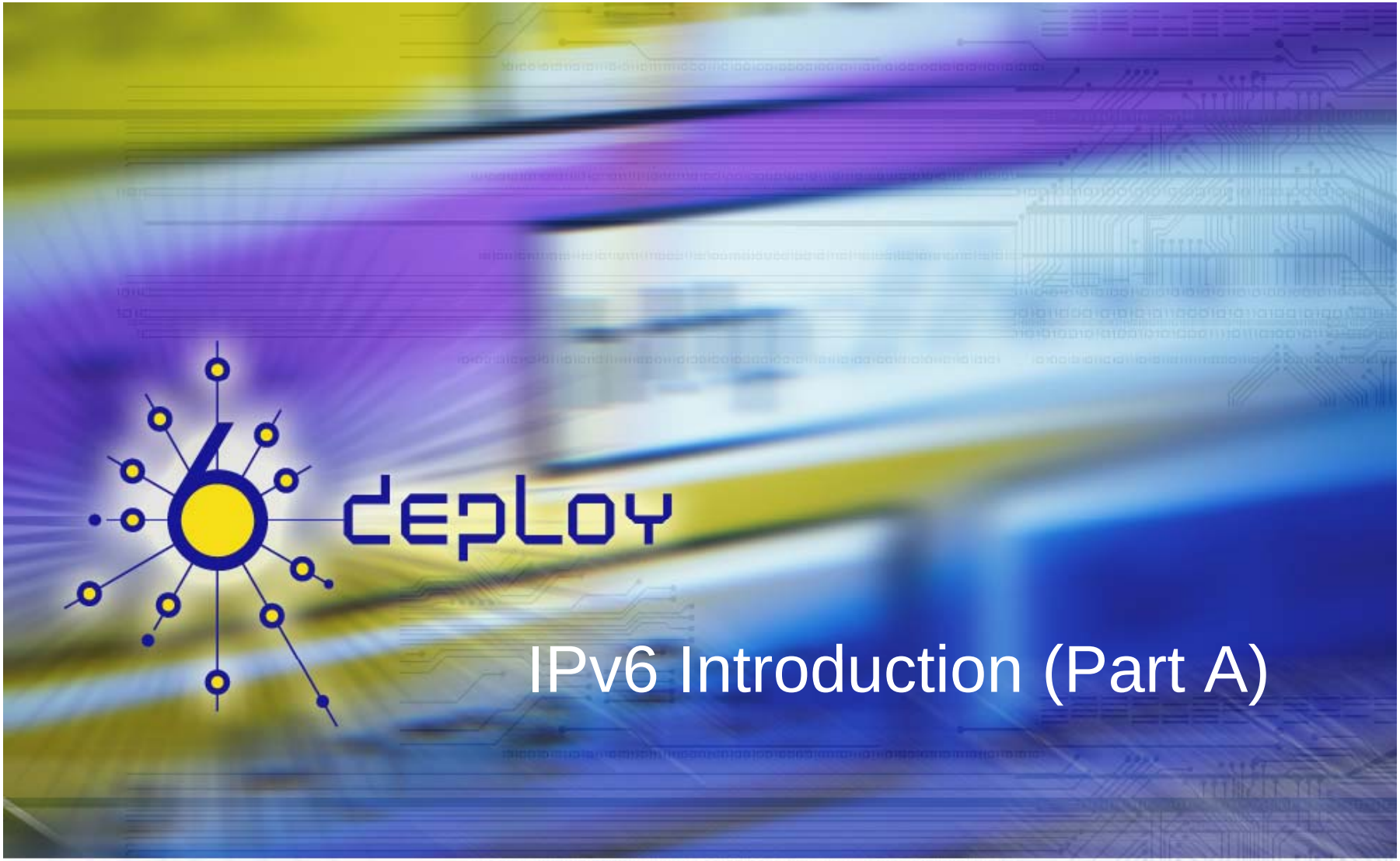

IPv6 Introduction (Part A)

Athanassios Liakopoulos (*aliako@grnet.gr*)

Greek IPv6 Training, Athens, June 2010

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- Athanassios Liakopoulos

Outline

Introduction to IPv6

Outline

Introduction

- Historical Facts
- IPv4 Address Space Status
- Emergency measures ... to IPv6
  - Last minute actions

IPv6 Basics

- IPv6 Header
  - Comparison with IPv4
- IPv6 Extension Headers
- Processing IPv6 Headers
  - Comparison with IPv4

Historical Facts

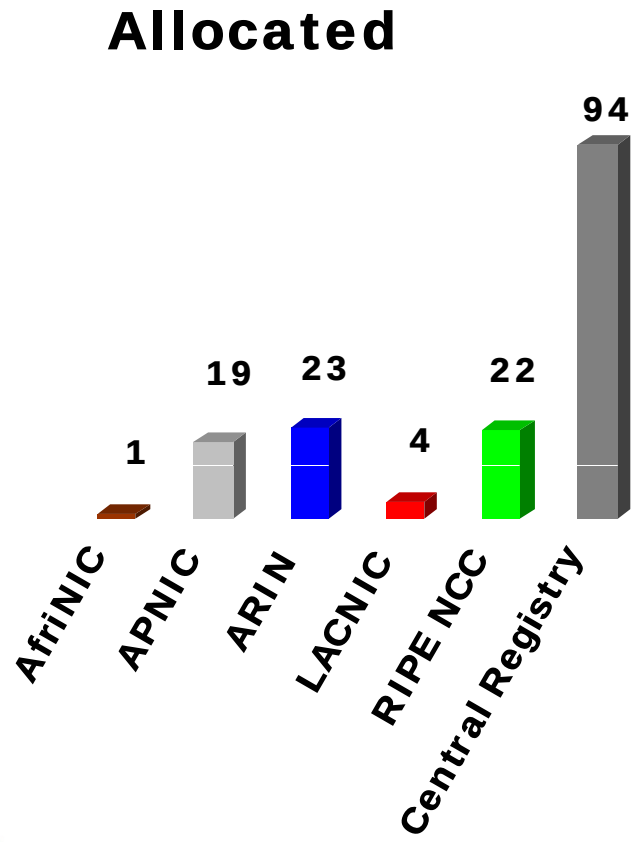
Introduction to IPv6

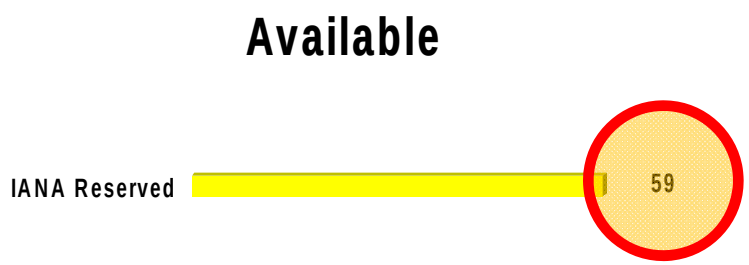
Historical facts

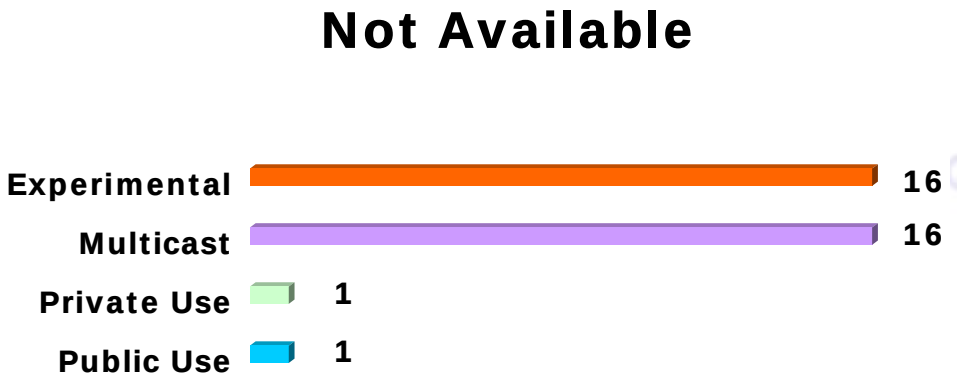
- 1983 : Research network for ~ 100 computers
- 1992 : Commercial activity
  - Exponential growth
- 1993 : Exhaustion of the class B address space
- Forecast of network collapse for 1994!

Introduction to IPv6

IPv4 Address Space Status (Sep. 06)

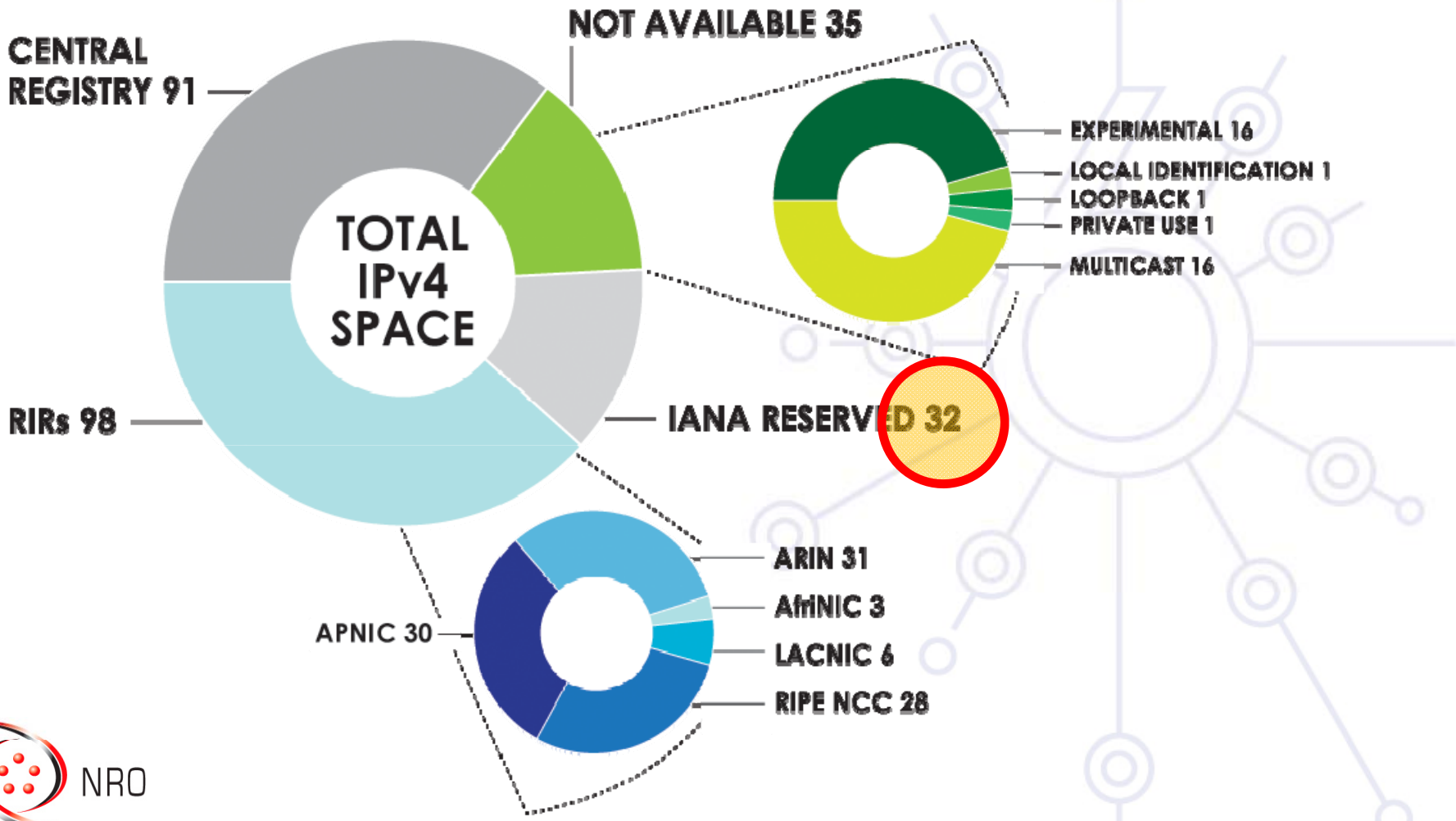






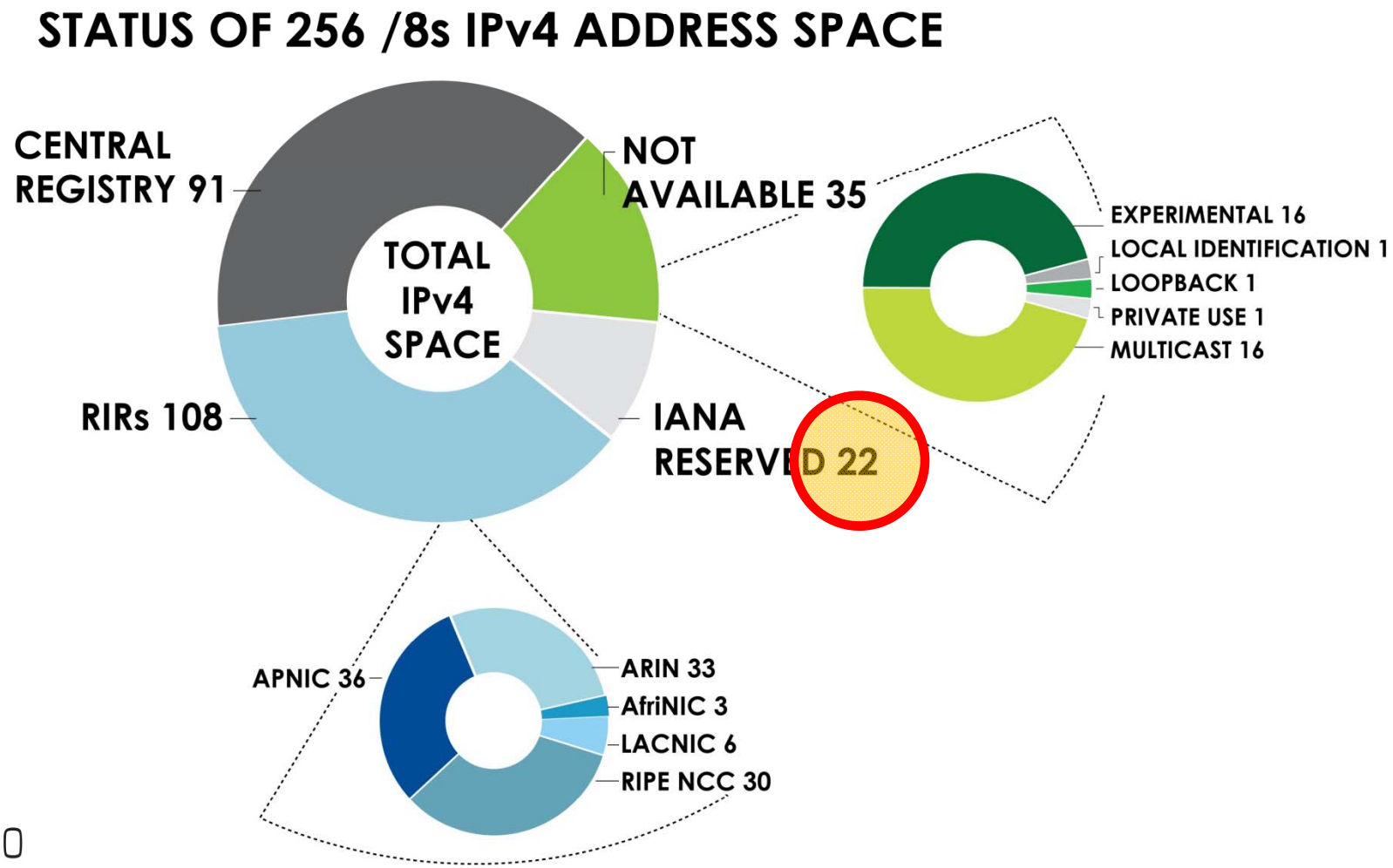
NRO

IPv4 Address Space Status (Mar. 09)



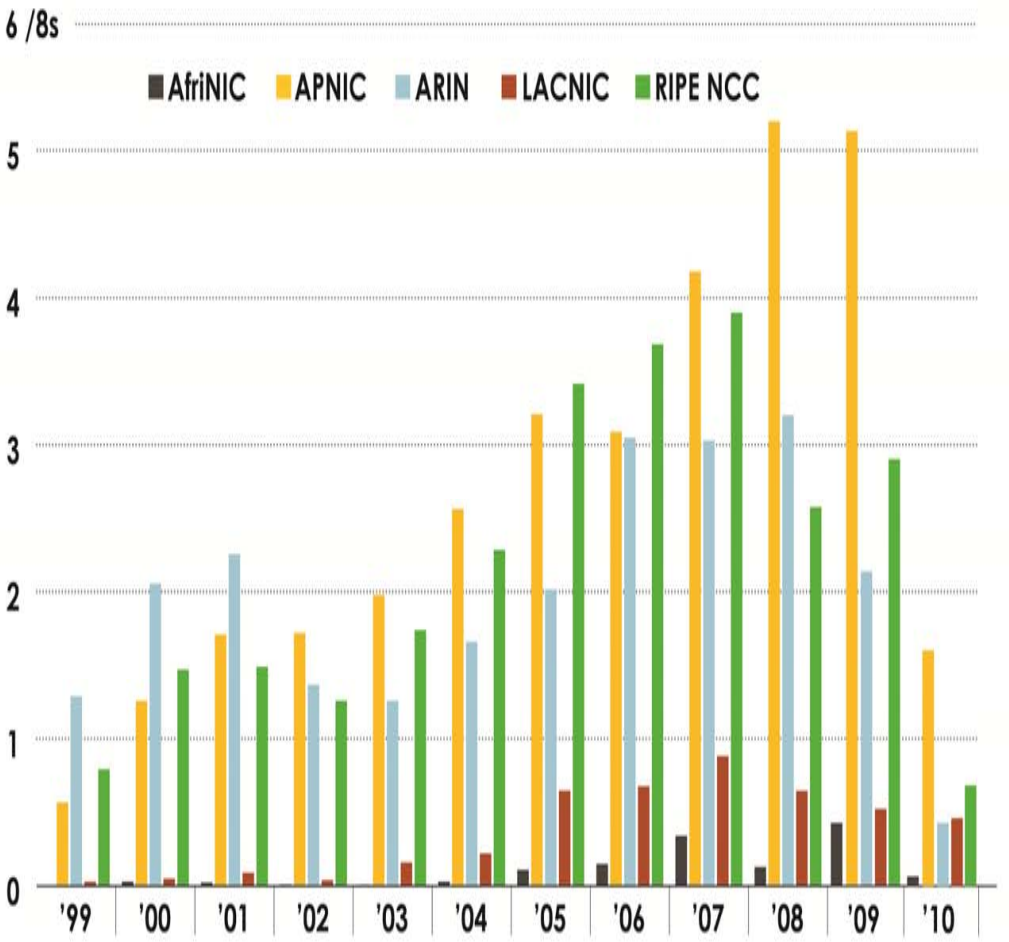
NRO

IPv4 Address Space Status (Mar. 10)

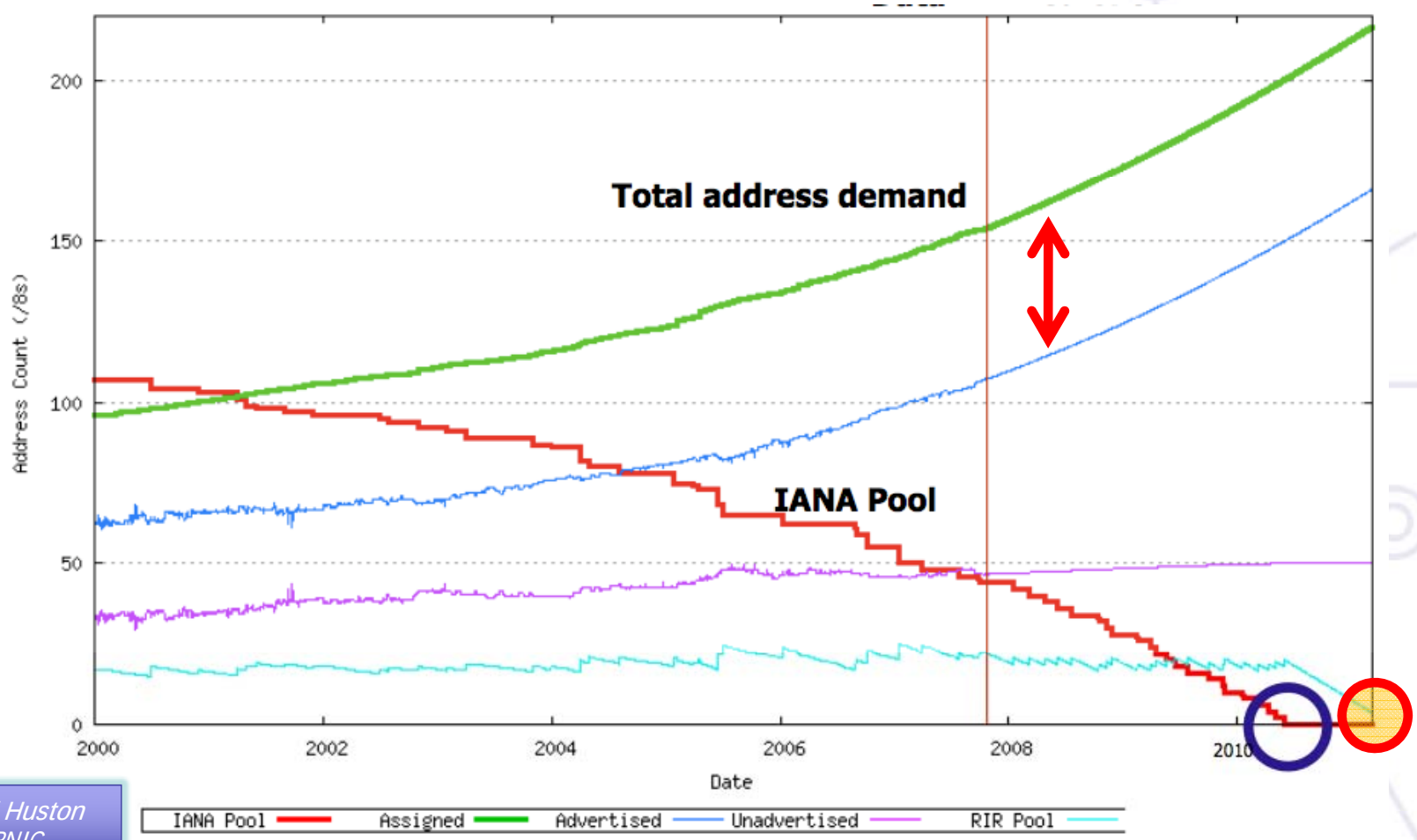


IPv4 Prefixes Consumption Pace

Year	Month	Available /8s (IANA)
2006	September	59
2006	December	55
2007	September	44
2008	September	39
2009	March	32
2010	March	22



IPv4 Address Space Depletion

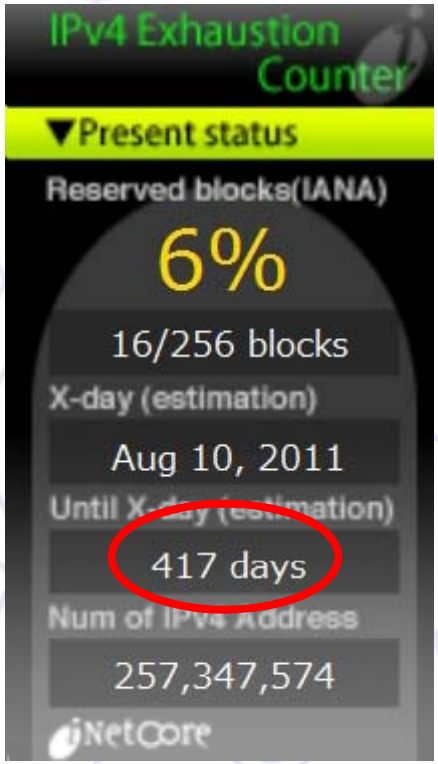


Geoff Huston
APNIC
Sept. 2007

How much time has left ?

- Resources exhaustion are projected as
  - IANA pool: August 2011
  - RIRs pool: April 2012

(Source: http://www.potaroo.net/tools/ipv4/index.html)



Emergency measures

Introduction to IPv6

Emergency measures ...

- Classless Internet Domain Routing (CIDR)
- Private addresses
- NAT

- ... and some recently proposals
  - NAT444
  - Dual Stack Lite (DS-Lite)
  - IPv4 Address Trading
  - IPv4 Renumbering

Classless Internet Domain Routing

- Allocate exceptionally class B addresses
- Re-use class C address space
- CIDR
  - network address = prefix/prefix length
  - classes abandon = less address waste
  - allows aggregation (reduces routing table size)

Private addresses (RFC 1918) (1/2)

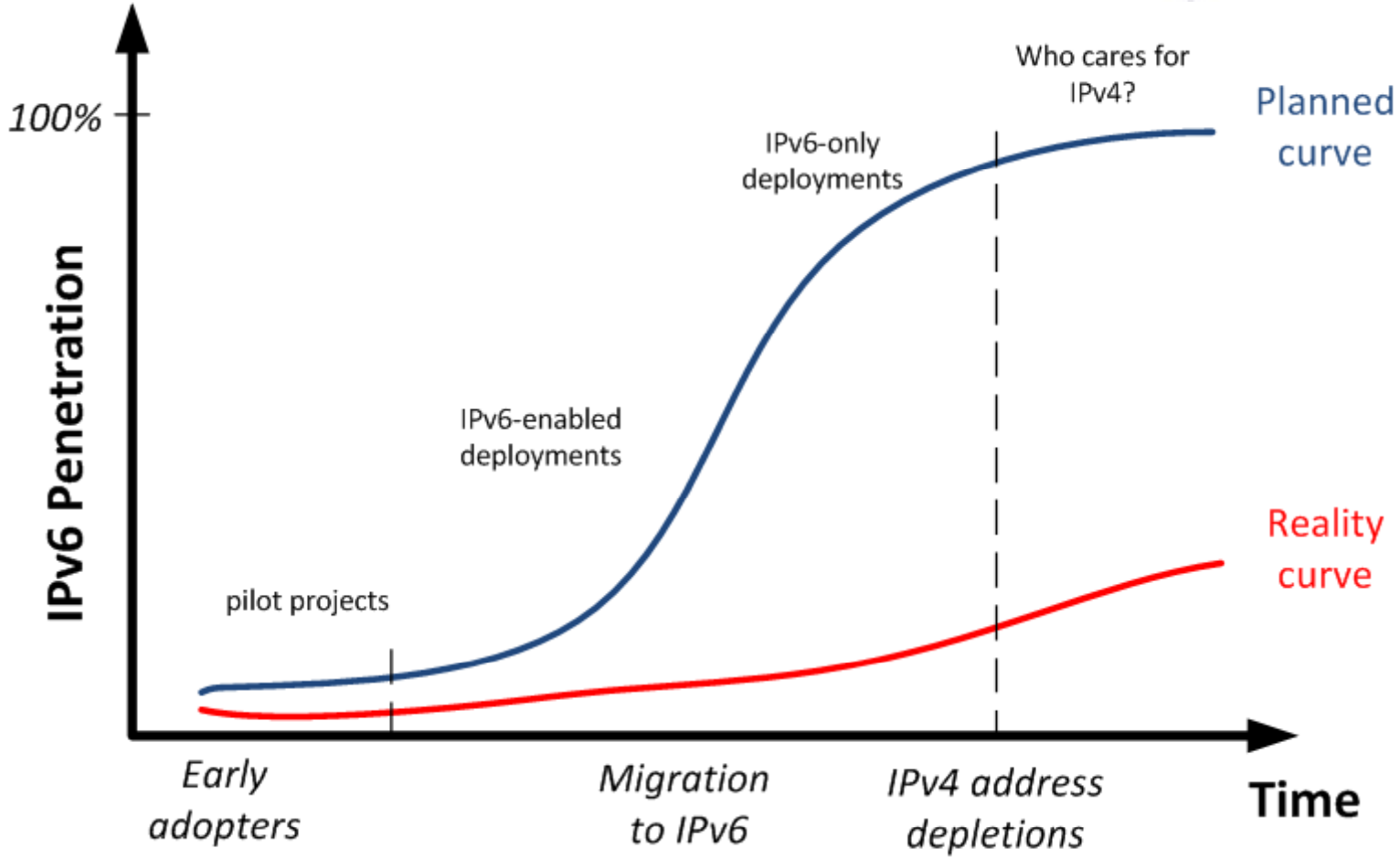
- Allow private addressing plans
- Addresses are used internally
- Similar to security architecture with firewall
- Use of proxies or NAT to go outside
  - RFC 1631, 2663 and 2993

Private addresses (2/2)

- Advantages:
  - Reduce the need of official addresses
  - Ease the internal addressing plan
  - Transparent to some applications
  - “Security” vs. obscurity
  - Netadmins/sysadmin
- Disadvantages:
  - Breaks the end-to-end paradigm
  - Translation sometime complex, e.g. FTP
  - Apps using dynamic ports
  - Does not scale (?)
  - Introduce states inside the network
  - Multi-homed networks
  - Security with IPsec

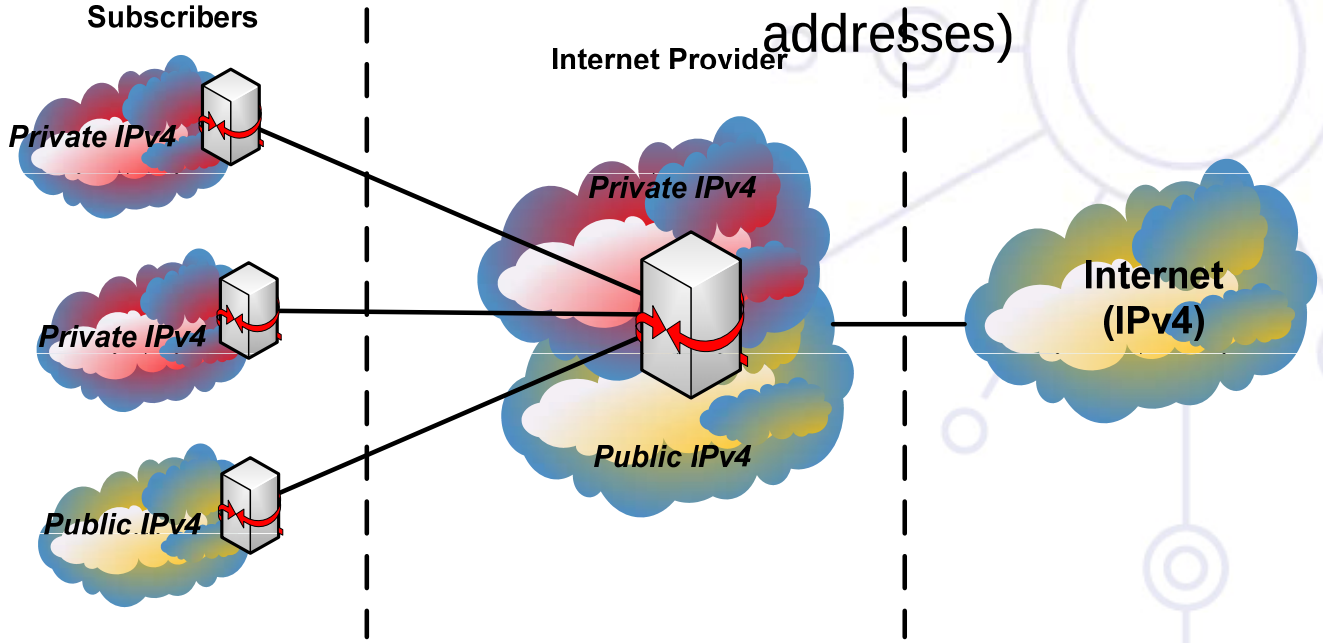
Introduction to IPv6

IPv6 Adoption (Plans vs. Reality)



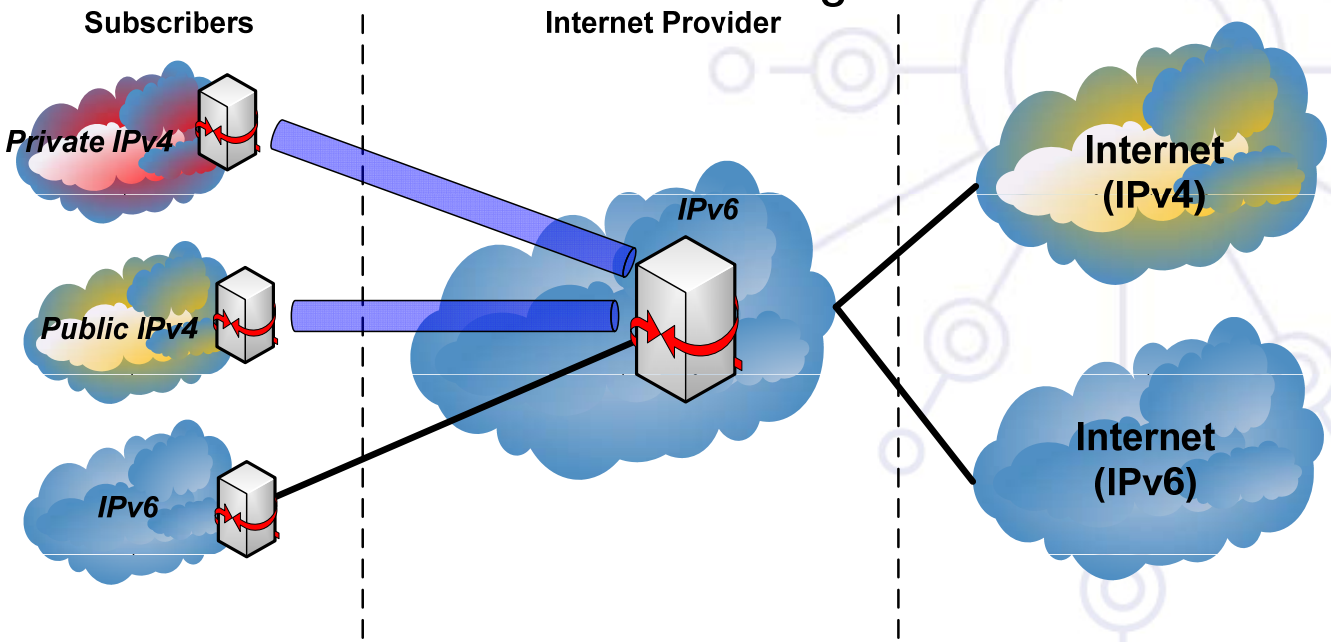
NAT444

- Reuse mature technology
- No changes to customers CPEs
- LNS Scalability
- States at the core (NAT44)
- Complexity (for existing / new protocols)
- Dual NAT (&mix of private addresses)



Dual Stack Lite

- No need for dual NAT44
- Tunnel IPv4-in-IPv6 is simple
- More “IPv6 friendly”
- States at the core (inc subscribers’ IPv6 addresses)
- Complexity (for existing / new protocols)
- Changes in CPEs



What next ?

- Emergency measures gave time to develop and test IPv6
  - IPv6 keeps principles that have made the success of IP
  - Corrects what was wrong with the current version (v4)

BUT are emergency measures enough?

From emergency to IPv6

- Emergency measures gave time to develop and test IPv6
- IPv6 is already there ...
  - NRENs in EU, North America, Asia ... are interconnected in IPv6
  - Lots of IXP are offering IPv6 connectivity
  - ISPs and Telcos exchange IPv6 routes

- Then the question is not “if” but “when ?” and “how?”

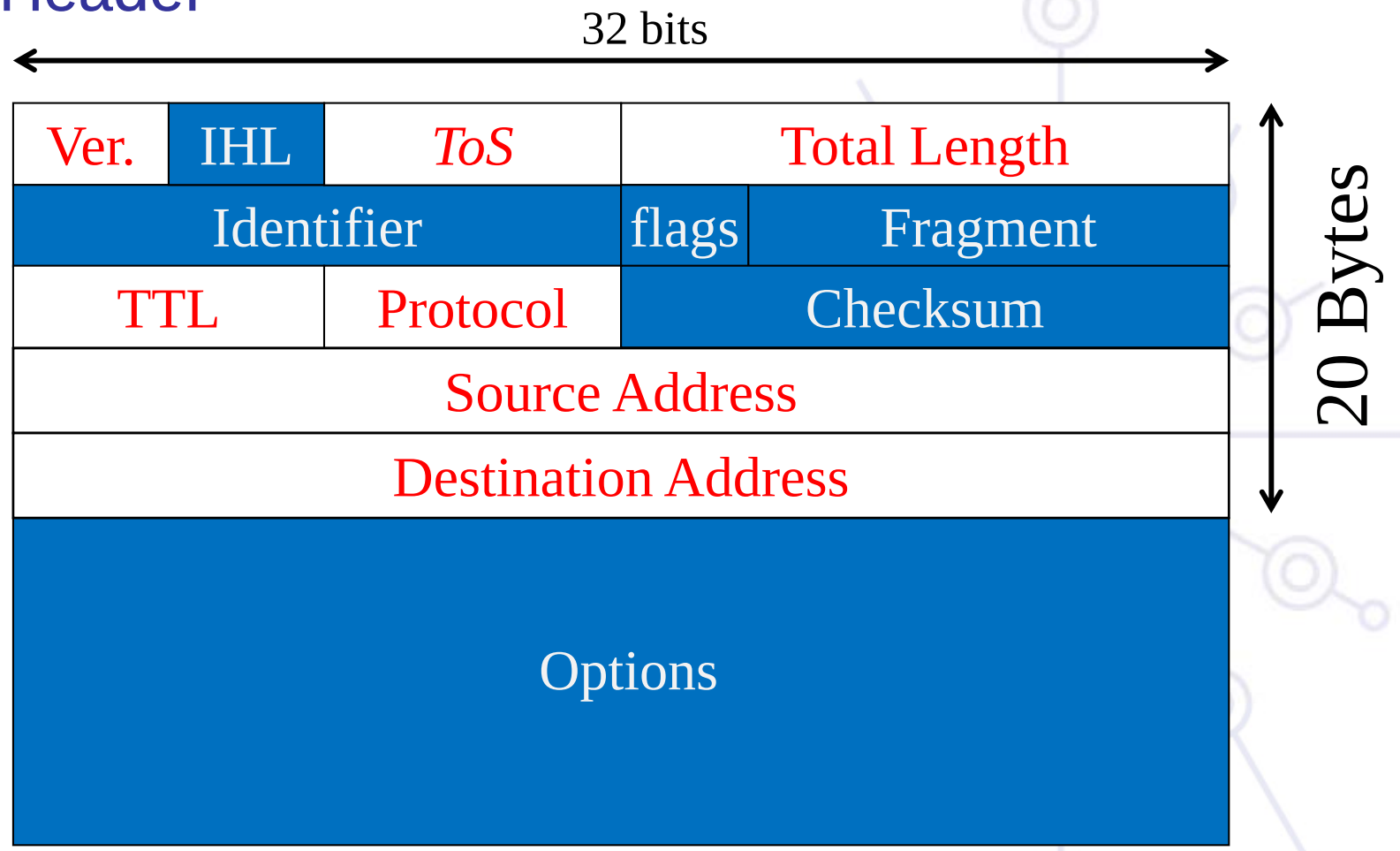
IPv6 Basics

IPv6 Header

- The IPv6 header is designed ...
  - ... to minimize header overhead
  - ... to reduce the header process for most of the packets
    - Less important information and option fields are moved to *extension headers*

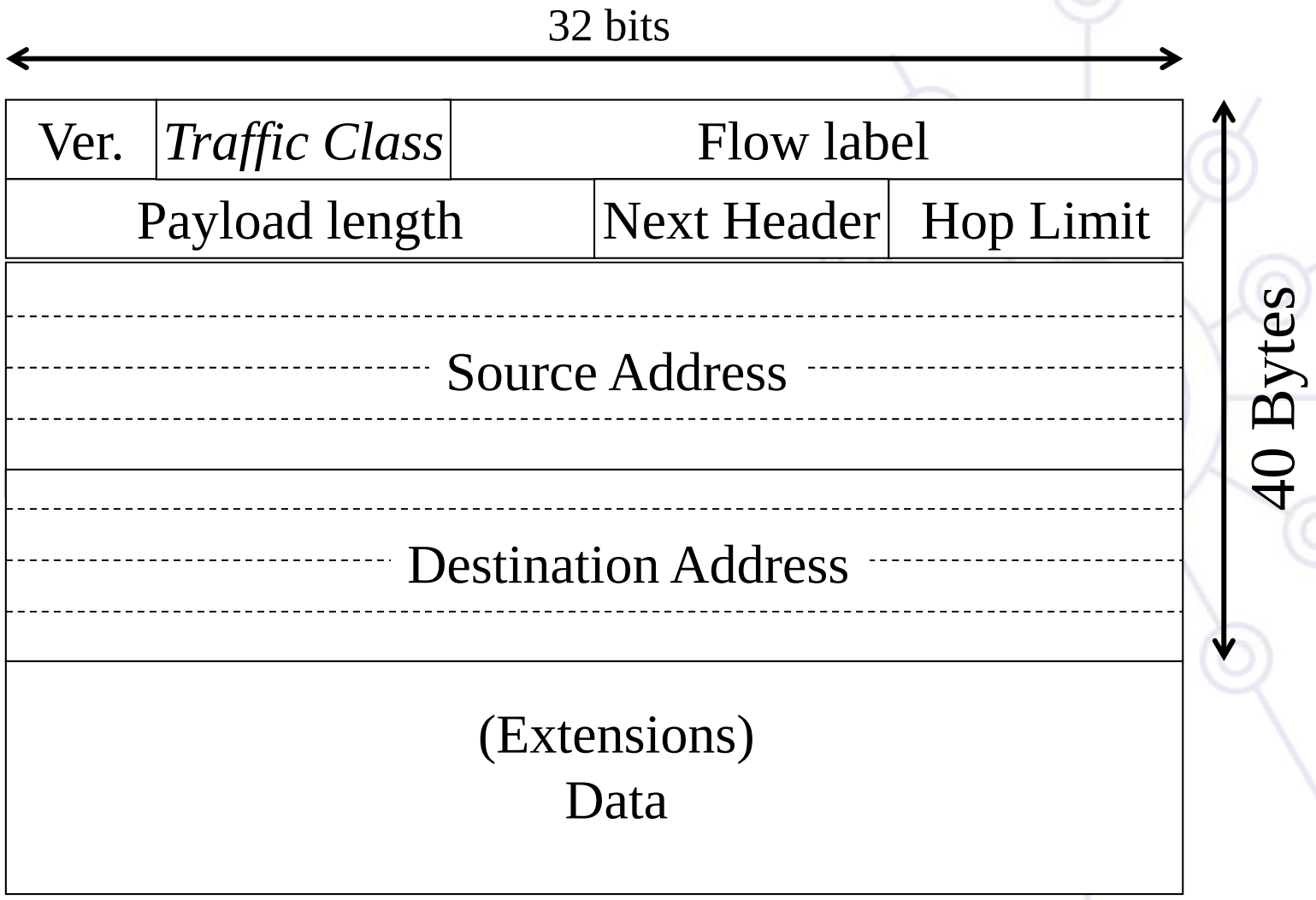
IPv6 & IPv4 headers are not interoperable

IPv4 Header



Fields in blue are removed!

IPv6 Header Simplification



IPv6 Header Fields

- Version
  - 4 bits
- Traffic class
  - 8 bits
- Flow label
  - 20 bits
- Payload length
  - Use Jumbogram for specific cases (payload = 0), 16 bits
- Hop limit
  - 8 bits
- Next header
  - 8 bits

CoS support in IPv6

- The *Traffic Class* field: *Used as in IPv4!*
  - Work done in DiffServ WG (closed): RFCs **2474**, 2475, 2597, 3260, ...

(CU is currently unused - reserved)

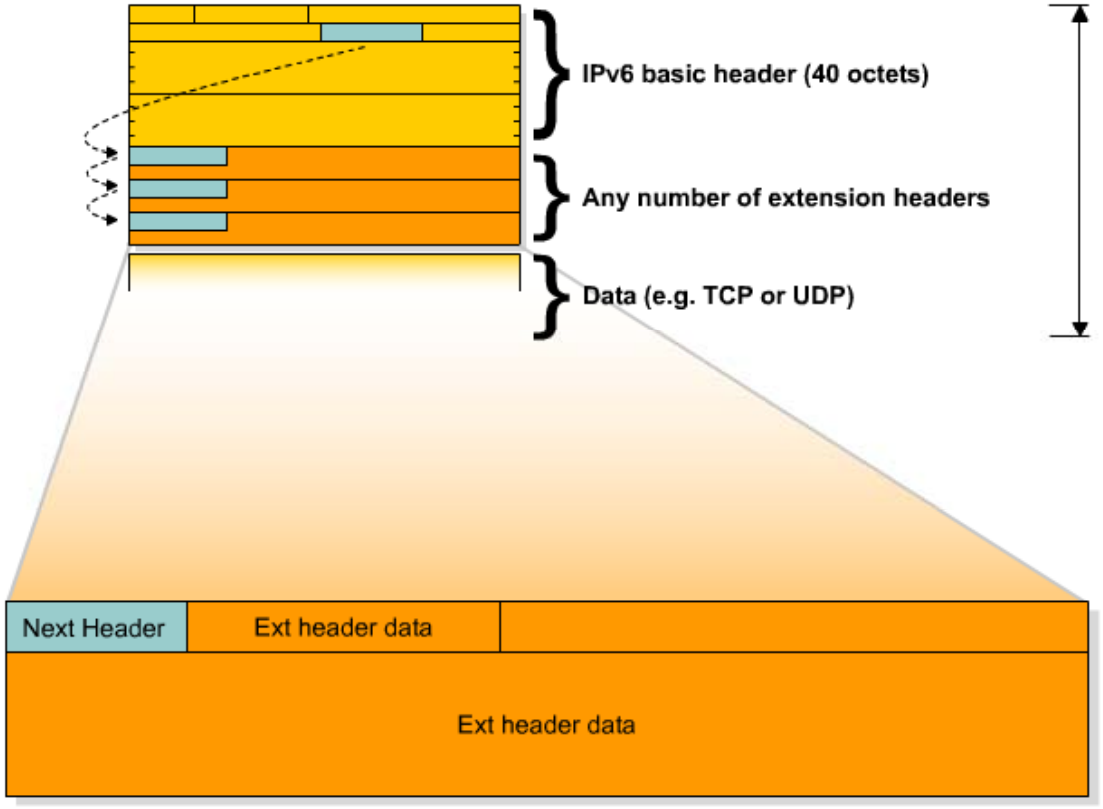
- The Flow Label field: Enable classification of packets belonging to a specific flow
  - A flow is a sequence of packets that should receive specific non-default handling from the network
  - Intuitively: 5-tuple of the same source/destination address/port and transport protocol values
  - Without the flow label the classifier must use transport next header value and port numbers
    - Less efficient (need to parse the option headers), may be impossible (fragmentation or IPsec ESP)
  - RFC 3697 (PS)

IPv6 Basics

IPv6: Optional Extensions

- New “mechanism” replacing IPv4 options
- An IPv6 extension
  - Has its own message format
  - Is a *n x 8-byte* datagram
  - Starts with a 1-byte ‘Next Header’ field
- Examples
  - Hop-by-hop (jumbogram, router alert)
    - Always the first extension, analyzed by every router
  - Destination
  - Routing (*loose source routing*)
  - Fragmentation
  - Security (Authentication (AH), Encapsulating Security Payload (ESP))

Extension Headers (RFC2460)



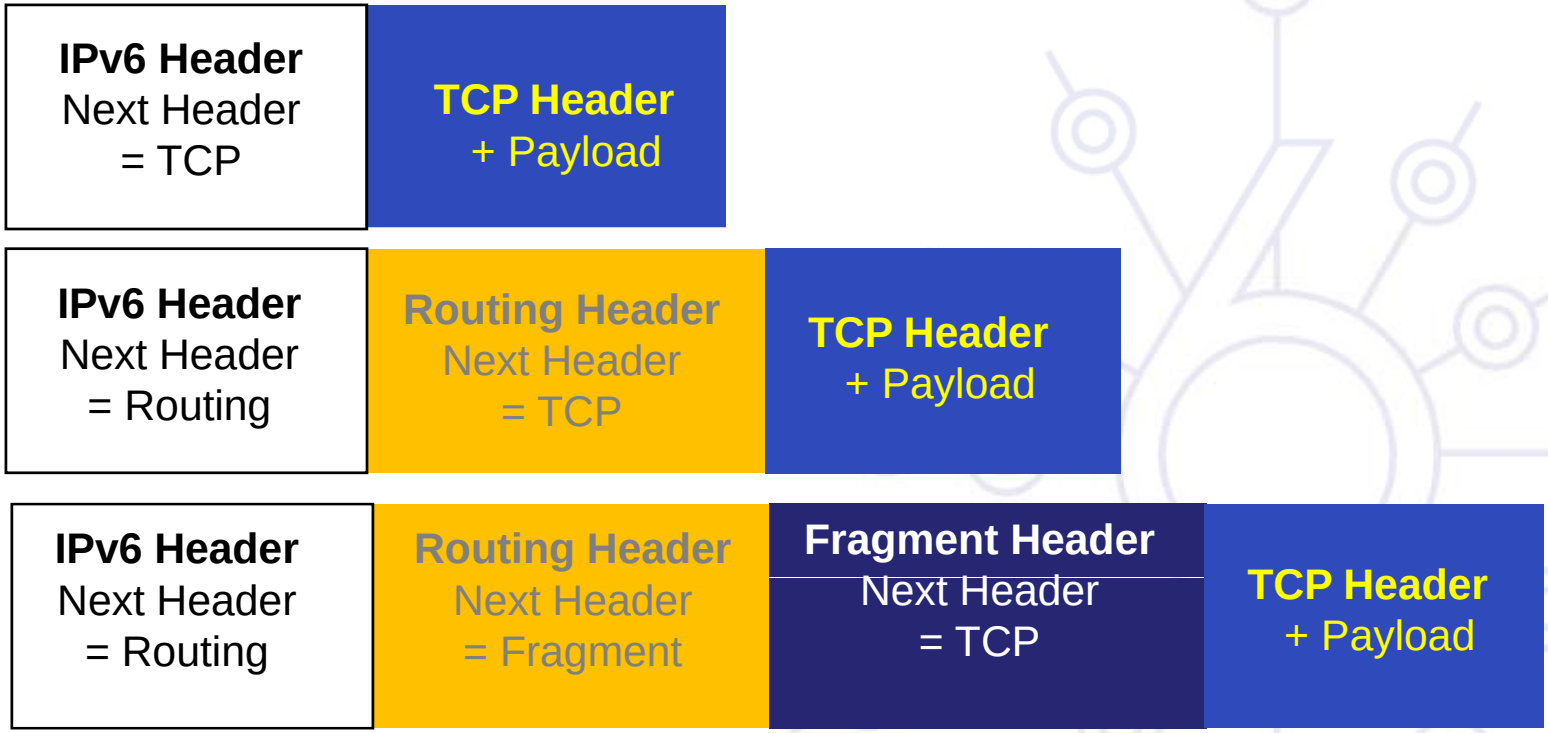
Processed only by node identified in IPv6 Destination address field

- much lower overhead than IPv4 options
- Exception: Hop-by-Hop Options header

Eliminated IPv4's 40-octet limit on options

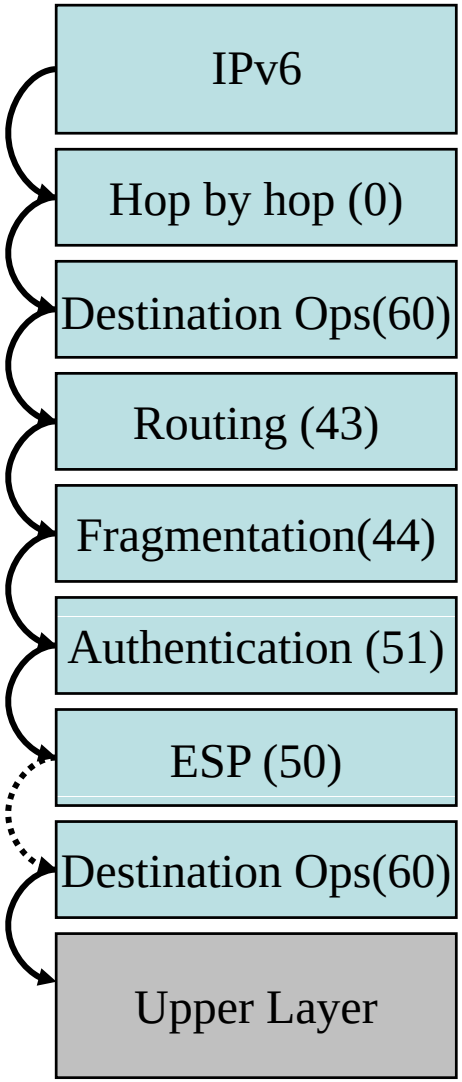
In IPv6, limit is total packet size, or Path MTU in some cases

IPv6: Optional headers



Extension headers are daisy chained

IPv6 extension headers: Order is important !

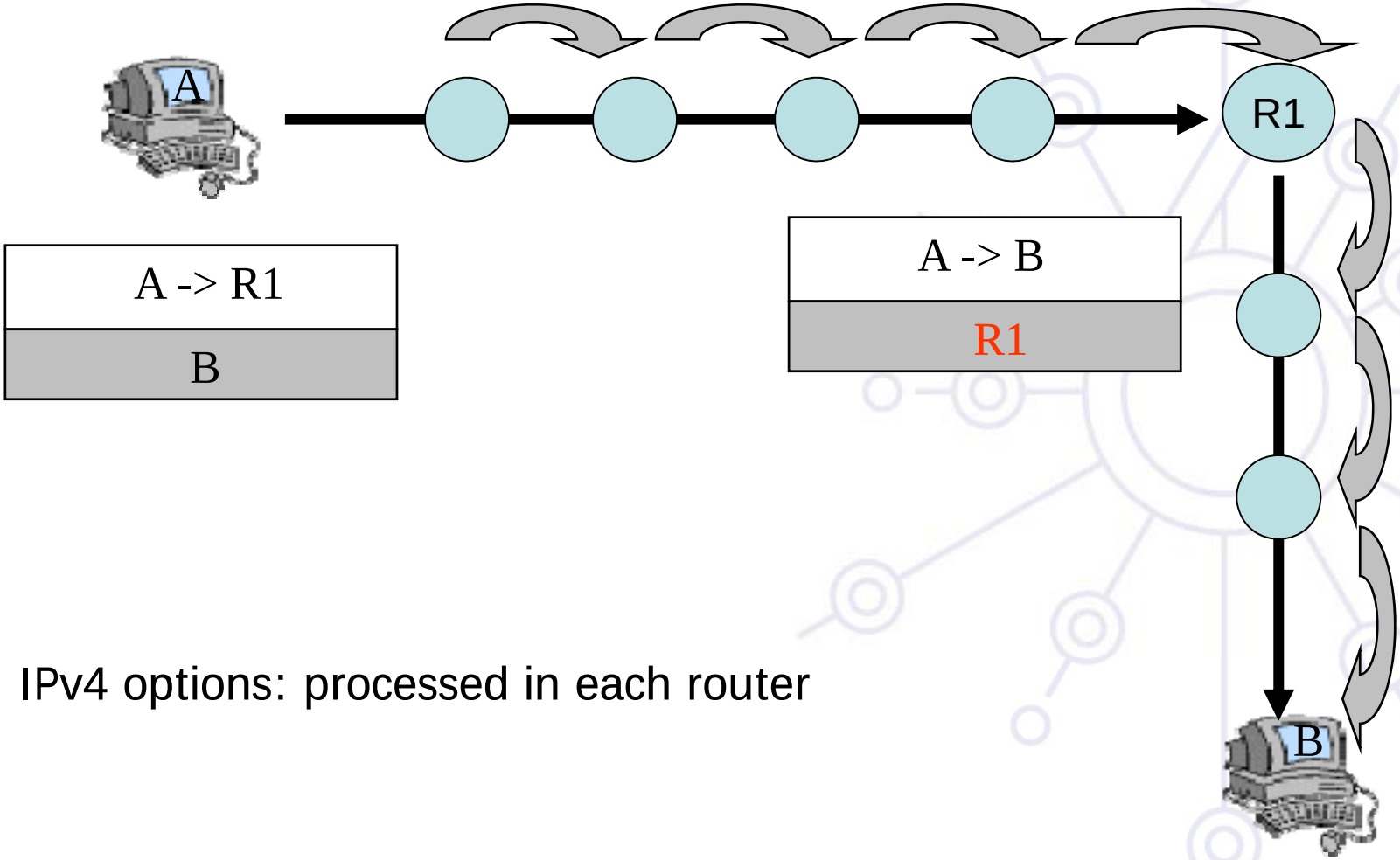


- Hop by hop (0): Processed by every router
- Destination Ops(60): Processed by routers listed in Routing extension
- Routing (43): List of routers to pass through
- Fragmentation(44): Processed by the destination
- Authentication (51): After reassembling the packet
- ESP (50): Cipher the content of the remaining information
- Destination Ops(60): Processed **only** by the destination

Processing Extensions Headers

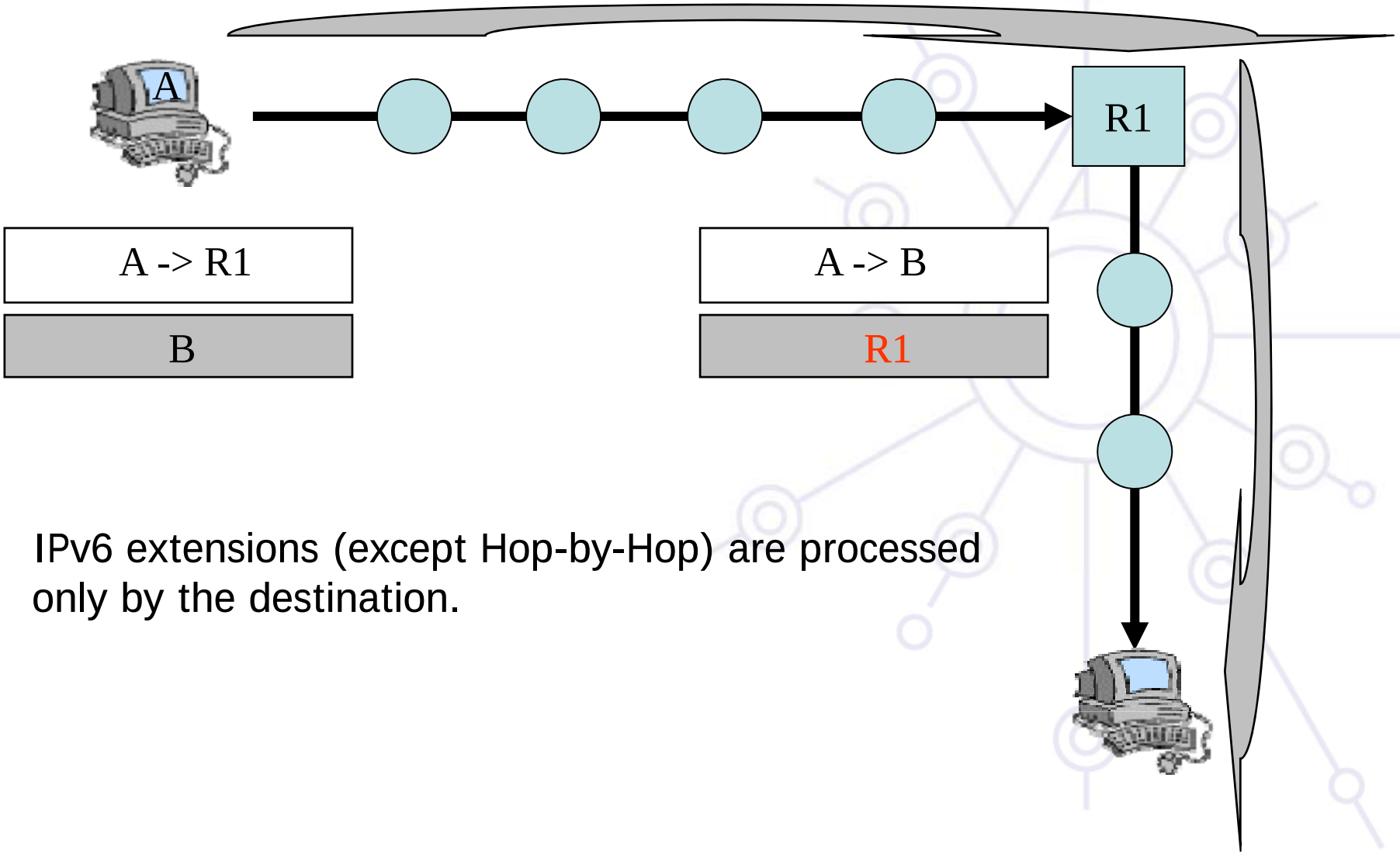
IPv6 Basics

IPv4 header options processing



IPv4 options: processed in each router

IPv6 Extension Header Processing



IPv6 extensions (except Hop-by-Hop) are processed only by the destination.

Conclusion

- Main changes in IPv6 protocol are within address format and datagram headers
- A lot of fields in the IPv6 header have disappeared
  - More efficient processing in the (intermediate) routers
- Optional extensions allow more functionalities (source routing, authentication, ...)
- Optional header mechanism allows new options introduction without modifying the protocol


deploy
Questions?