Labcourse “Routerlab”

Internet Protocol Version 6 (IPv6)

IPv4 Shortcomings

- IPv4 addresses have 32 bits only
  - not enough for 1 IP address per person
  - dynamic IPs, NAT, …
- Manual configuration
  - time consuming (in larger networks)
  - error-prone (wrong addresses, duplicates, …)
- IPv4 header format
  - variable length header (option field)
  - inefficient to parse if IP options present

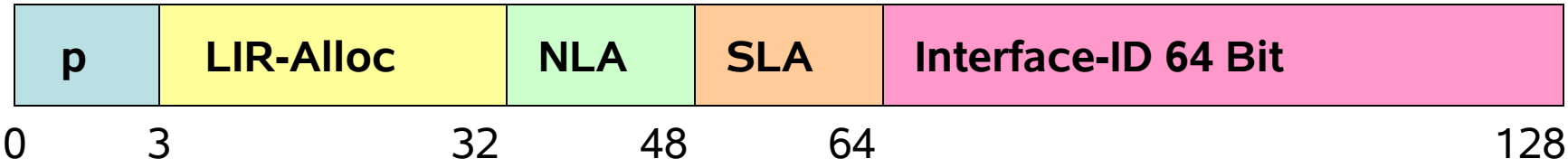
IP Next Generation = IPv6

- New layer 3 protocol
- Key changes
  - 128 bit address length (vs. 32 bit)
  - Autoconfiguration
  - Restructured / optimized layer 3 headers
  - IPSEC security layer
  - Mobile IP(v6)
- But: *all basic principles stay the same*

IPv6 Benefits: Address Format

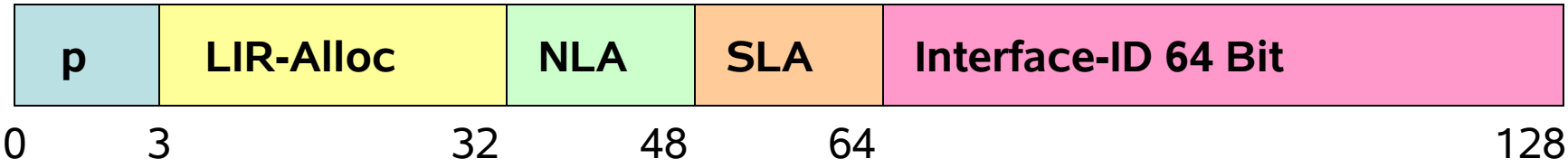
- 32 bits in IPv4 ↔ 128 bits in IPv6
- IPv4
  - 4 x 8 bits, decimal notation, separated by "."
- IPv6
  - 8 x 16 bits, hexadecimal, separated by ":"
  - Drop leading zeroes (':0123:0001' = ':123:1')
  - Only one series of zeroes can be reduced to '::'
  - Examples:
    - 2001:200:0:8002:203:47ff:fea4:3085
    - 2001:608::2
    - fe80::210:60ff:fe80:3a16

IPv6 Address delegation: Hierarchy



- Bigger networks, *fixed size* assignments
  - Providers receive /19../32 network blocks
  - Every customer receives a /48 network block
  - Every LAN uses a /64 network
  - Inside LAN: 64 bit host part = "interface ID"
- Right now: Only allocations from p=001
  - 2xxx:: and 3xxx::)

IPv6 Routing



- Forwarding / routing table lookup: similar to IPv4
- Same basic rule: "most specific wins"
  - 2001:608:b:1::/64
  - 2001:608:b::/48
- Default route is 0::0/0
- Routing protocols (BGP, OSPF) and routing table buildup follow same principles as IPv4

IPv6 Benefits: Autoconfiguration

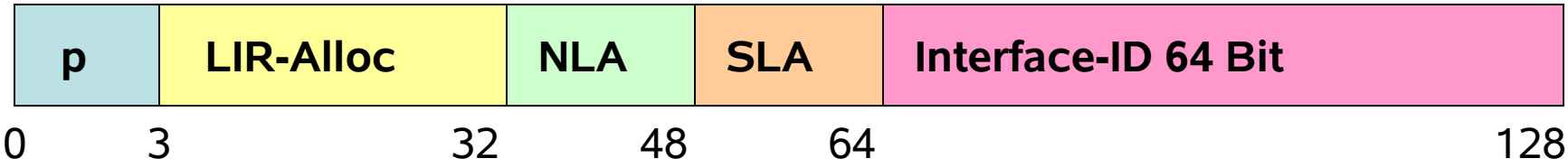
- *Every* link uses fe80::/64 for link-local stuff
  - Hosts in isolated networks automagically communicate
- Router can announce global addresses
  - Router Advertisement (RA) ICMP packets
  - e.g., 2001:608:4:0::/64)
- Clients will use *all* available /64 prefixes
  - Compute the host part from their MAC address
  - EUI-64: Algorithm for computing 64-bit host part from 48-bit (Ethernet) MAC address

EUI-64 Autoconfiguration Example

- MAC address: 00:10:60:80:3A:16
- Link-local prefix fe80::64
- Router advertises prefix 2001:608:4:0::/64
- MAC converted to host part of IPv6 address
  - 00:10:60:80:3A:16 → ::210:60**ff**:**fe**80:3a16
  - Append this to all (!) prefixes
- Resulting interface configuration

eth0 Link encap: Ethernet HWaddr 00:10:60:80:3A:16
inet addr:193:149:48:163 Mask: 255.255.255.224
inet6 addr: 2001:608:4:0:210:60ff:fe80:3a16/64 Scope:Global
inet6 addr: fe80::210:60ff:fe80:3a16/64 Scope:Link

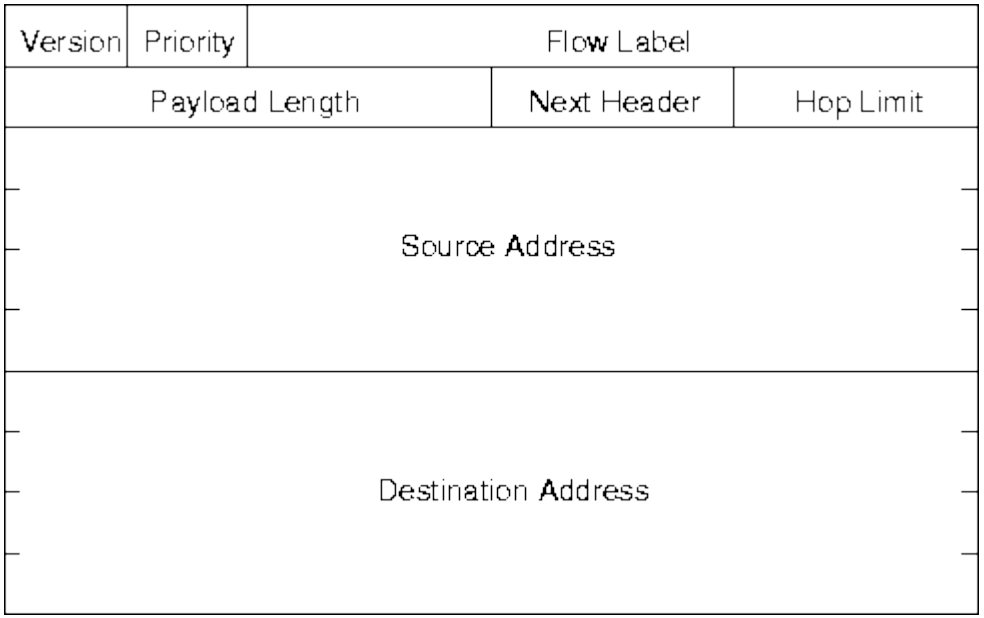
IPv6 Addresses frequently seen



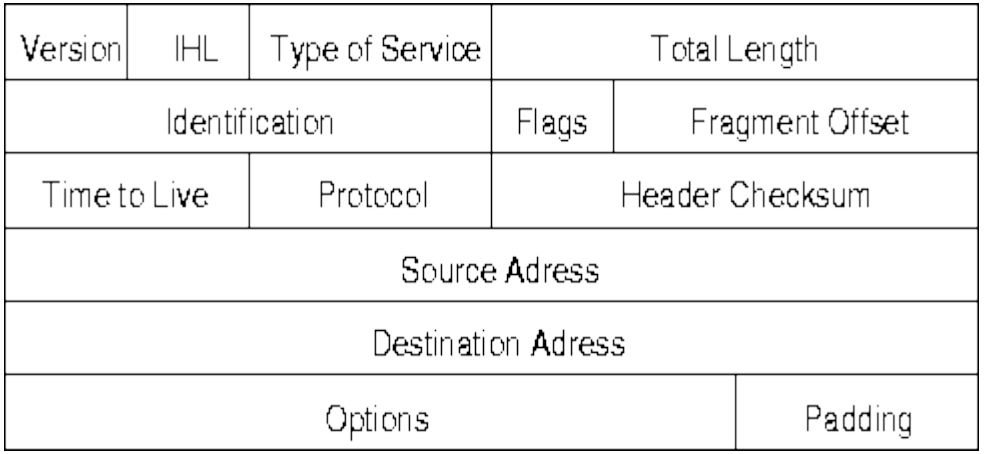
- "local" addresses
  - fe80::/64 link-local addresses
- "global" addresses
  - 2001:: early IPv6 production networks
  - 2002:IPv4::/48 6to4 migration method
  - ff0x:: global multicast address ranges

Ipv4 vs. IPv6 header

IPv6 header



IPv4 header



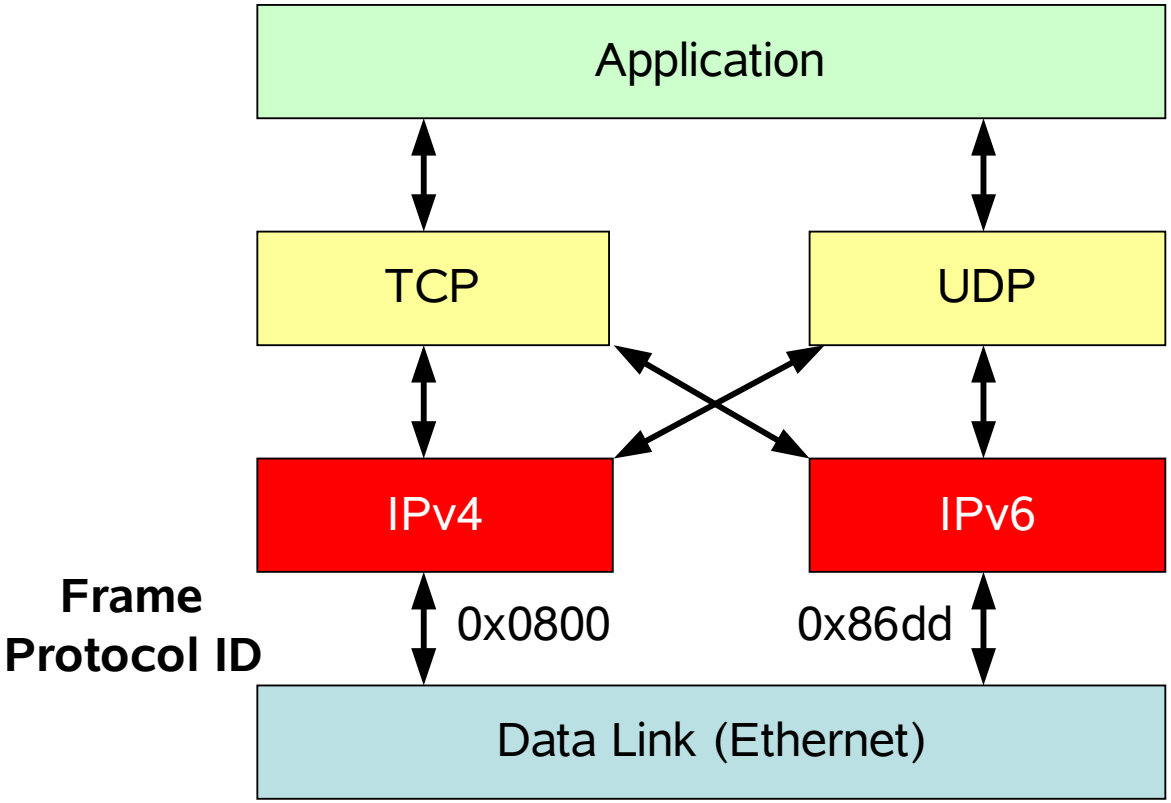
Migration towards IPv6

Problems

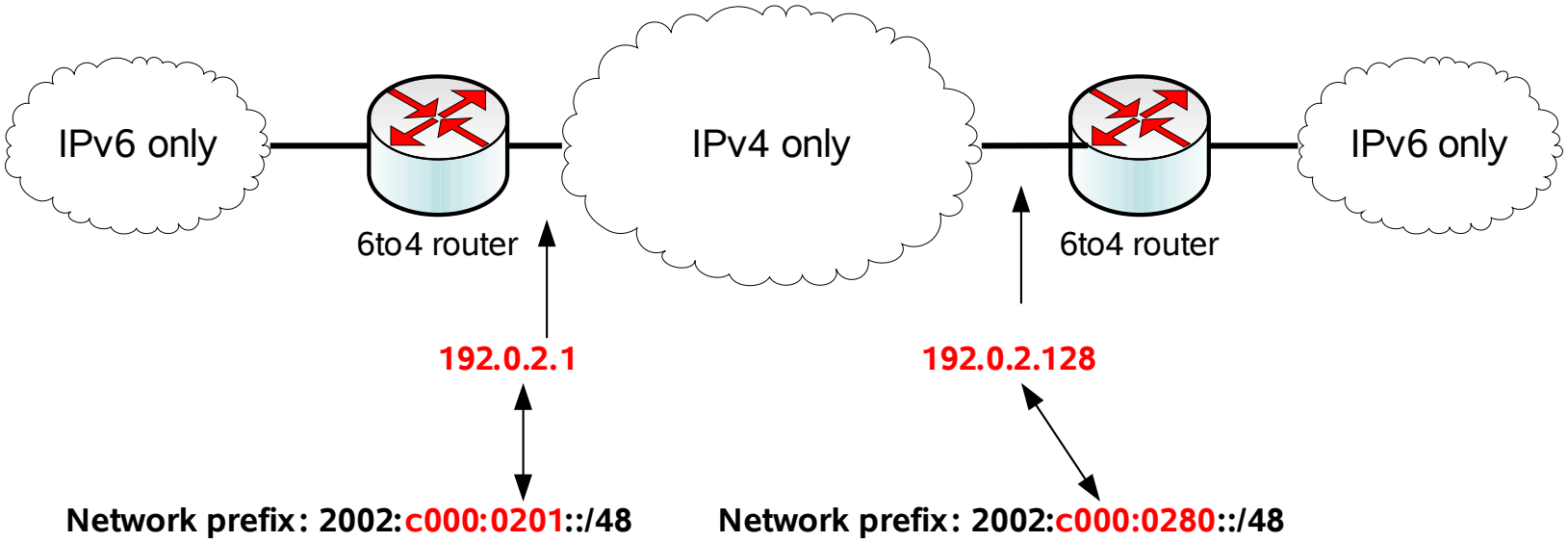
- v4 host wanting to talk to v6 host
- v6 networks that are only connected by v4 infrastructure

- Migration techniques:
  - Dual-stacked hosts/router (v4+v6 IP stack on same machine)
  - Dual-stacked proxies / application-level gateways
  - Tunneling
    - Manually configured tunnels
    - Automatic tunneling (6to4, ISATAP, Teredo)
    - Tunnels configured by tunnel broker

Dual Stack

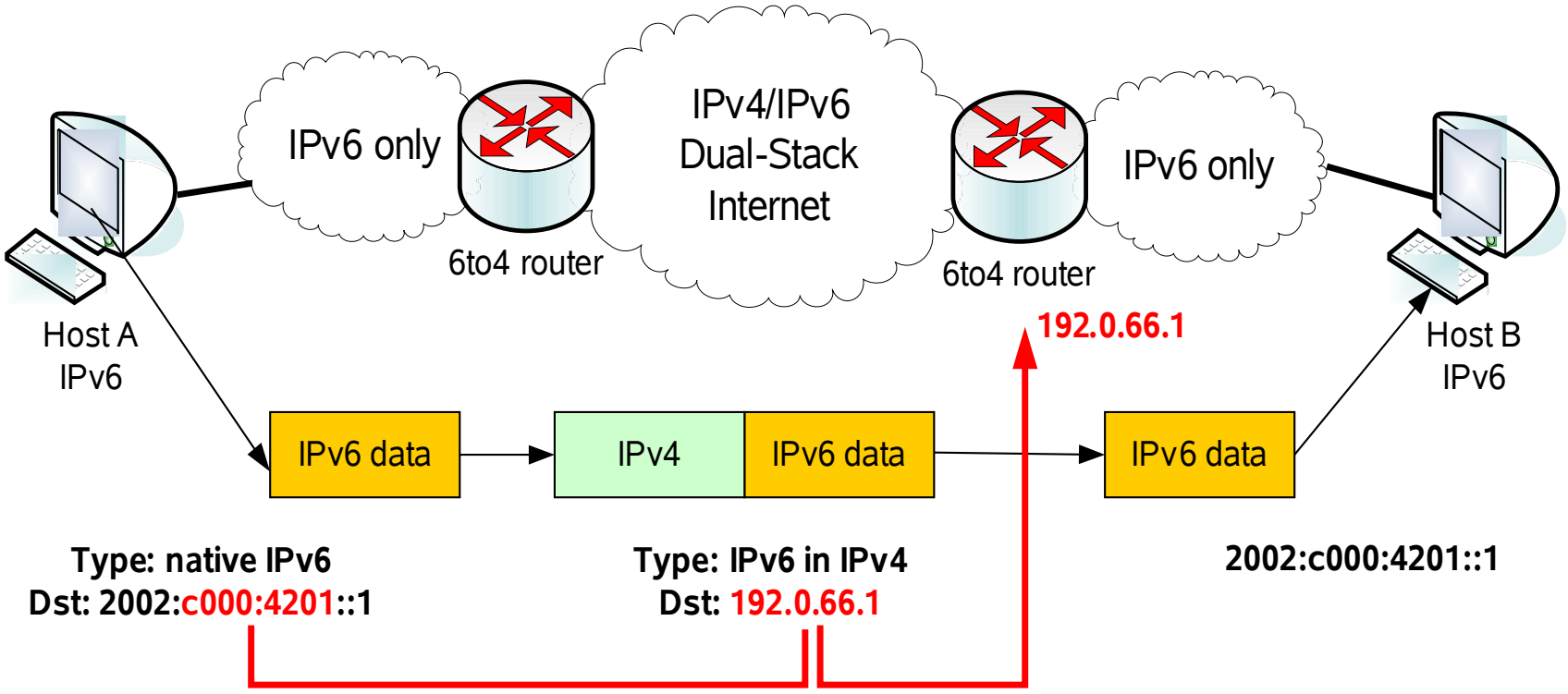

Application
TCP
UDP
IPv4
IPv6
Frame Protocol ID
0x0800
0x86dd
Data Link (Ethernet)

6to4 IPv6 Addresses



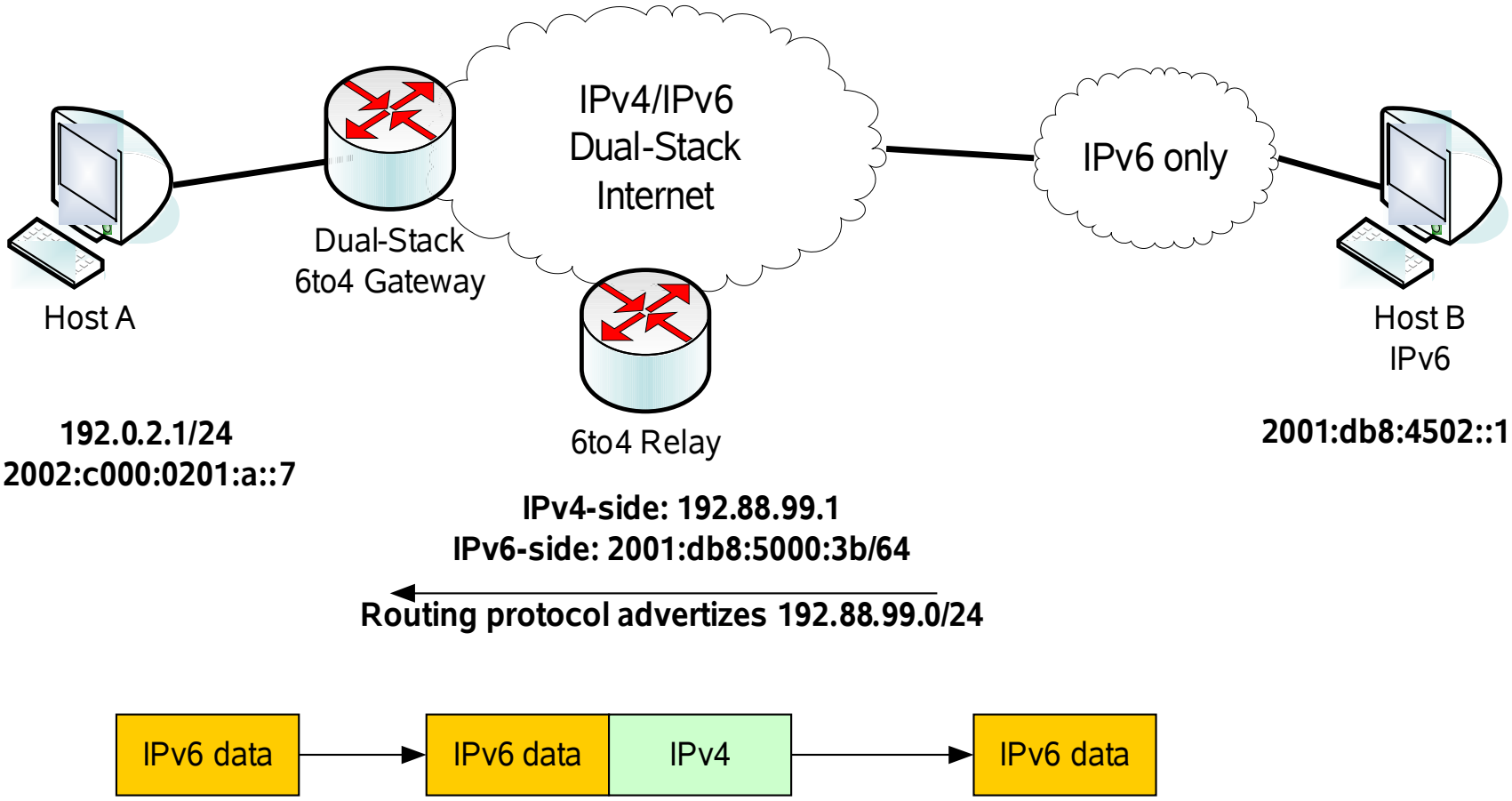
- Converts IPv4 to hex and integrates into 6to4 IPv6 address
- Gives a /48 prefix to attached IPv6 networks

6to4 Tunneling



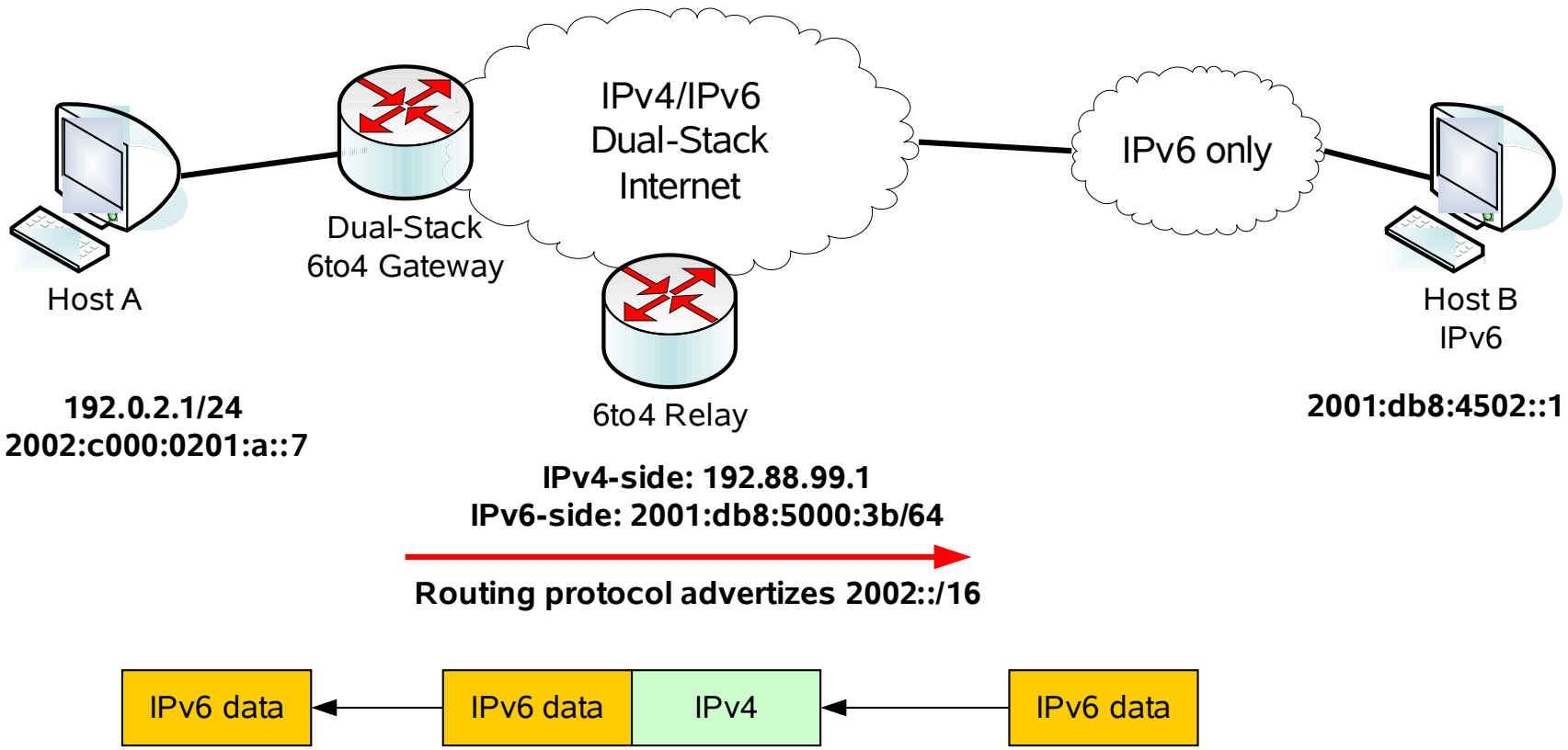
- Tunnel automatically created by dual-stacked router

6to4 Relays


IPv4/IPv6
Dual-Stack
Internet
IPv6 only
Dual-Stack
6to4 Gateway
Host A
6to4 Relay
Host B
IPv6
192.0.2.1/24
2002:c000:0201:a::7
2001:db8:4502::1
IPv4-side: 192.88.99.1
IPv6-side: 2001:db8:5000:3b/64
Routing protocol advertizes 192.88.99.0/24

IPv6 data
IPv6 data
IPv4
IPv6 data

6to4 Relays (Reverse Direction)



- 192.88.99.1: Anycast address