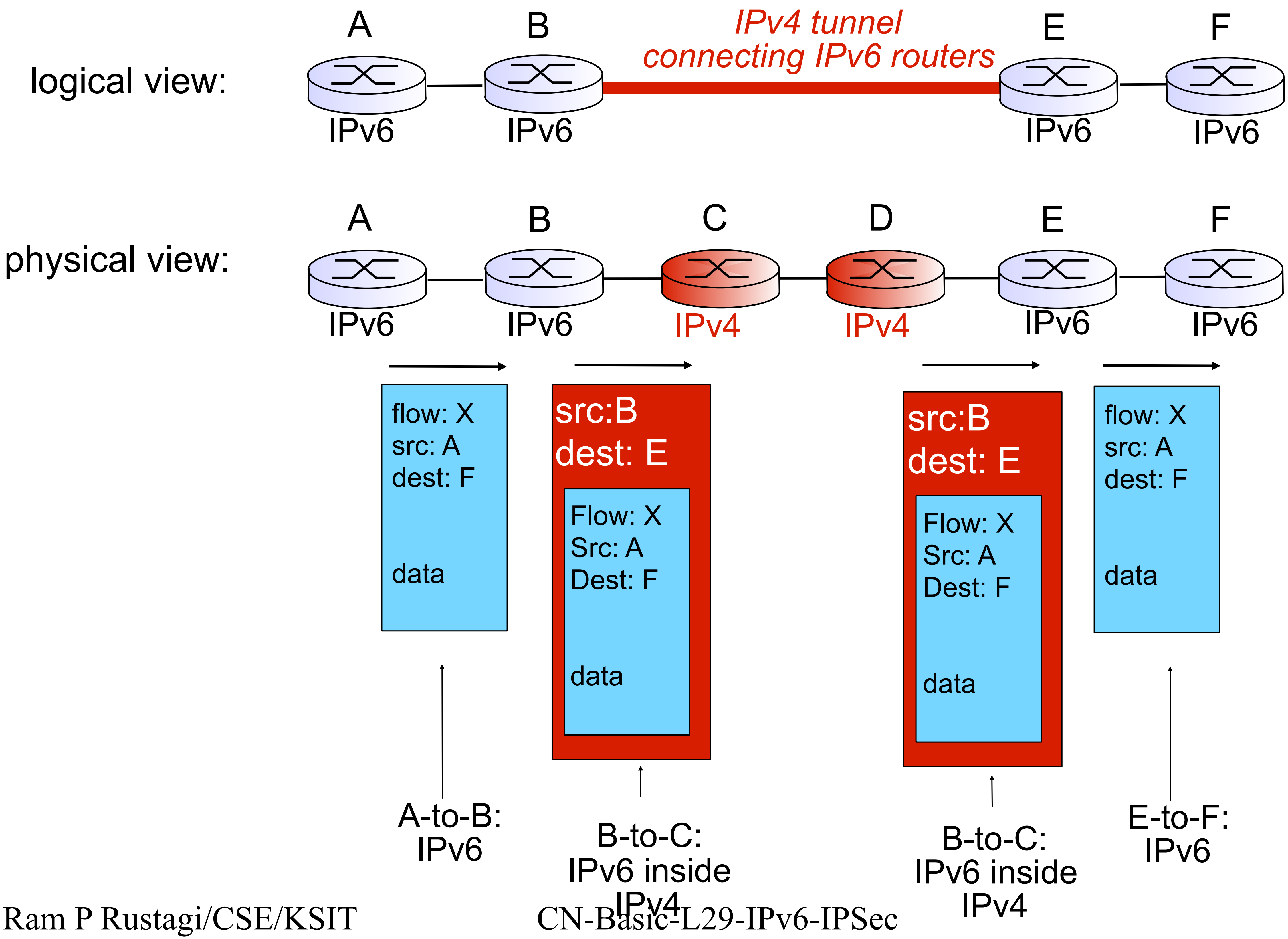
- *tunneling:* IPv6 datagram carried as *payload* in IPv4 datagram among IPv4 routers
  - similar to IP in IP tunnels
- There is no virtual connection setup
  - two end points need to be configured
- intermedia IPv4 routers treat it as IPv4 packet



Tunneling


A
B
IPv4 tunnel connecting IPv6 routers
E
F
logical view:
IPv6
IPv6
IPv6
IPv6
A
B
C
D
E
F
physical view:
IPv6
IPv6
IPv4
IPv4
IPv6
IPv6

Tunneling


A
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IPv4 tunnel
connecting IPv6 routers
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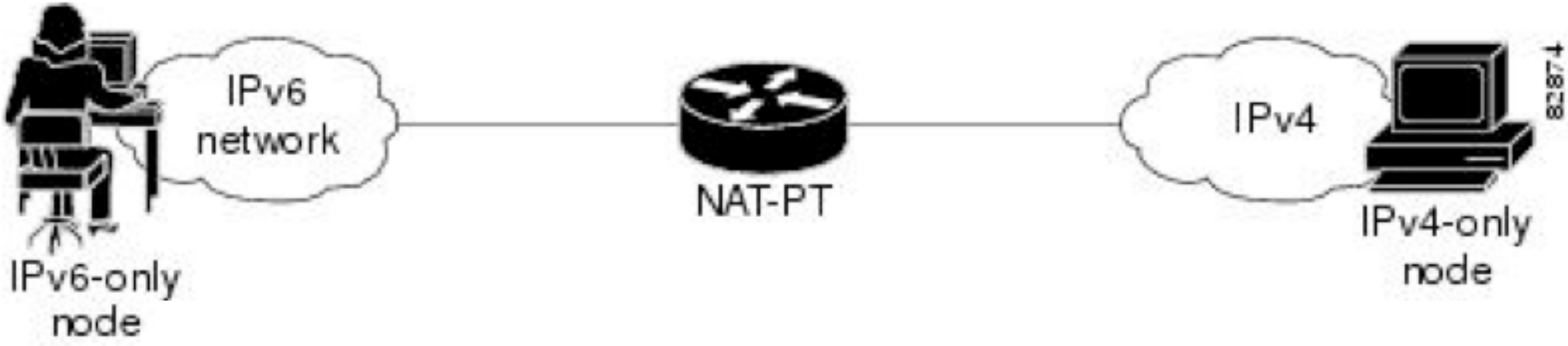
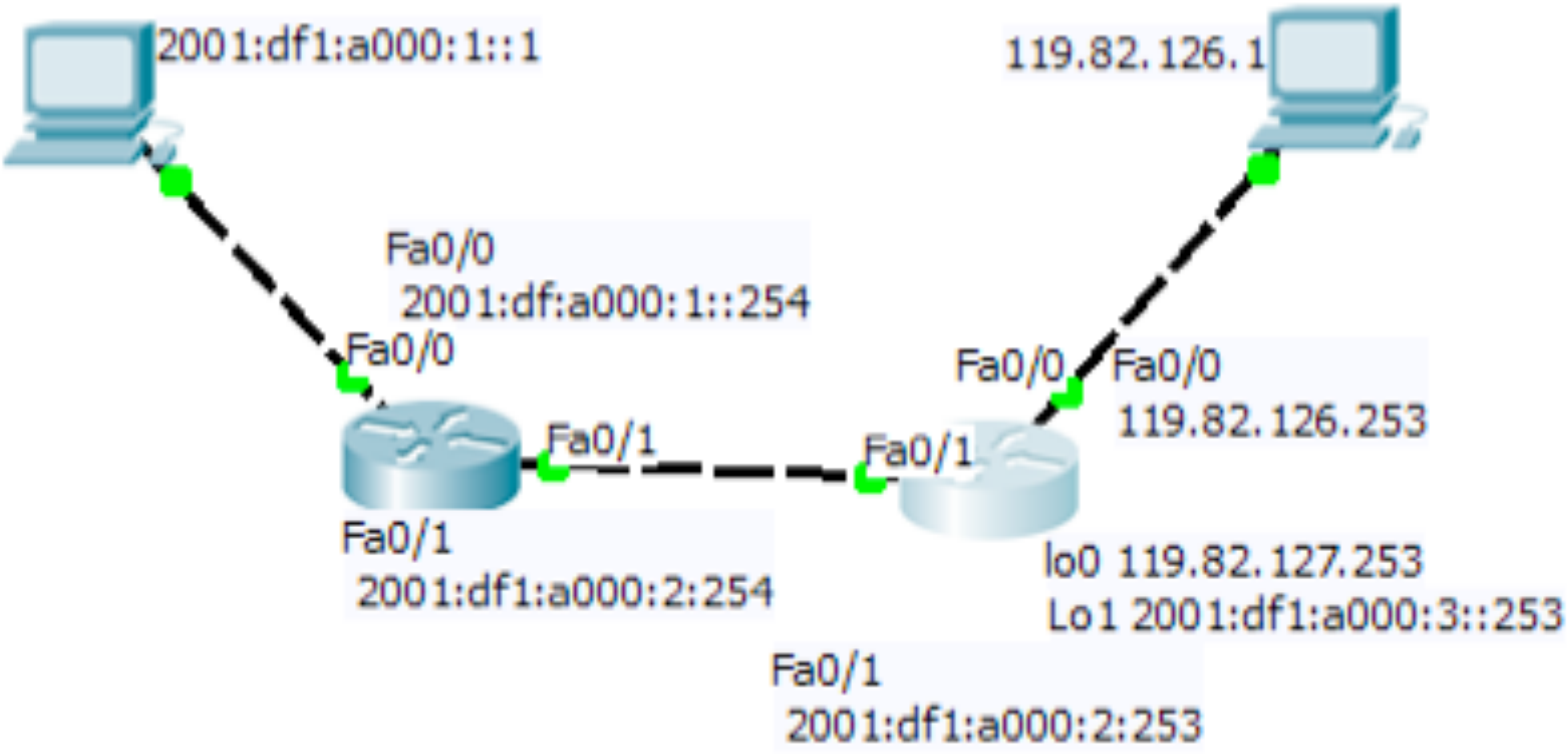
logical view:
IPv6
IPv6
IPv6
IPv6
A
B
C
D
E
F
physical view:
IPv6
IPv6
IPv4
IPv4
IPv6
IPv6
flow: X
src: A
dest: F
data
src:B
dest: E
Flow: X
Src: A
Dest: F
data
src:B
dest: E
Flow: X
Src: A
Dest: F
data
flow: X
src: A
dest: F
data
A-to-B:
IPv6
B-to-C:
IPv6 inside
IPv4
B-to-C:
IPv6 inside
IPv4
E-to-F:
IPv6

Transition from IPv4 to IPv6

- Address Translation (NAT64)
  - provides full functionality when talking to IPv6
  - Normal/degraded functionality when talking to IPv4
  - IPv6 address is changed to IPv4 and vice versa
    - If mapped address, then use last 32 bits
  - The value of IPv6 priority, flow is discarded
  - TOS bits in IPv4 are set to 0
  - Checksum for IPv4 is computed and added
    - no checksum in IPv6
  - IPv6 extension headers compatible to IPv4 options
    - converted appropriately
  - Other IPv4 fields computed and inserted

Basic NAT-PT Operation





src: Cisco Inc.

NAT64

- Benefits
  - No changes required for existing hosts
  - All configurations are done at NAT-PT router
  - Existing IPv4 network can augment
    - Add IPv6 network to existing installation
    - Seamless communication between two network
- Caveats
  - Not to be used along with
    - Dual stack
    - Tunneling
  - Need to enabled on both i/c and o/g interfaces

NAT64 Limitations

- Details in RFC 4966
  - ALG issues
    - DNS-ALG, FTP-ALG, HTTP-Proxy etc.
- NAT46 can not work well
  - mapping 128bit address space to 32bit is hard
  - IPv4 clients accessing IPv6 content
  - NAT64 solves
    - IPv6 client accessing IPv4 content
- NAT-PT router must be on the path to DNS query
  - A serious issue for ISPs

IPSec

- IPv4 designed in 1970
  - No security support initially
- IPSec: Most populare secure network layer protocol
  - Widely deployed in VPNs
  - Backward compatible with IPv4 and IPv6
  - Can work with existing routers (w/o replacing these)
- IPSec can be end to end
  - Established between two hosts
  - No intermediate routers need to run IPSec
  - Works with both IPv4 and IPv6

IPSec Transport Mode

- Two end to end hosts establish IPSec session
    - Thus, IPSec is connection oriented
- All TCP and UDP run on top of IPSec
    - Enoys the support of security services provided by IPSec
    - IPSec encrypts the transport pkt on sender side
    - Encapsulates the resulting payload in IP datagram
    - Sends the payload in IPv4 datagram on internet
    - Destination host decrypts the payload, and gives to application

IPSec Transport Mode

- IPSec services
  - Cryptographic agreement
    - 2 hosts agree on cypto algorithm and keys
  - Encryption of IP datagram payload
    - Only receiving host can decrypt
  - Data integrity
    - Enables receiver to verify that header and encrypte data has not been tempered with.
  - Origin authentication (src IP in pkt is verified)
    - receiver is assured of sender’s IP address
- Basically provides blanket services between 2 hosts
  - Both TCP and UDP protocols

IPv6 Summary

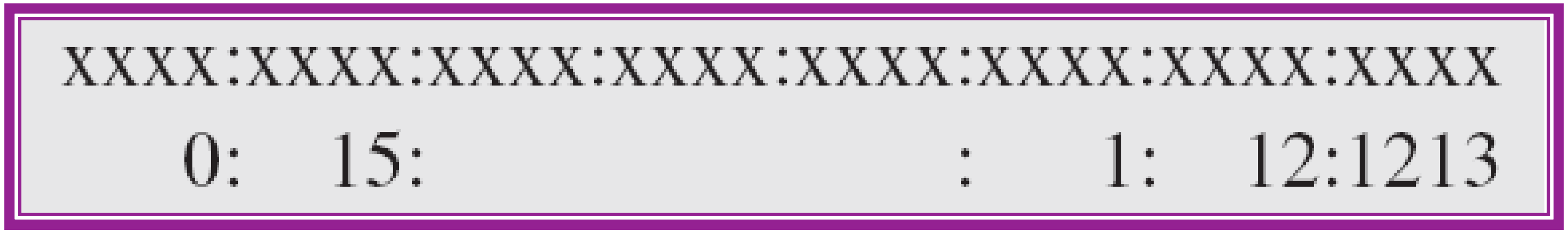
- Anycast, unicast, multicast addresses
- Auto configuration
- Colon Hexadecimal notation
- Destination option
- Dual Stack
- Extension headers
- Link Local addresses
- IPv4 compatible addresses
- Address translation

IPv6 Address

- Exercise 1
  - Given the address
    - 2001:0DB8:0000:CD30:0000:0000:0000:0000/60
  - which are correct representations
    - 2001:0DB8::CD30:0:0:0:0/60
    - 2001:0DB8:0:CD30::/60
    - 2001:0DB8:0:CD3/60
    - 2001:0DB8::CD30/60
    - 2001:0DB8::CD3/60

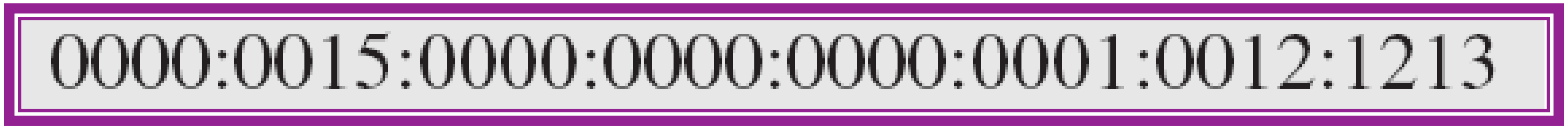
IPv6 Addresses

- Exercise 2
  - *Expand the address 0:15::1:12:1213 to its original*
- Answer
  - Align to the left side of double colon
  - Align to the right side of double colon
  - Fill the gaps with zeros



```
xxxx:xxxx:xxxx:xxxx:xxxx:xxxx:xxxx:xxxx
     0:   15:               :     1:   12:1213
```

  - The original address is



```
0000:0015:0000:0000:0000:0001:0012:1213
```

Src: Forouzan Computer Networking 4th edition