

IPv6

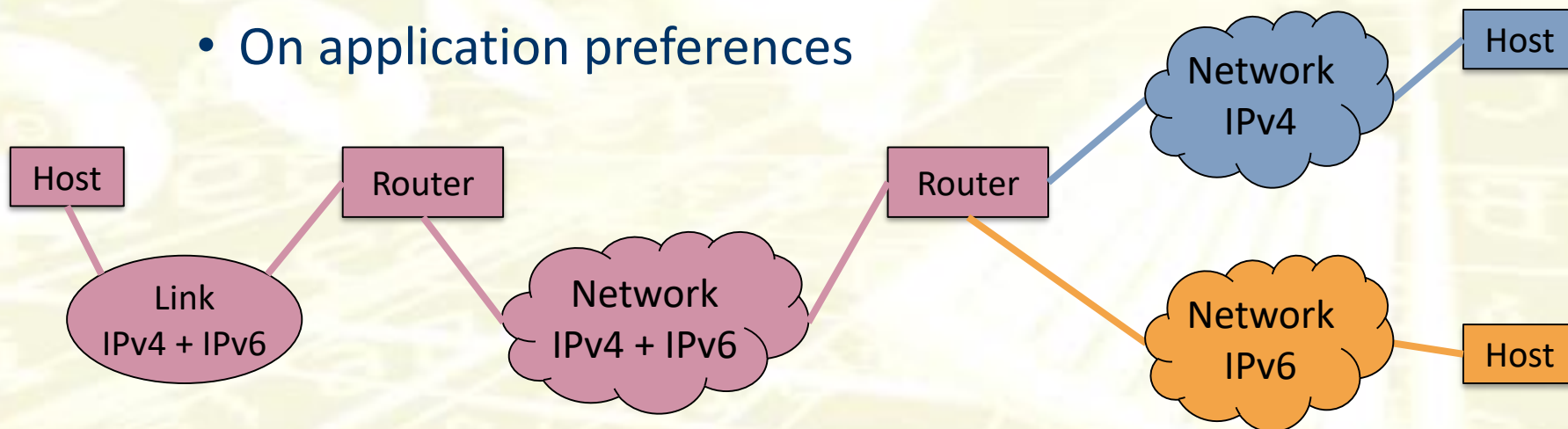
Interoperability with IPv4

Interoperability with IPv4

- IPv6/IPv4 coexistence is unavoidable
- Techniques to ease the transition
 - Dual-stack
 - Allows IPv4 and IPv6 to coexist in the same devices and networks
 - Tunneling
 - Allows the transport of IPv6 traffic over the existing IPv4 infrastructure
 - *Translation*
 - *Allows IPv6-only devices to communicate with IPv4-only nodes*

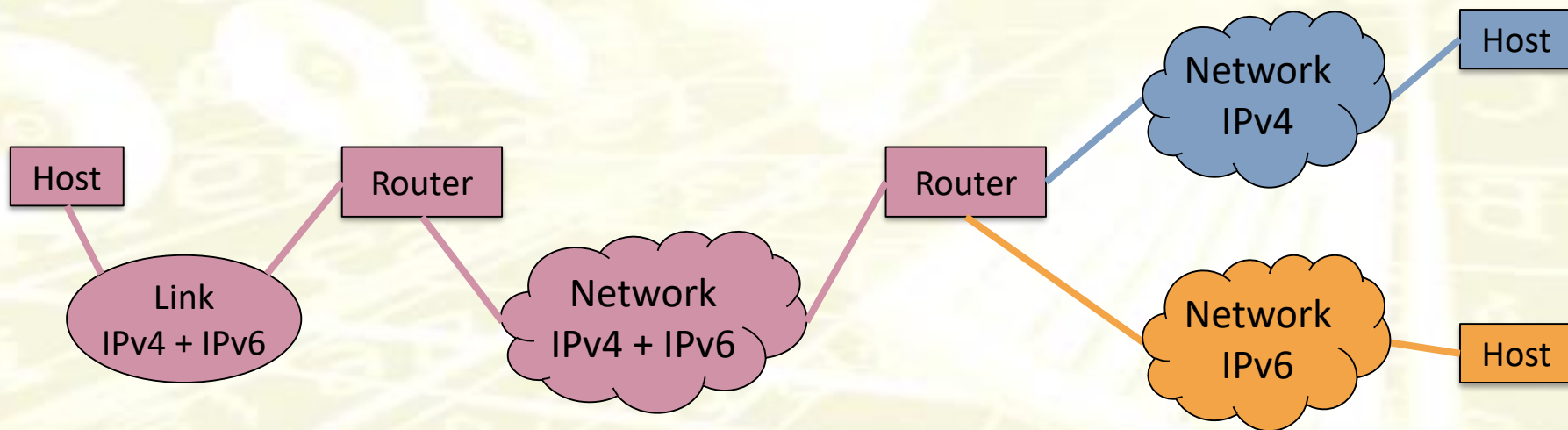
Dual-stack techniques

- A dual-stack node has full support for both protocol versions
 - At least one address per protocol version
 - The protocol used depends
 - On the address type returned by DNS resolver
 - On application preferences



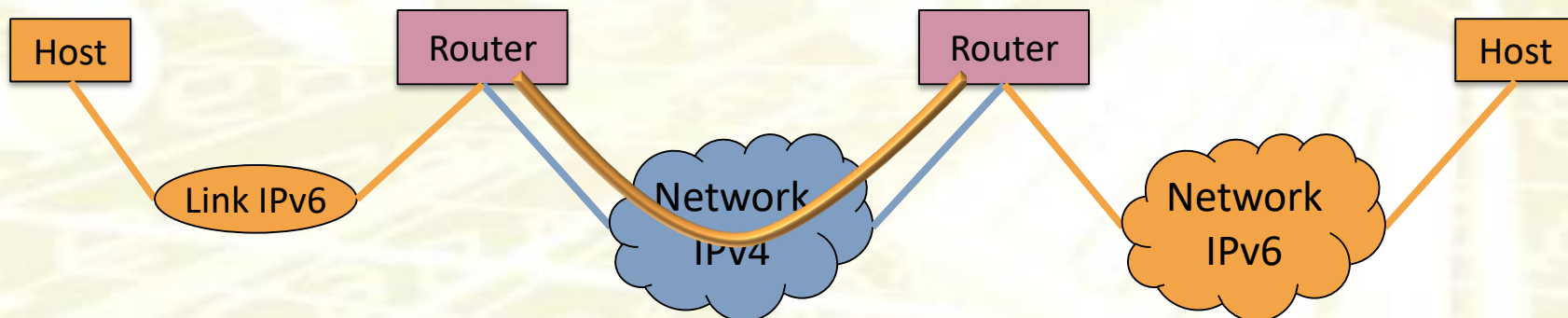
Dual-stack techniques

- A dual-stack network is an infrastructure in which both IPv4 and IPv6 forwarding is enabled on routers
 - Tables kept simultaneously with both routing protocols configured



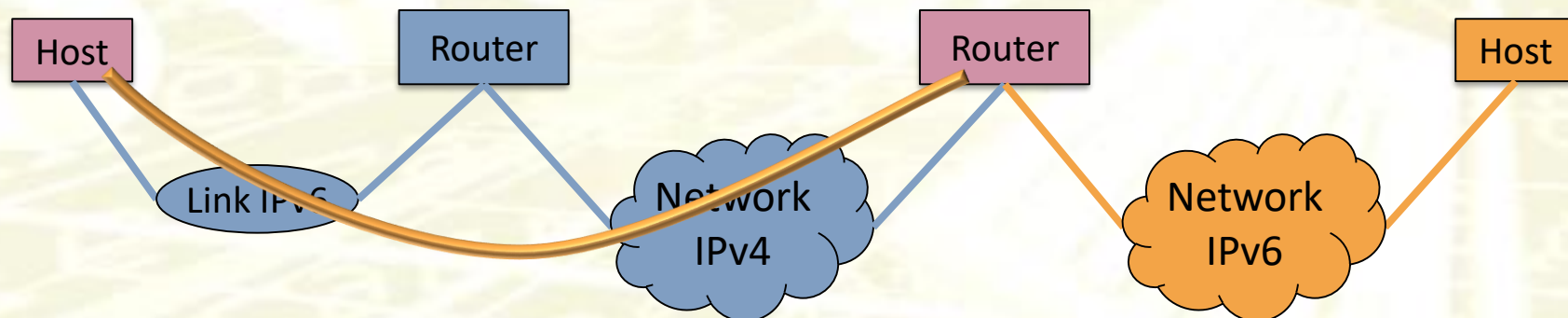
Tunneling techniques

- IPv6 forwarding using an overall IPv4 infrastructure as a basis
 - IPv6 packets (header plus payload) are encapsulated into IPv4 packets



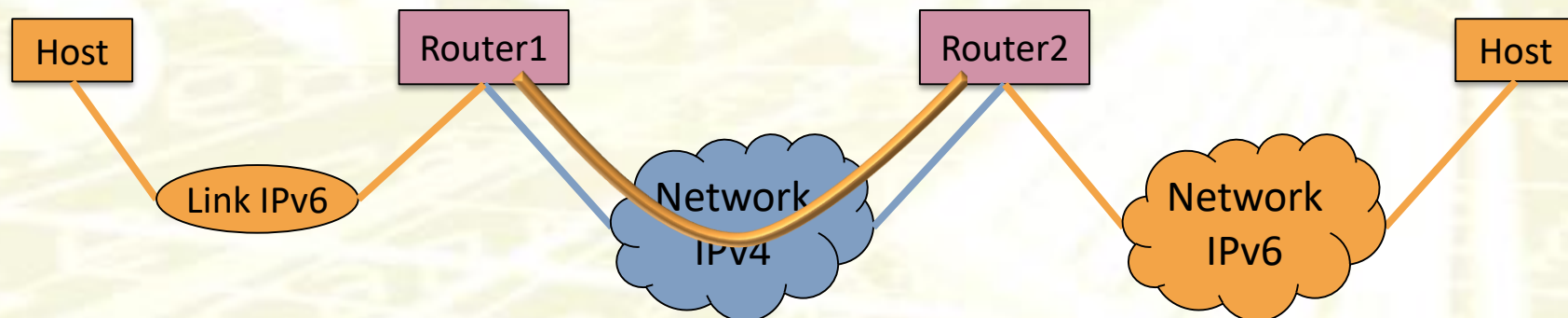
Tunneling techniques

- Different tunnel setups are possible
- Depending on the scenario, the tunnel entry and exit point can be either a host or a router



Tunnel entry point

- Router1 is the entry point of the tunnel
 - encapsulates the IPv6 packet as payload in an IPv4 packet
 - transmits the IPv4 packet to Router2 (if necessary, the IPv4 packet is fragmented)



Encapsulation

- Before encapsulation, the Hop Limit field in the IPv6 header is decremented by one
 - The IPv6-over-IPv4 tunnel is hidden, and appears as a single hop



Original IPv6 packet sent from source host to tunnel entry point.



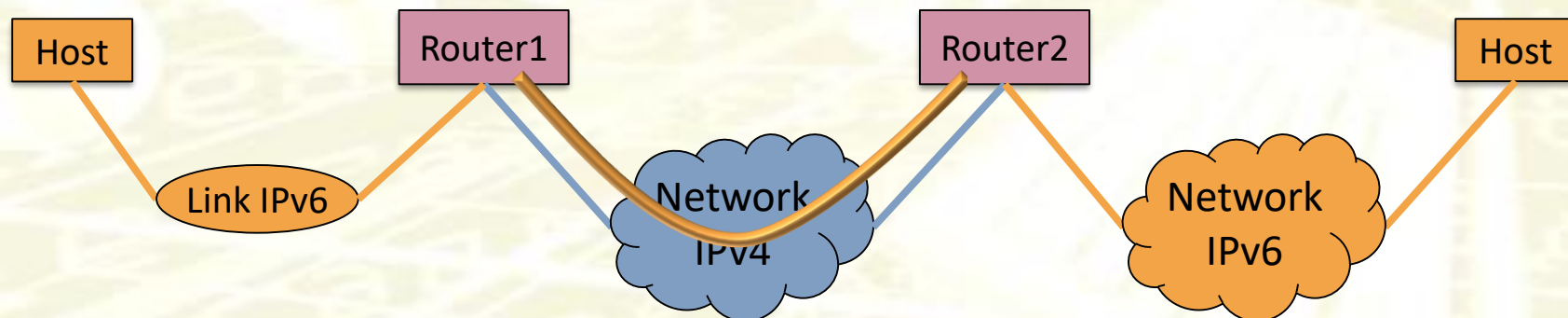
Encapsulated packet sent to tunnel exit point.

Fields in IPv4 Header:

Header Length:	Length of IPv4 header plus IPv6 header plus any extension headers and IPv6 payload.
Time to Live (TTL):	Implementation-specific.
Protocol:	Value 41 (assigned for IPv6).
Source Address:	IPv4 address of outgoing interface of tunnel entry point.
Destination Address:	IPv4 address of tunnel exit point.

Tunnel exit point

- Router2 is the exit point of the tunnel
 - Protocol value = 41 → tunnel
 - Verify that the tunnel Source Address is acceptable
 - Verify that the IPv6 Source Address is valid
 - Decapsulates and forwards the IPv6 packet

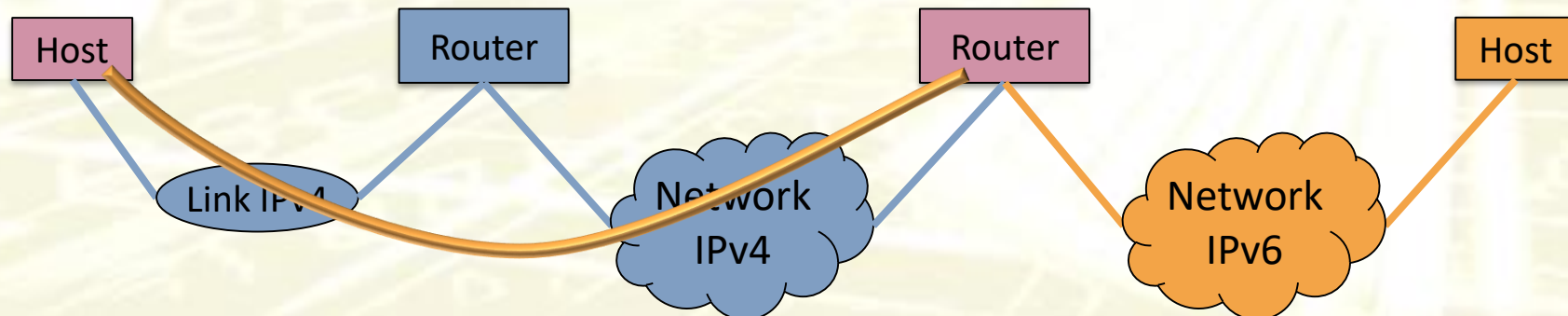


Types of tunnels

- Configured tunneling (static)
 - Point-to-point bi-directional tunnels that need to be **configured manually**
- Automatic tunneling (dynamic)
 - Allows IPv6 nodes to communicate over an IPv4 infrastructure without the need for tunnel destination preconfiguration
 - IPv6 nodes use special addresses (e.g., 6to4 or ISATAP addresses), which carry an IPv4 address in some parts of the IPv6 address fields

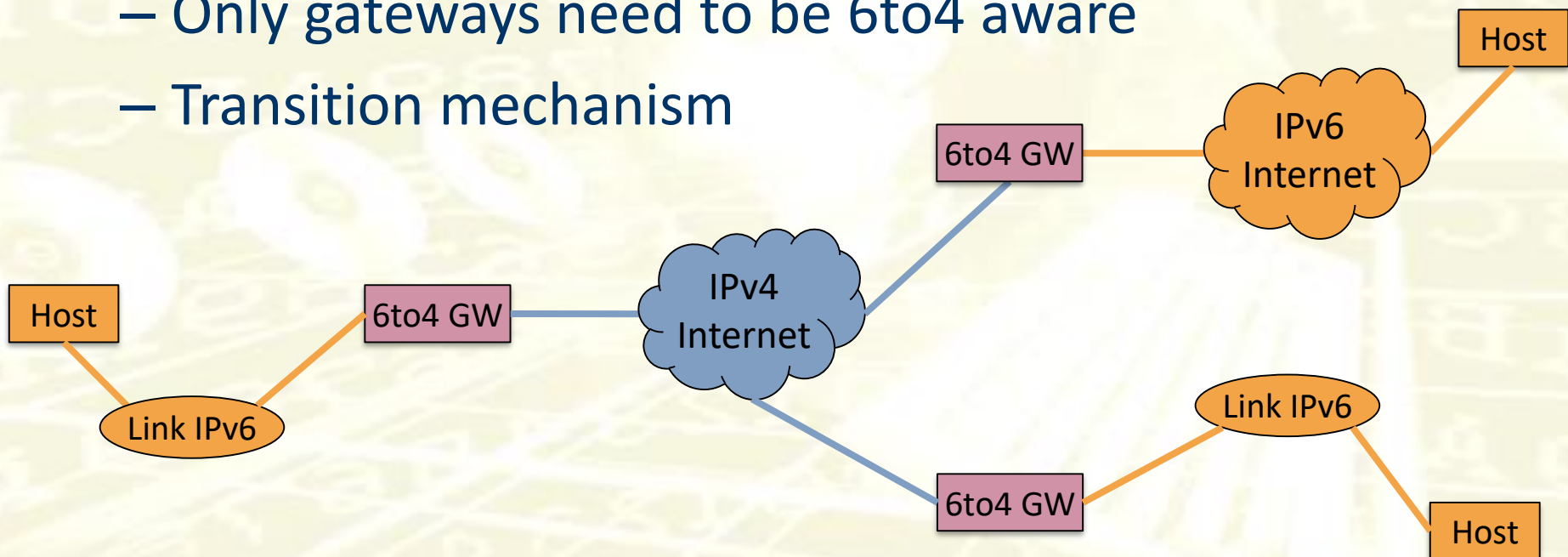
Configured tunneling

- Administrative work overhead
 - Could be desirable for security reasons
 - IPsec, Generic Routing Encapsulation (GRE)
- Configuration
 - ingress filtering, deal with ICMPv4 or ICMPv6 messages, tunnel MTU sizes, fragmentation, the header fields, Neighbor Discovery (ND) over tunnels



Automatic tunneling

- **6to4** (RFC 3056: Connection of IPv6 Domains via IPv4 Clouds)
 - IPv4 Internet treated as a unicast p2p link layer
 - Only gateways need to be 6to4 aware
 - Transition mechanism



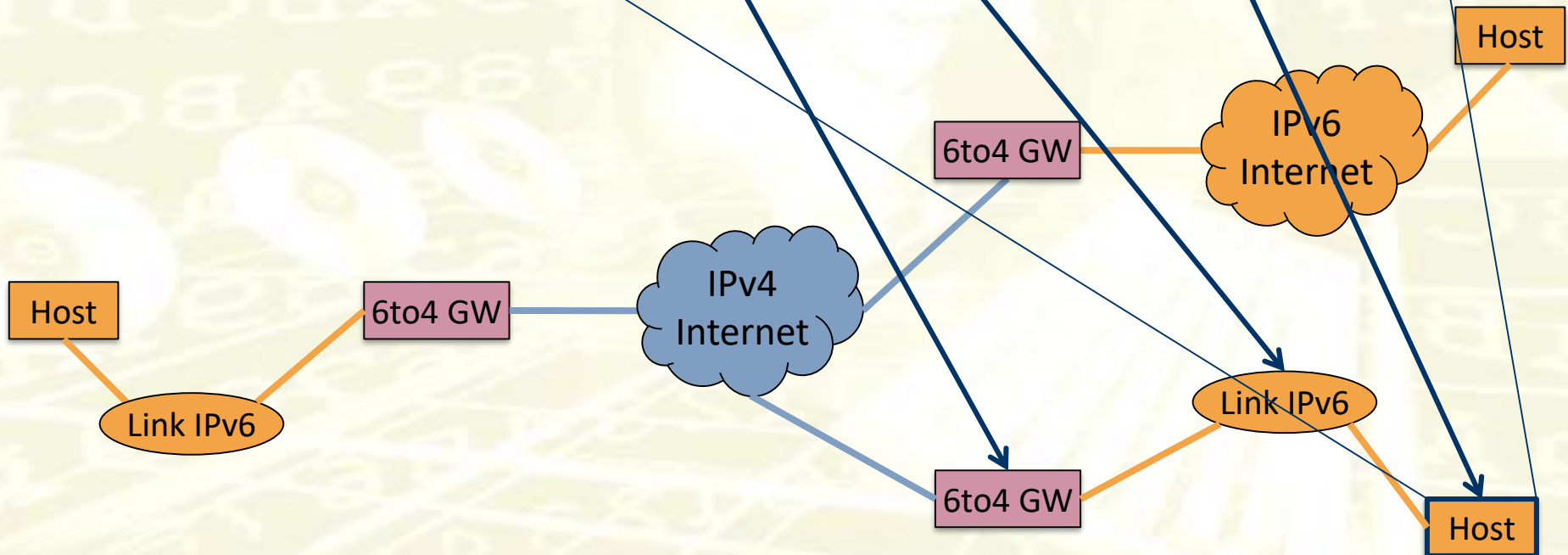
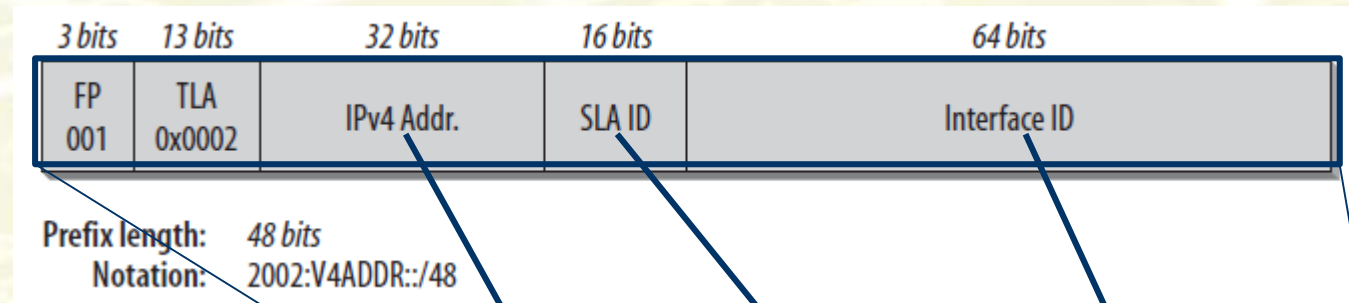
6to4 addressing

- Special global prefix (2002::/16) for the 6to4 scheme
 - 32 bits: IPv4 address of the 6to4 gateway exit point of the tunnel
 - 16 bits: local network addressing
 - 64 bits: interface ID

3 bits	13 bits	32 bits	16 bits	64 bits
FP 001	TLA 0x0002	IPv4 Addr.	SLA ID	Interface ID

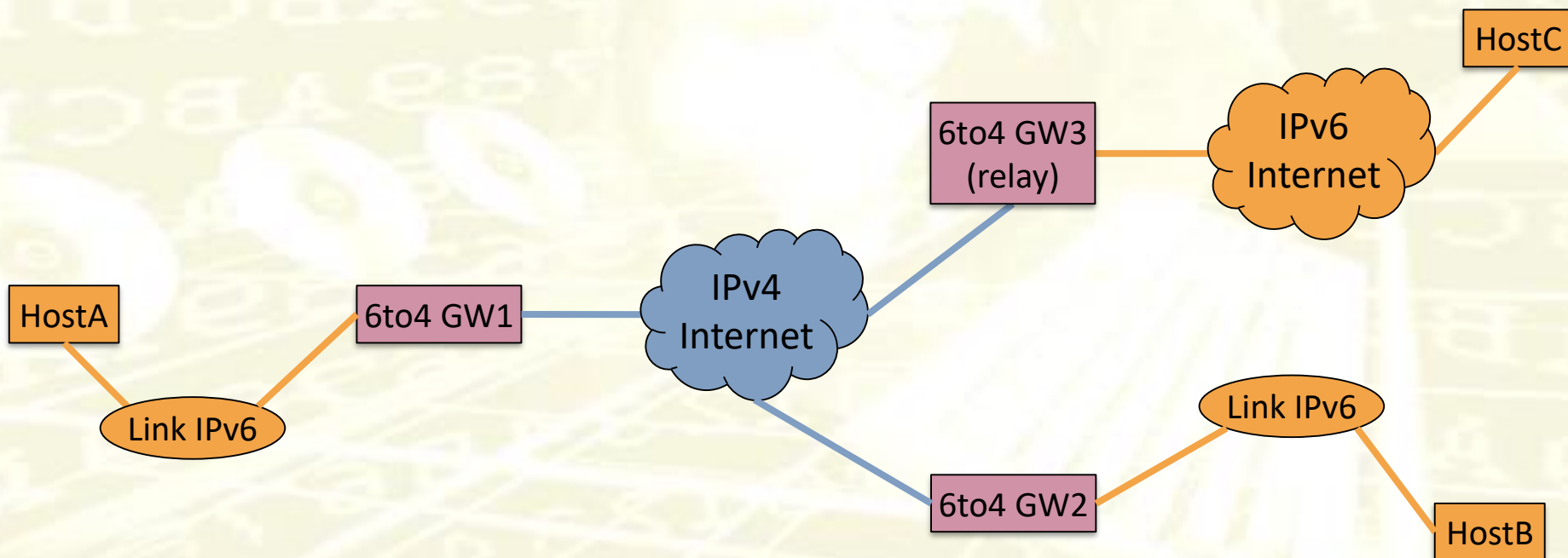
Prefix length: 48 bits
Notation: 2002:V4ADDR::/48

6to4 addressing



6to4 tunneling

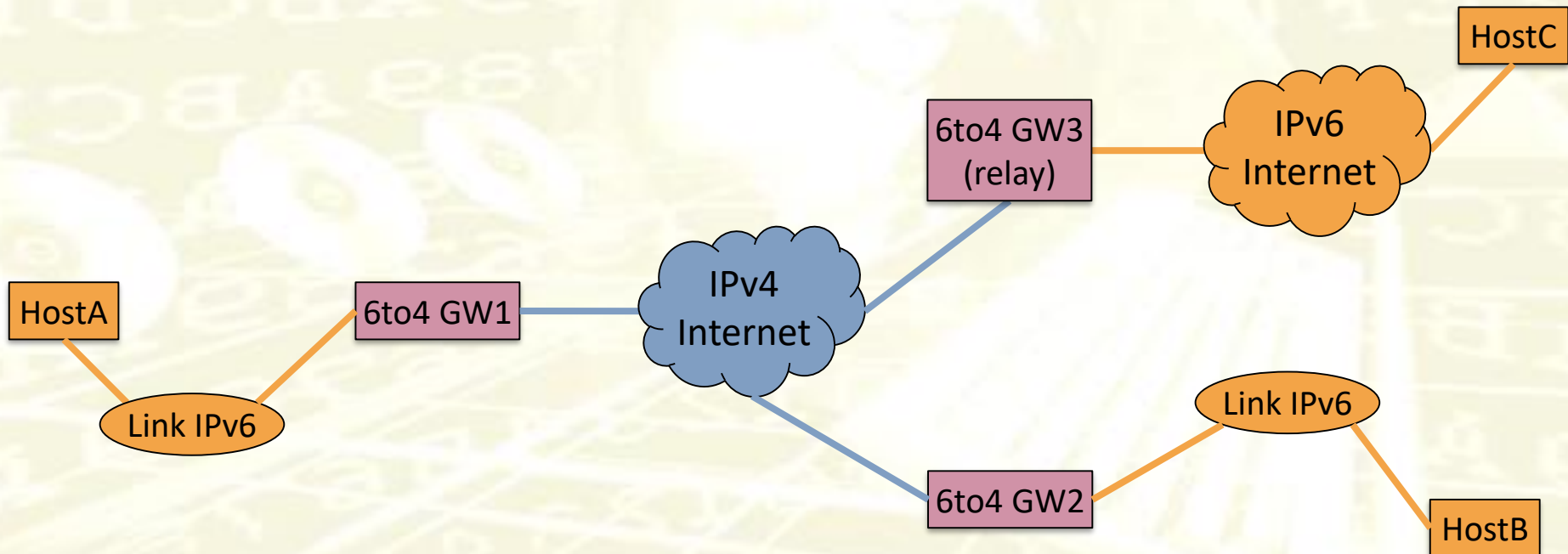
- Router GW1 advertises the 6to4 prefix in RA messages
 - *2002:IPv4-address-GW1:subnet::/64*



6to4 tunneling

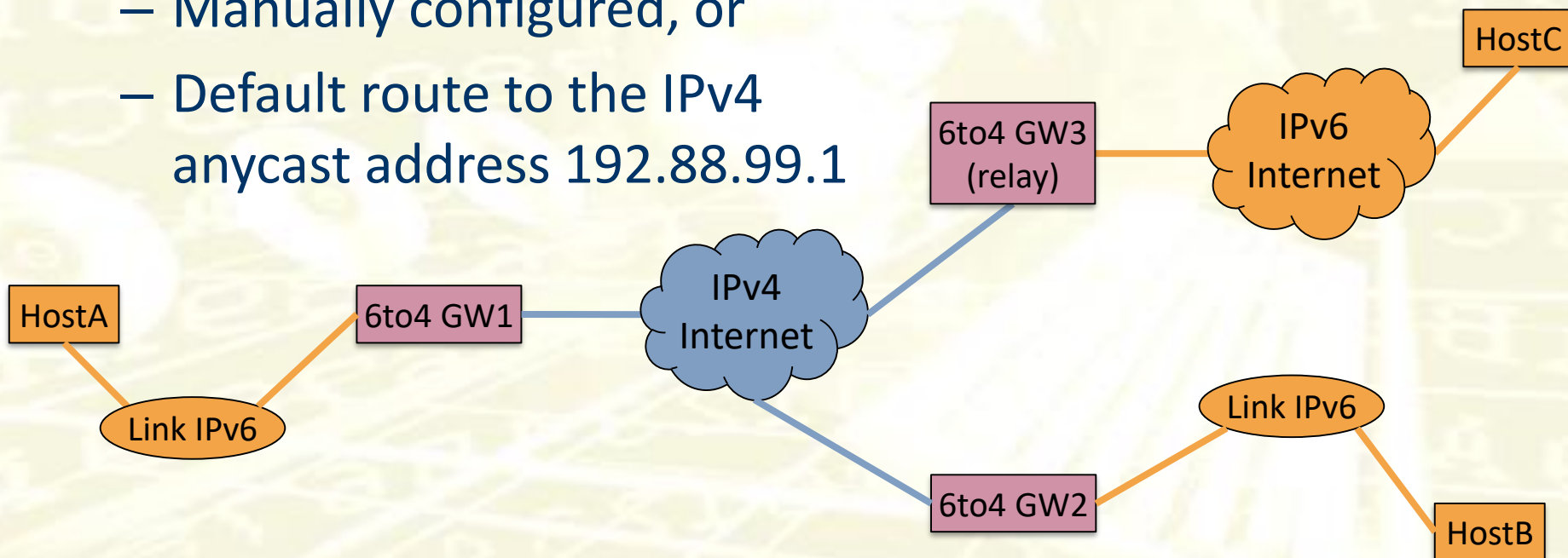


- HostA to HostB communication example
 - Destination address
2002:IPv4-addr-GW2:subnet-HostB:int-ID-HostB



6to4 tunneling

- HostA to HostC communication example
 - Destination address, e.g., 2000:b00:c18:1::10
- Router GW1 will forward the packet to a **6to4 relay**
 - Manually configured, or
 - Default route to the IPv4 anycast address 192.88.99.1



6to4 relay



```
C:\Windows\system32\cmd.exe

C:\Users\mingozzi>tracert 192.88.99.1

Tracing route to 192.88.99.1 over a maximum of 30 hops

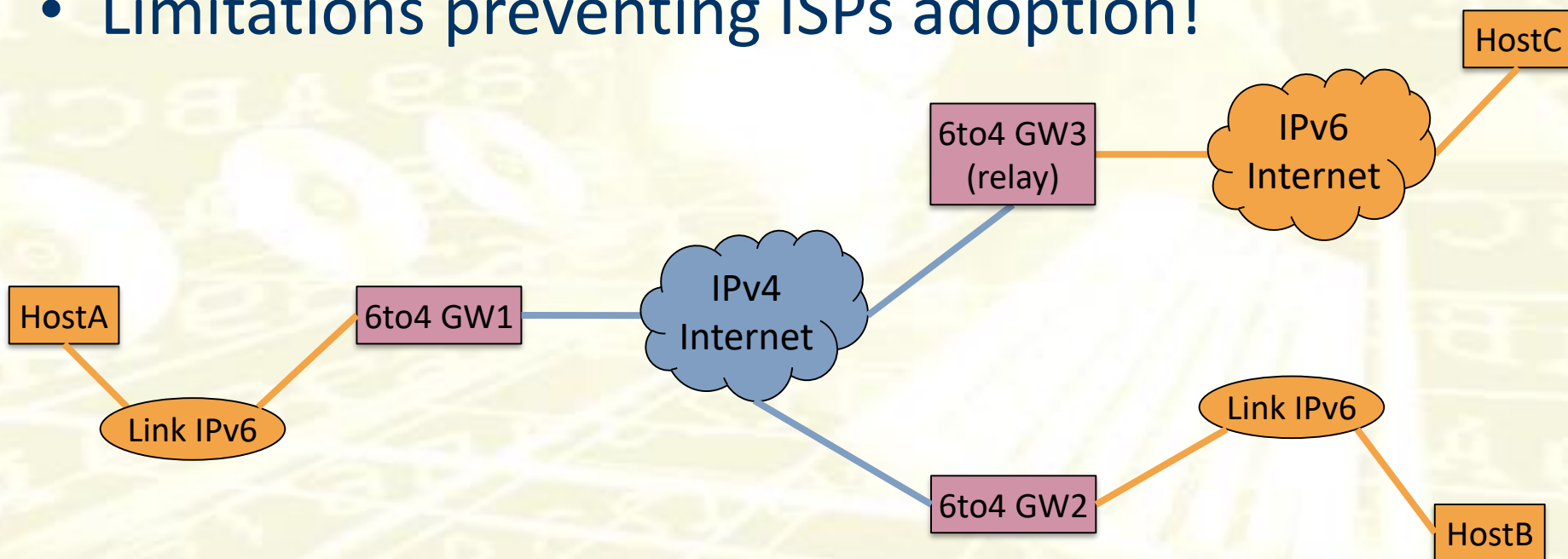
  1  <1 ms    <1 ms    <1 ms    131.114.58.1
  2  <1 ms    <1 ms    <1 ms    131.114.186.33
  3  <1 ms    <1 ms    <1 ms    131.114.192.205
  4   3 ms    <1 ms    <1 ms    ru-unipi-rx1-pi1.pi1.garr.net [193.206.136.13]
  5   7 ms    7 ms     7 ms     rx1-pi1-rx2-mi2.mi2.garr.net [90.147.80.210]
  6   7 ms    7 ms     7 ms     rx2-mi2-r-mi2.mi2.garr.net [90.147.80.77]
  7   7 ms    7 ms     7 ms     garr.mx1.mil2.it.geant.net [62.40.125.180]
  8  16 ms    16 ms    16 ms    ae2.mx1.gen.ch.geant.net [62.40.98.112]
  9  24 ms    24 ms    24 ms    ae4.mx1.par.fr.geant.net [62.40.98.152]
 10  29 ms    29 ms    29 ms    ae1.mx1.lon.uk.geant.net [62.40.98.76]
 11  37 ms    37 ms    37 ms    ae0.mx1.ams.nl.geant.net [62.40.98.81]
 12  37 ms    37 ms    37 ms    ae2.rt1.ams.nl.geant.net [62.40.98.114]
 13  37 ms    37 ms    37 ms    surfnet-gw.rt1.ams.nl.geant.net [62.40.124.158]
 14  37 ms    37 ms    37 ms    U1131.sw4.amsterdam1.surf.net [145.145.19.170]
 15  37 ms    37 ms    37 ms    192.88.99.1

Trace complete.

C:\Users\mingozzi>
```


6to4 tunneling

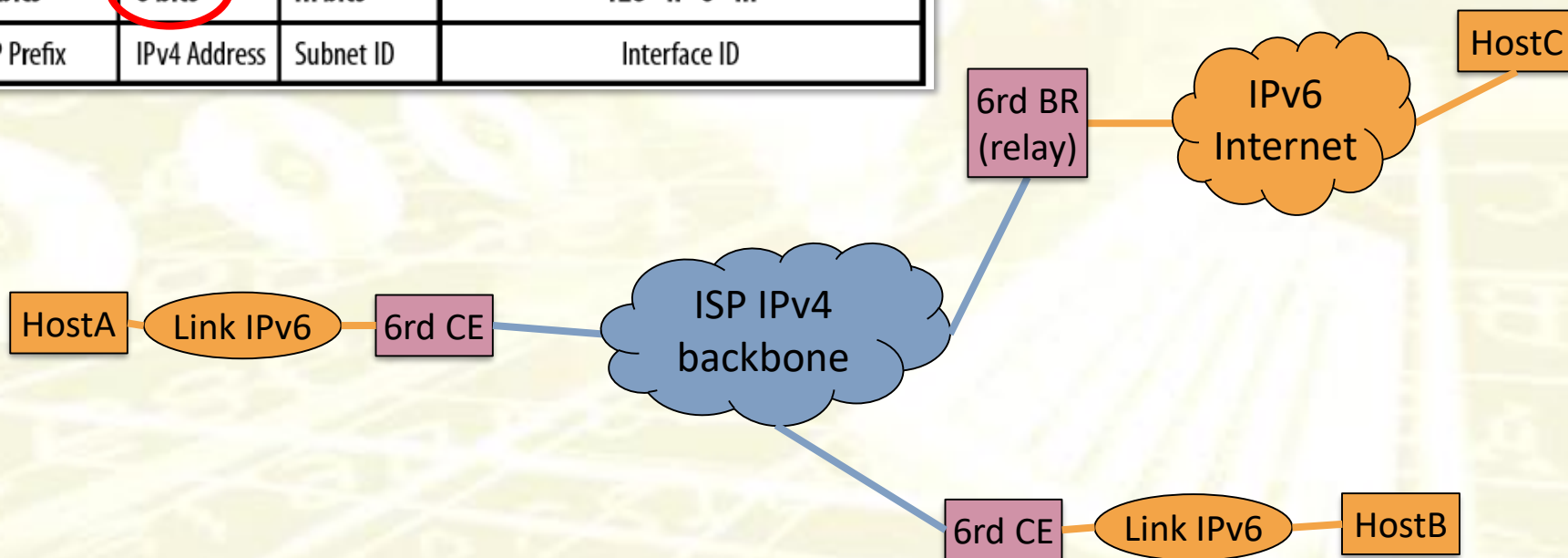
- HostC to HostA communication example
 - route its packets to the nearest 6to4 relay router advertising the prefix 2002::/16
- Limitations preventing ISPs adoption!



IPv6 Rapid Deployment – 6rd

- Developed for ISPs networks
 - 6rd prefix is assigned by the ISP (one per 6rd domain)
 - BR's anycast address shared within the 6rd domain

n bits	o bits	m bits	128 - n - o - m
SP Prefix	IPv4 Address	Subnet ID	Interface ID



References

- RFC 2473 “Generic Packet Tunneling in IPv6 Specification”
- RFC 4213, “Basic Transition Mechanisms for IPv6 Hosts and Routers”
- RFC 3056, “Connection of IPv6 Domains via IPv4 Clouds (6to4)”
- RFC 5969 , “IPv6 Rapid Deployment on IPv4 Infrastructures (6rd) -- Protocol Specification”

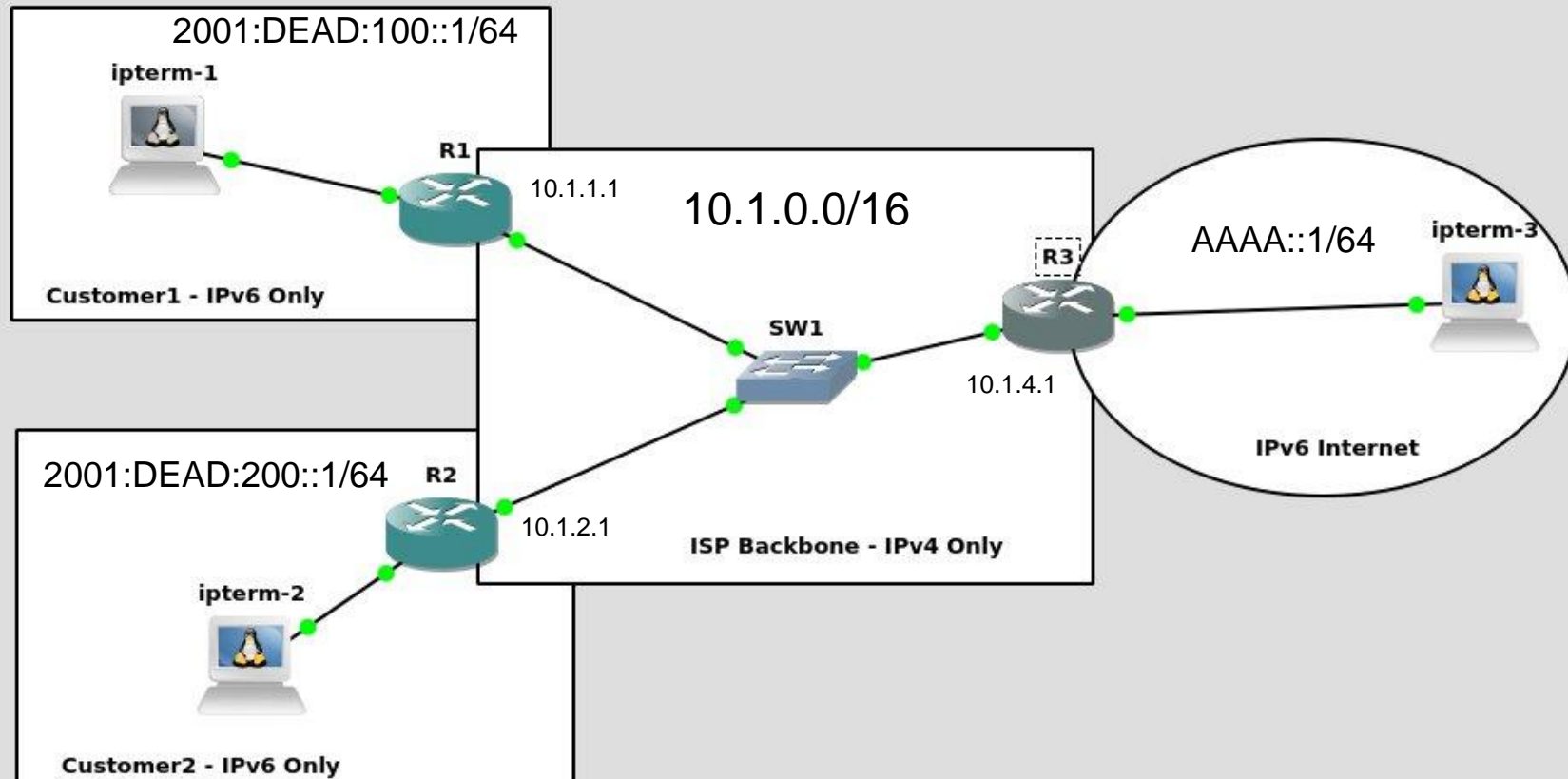
IPv6 interoperability implementation

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6br scenario



Operator IPv6 prefix
2001:DEAD::/32

6rd Tunneling Configuration

- On R1 and R2 create a new tunnel interface :
 - interface Tunnel0
 - no ip address
 - no ip redirects
 - ipv6 enable
 - tunnel source Ethernet0/0
 - tunnel mode ipv6ip 6rd
 - tunnel 6rd ipv4 prefix-len 16 suffix-len 8
 - tunnel 6rd prefix 2001:DEAD::/32
 - tunnel 6rd br 10.1.4.1



6rd Border Router Configuration



- On R3, the router connected to the IPv6 internet configure the other end of the tunnel:
 - `interface Tunnel0`
 - `no ip address`
 - `no ip redirects`
 - `ipv6 address 6RD-PREFIX ::/128 anycast`
 - `ipv6 enable`
 - `tunnel source Ethernet0/0`
 - `tunnel mode ipv6ip 6rd`
 - `tunnel 6rd ipv4 prefix-len 16 suffix-len 8`
 - `tunnel 6rd prefix 2001:DEAD::/32`

6rd Border Router Configuration

- On R3, configure the interface towards the IPv6 Internet with another address:
 - `interface Ethernet0/1`
 - `no ip address`
 - `ipv6 address AAAA::1/64`
 - `ipv6 enable`
- On all the routers configure the IPv4 interfaces accordingly

6rd Configuration

- Add static routing information :
 - On R1 and R2:
 - `ipv6 route ::/0 Tunnel0 2001:DEAD:400::1`
 - On R3:
 - `ipv6 route 2001:DEAD::/32 Tunnel0`
- Configure the local interface:
 - `interface Ethernet0/1`
 - `no ip address`
 - `ipv6 address 2001:DEAD:100::1/64`
 - `ipv6 enable`
- Finalize 6rd configuration:
 - `ipv6 general-prefix 6RD-PREFIX 6rd Tunnel0`
 - `ipv6 unicast-routing`

References

- IPv6 configuration:
<http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/ipv6/configuration/12-4t/ipv6-12-4t-book/ip6-addrg-bsc-con.html>
- Tunnel 6rd:
<https://www.cisco.com/c/en/us/td/docs/ios-xml/ios/interface/configuration/xe-3s/ir-xe-3s-book/ip6-6rd-tunls-xe.pdf>
- Tunnel 6to4:
<http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/ipv6/configuration/12-4t/ipv6-12-4t-book/ip6-tunnel.html#GUID-26B4E1CE-B36F-4C82-8A38-78199FBCA0DF>