

Migrating from IPv4 to IPv6: planning an effective IPv6 transition

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Why a transition to IPv6?

- The IPv4 addresses are running out
- The Internet routing system is getting overloaded
- IPv6 provides new features
 - virtually unlimited addressing space
 - native support for mobility, security, multicast, etc.
 - plug & play
- The cost of a “non-transition”
 - the use of private addresses and NATs breaks end-to-end transparency (failure of some applications & loss of flexibility)
 - enhancing IPv4 to make it IPv6-like is costly

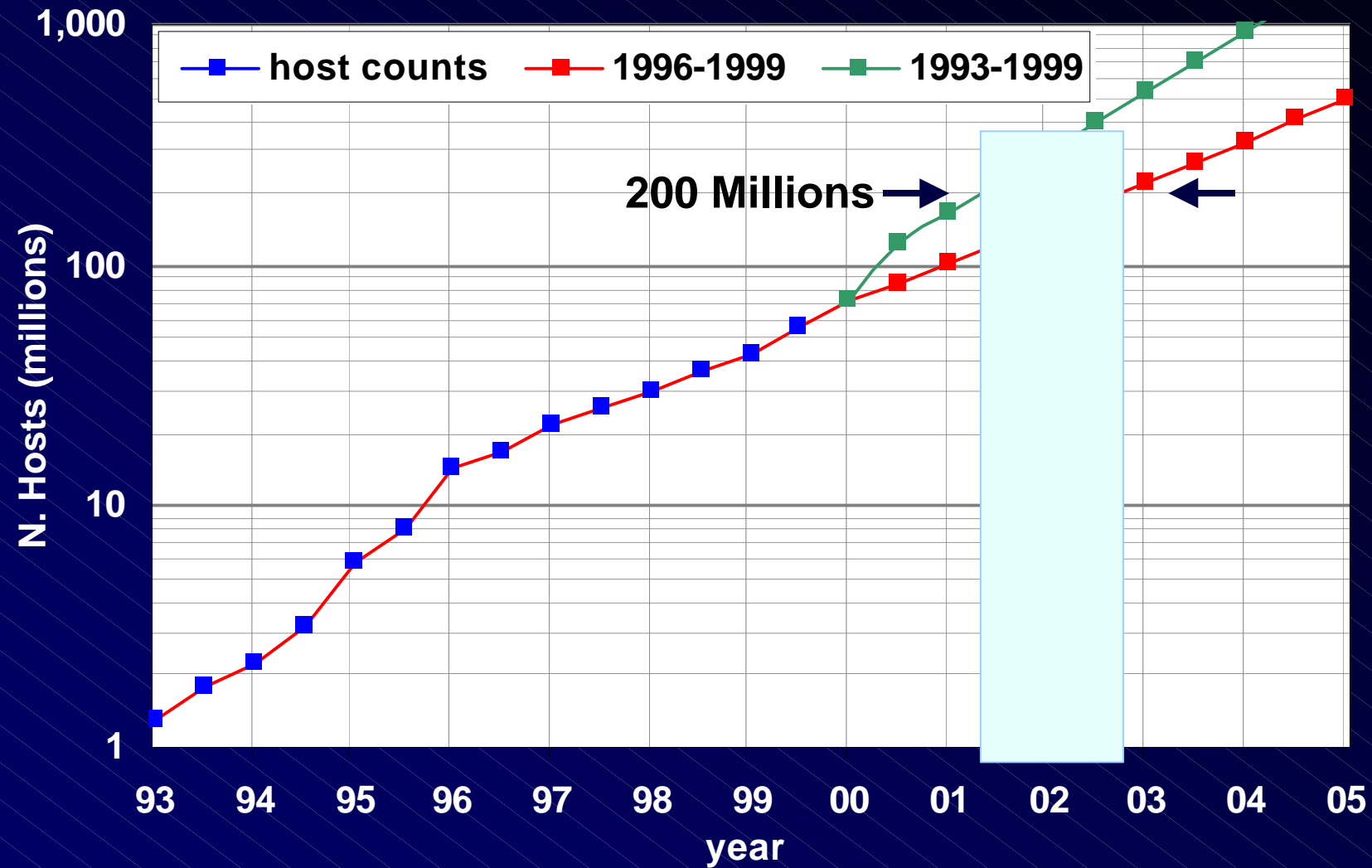


Availability of IPv4 addresses

- Theoretical upper bound: $2^{32} \sim$ **4 billions**
- Practical upper bound: **~ 200 millions**
 - the hierarchical nature of the Internet limits the assignment efficiency (rfc1715)
- **Assigned IPv4 addresses**
 - **~ 72 millions** (January 2000)
 - these are just the addresses registered in the DNS system (i.e. a lower bound)
 - the growth is exponential
- **When will we reach the upper bound of 200 million hosts in the Internet?**



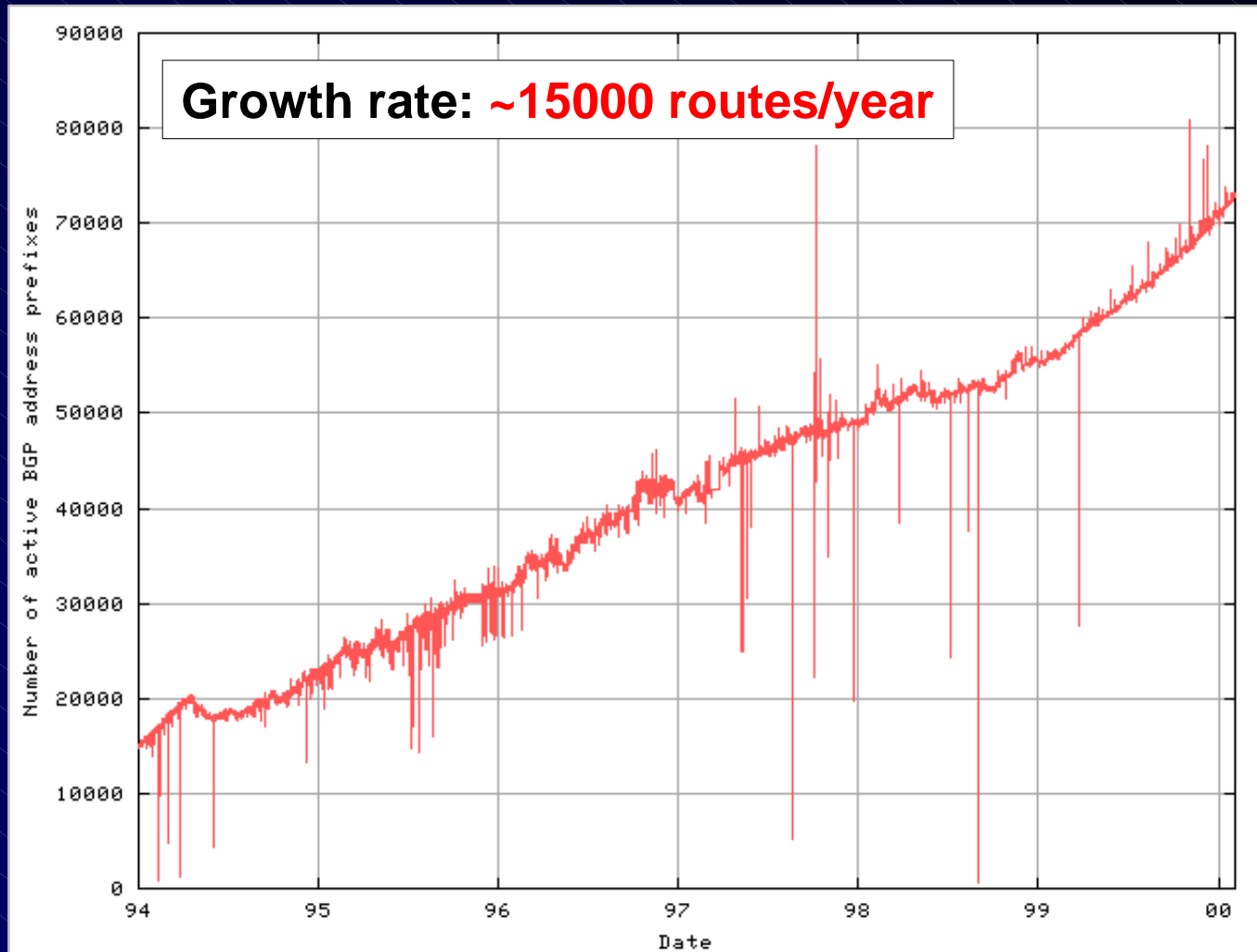
Internet growth forecasts



Source: Internet Software Consortium
(<http://www.isc.org>)



Backbone routing overload



Source: <http://telstra.net/ops/bgptable.html>



When should we start?

- **Certainly not later than 2003**
 - sometime between 2001 and 2003 getting a bunch of global IPv4 addresses might become really difficult
- **But it is much better to start sooner**
 - more time to plan a smooth transition
 - more time to gain the necessary IPv6 expertise
 - just setting up an early IPv6 service is cheap
 - several ISPs and user communities have already begun



IPv6 deployment issues

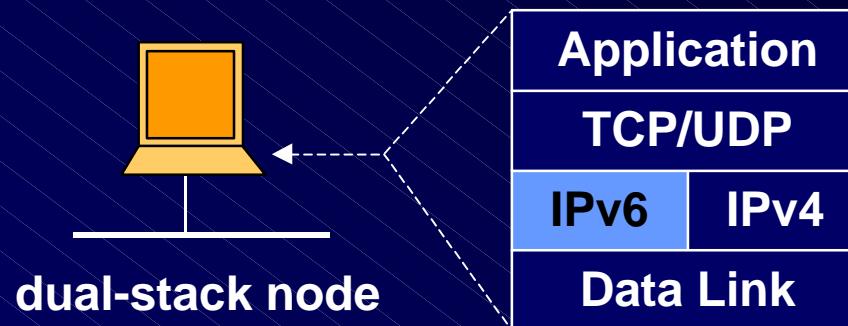
- **IPv4 and IPv6 do not interoperate**
 - IPv4 applications do not work with IPv6
 - IPv4 nodes can not communicate with IPv6 nodes
- **The applications have to be modified**
 - a lot of work still has to be done.....
- **It is likely that IPv4 and IPv6 will coexist for a long period of time**
 - how to enable communications among IPv6 islands isolated in the IPv4 world?
 - how to enable communications between the existing IPv4 world and the new IPv6 world?



Basic transition mechanisms

- **Dual IP Stack**

- provision of complete support for both IPv4 and IPv6 in hosts and routers

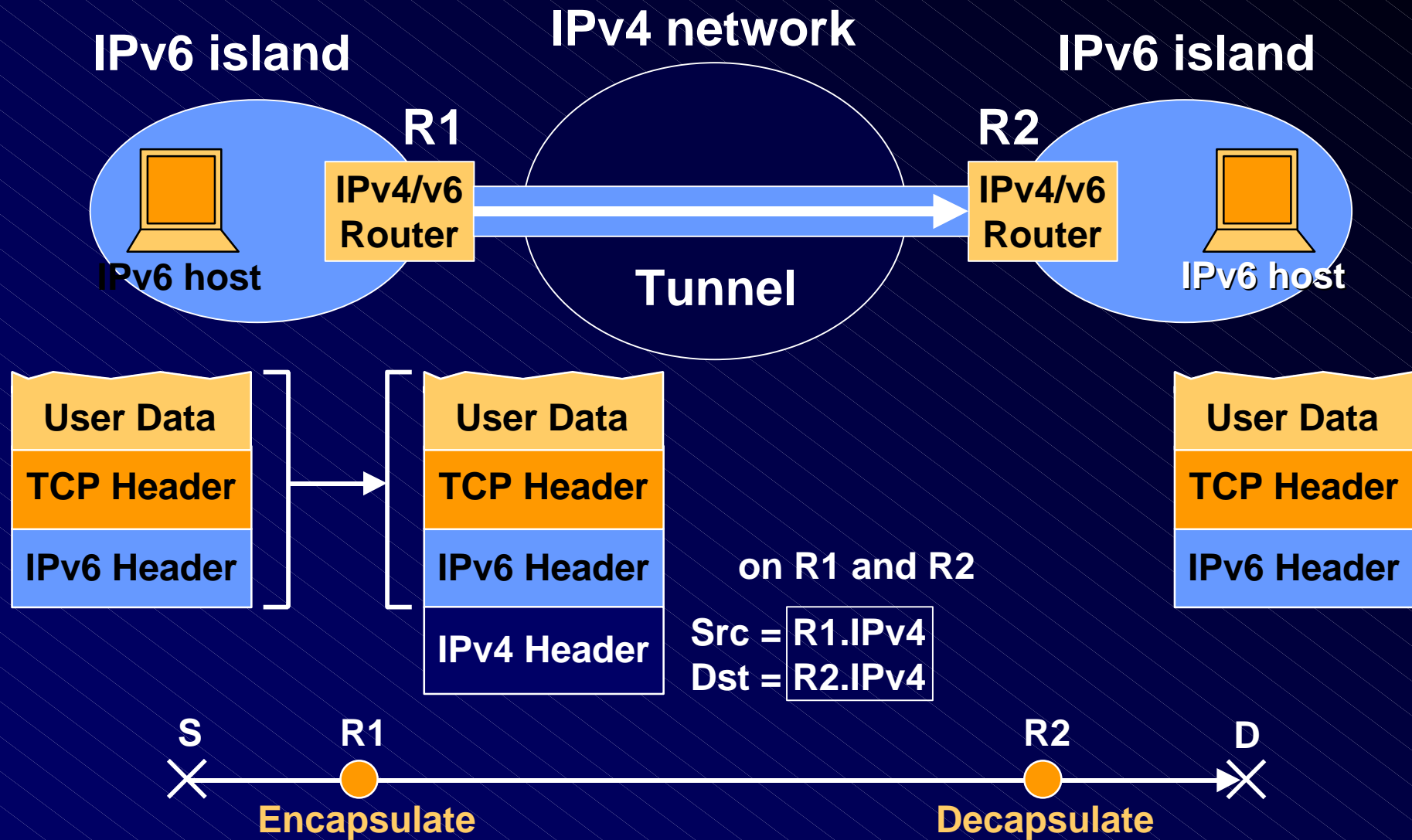


- **IPv6 over IPv4 tunneling**

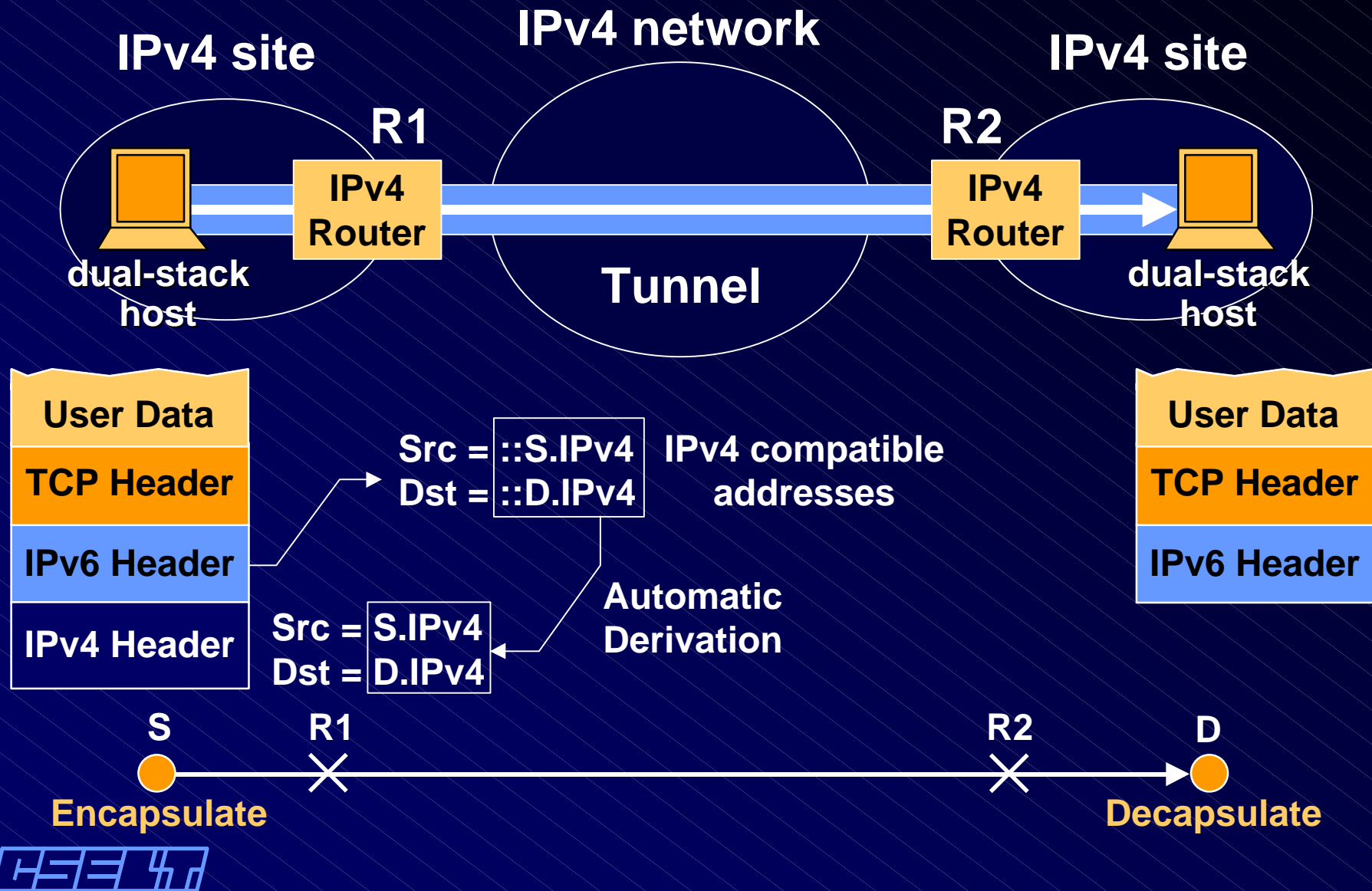
- encapsulation of IPv6 packets within IPv4 headers to carry them over an IPv4 network (e.g. Internet)
- two types of tunneling: **configured** and **automatic**



Configured tunneling



Automatic tunneling



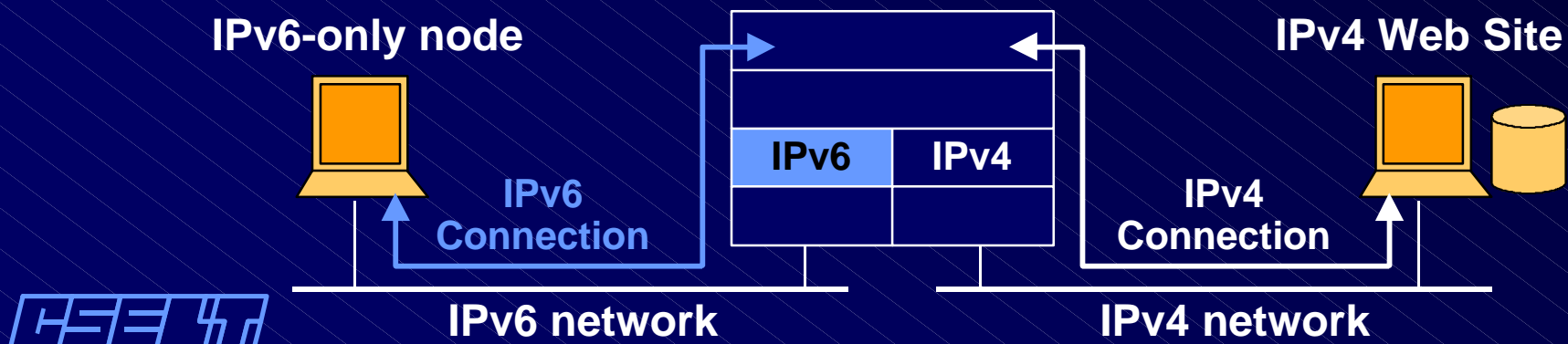
The need for other tools

- **Issues with simple dual-stack**
 - it does not reduce the demand for globally routable IPv4 addresses
 - it increases network complexity due to the need for a double (IPv4/IPv6) routing infrastructure
- **Issues with simple tunneling**
 - configured tunneling requires heavy manual configuration and therefore does not scale well
 - automatic tunneling is not the solution because it can be used only between individual hosts



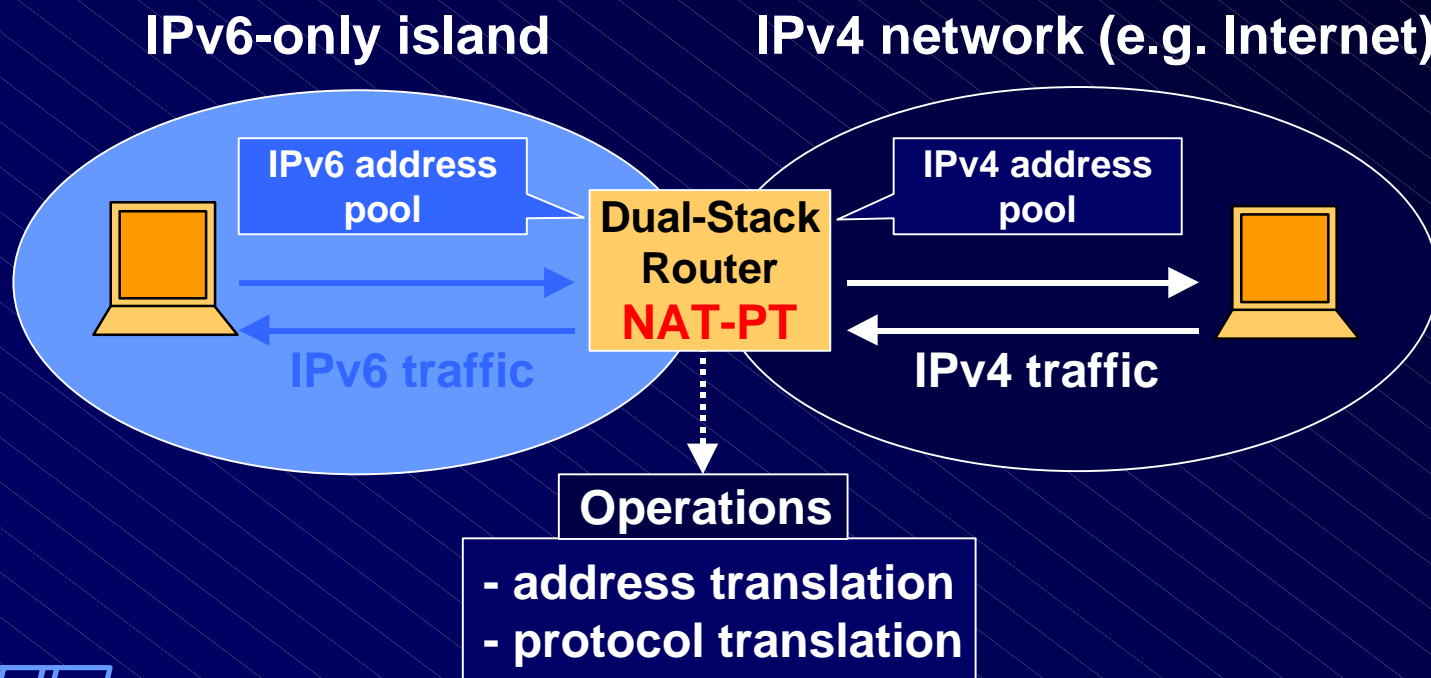
Other dual-stack approaches

- **DSTM (Dual Stack Transition Mechanism)**
 - deployment of dual-stack nodes with dynamically assigned IPv4 addresses
 - IPv4 over IPv6 tunneling to avoid the need for a dual-stack routing infrastructure
- **Application Level Gateways (ALG)**
 - the client is IPv6-only and the communication with the IPv4 world goes through a dual-stack proxy



A dual-stack alternative

- **NAT-PT (NAT - Protocol Translator)**
 - the customer site is an IPv6-only network
 - the communication with the IPv4 world relays on a NAT box that translates between IPv4 and IPv6



Issues with NAT-PT

- **More or less the same as IPv4 NATs**
 - some applications may not work (need for ALGs)
 - IPsec, Mobile IP, etc. fail (no e2e transparency)
 - performance degradation
 - single point of failure
 - need for strict coordination with DNS for automatic translation state initialization
- **But**
 - unlike IPv4 NATs, NAT-PTs are just a temporary solution
 - after the transition has been completed the NAT-PT box may be removed

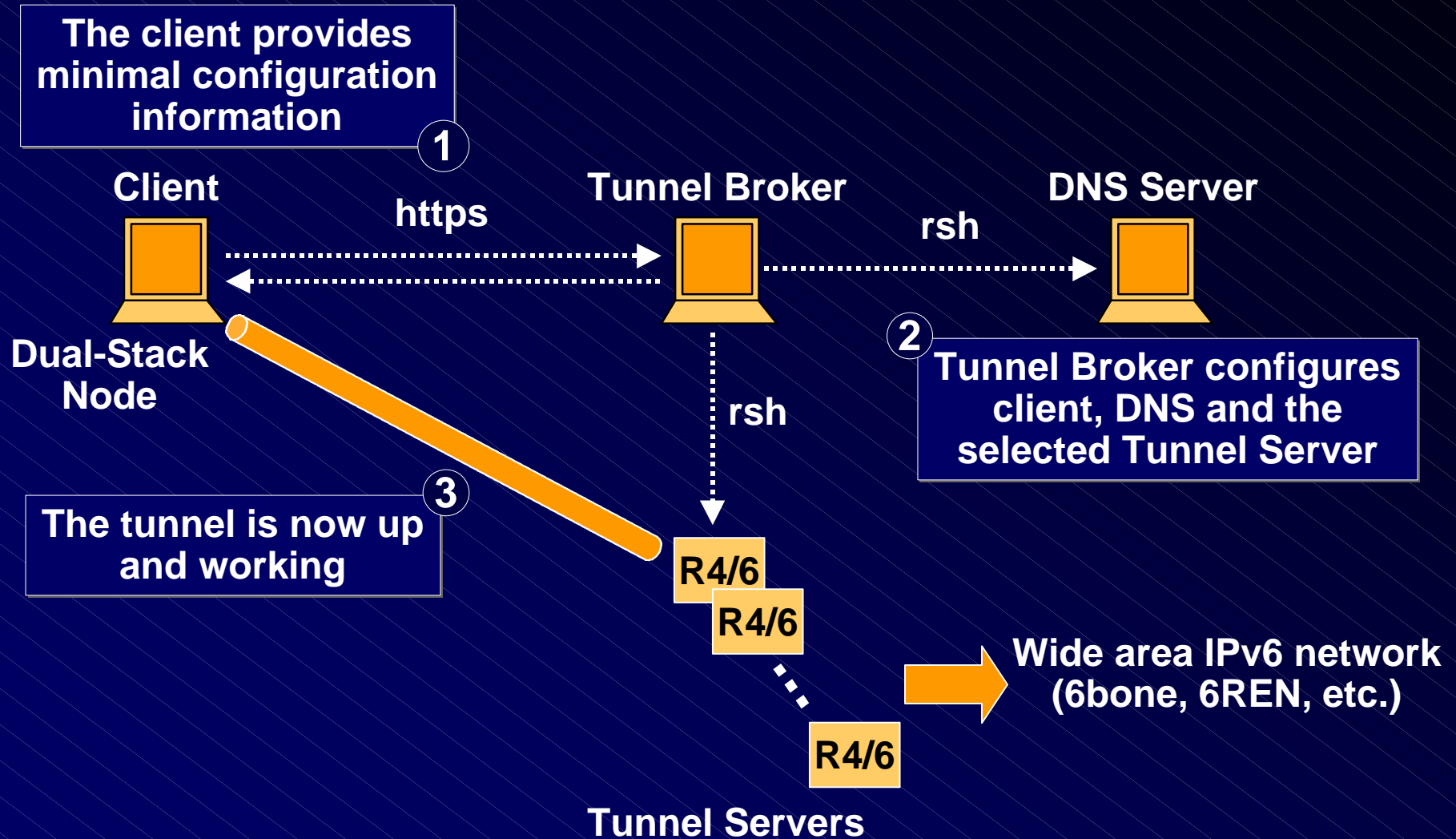


Tunneling enhancements

- **Tunnel Broker**
 - automatic tunnel and DNS setup assisted by a tunnel broker server operated by the IPv6 ISP
- **6over4**
 - IPv6 hosts in an IPv4 site communicate through automatic IPv6 over IPv4 encapsulation
 - a virtual link is created relaying on IPv4 multicast to enable IPv6 Neighbor Discovery over IPv4
- **6to4**
 - interconnection of isolated IPv6 domains in an IPv4 world (e.g. Internet)
 - the egress router of the IPv6 domain automatically creates a tunnel to the other domain

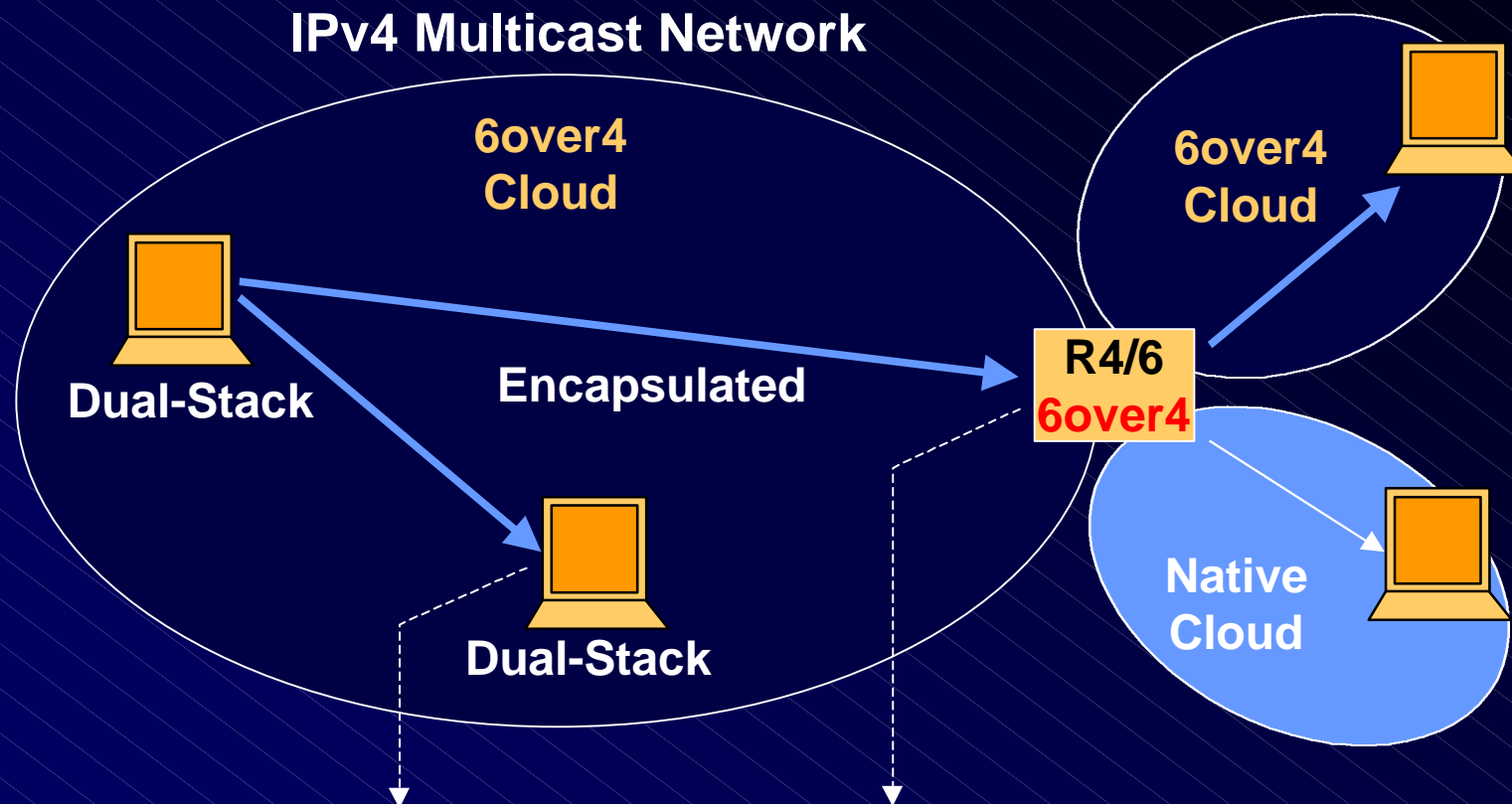


The tunnel broker service at CSELT



Service available at: <https://carmen.cselt.it/ipv6tb>

6over4 operation



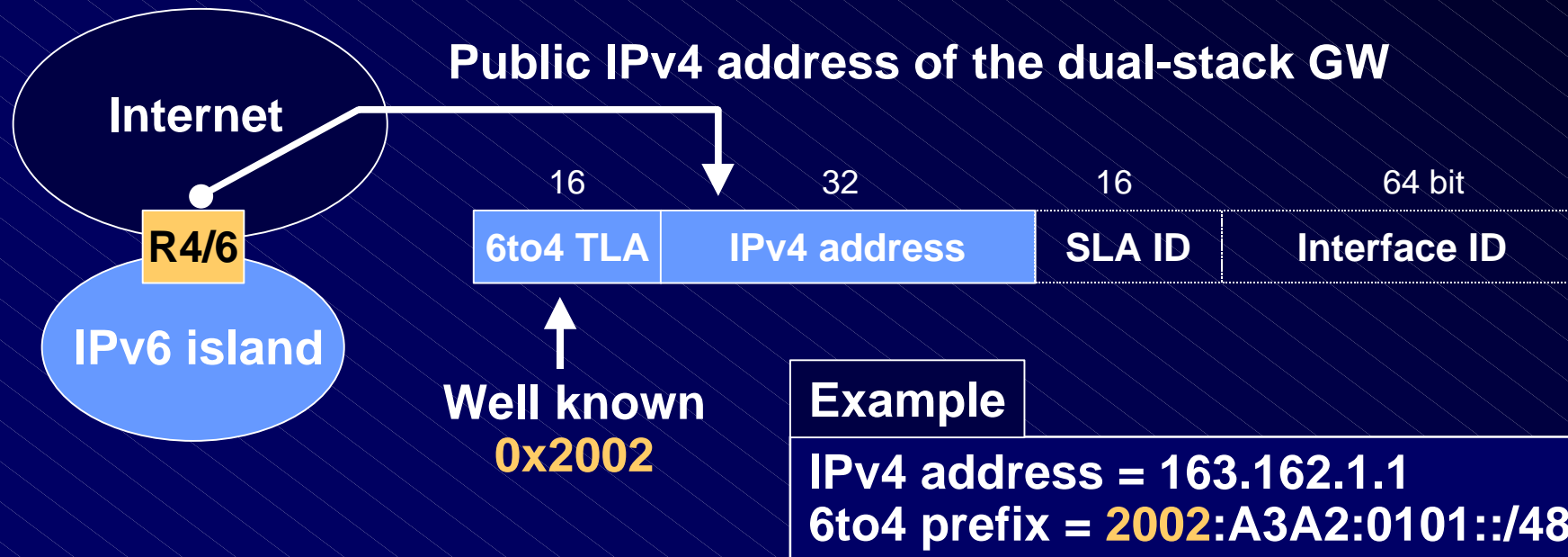
IPv4 end-point and router discovery via ND

- the whole IPv4 network becomes a virtual IPv6 link
- IPv6 multicast mapped over organization-local IPv4 multicast

6to4 operation

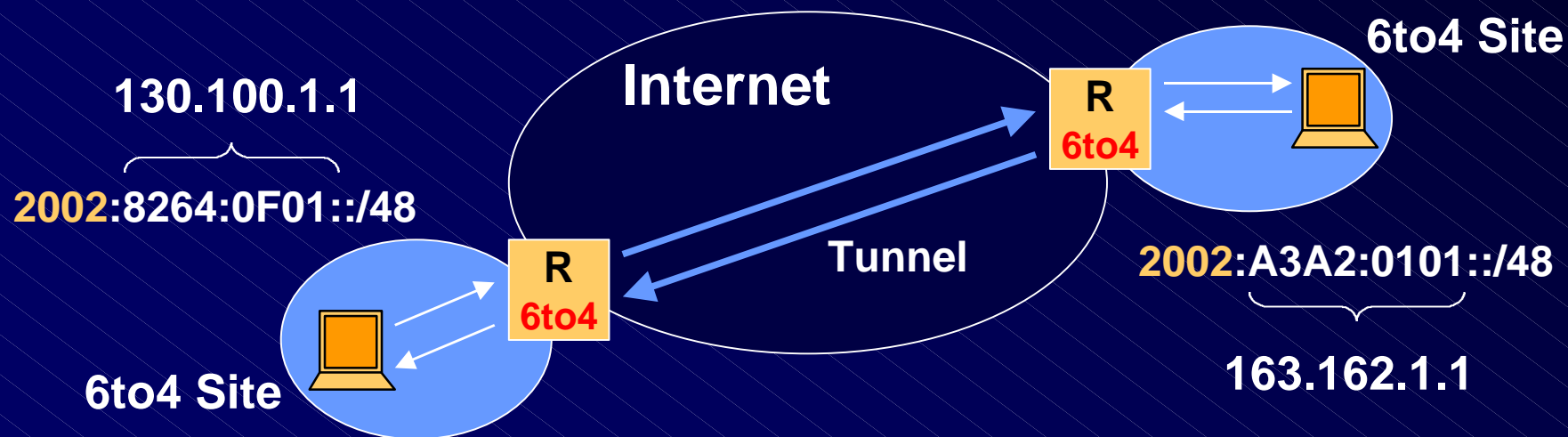
- **IPv6 Addressing**

- any isolated IPv6 domain can autonomously build its own globally unique IPv6 prefix
- the globally unique IPv4 address of the domain border router is used for this purpose



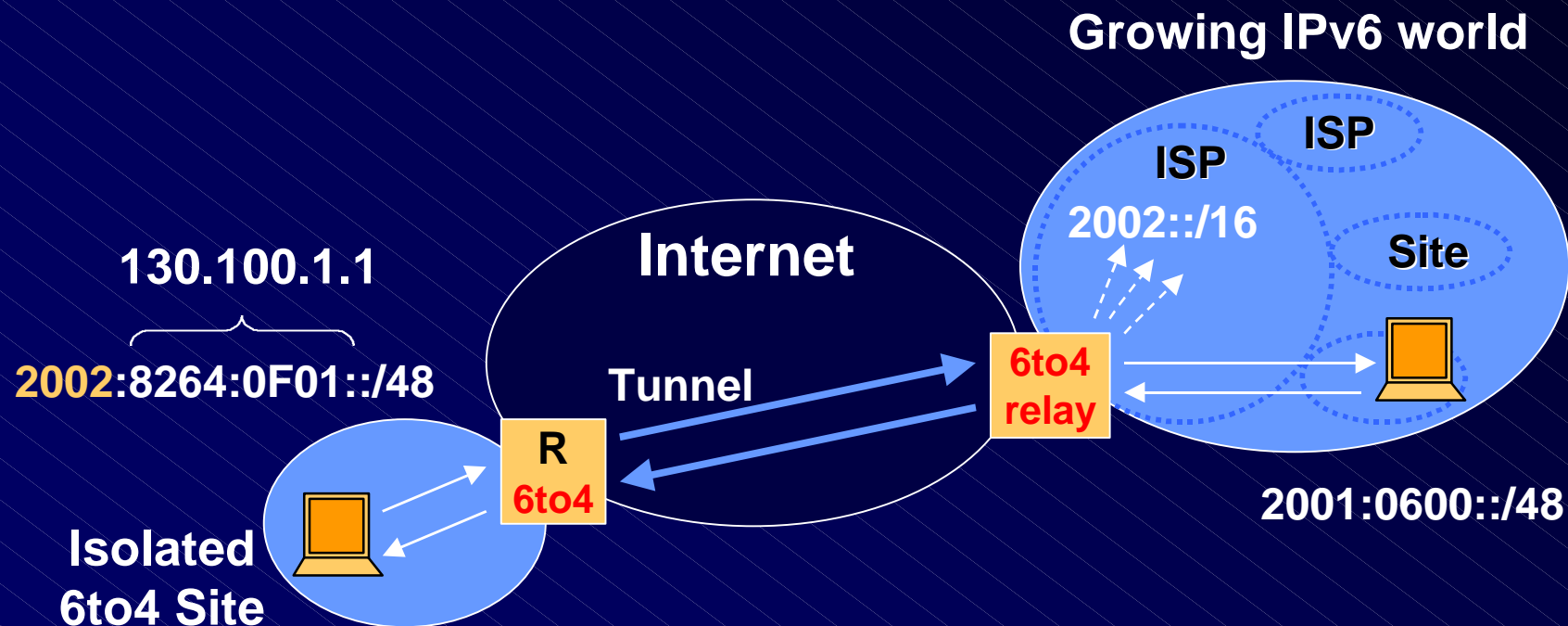
6to4 operation (cont.)

- **Communication among 6to4 sites**
 - the egress router automatically creates a tunnel to the destination domain
 - the IPv4 endpoint is extracted from the destination IPv6 prefix
 - only the egress router has to be 6to4 capable



6to4 operation (cont.)

- **Communication with the native IPv6 world**
 - based on 6to4 relays
 - a 6to4 router must be able to locate at least one 6to4 relay (e.g. manual conf.)



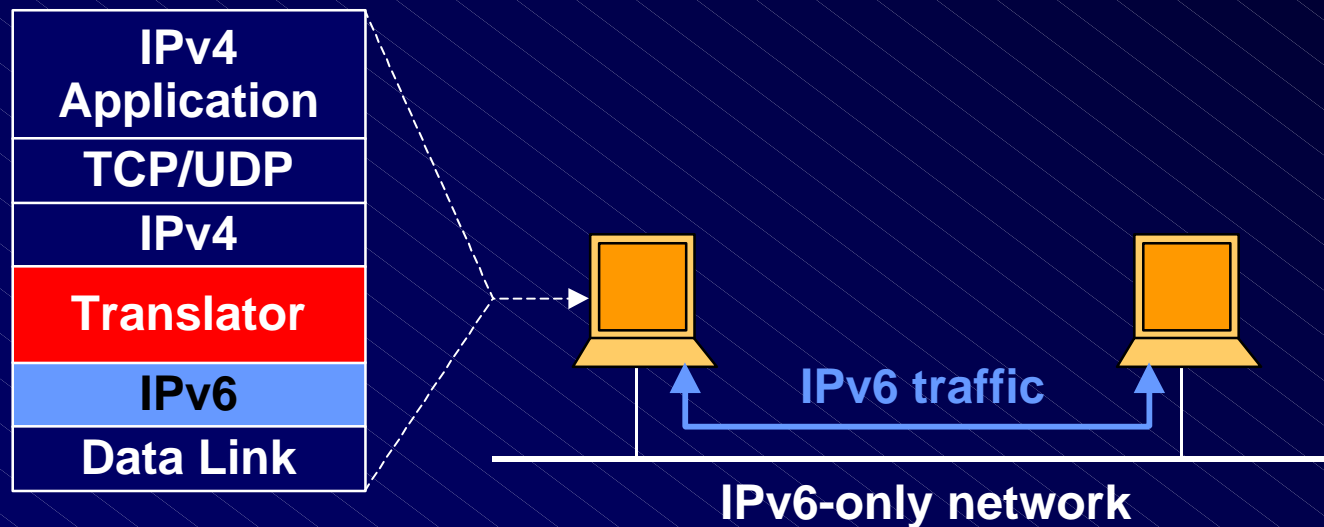
Summary

- **How to enable communications among IPv6 islands isolated in the IPv4 world?**
 - simple tunneling (configured or automatic)
 - Tunnel Broker
 - 6over4
 - 6to4
- **How to enable communications between the existing IPv4 world and the new IPv6 world?**
 - simple dual-stack
 - Application Level Gateways (ALG)
 - DSTM
 - NAT-PT



Availability of IPv6 applications

- **A lot of work still has to be done**
 - just a few IPv6 applications are available to time (e.g. ftp, telnet, ping, some WWW browsers)
- **BIS (Bump In the Stack) may be of help**
 - to use of IPv4 applications over an IPv6 network
 - it is like NAT-PT implemented within the host



Transitions scenarios

- **Company**
 - new organization
 - existing organization with lots of IPv4 addresses
 - existing organization with private IPv4 addresses and NATs
- **ISP**
 - backbone ISP
 - small/medium ISP

New organization

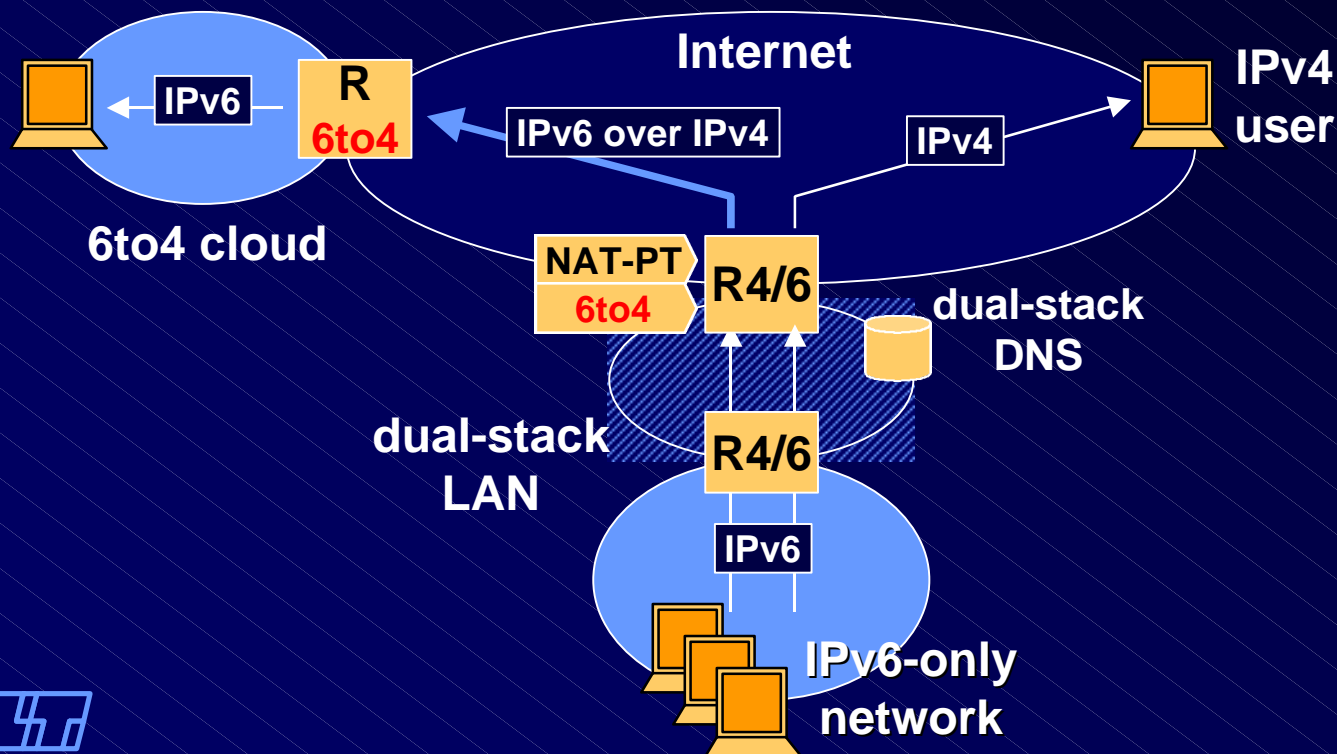
- **Network technology:**
 - deploying an IPv6-only network is future proof
- **Communication with the IPv4 world**
 - at least one global IPv4 address
 - NAT-PT or dual-stack ALG (e.g. WWW proxy)
- **Communication with other IPv6 domains**
 - IPv4-only ISP: configured tunneling or 6to4
 - dual-stack ISP: relay on the upstream IPv6 service
- **DNS**
 - a dual-stack DNS is required if the upstream ISP does not provide native IPv6 DNS



New organization (cont.)

- Applications

- at least all the basic Intranet/Internet services (e.g. WWW, e-mail) must be provided over IPv6
- BIS may be used to support IPv4-only applications



Existing organization

- **Network technology**
 - migration to dual-stack anywhere with configured tunneling or 6over4 during the transition
- **Communication with the IPv4 world**
 - IPv4 end-to-end (if lots of addresses are available)
 - or use the existing proxy or NAT box
- **Communication with other IPv6 domains**
 - IPv4-only ISP: configured tunneling or 6to4
 - dual-stack ISP: relay on the upstream IPv6 service
- **DNS**
 - AAAA Records must be supported



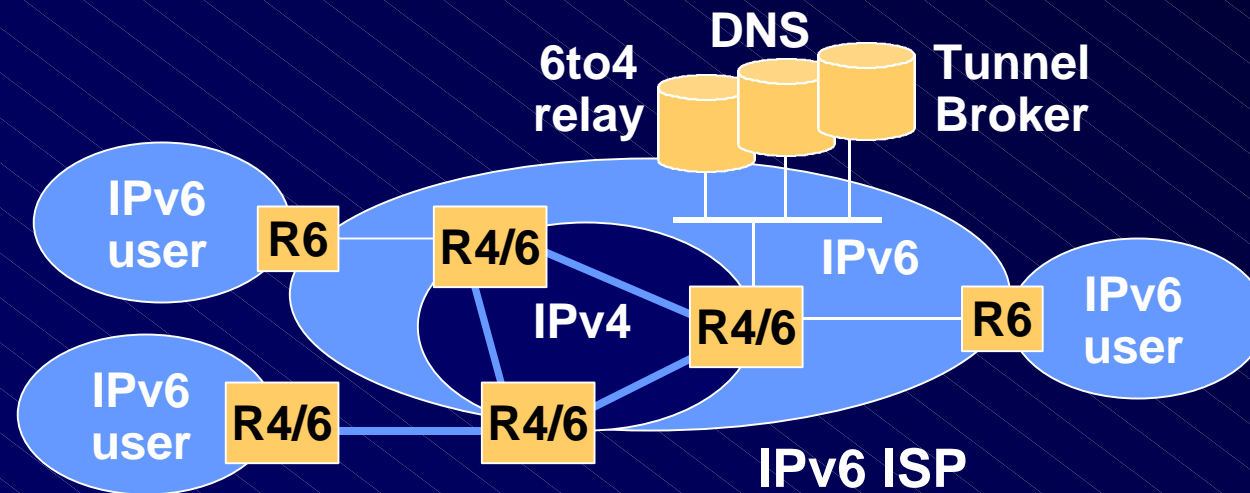
Backbone ISP

- **IPv6 equipment**
 - deployment of dedicated IPv6 routers and servers
- **Addressing**
 - apply for a TLA prefix (RIPE, ARIN or APNIC)
- **IPv6 connectivity in the backbone**
 - initially configured tunneling over the existing IPv4 infrastructure should be enough
 - migration to native links as the IPv6 traffic grows
- **IPv6 connectivity with other ISPs**
 - setup of IPv6 peerings with other big ISPs
 - the IPv6 peering policies should be similar to those in place for IPv4



Backbone ISP (cont.)

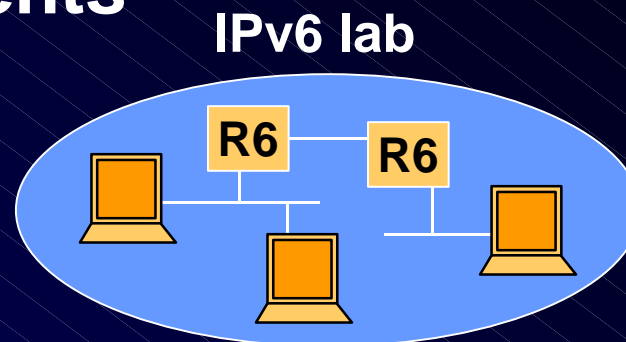
- **IPv6 connectivity to customers**
 - configured tunneling or native connections
 - provision of a 6to4 relay service to reach isolated 6to4 clouds
 - the Tunnel Broker approach may be suitable for residential customers or small networks



Transition steps

- **Laboratory experiments**

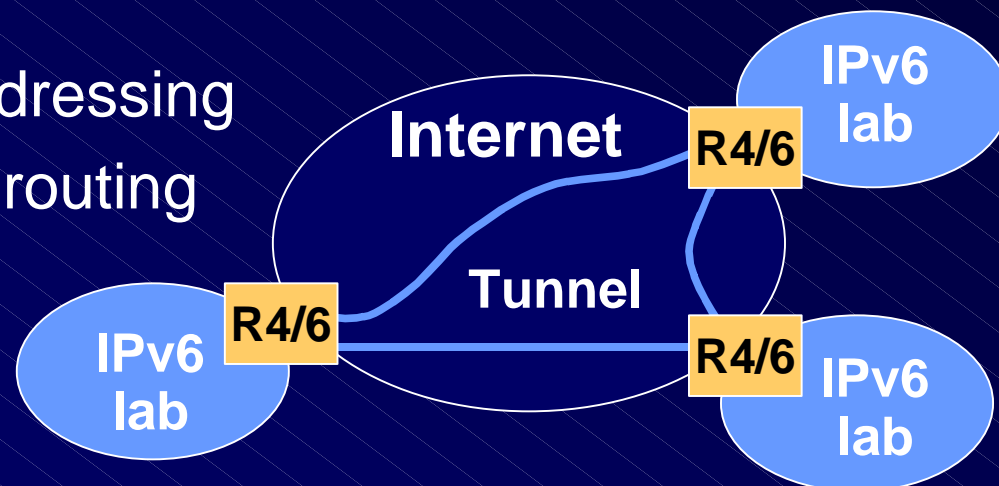
- network services
- applications



1995

- **Geographical experiments (6bone)**

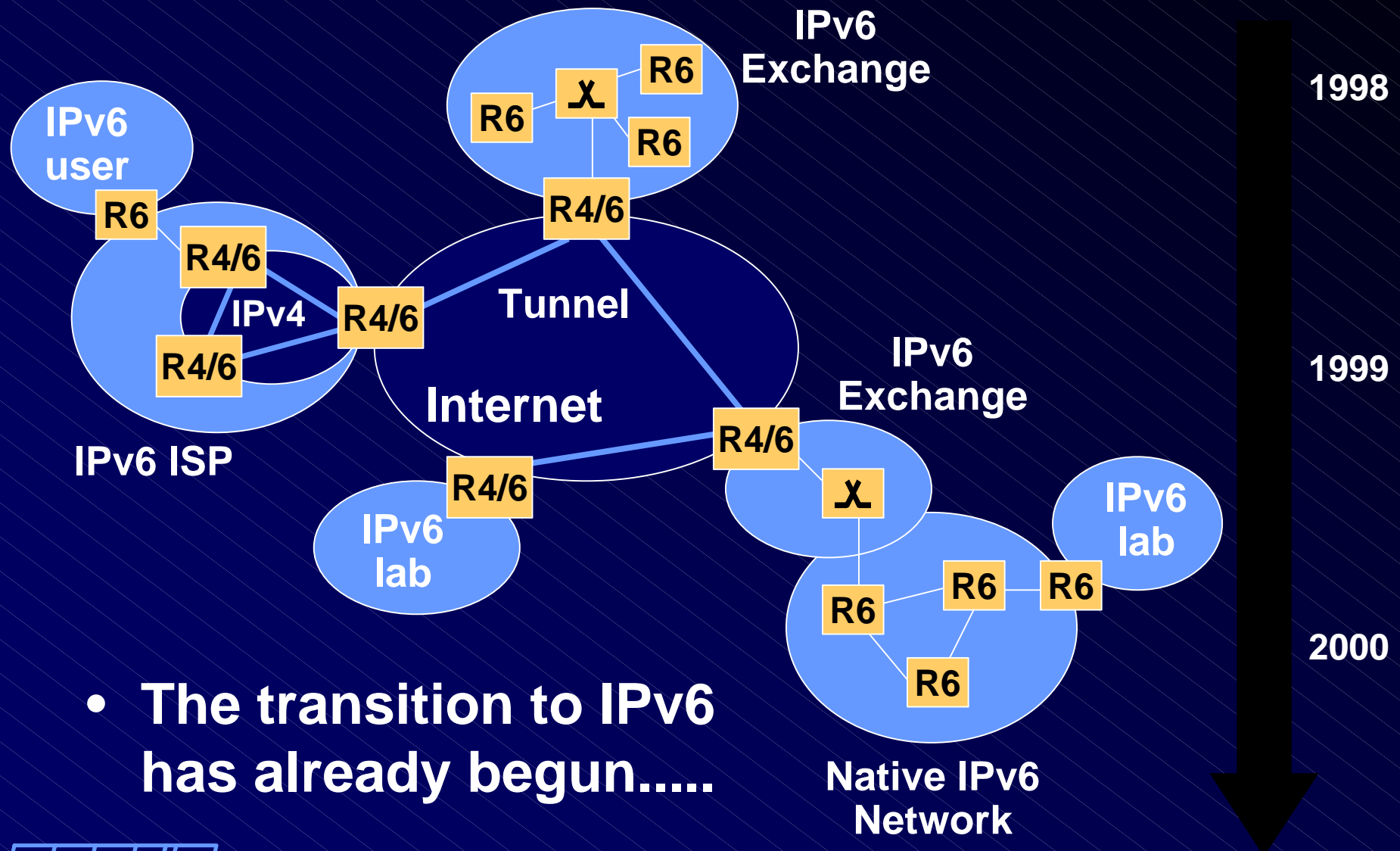
- DNS
- IPv6 addressing
- BGP4+ routing



1996

1997

Transition steps (cont.)



For further information....

- **IETF ipng working group**
 - <http://www.ietf.org/html.charters/ipngwg-charter.html>
- **IETF ngtrans working group**
 - <http://www.ietf.org/html.charters/ngtrans-charter.html>
- **6bone**
 - <http://www.6bone.net>
- **IPv6 Forum**
 - <http://www.ipv6forum.com>
- **CSELT Official IPv6 Site**
 - <http://carmen.cselt.it/ipv6> (IPv4)
 - <http://carmen.ipv6.cselt.it/ipv6> (IPv4 & IPv6)

