Introduction to IPv6 (Part A)

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IPv6 Deployment and Support

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Why a new versions of IPv6?

IPv6 Deployment and Support

- Historical Facts
- IPv4 Address Space Status
- From Emergency measures … to IPv6

Historical facts

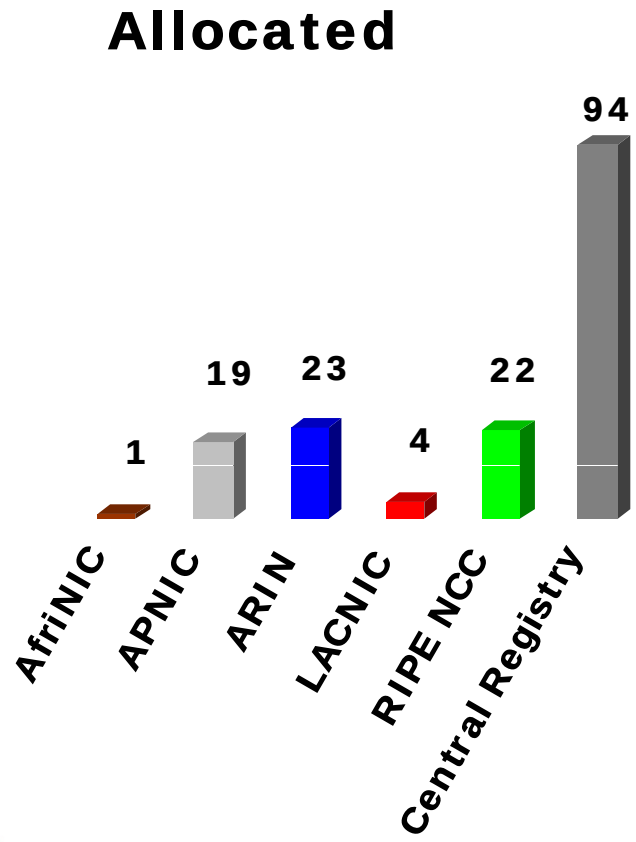
IPv6 Deployment and Support

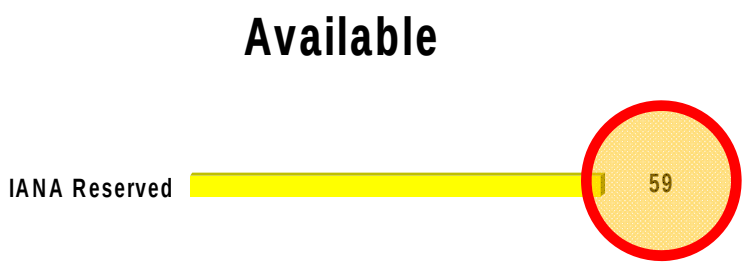
- 1983 : Research network for ~ 100 computers
- 1992 : Commercial activity
  - Exponential growth
- 1993 : Exhaustion of the class B address space
- Forecast of network collapse for 1994!

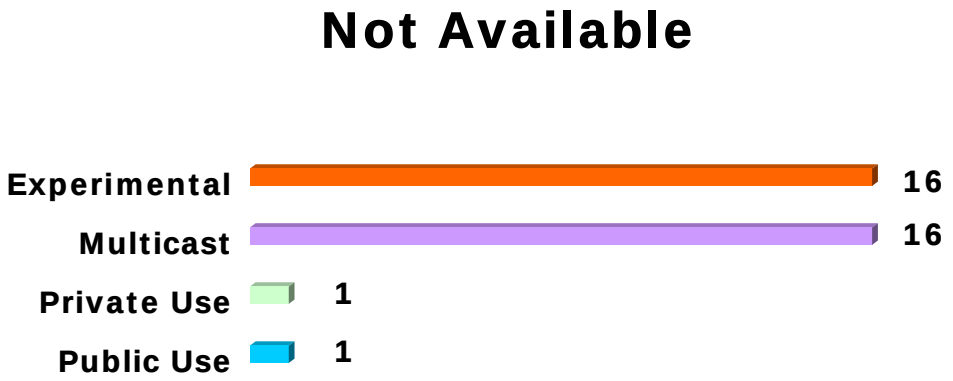
IPv4 Address Space Status

(Sep. 06)

IPv6 Deployment and Support





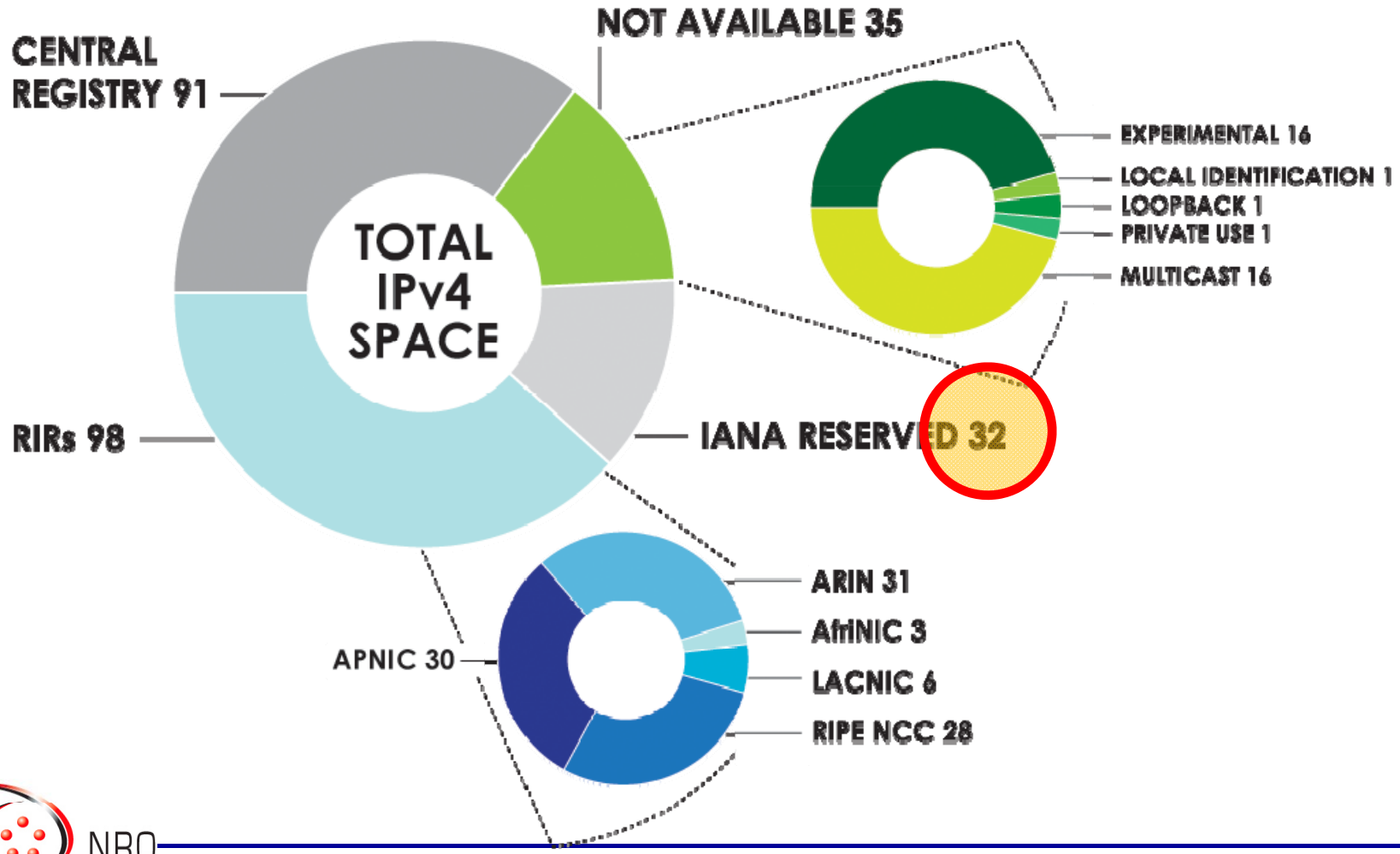


NRO

IPv4 Address Space Status

(Mar. 09)

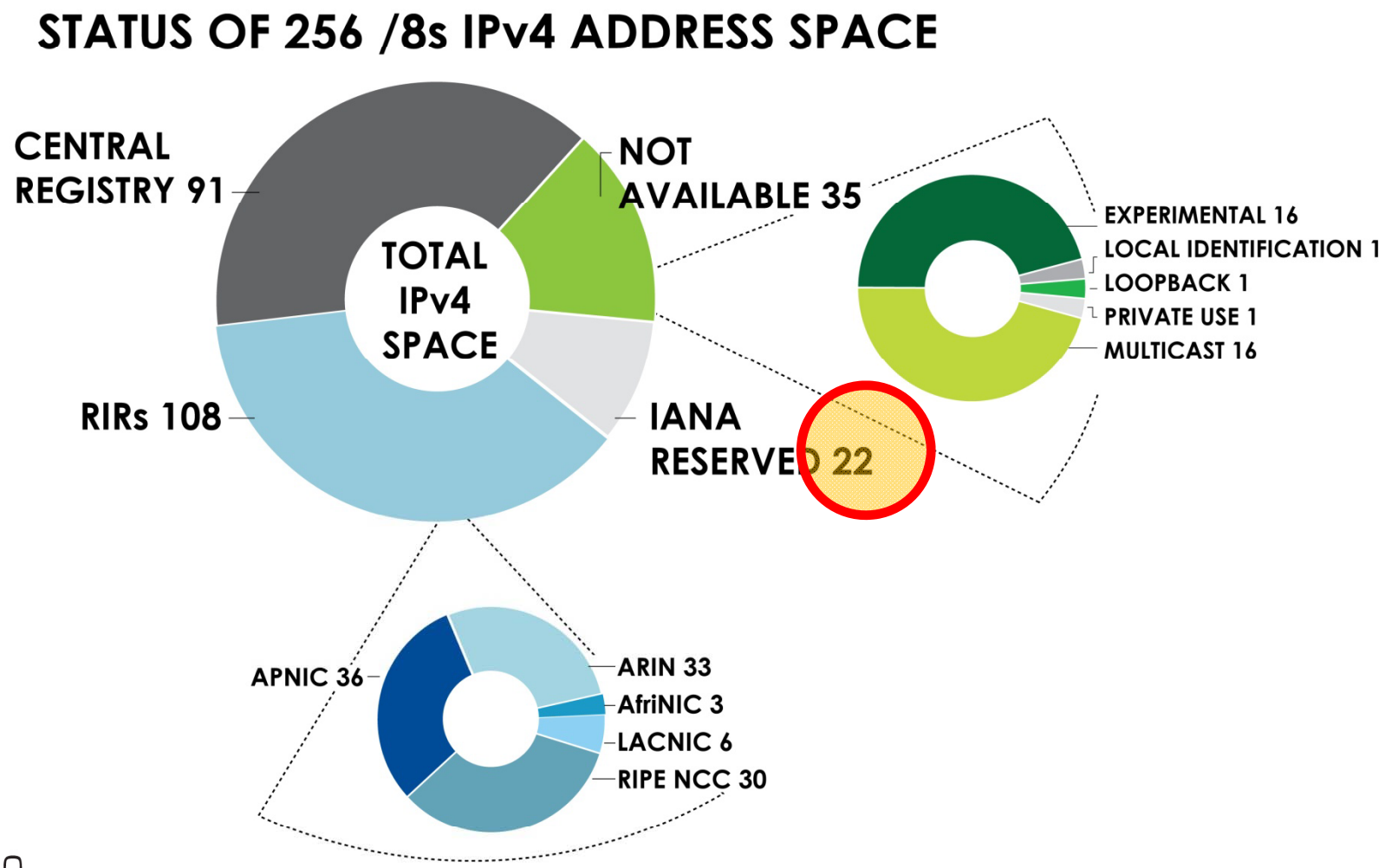
IPv6 Deployment and Support



NRO

IPv4 Address Space Status

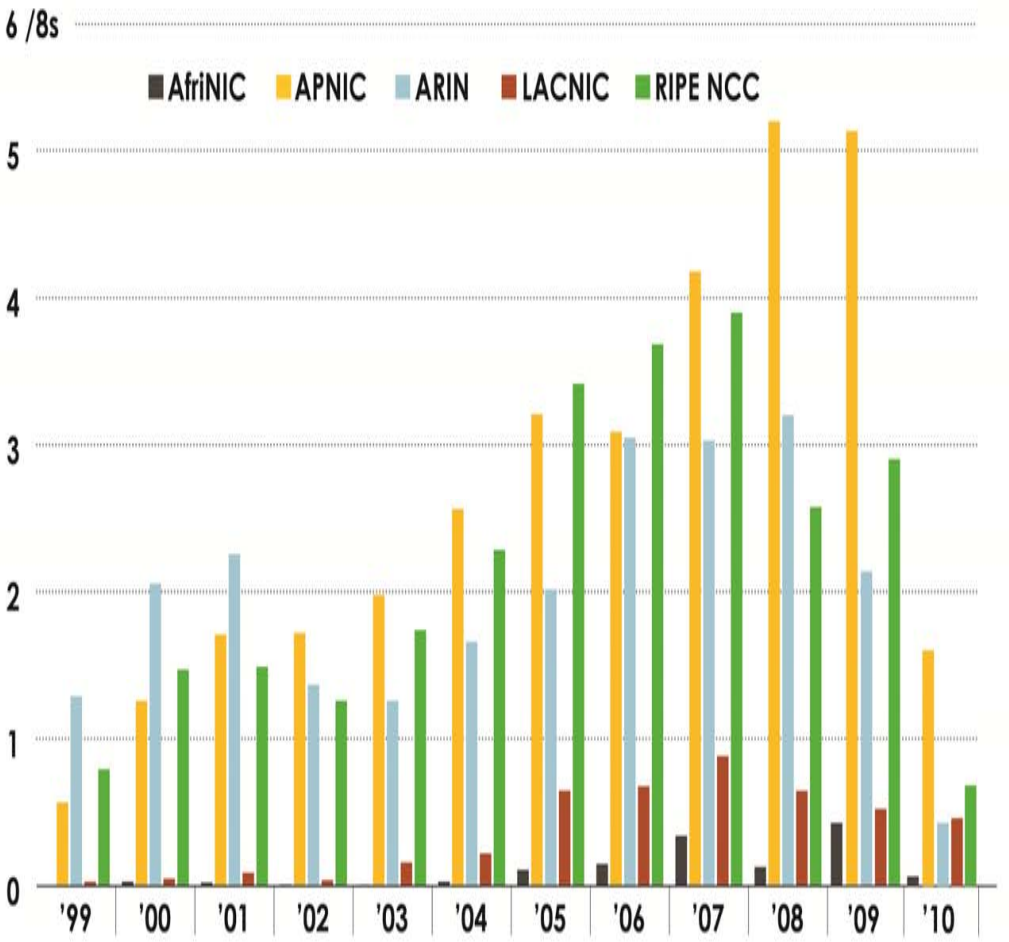
(Mar. 10)



IPv4 Prefixes Consumption Pace

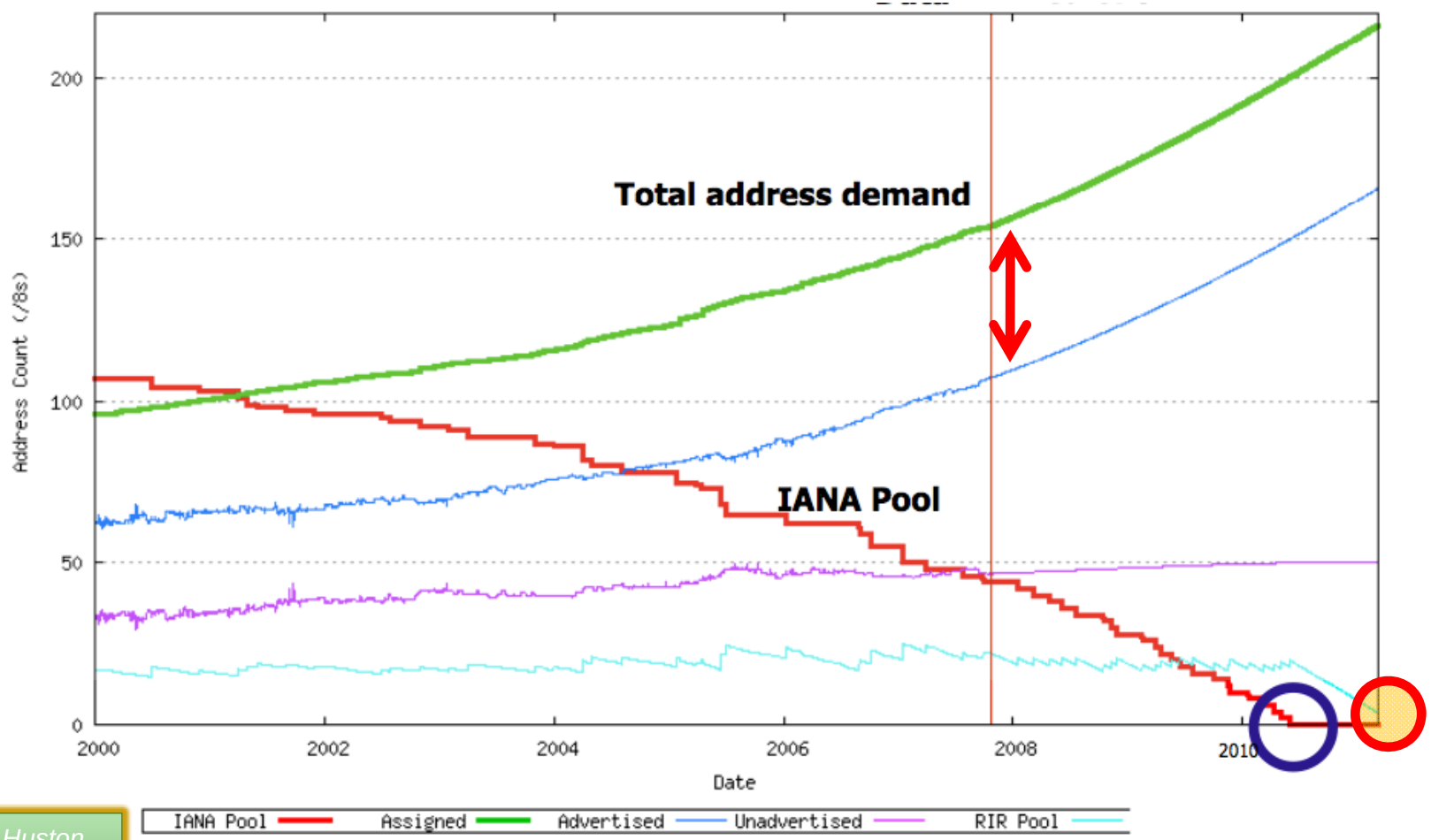
NRO

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

IPv6 Deployment and Support



Geoff Huston
APNIC
Sept. 2007

Emergency measures …

IPv6 Deployment and Support

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

- **… and some recently proposals**
  - Large Scale NAT (Carrier-grade NAT)
  - Dual Stack Lite (DS-Lite)
  - IPv4 Address Trading
  - IPv4 Renumbering

Classless Internet Domain Routing

IPv6 Deployment and Support

- **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)

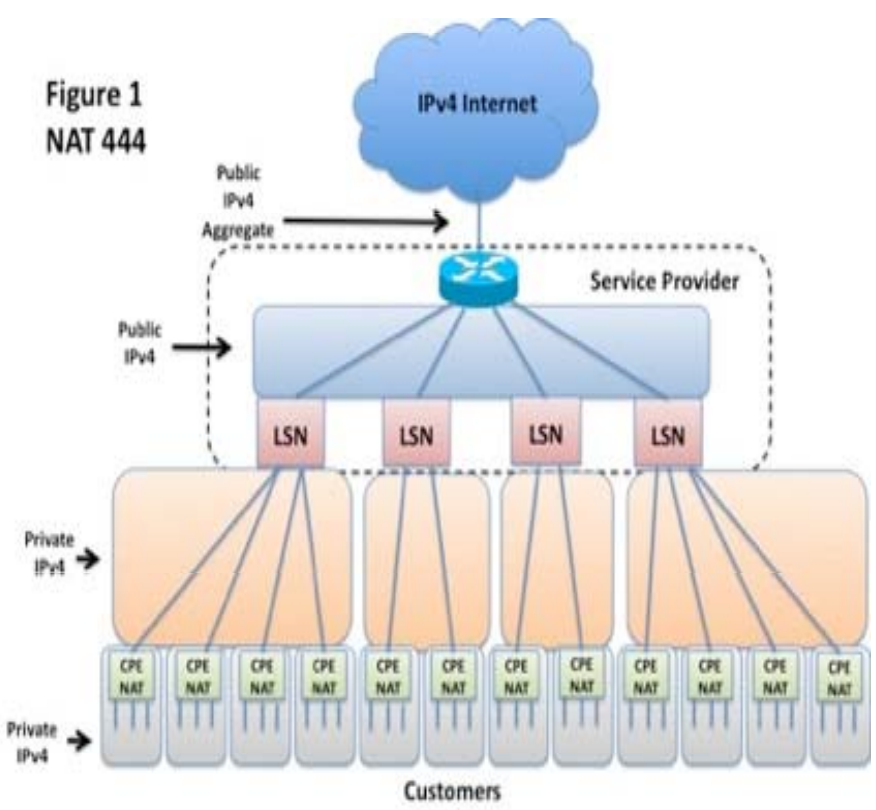
IPv6 Deployment and Support

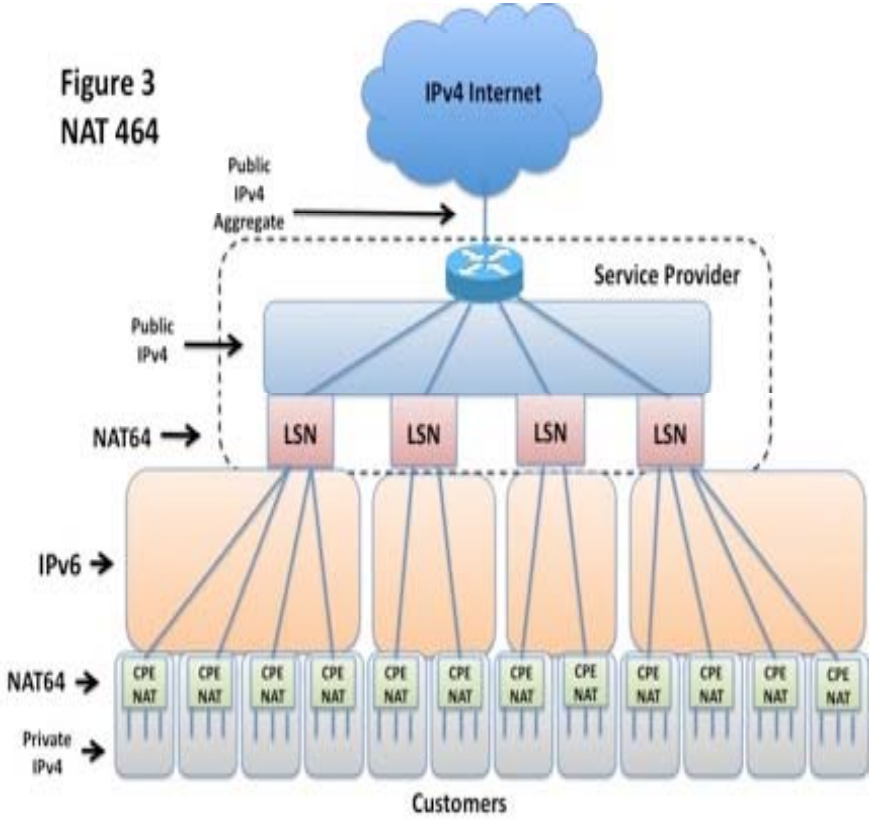
- **Advantages:**
  - Reduce the need of official addresses
  - Ease the internal addressing plan
  - Transparent to some applications
  - “Security” vs. obscurity
  - Netadmins/sysadmin
- **Disadvantages:**
  - Translation sometime complex (e.g. FTP)
  - Apps using dynamic ports
  - Does not scale
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

=> Should be reserved for small sites in Client/Server mode

Large Scale NAT

IPv6 Deployment and Support





Source: *NetworkWorld*

Dual Stack Lite (DS-Lite)

IPv6 Deployment and Support

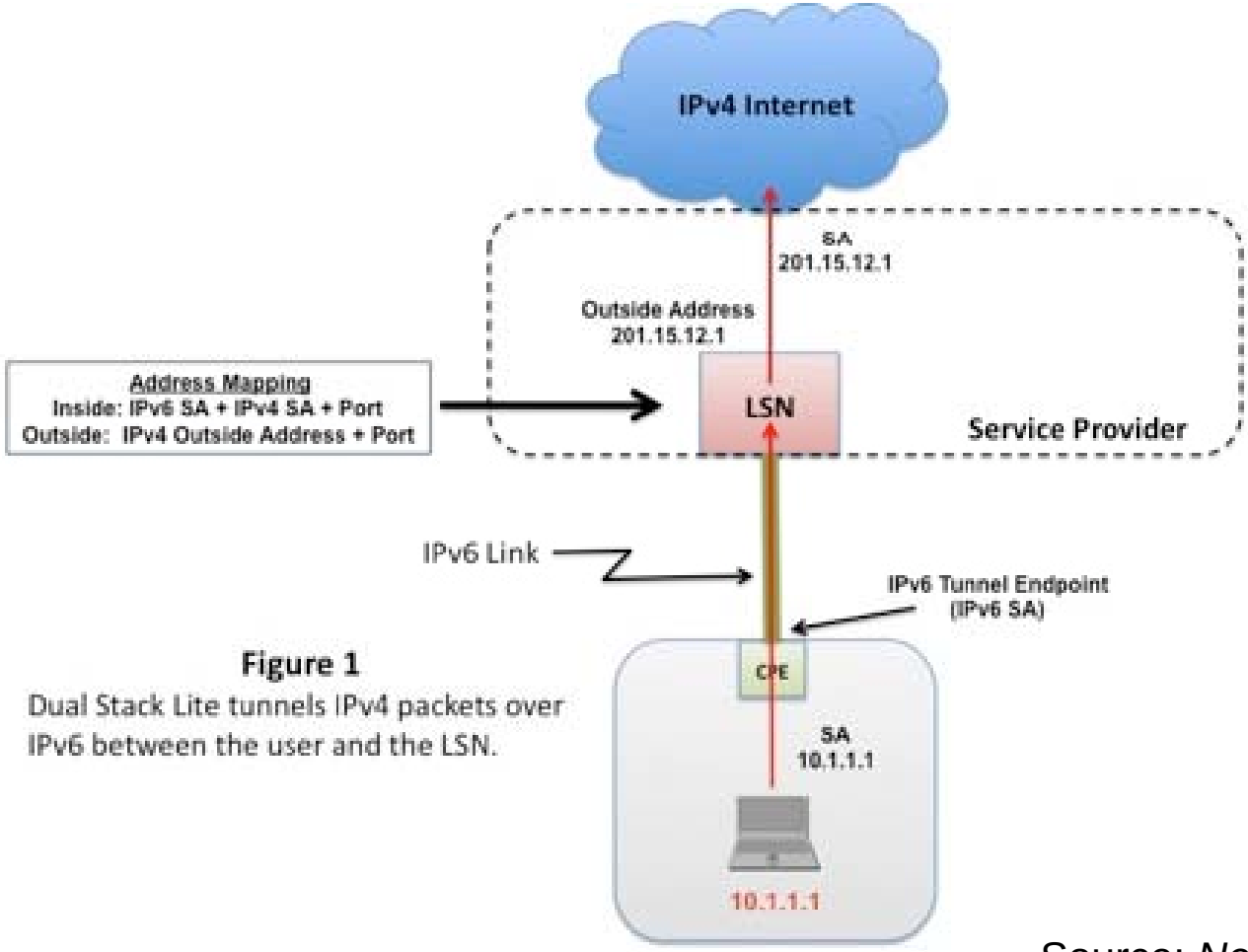


Figure 1

Dual Stack Lite tunnels IPv4 packets over IPv6 between the user and the LSN.

Source: *NetworkWorld*

Emergency Measures

IPv6 Deployment and Support

- **These emergency measures gave time to develop a <u>new</u> <u>version</u> of IP, named 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

IPv6 Deployment and Support

- **IPv6 is already there …**
  - Internet v6 is there today :
  - 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?”**
- Resources exhaustion are projected as
  - IANA pool : Sept. 2011
  - RIRs pool : April 2012
  - **(**Source: **http://www.potaroo.net/tools/ipv4/index.html)**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IPv6 Basics

Agenda

IPv6 Deployment and Support

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

IPv6 Header

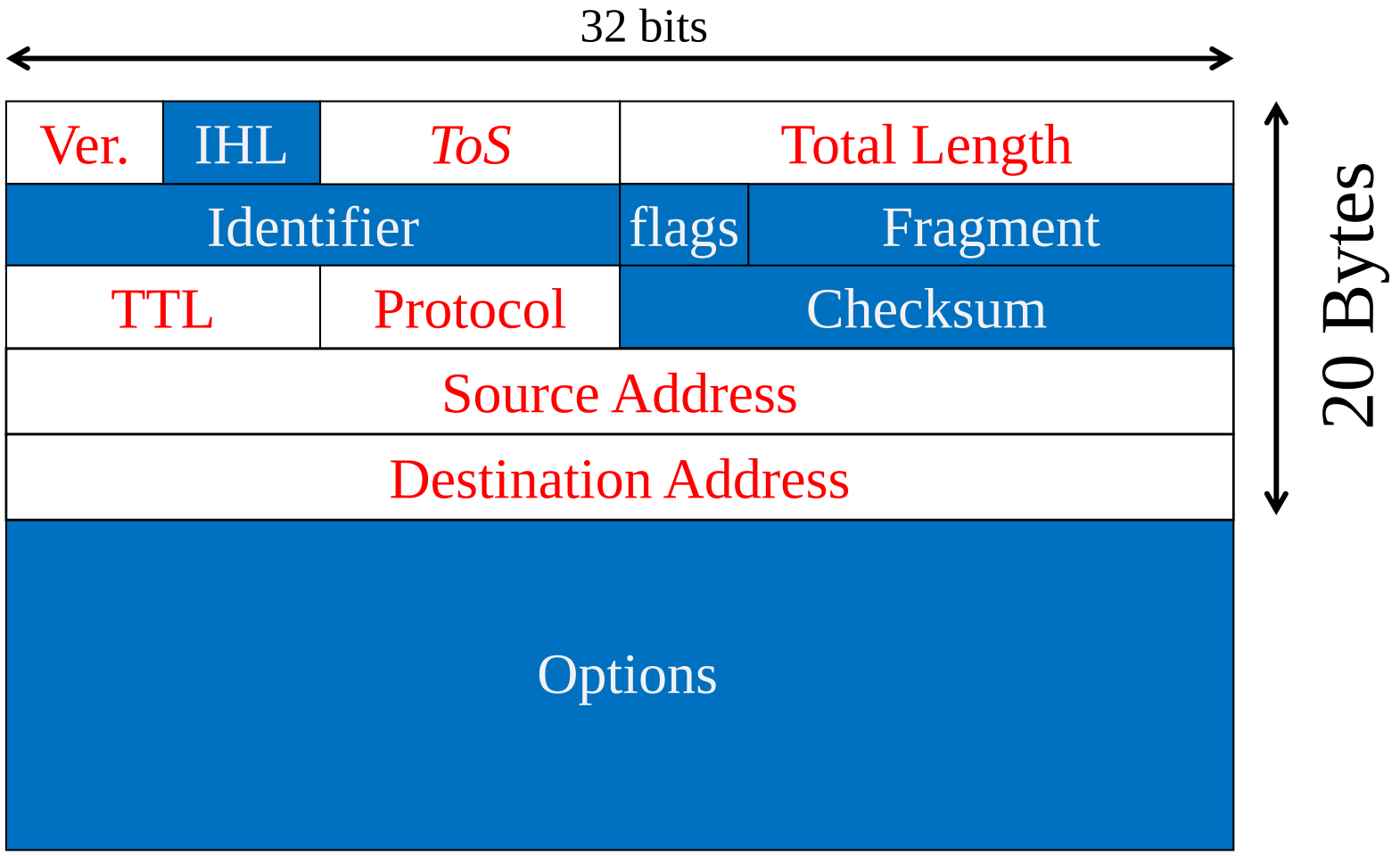
IPv6 Deployment and Support

- **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

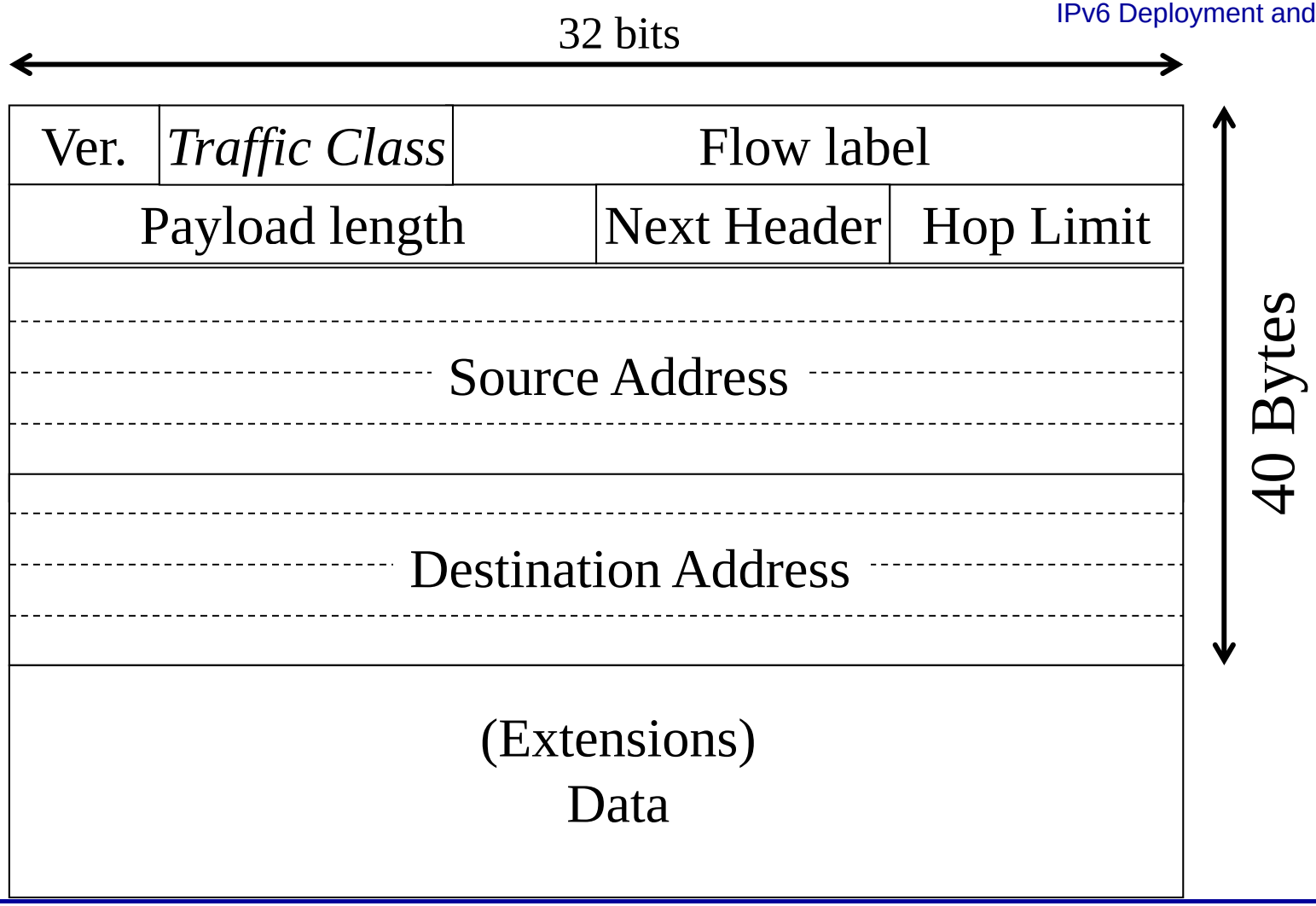
IPv4 Header

IPv6 Deployment and Support



IPv6 Header Simplification

IPv6 Deployment and Support



IPv6 Header Fields

IPv6 Deployment and Support

- **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

IPv6 Deployment and Support

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

(CU is currently unused - reserved)

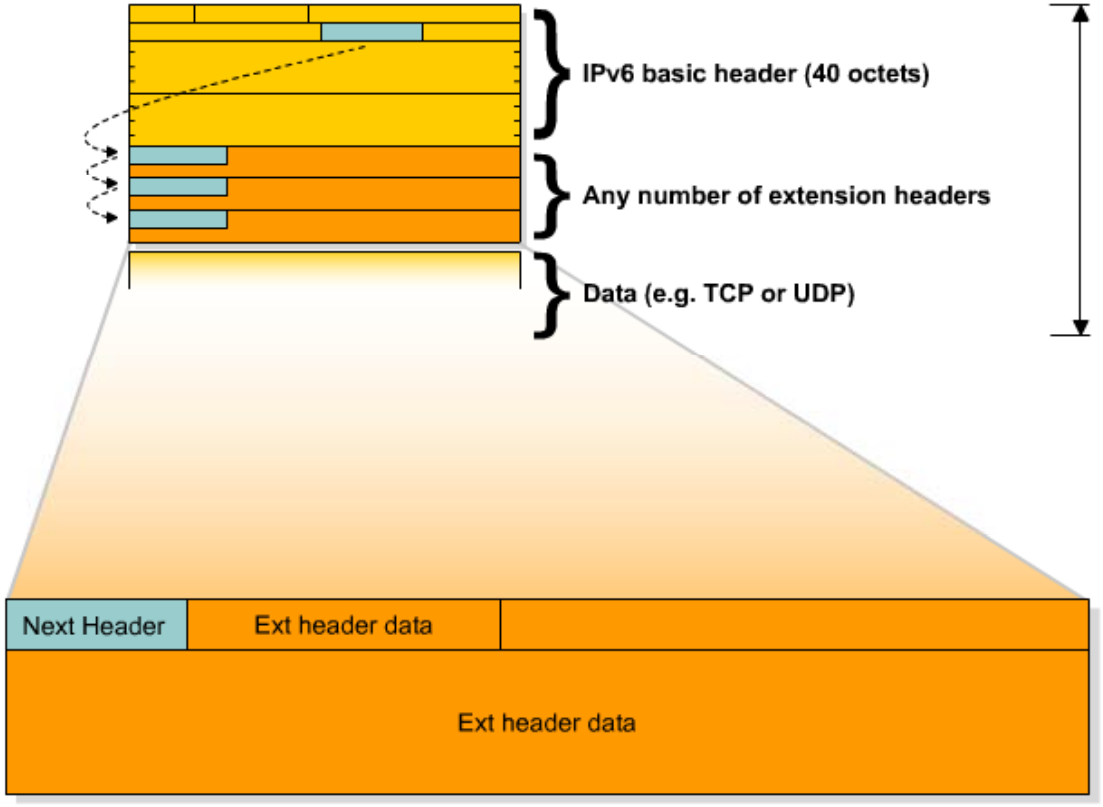
- **The Flow Label field:** Enable classification of packets belonging to a specific flow
  - **A flow is a sequence of packets that should receive specific non-default handling from the network**
  - **Intuitively: 5-tuple of the same source/destination address/port and transport protocol values**
  - **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: Optional Extensions

IPv6 Deployment and Support

- 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)

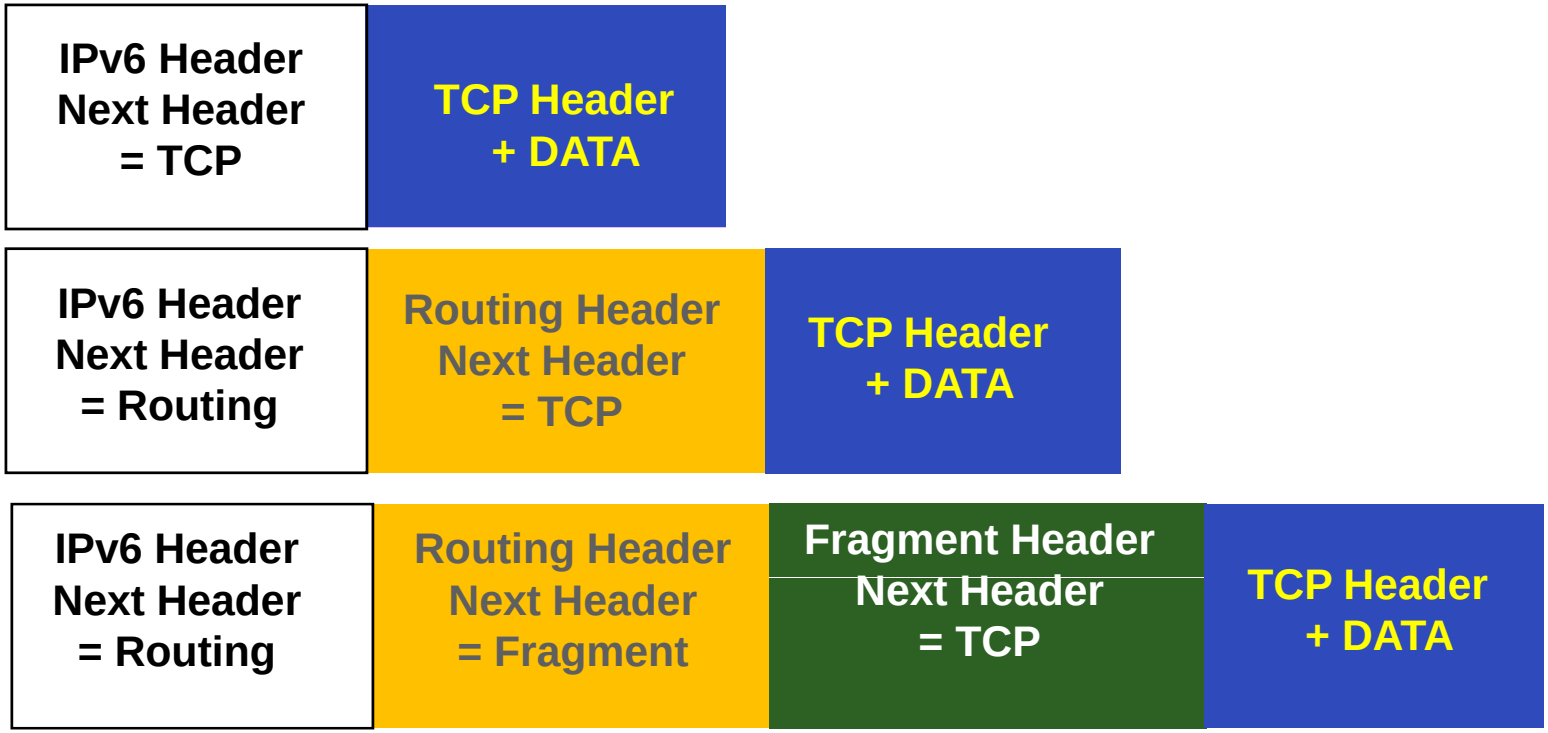
Extension Headers (RFC2460)



- **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

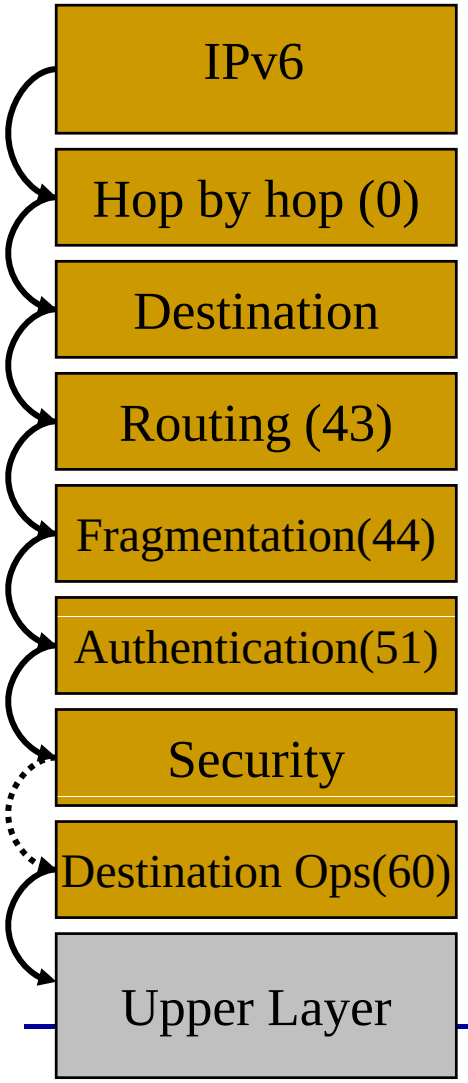
IPv6 Deployment and Support



Extension headers are daisy chained

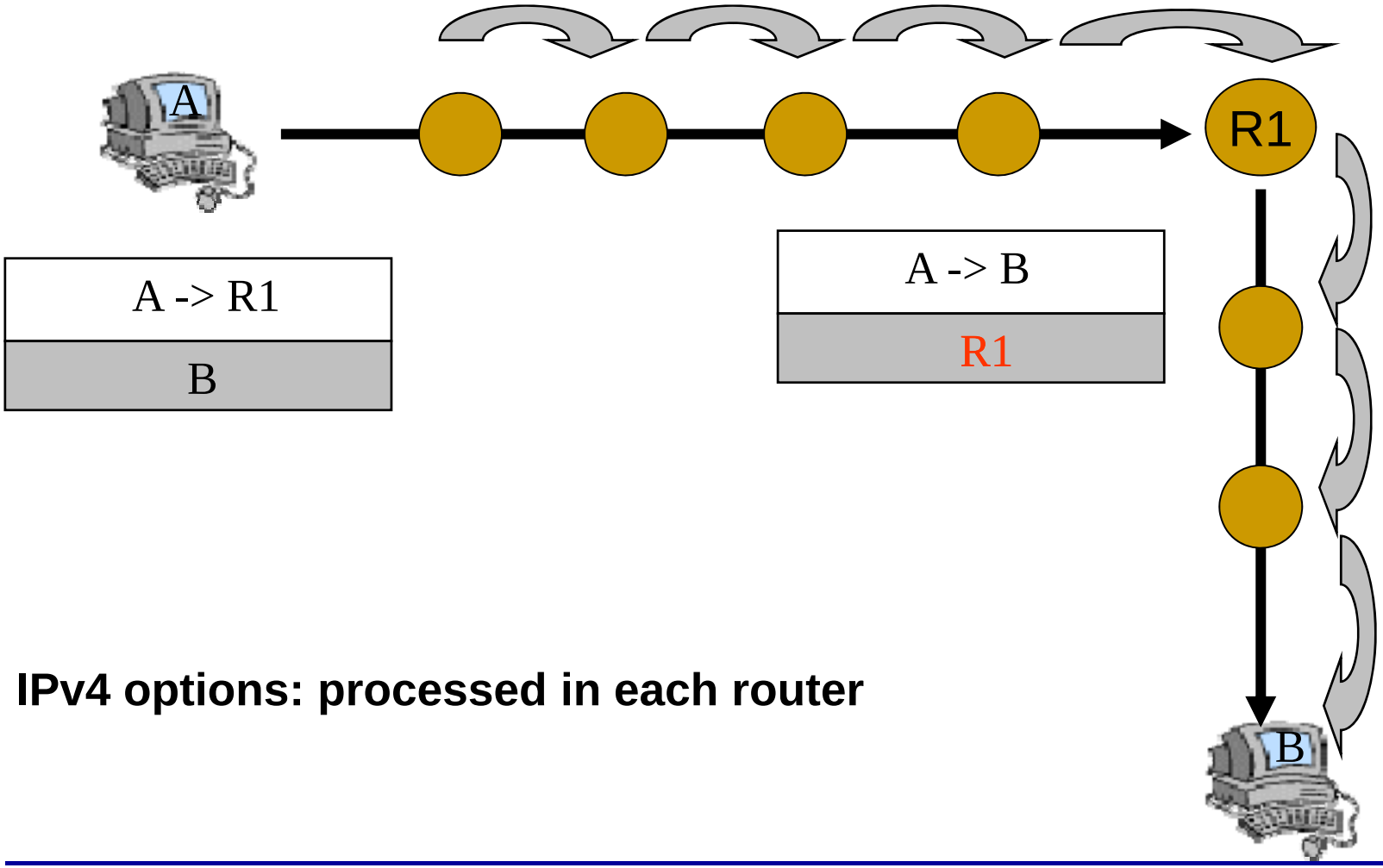
IPv6 extension headers:

Order is important !



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

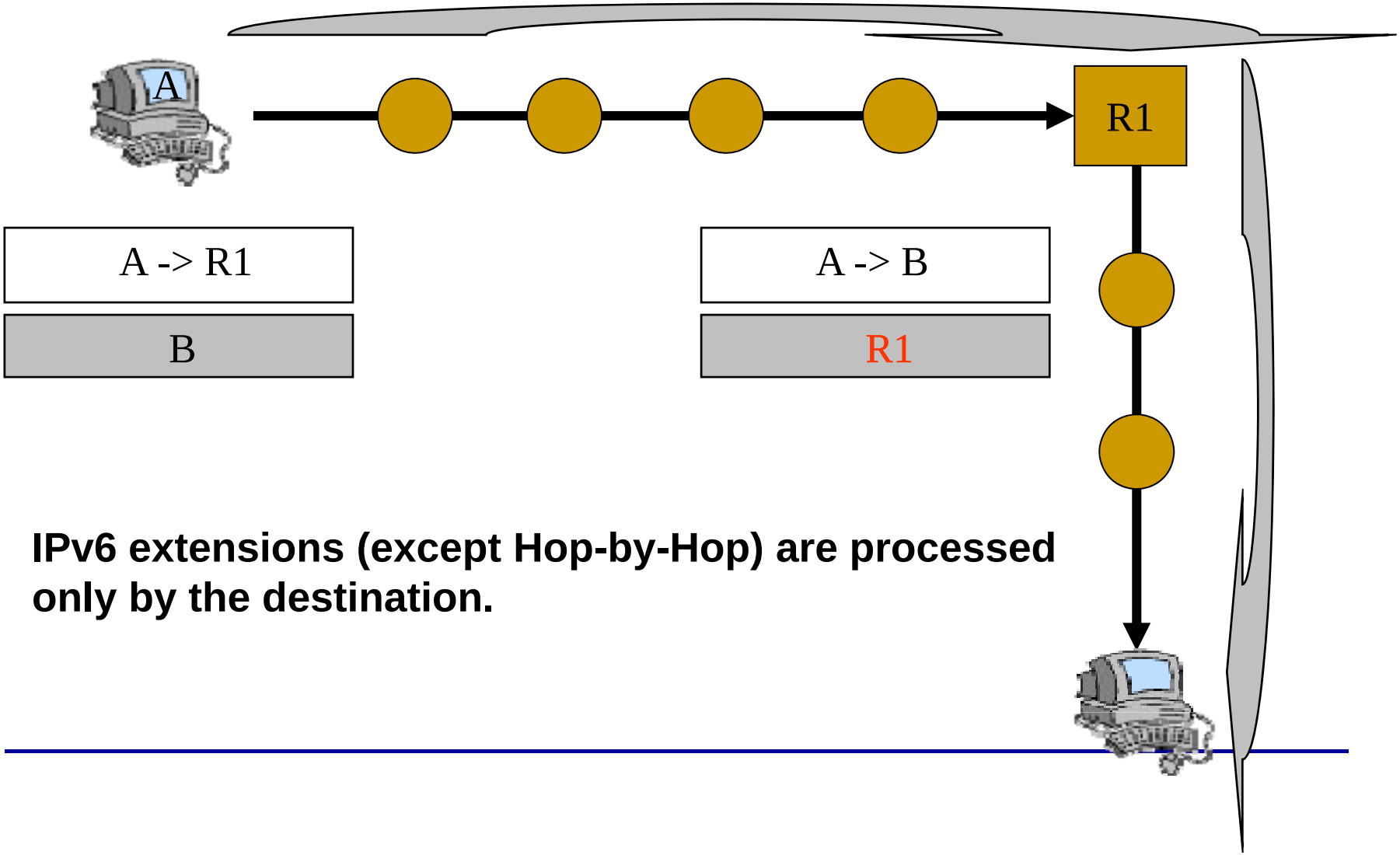
IPv4 header options processing



IPv4 options: processed in each router

IPv6 Extension Header Processing

IPv6 Deployment and Support



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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Questions?