IPv6 Configuration

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IPv6 address configuration

- Configuration:
  - `interface Ethernet0/0`
  - `ipv6 enable`
    - (Automatically configure an IPv6 link-local address on the interface, and enable the interface for IPv6 processing)
  - `ipv6 address 2001:aaaa:bbbb:cccc::/64 eui-64`
  - `ipv6 unicast-routing`
    - Enable forwarding of IPv6 unicast data packets

- Check configuration status:
  - `show ipv6 interface Ethernet0/0`

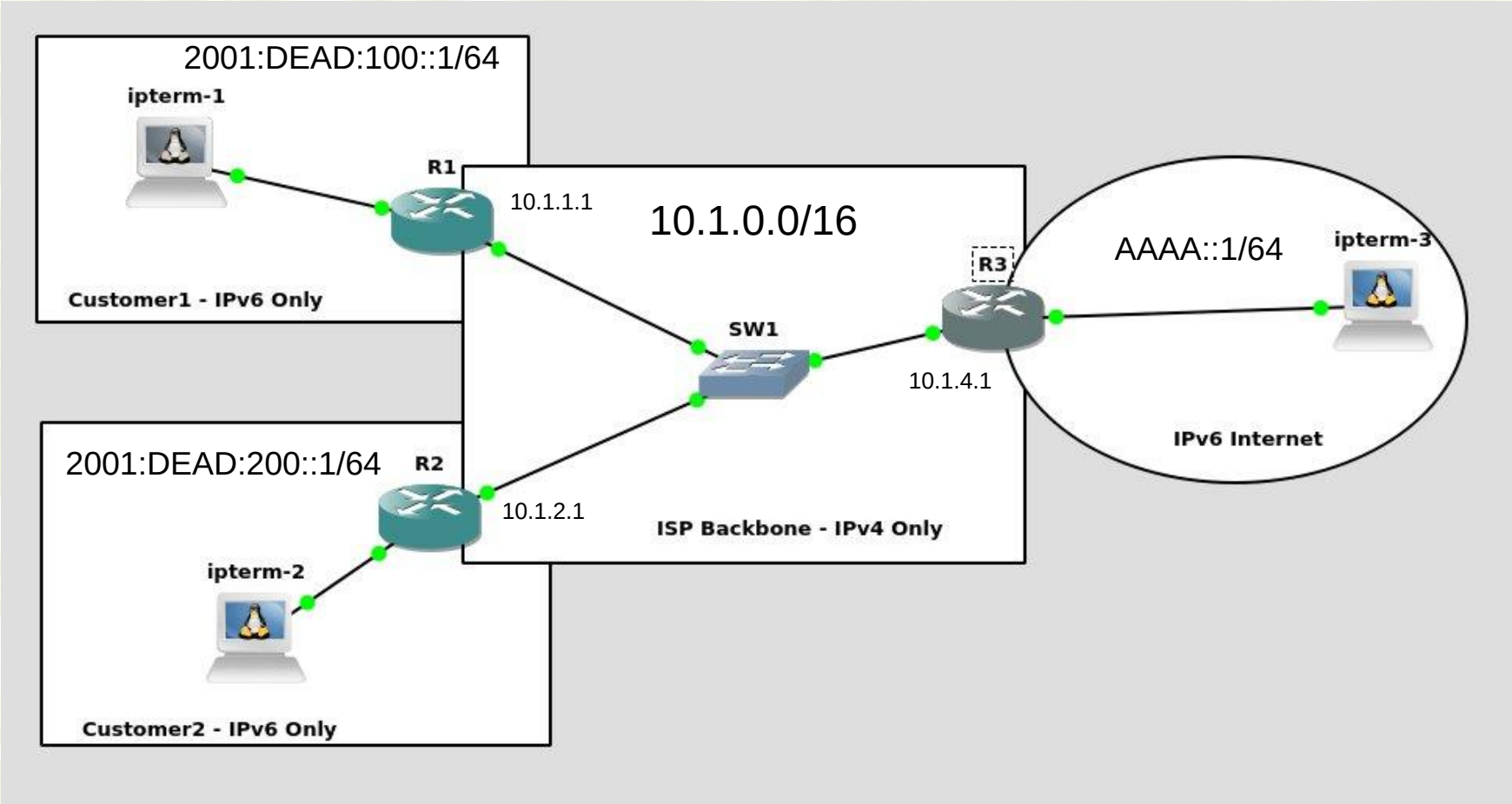
IPv6 host configuration

- Go to Linux Console 1:
  - ifconfig
    - Address already obtained! When a Router Advertisement is received by a client, and IPv6 autoconfiguration is enabled (default on non-router), the client configures itself an IPv6 address according to the prefix contained in the advertisement.
- Ping:
  - ping6 [IPv6 address]
    - From Host, try both link-local and global
  - Use wireshark to see what's going on the net!

RIPv6 Configuration

- Configuration:
  - `ipv6 unicast-routing`
    - Enable forwarding of IPv6 unicast data packets
  - `interface fastEthernet0/0`
    - From Host, try both link-local and global
  - `ipv6 rip process1 enable`
- Check IPv6 Routing Table
  - `show ipv6 route`

Do IT!



Configure the interfaces on R1, R2 and R3 connected to an IPv6 network and check connectivity using ping and wireshark

IPv6

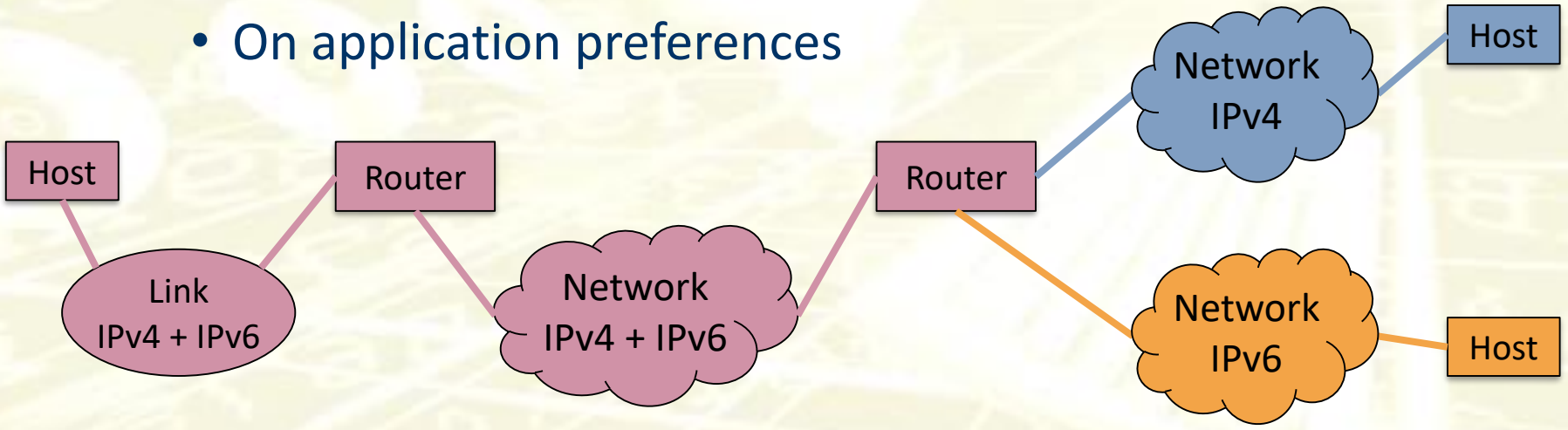
Interoperability with IPv4

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*

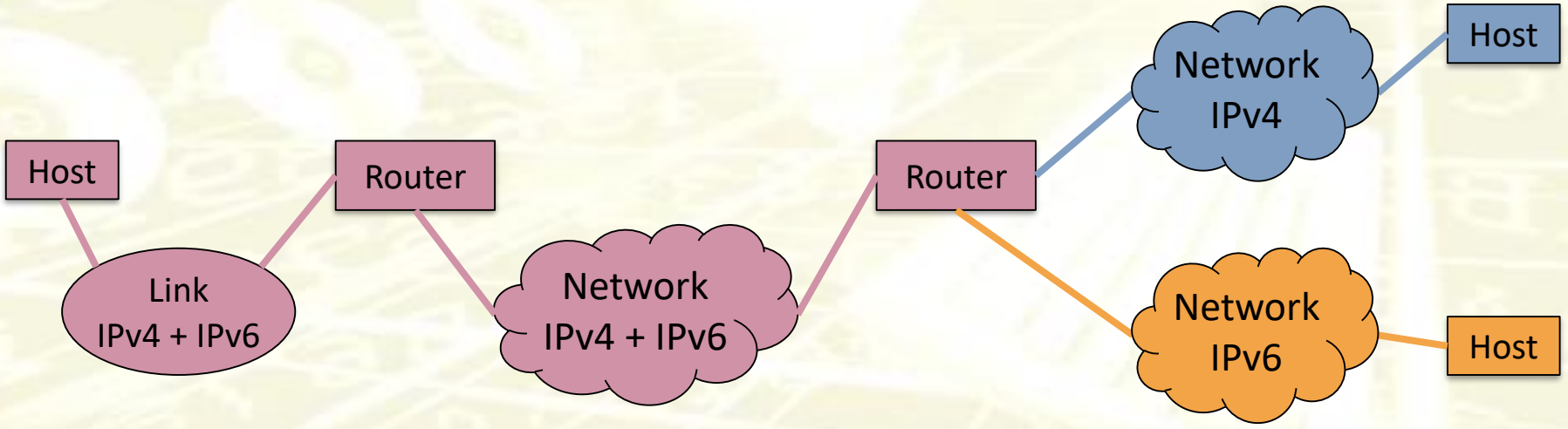
Dual-stack techniques

- 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



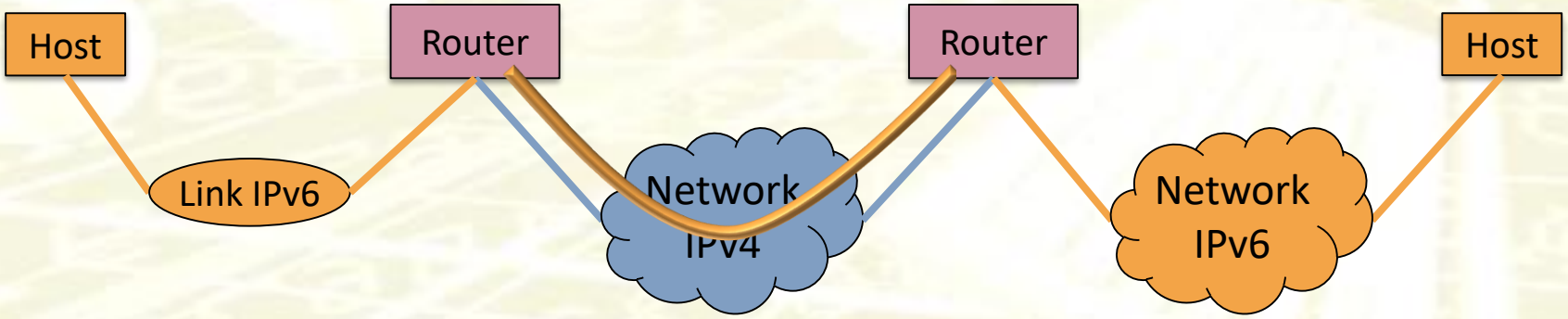
Dual-stack techniques

- 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



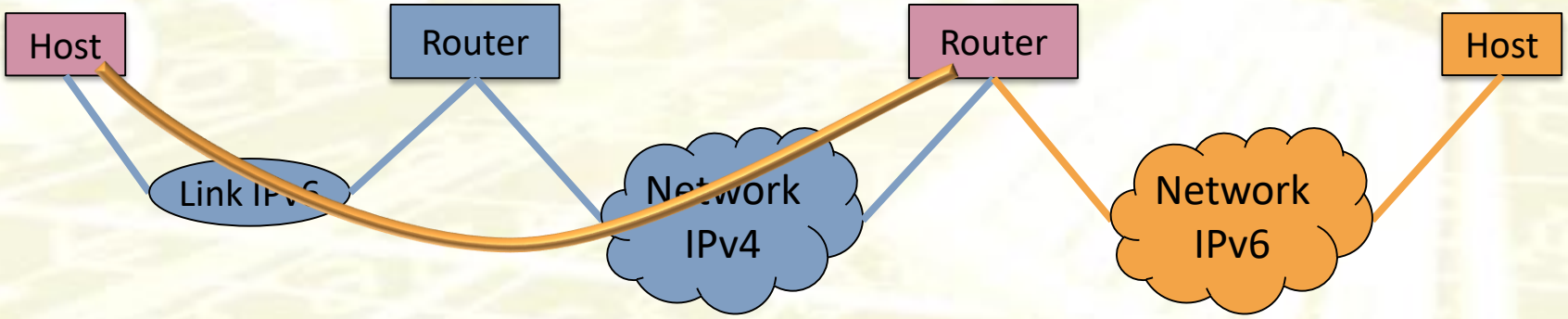
Tunneling techniques

- IPv6 forwarding using an overall IPv4 infra-structure as a basis
  - IPv6 packets (header plus payload) are encapsu-lated into IPv4 packets



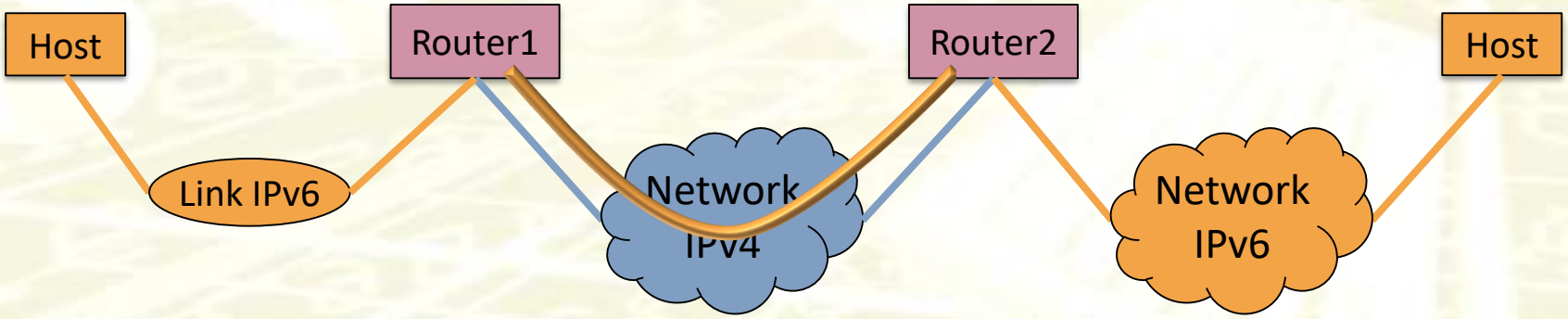
Tunneling techniques

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



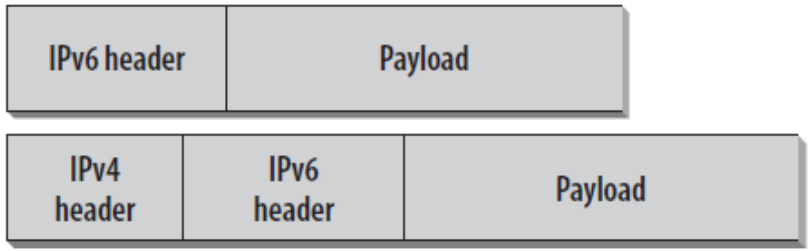
Tunnel entry point

- 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.

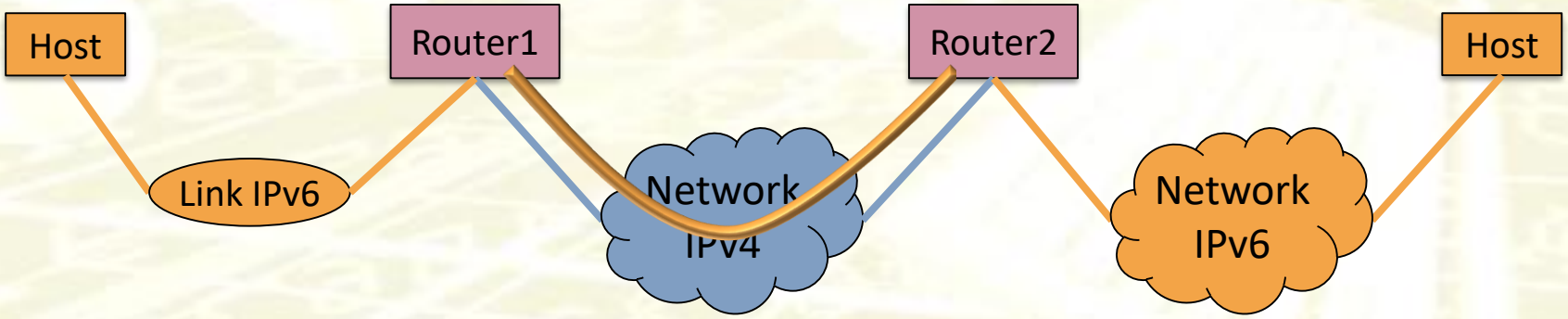
Encapsulated packet sent to tunnel exit point.

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

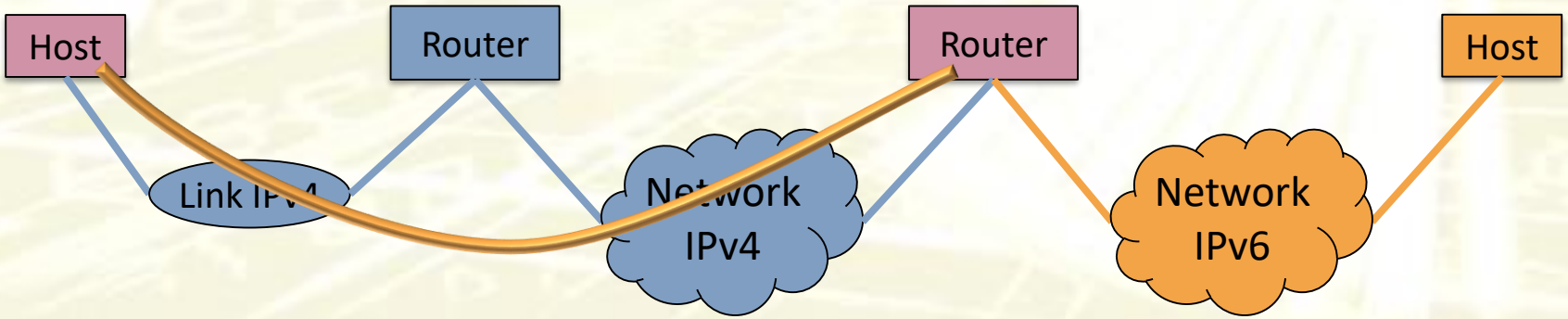


Types of tunnels

- 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

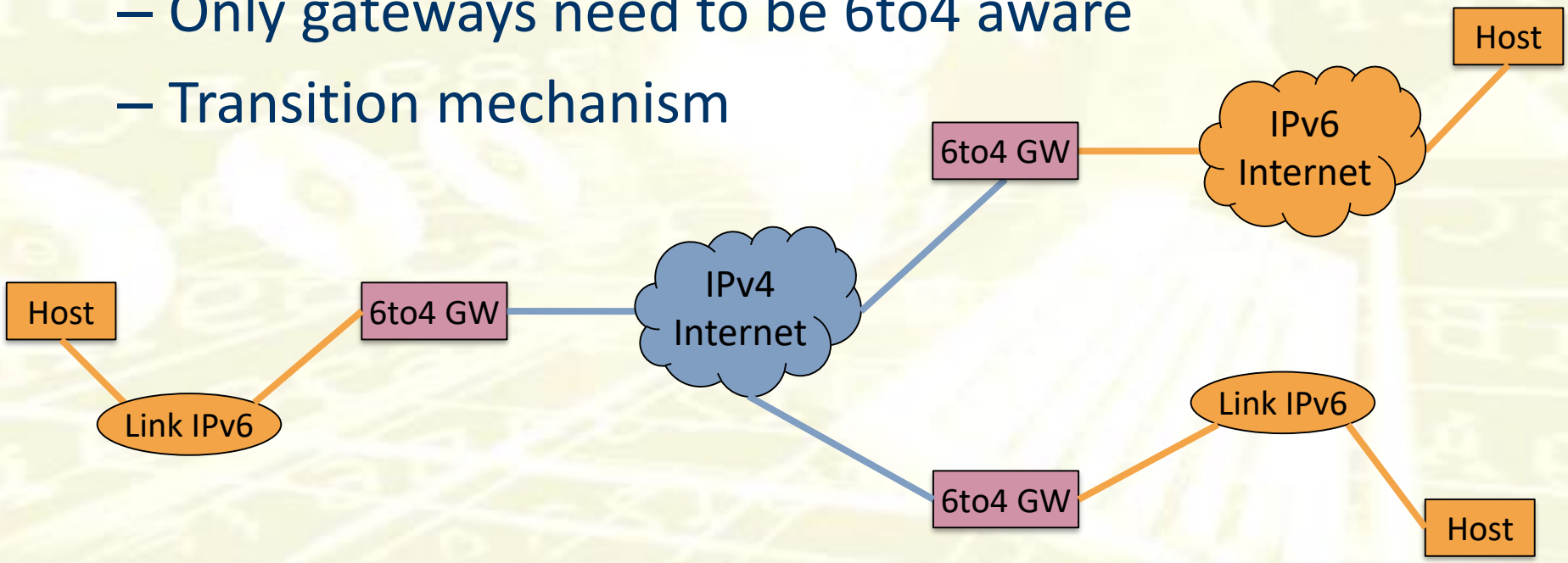
Configured tunneling

- 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



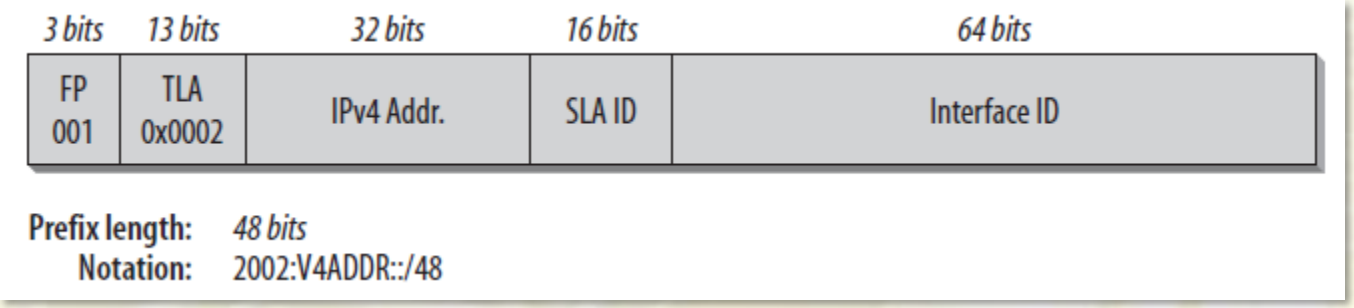
Automatic tunneling

- **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

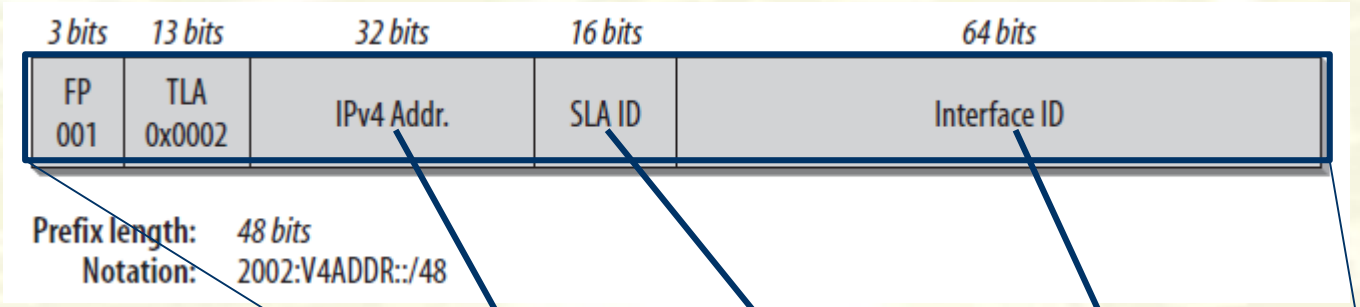


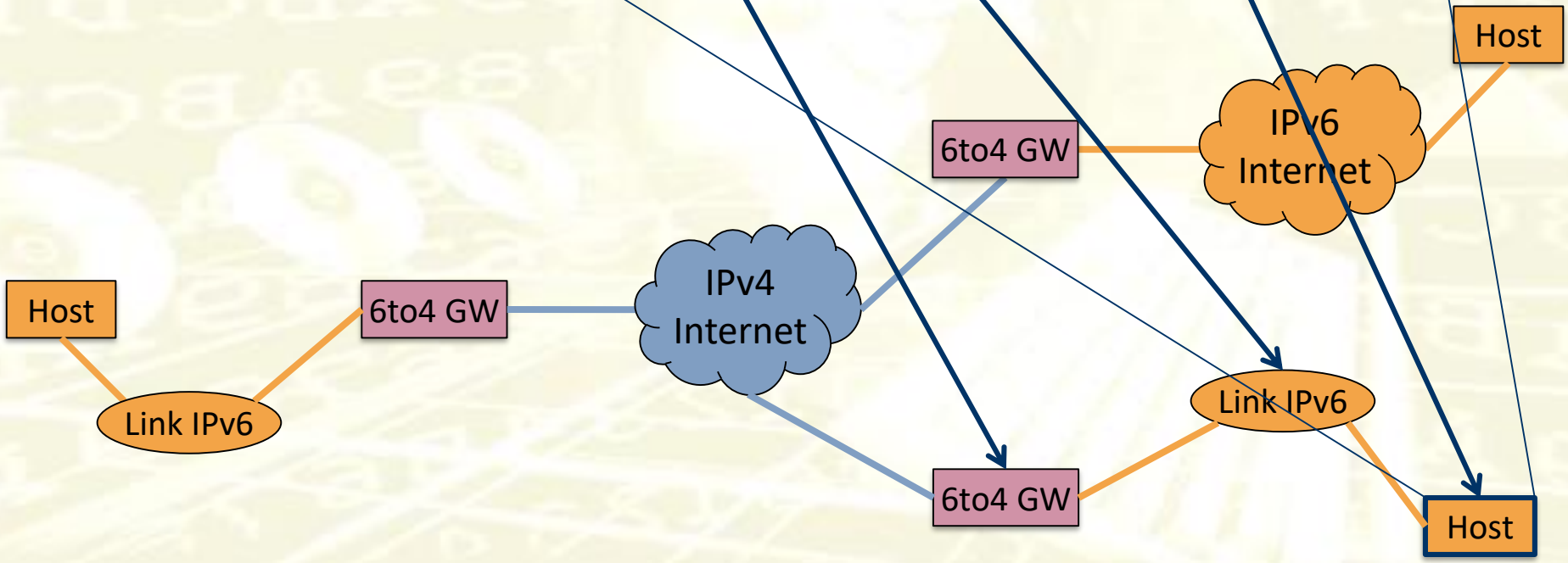
6to4 addressing

- 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



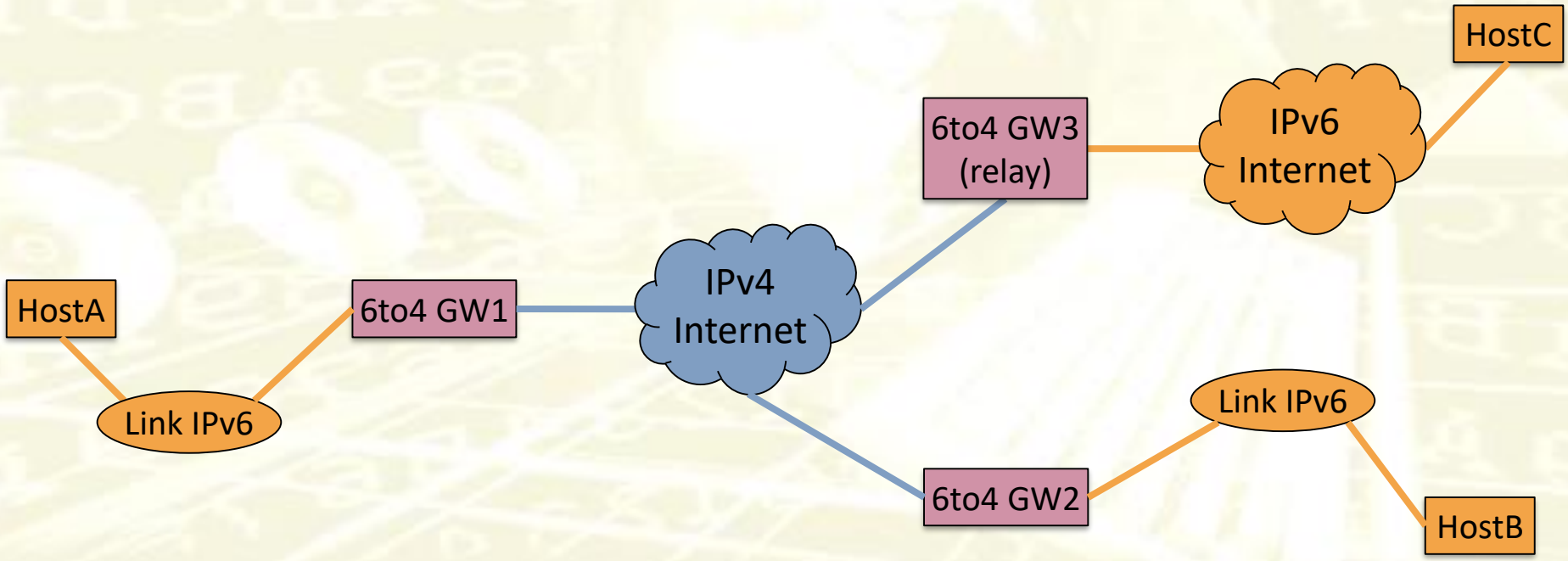
6to4 addressing





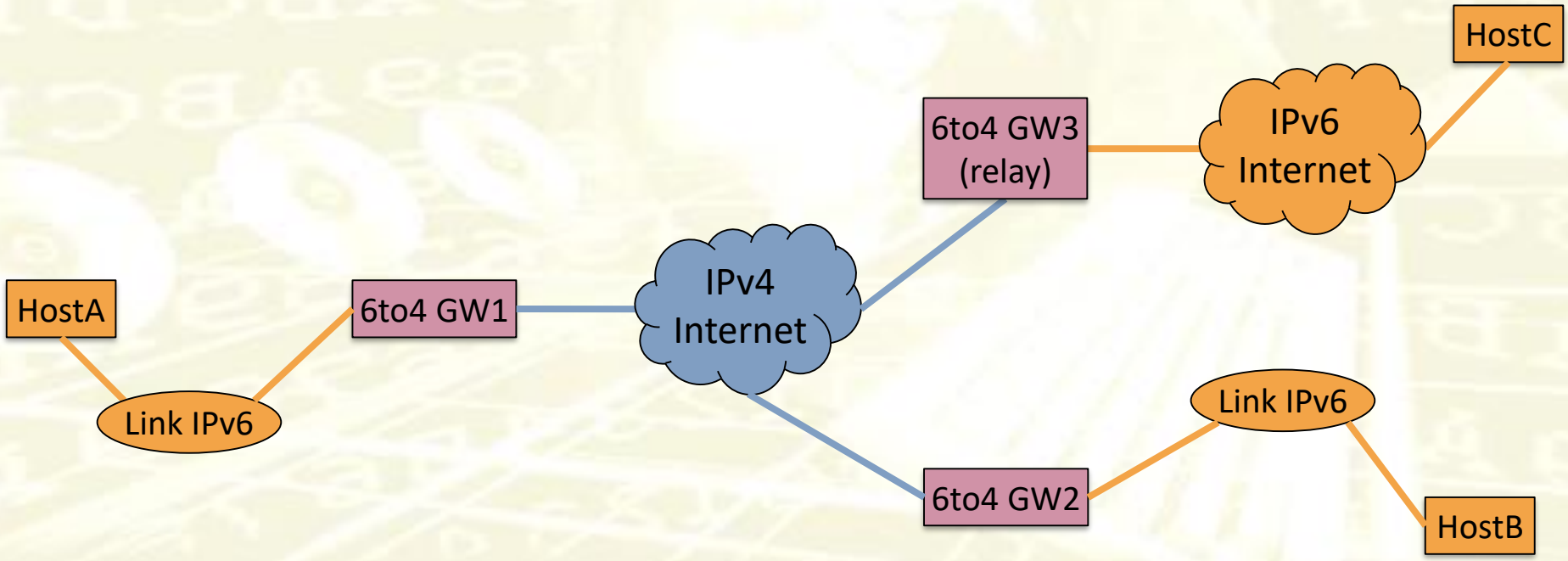
6to4 tunneling

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



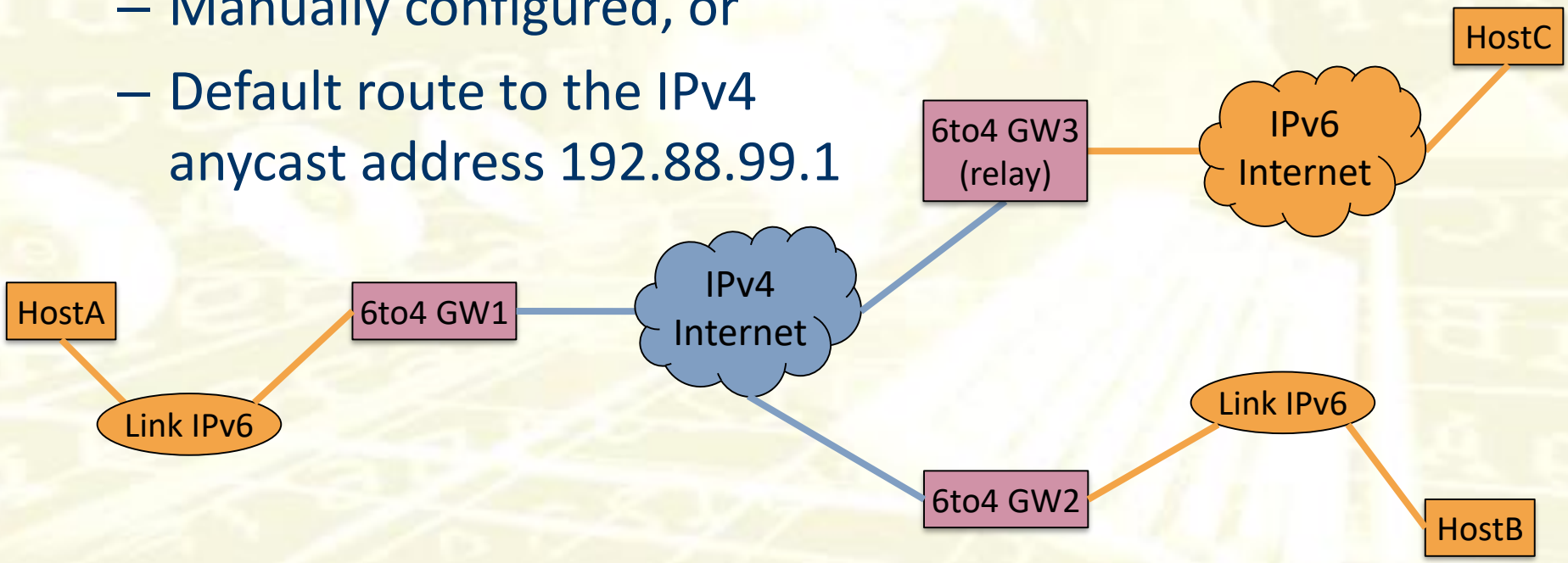
6to4 tunneling

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

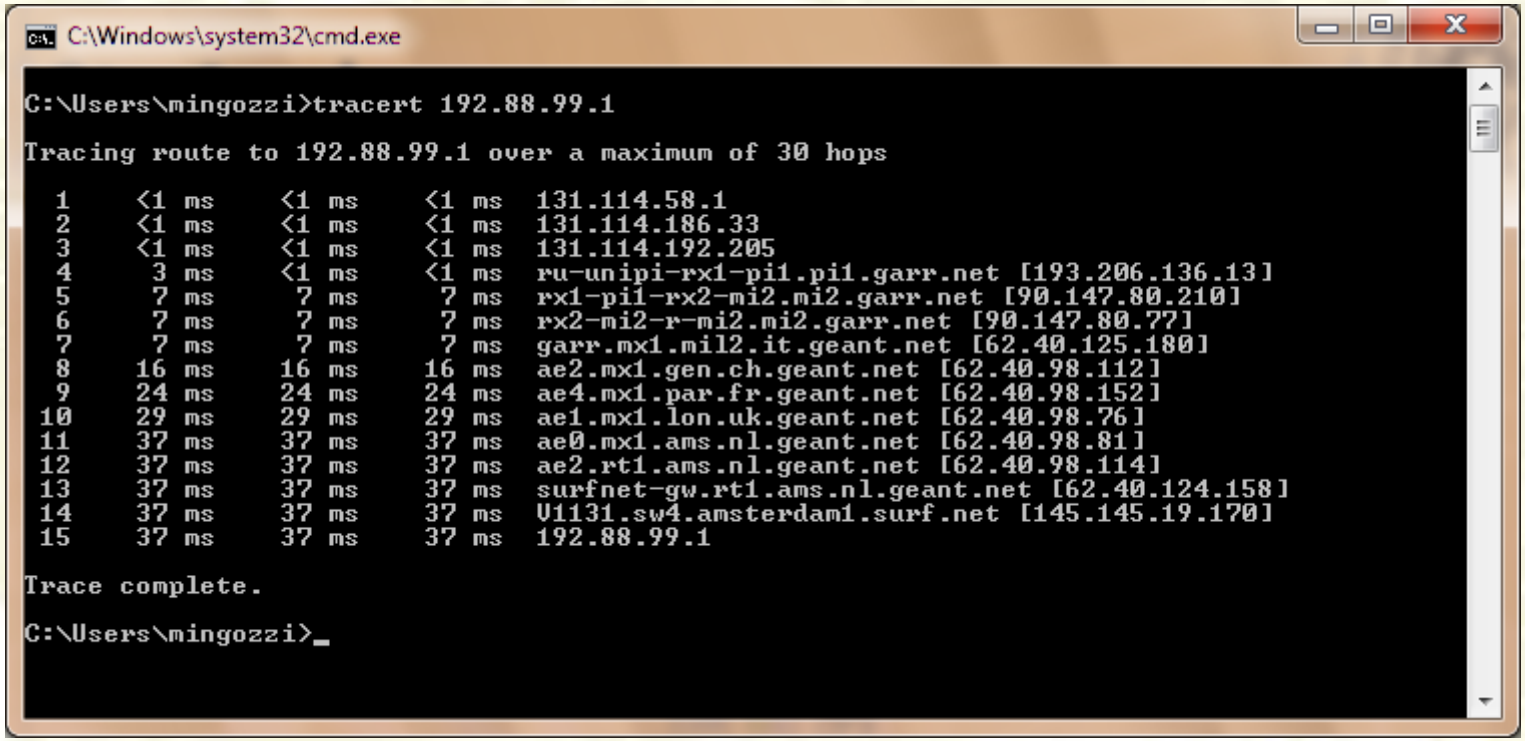


6to4 tunneling

- 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

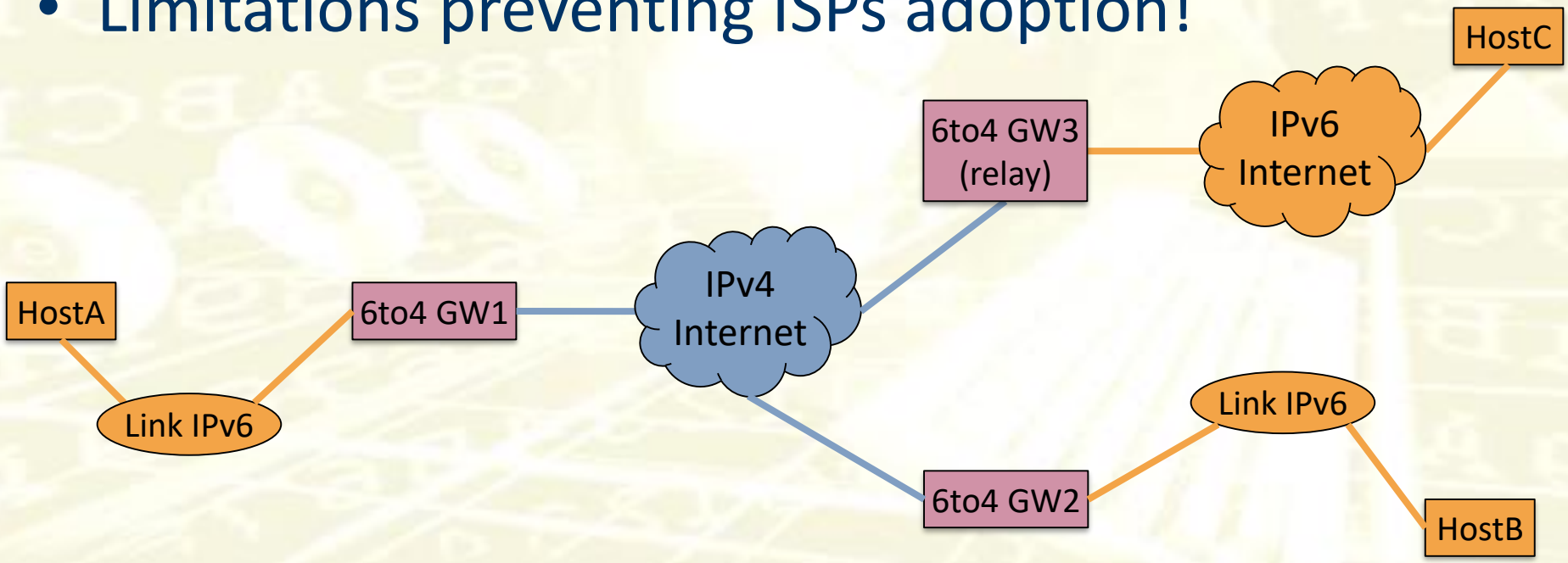


6to4 relay


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 V1131.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

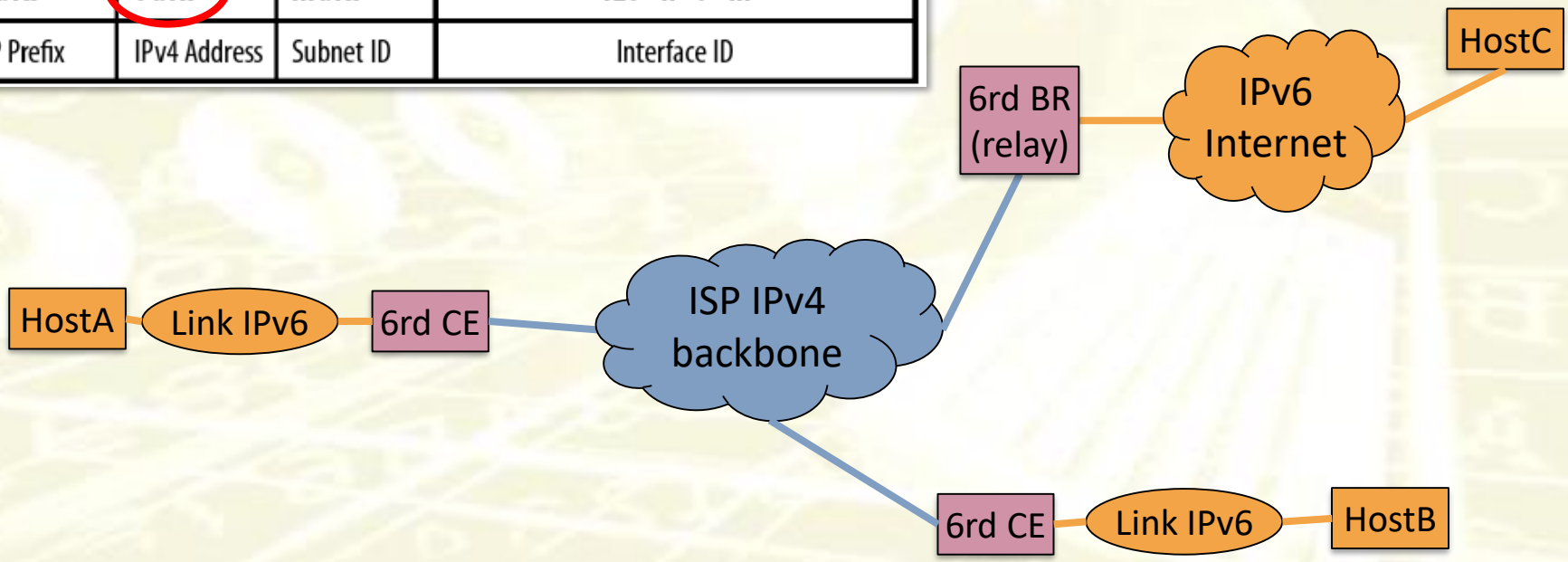
- HostC to HostA communication example
  - route its packets to the nearest 6to4 relay router advertising the prefix 2002::/16
- Limitations preventing ISPs adoption!



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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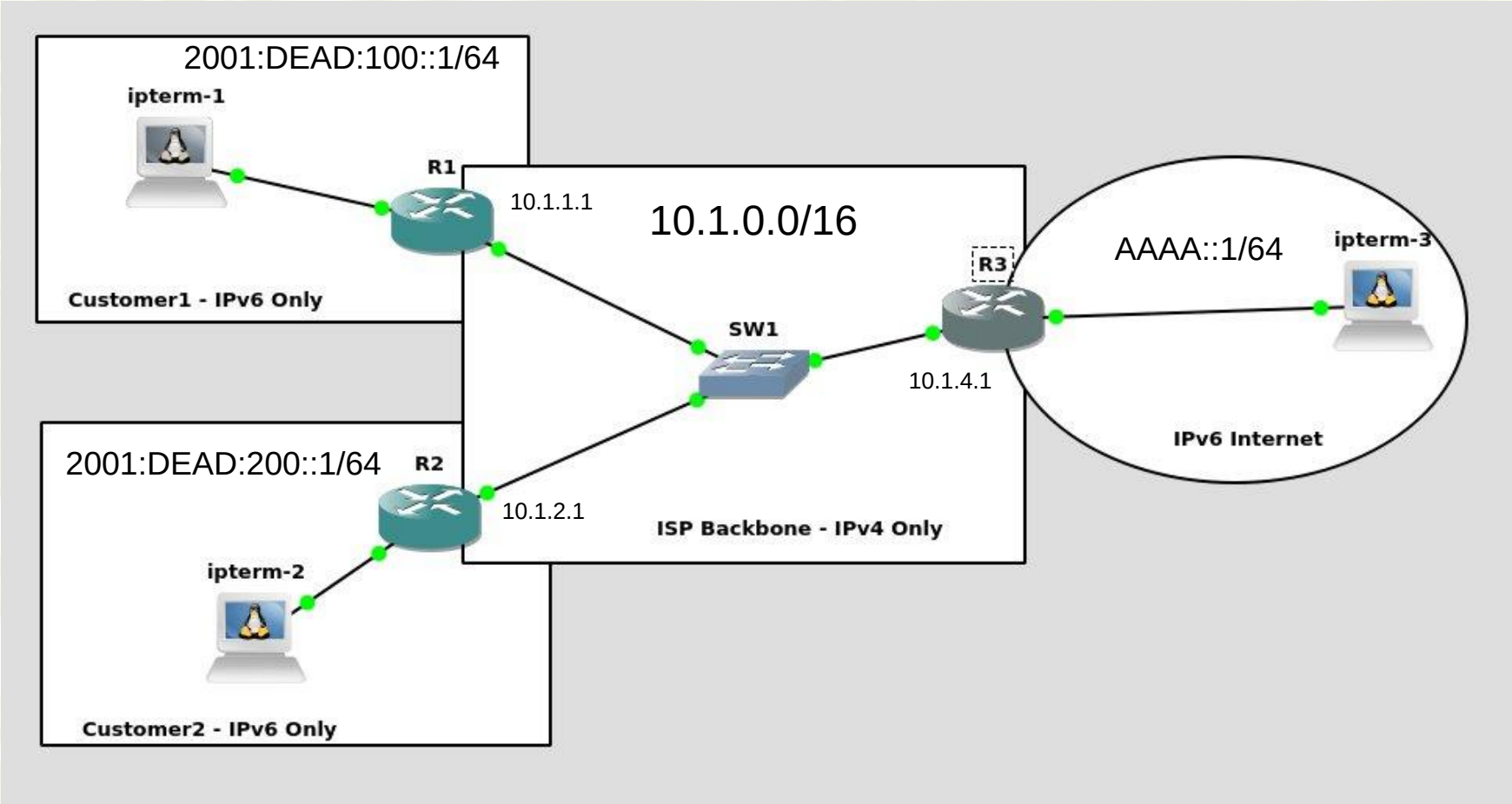
6rd scenario



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 (R1 and R2):
  - `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