
IPv6
the next generation

AGENDA

- Warum IPv6
- Vorteile von IPv6
- IPv6 Adressen

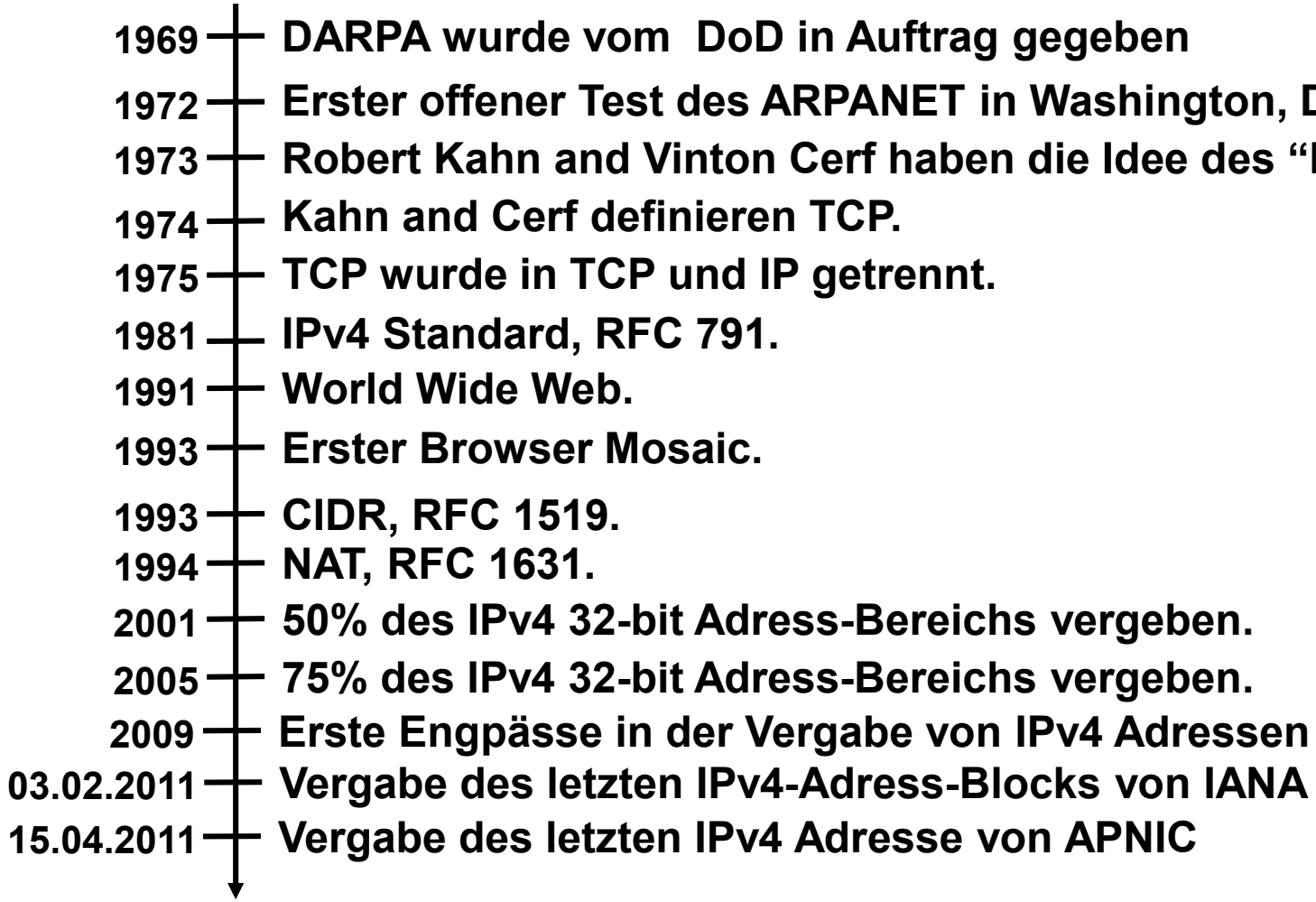
- IPv6 Security

- IPv6 Demo
  - Native IPv6
  - IPv6 Manual Tunnel
  - NAT-64

Warum IPv6

- Internet Teilnehmer
  - Knapp zwei Milliarden Internet Nutzer heute
  - PDAs, Tablet-PCs, Smartphones, etc.
- Immer mehr „Dinge“ brauchen Adressen
  - Autos (Service, Navigation, Internet Radio, etc.)
  - Energieversorger, Spielen im Internet
- Vergabe der letzten IPv4 Adressen ca. Anfang 2012
  - Vergabe letzter Adressblock IANA: 03. Februar 2011
  - Vergabe letzte IP Adresse von APNIC: 15.04.2011
- Direkte Adressierung ohne NAT
  - z.B. VoIP: direkte Kommunikation Phone - Phone

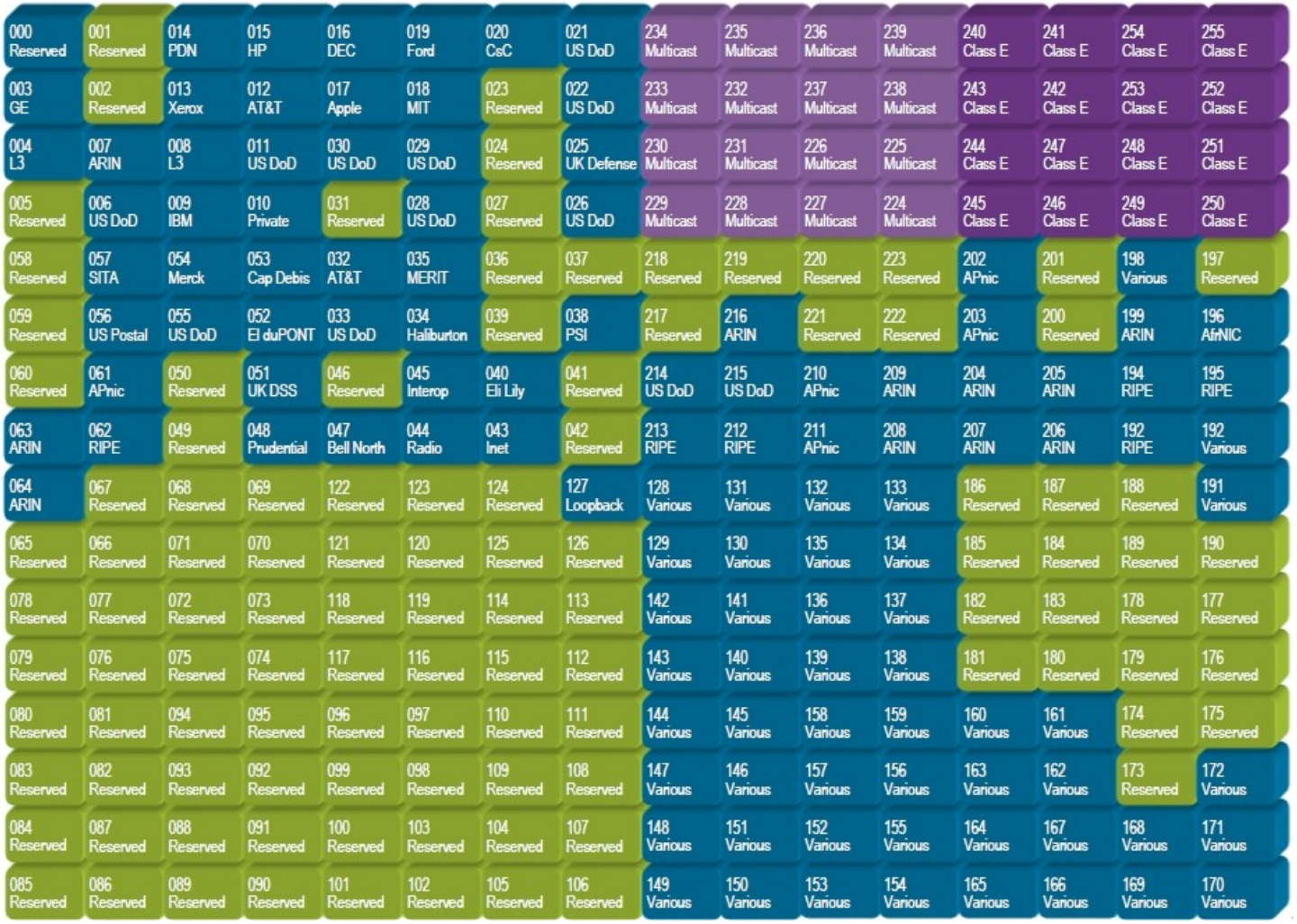
Überblick IPv4



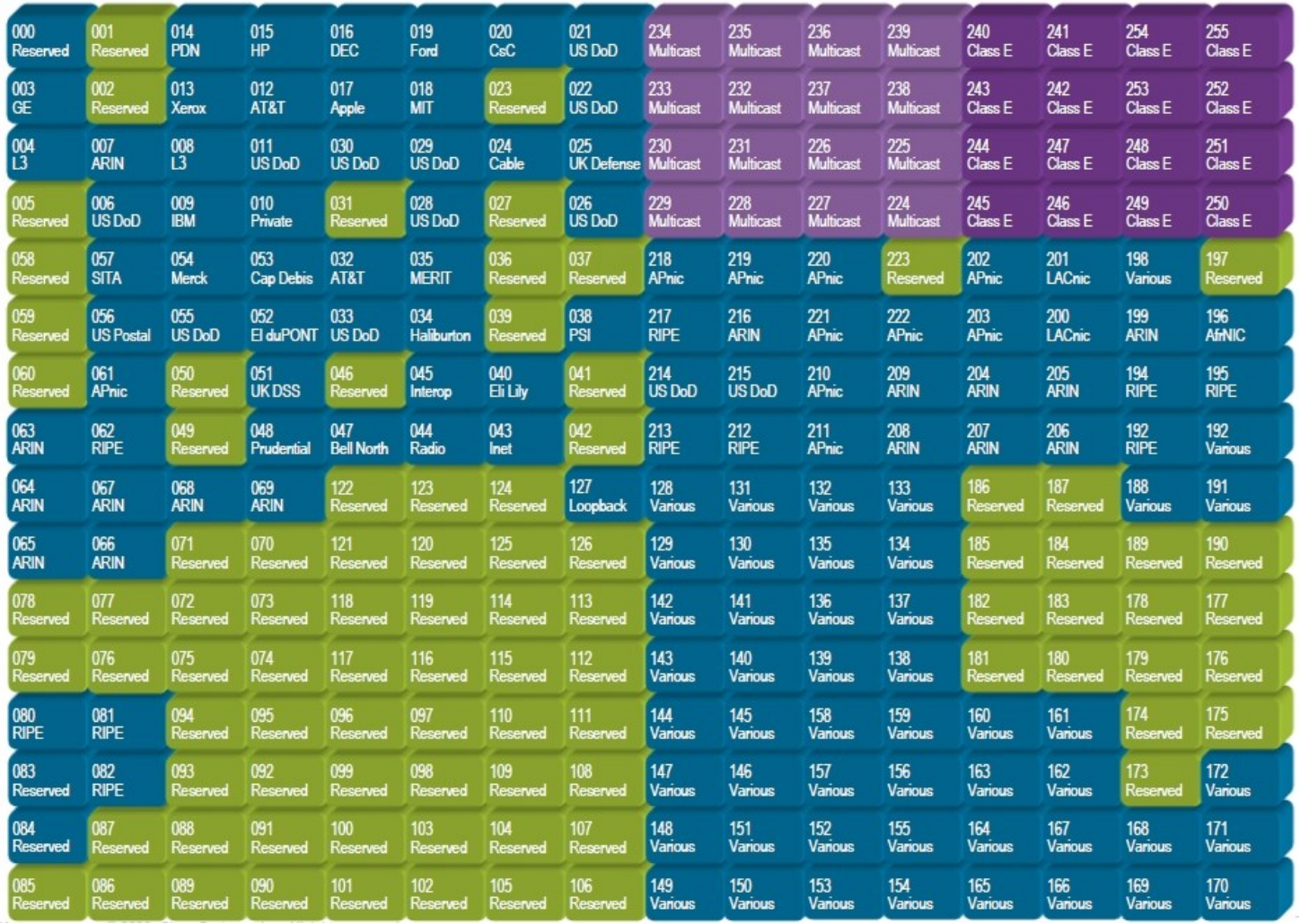
Überblick IPv6

- 1990 — Vorhersage das IPv4 Class B 1994 vergeben sein wird.
- 1991 — Gründung der Routing and Addressing (ROAD) group.
- 1992 — Vorhersage das IPv4 Adressen 2005–2011 vergeben sein werden.
- 1993 — IPng Idee (RFC 1550).
- 1994 — NAT RFC definiert (RFC 1631—heute obsolete).
- 1995 — Erster Standard: RFC 1883.
- 1996 — Start des 6bone.
- 1997 — Erster Versuch für ein Provider-basierendes Adress Format.
- 1998 — Erster IPv6 exchange: 6tap.
- 1999 — Registries vergeben IPv6 prefixes. IPv6 Forum gegründet.
- 2001 — Erste Hersteller implementieren IPv6 in deren Produkte
- 2006 — 6Bone wird beendet
- 2007 — IETF Working Group wird geschlossen

IPv4 Verteilung Januar 2000



IPv4 Verteilung Januar 2004



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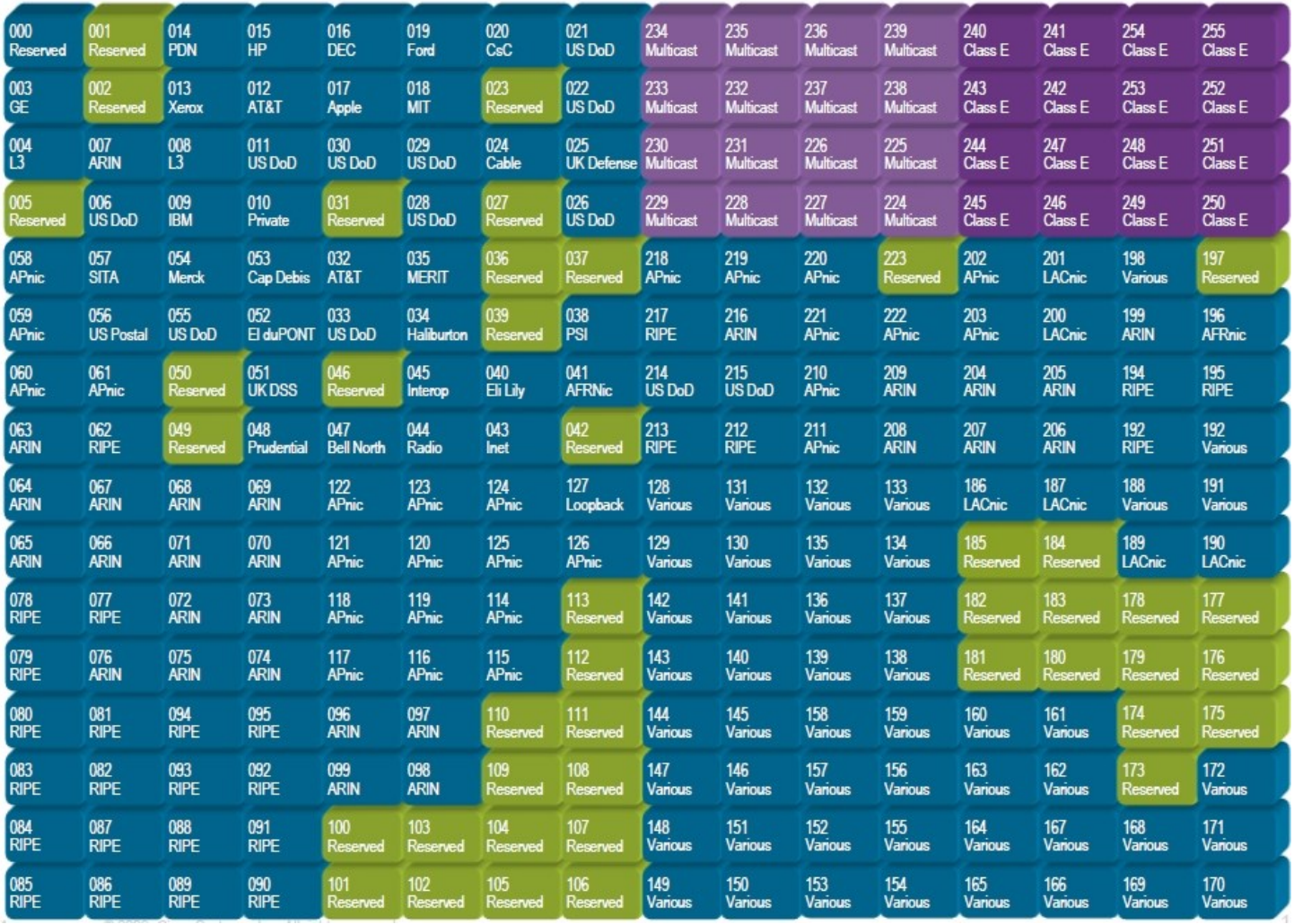
IPv4 Verteilung Januar 2008



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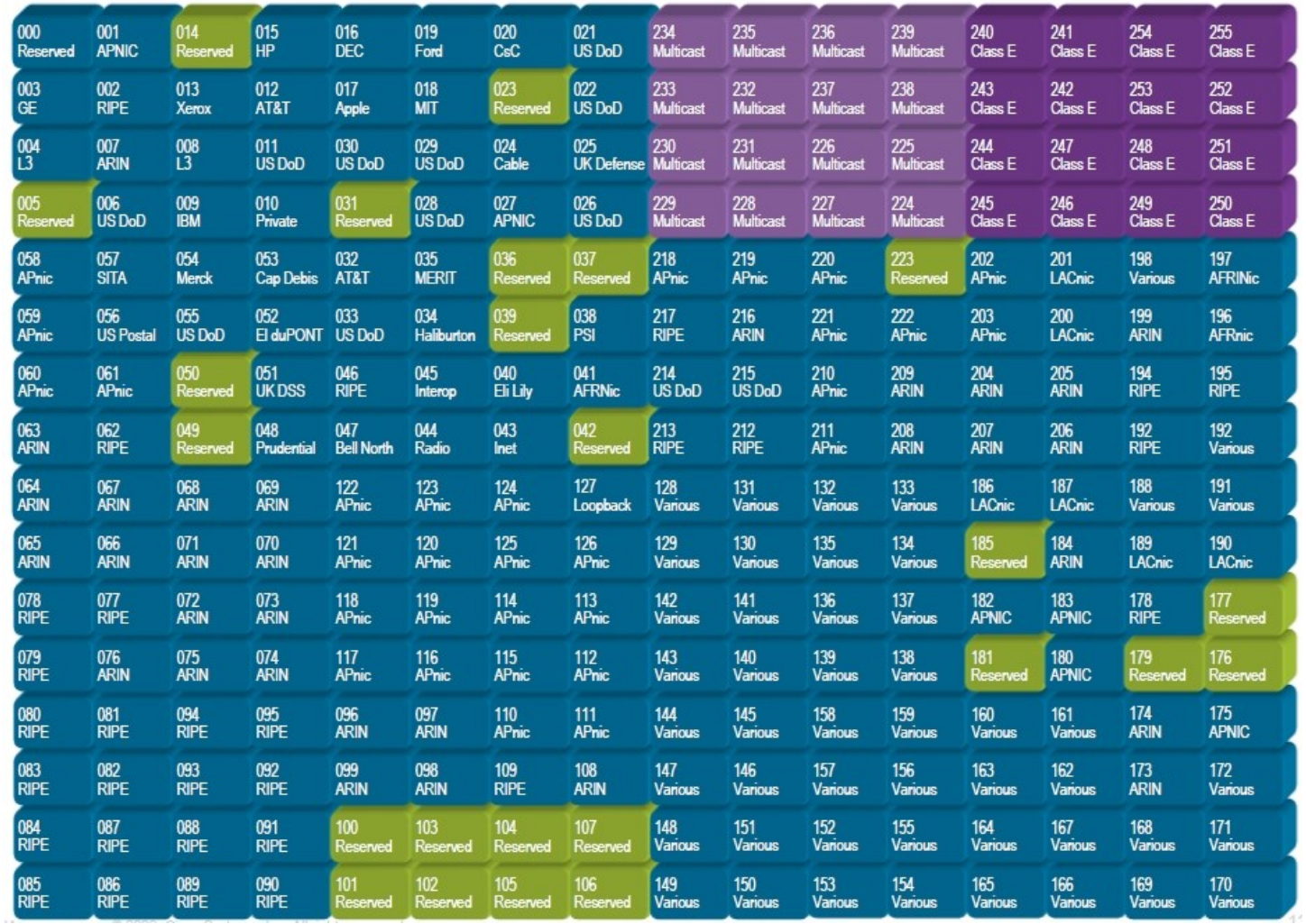
IPv4 Verteilung Januar 2010



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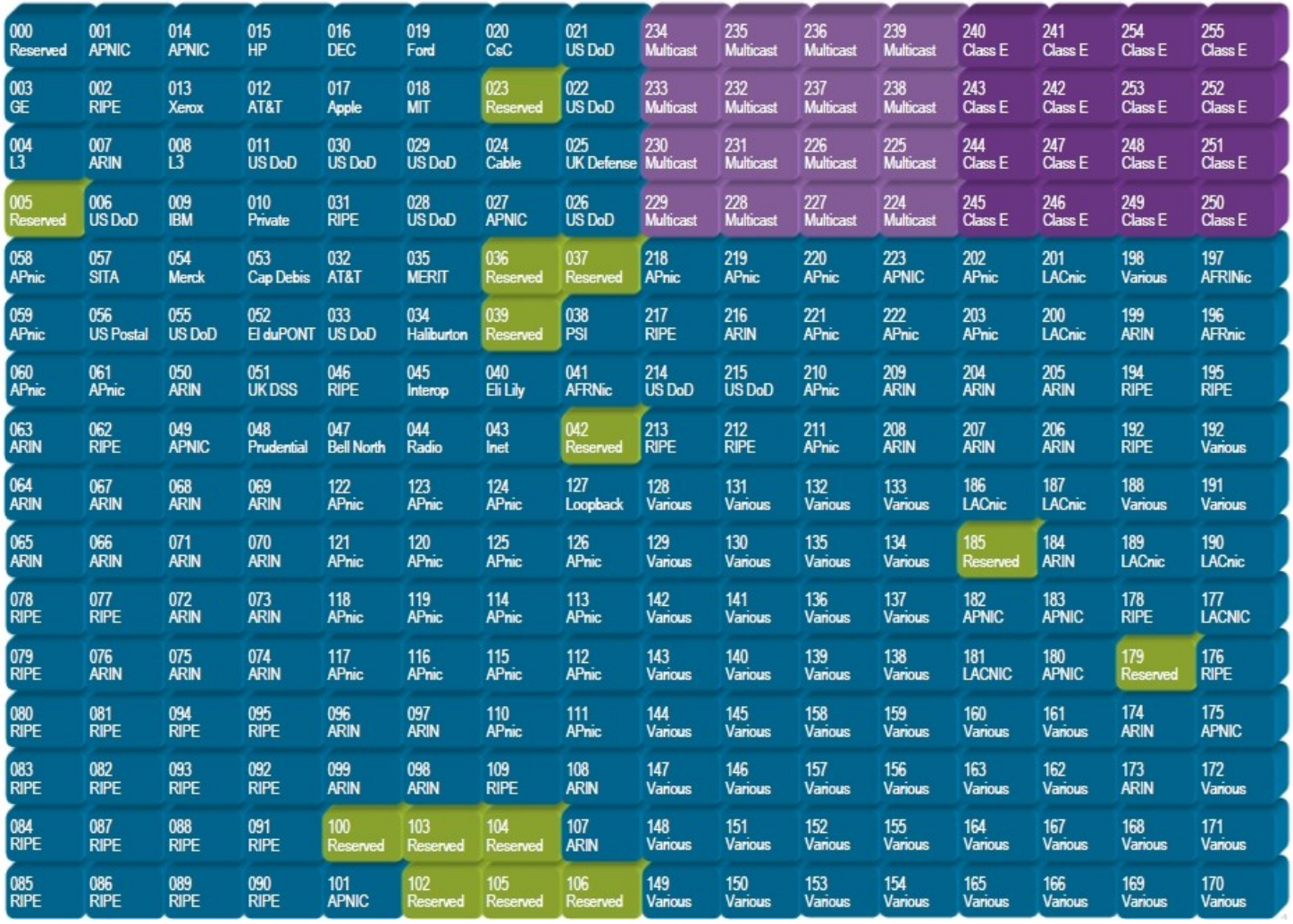
IPv4 Verteilung August 2010



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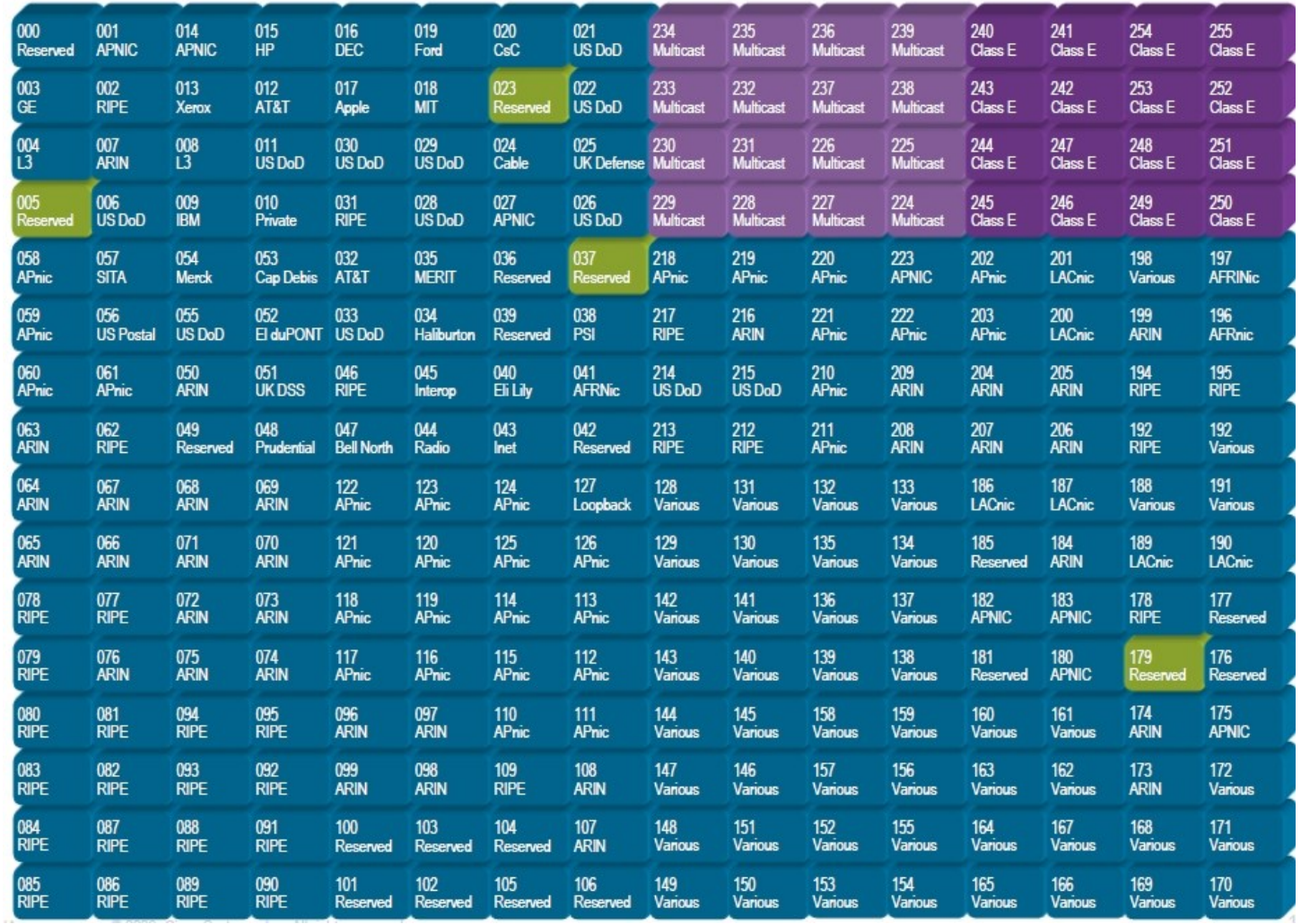
IPv4 Verteilung Januar 2011



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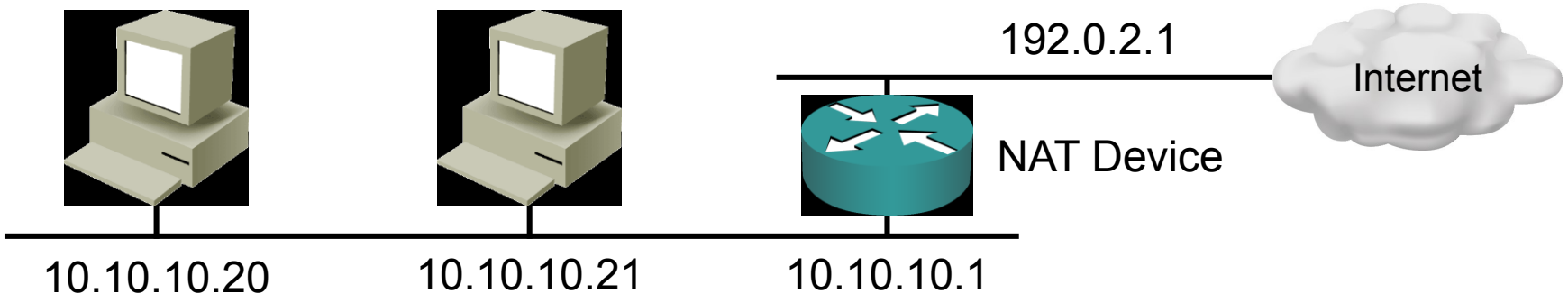
IPv4 Workarounds

- Subnetting
- Einführung Classless Interdomain Routing
  - CIDR (1993), kleine Routing Tables
- Variable Length Subnet Masking VLSM
- Network Address Translation NAT
  - Private Adressen RFC1918 (1996)

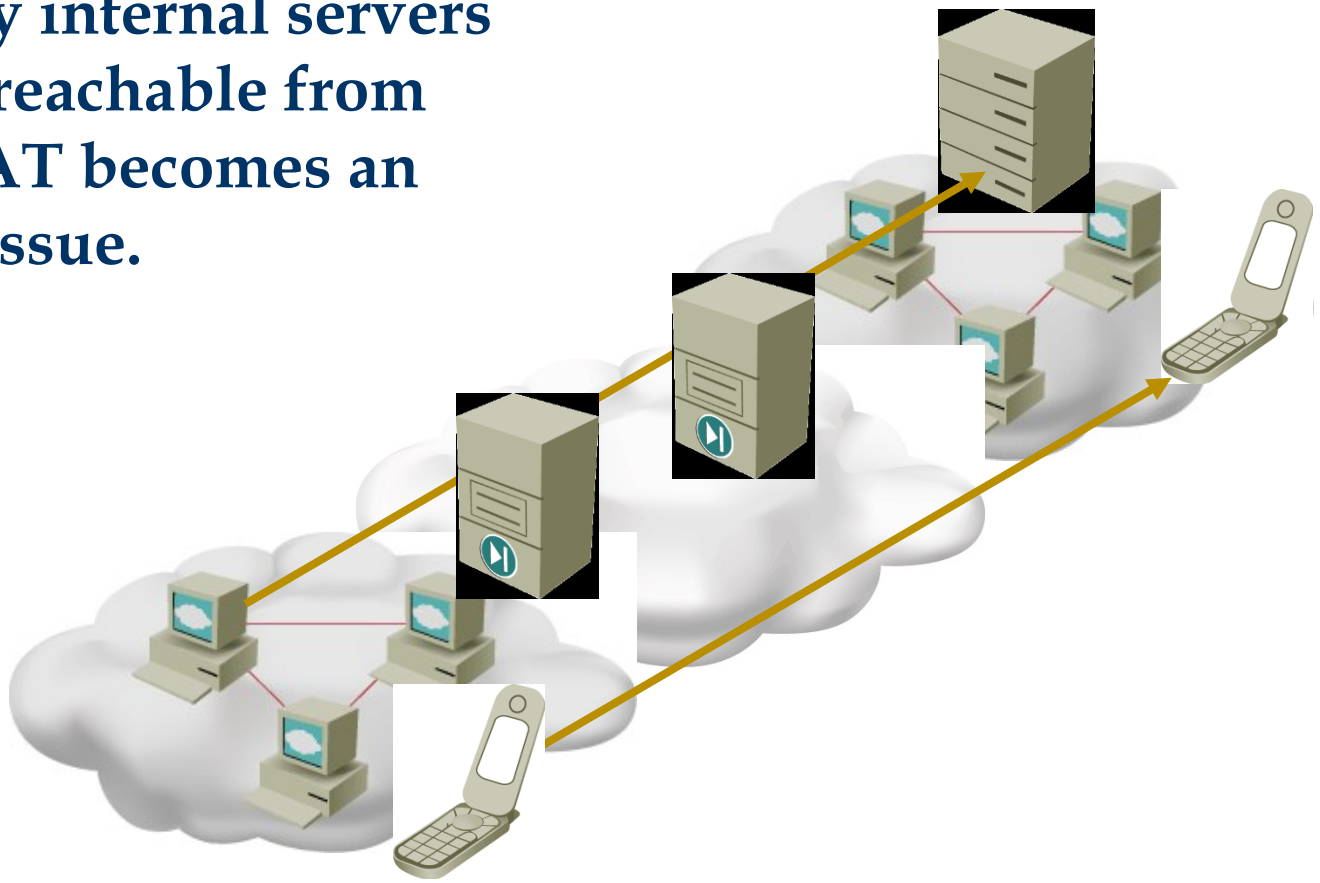
Network Address Translation



- NAT provides a way to hide many internal addresses behind one or a small number of routable addresses.
- NAT has many implications:
  - Breaks the end-to-end model of IP
  - Makes fast rerouting difficult

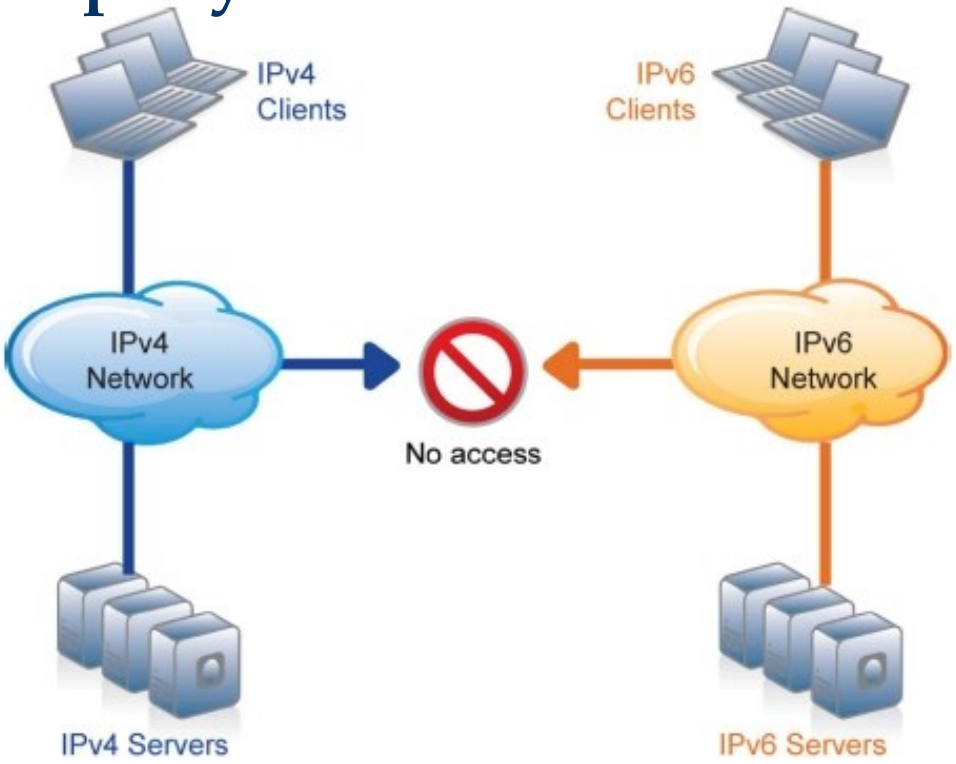
NAT Inhibits Access to Internal Servers

When many internal servers need to be reachable from outside, NAT becomes an important issue.



IPv4 and IPv6

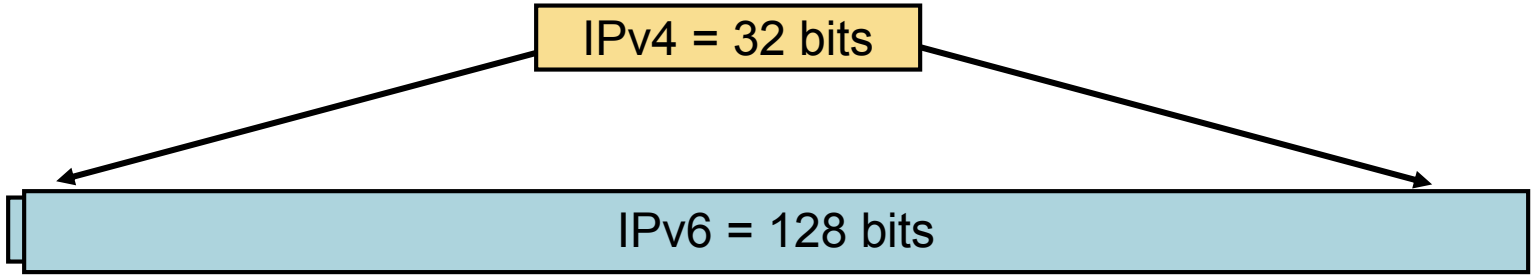
- IPv4 is 100% incompatible with IPv6
- Problems are inevitable when one is not prepared properly



IPv6 Main Features

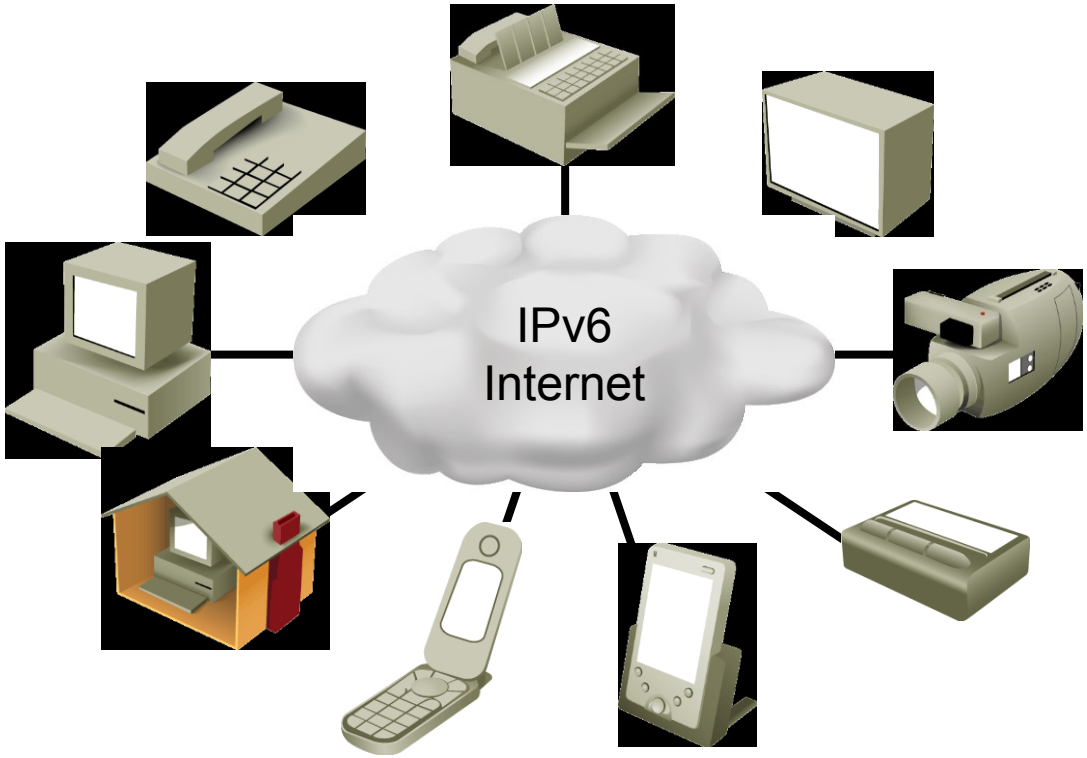
- Larger address space:
  - Global reach capability, flexibility, aggregation, multihoming, autoconfiguration, "plug-and-play," renumbering
- Simpler header:
  - Streamlining of routing code
- Security and mobility
- Transition richness

Larger Address Space



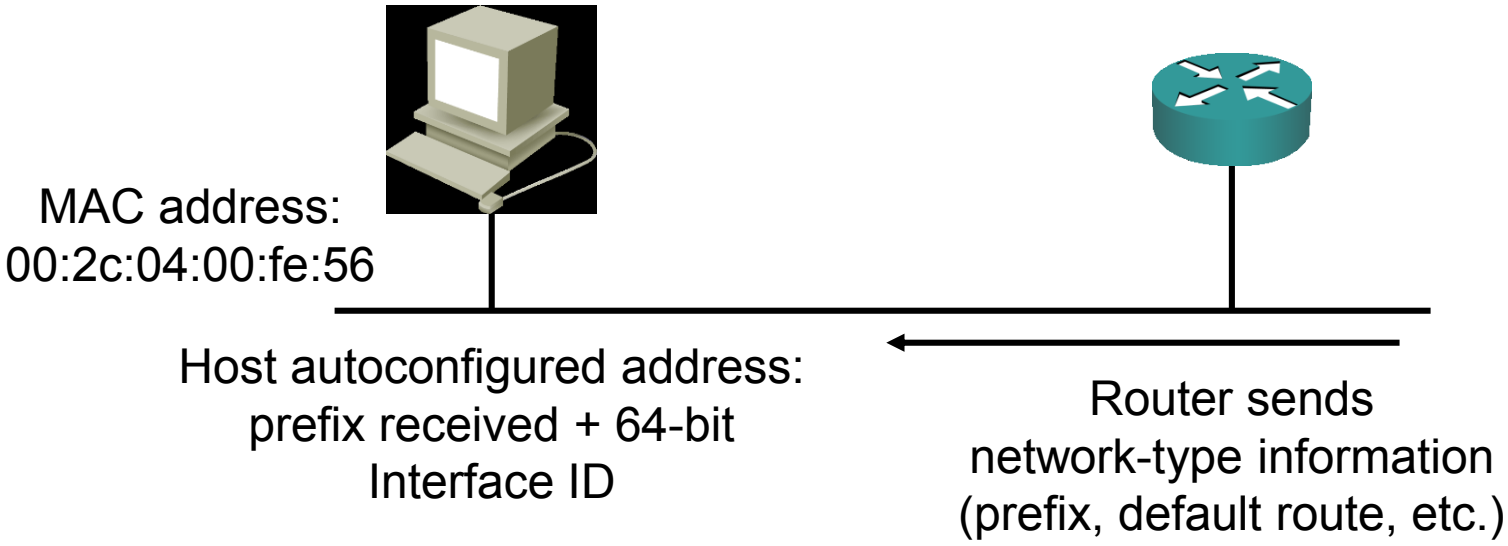
- IPv4
  - 32 bits
  - = 4,294,967,296 possible addressable nodes
- IPv6
  - 128 bits: 4 times larger in bits
  - = ~3.4 * 10^{38} possible addressable nodes
  - = 340,282,366,920,938,463,463,374,607,431,768,211,456
  - = ~53,730,194,312 * billion * billion addresses per person on the planet or
  - 665 billion addresses per mm^2 surface of the earth

Global Reachability



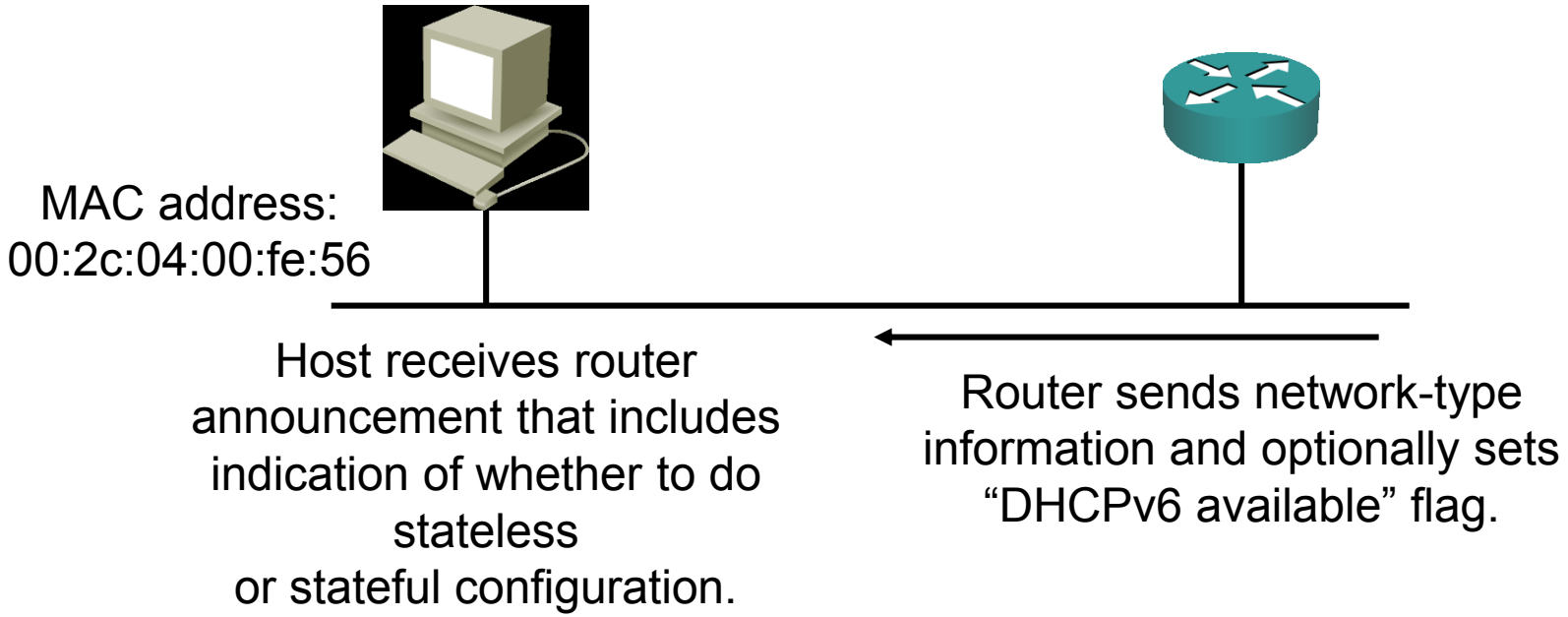
- Larger address space:
  - A globally reachable address for everything
  - End-to-end reachability, full support of application protocols, end-to-end security

Stateless Autoconfiguration



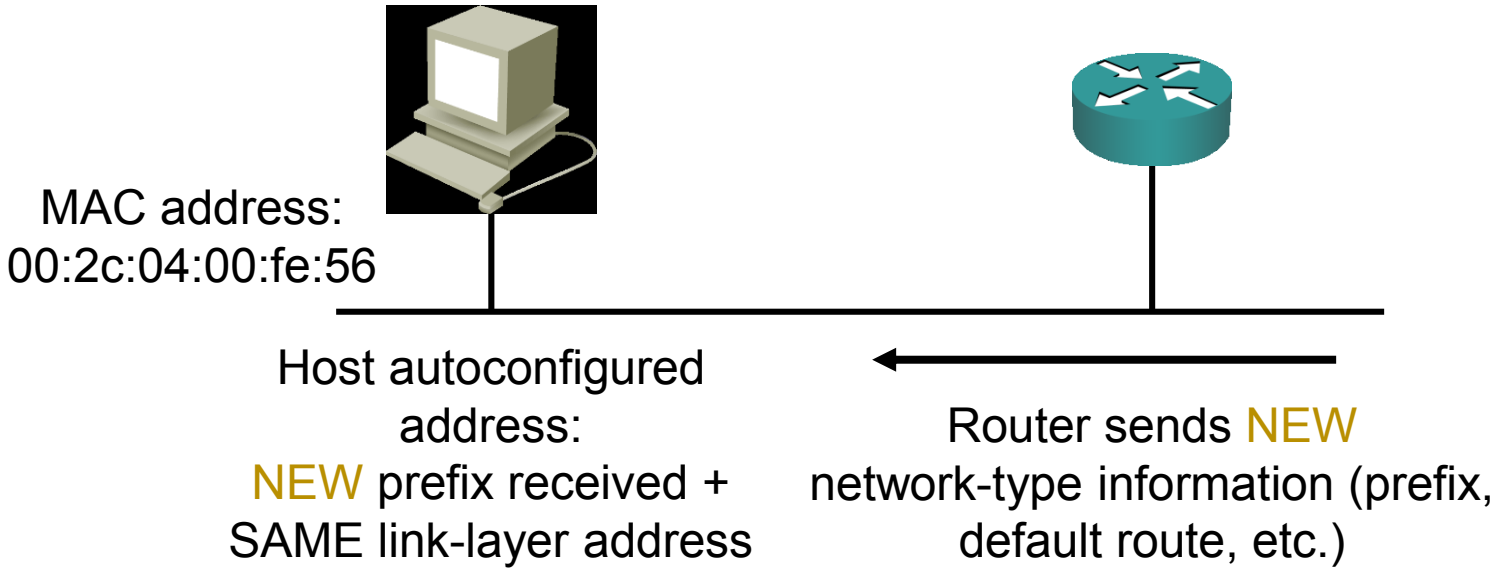
- Larger address space:
  - Often uses Layer 2 identifier
  - Autoconfiguration with no collisions
  - "Plug-and-play"

Stateful Autoconfiguration



- **Router announcement can indicate to hosts whether or not additional configuration parameters are available via stateful configuration (DHCPv6).**

Renumbering



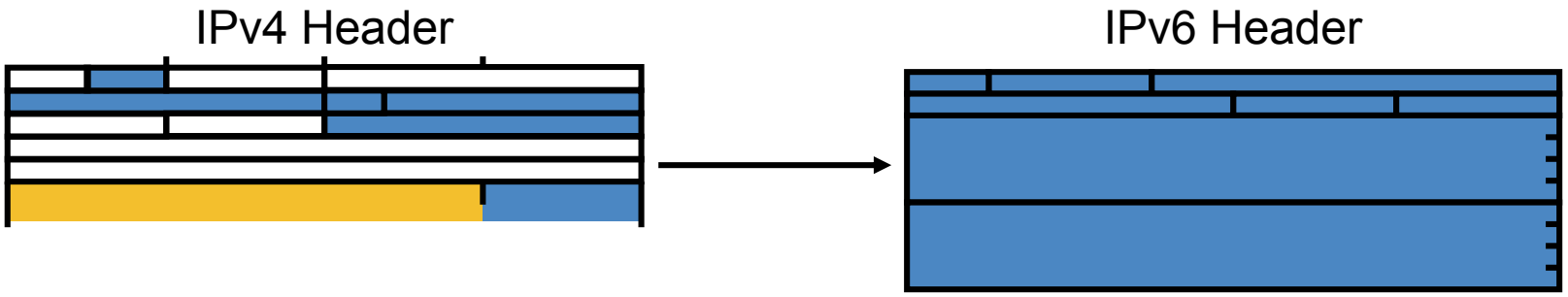
Larger address space:

- Renumbering, using autoconfiguration and multiple addresses

Multicast Use

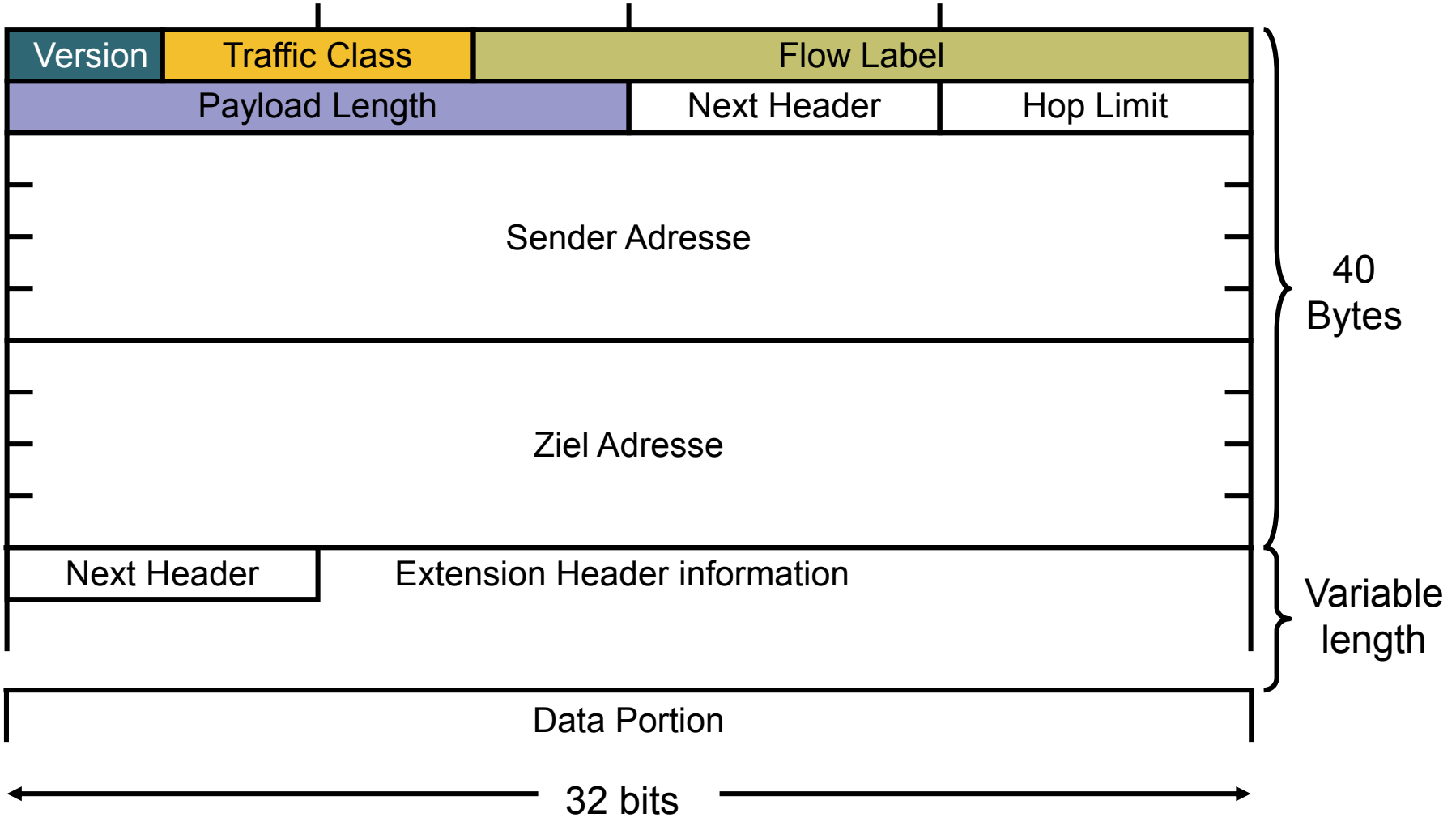
- Broadcasts in IPv4
  - Interrupt all computers on the LAN, even if the destination is only one or two computers
  - Can completely bring down a network ("broadcast storm")
- No broadcast in IPv6
  - Replaced by scoped multicast
- Multicast
  - Enables efficient use of the network
  - Has much larger address range

Simple and Efficient Header



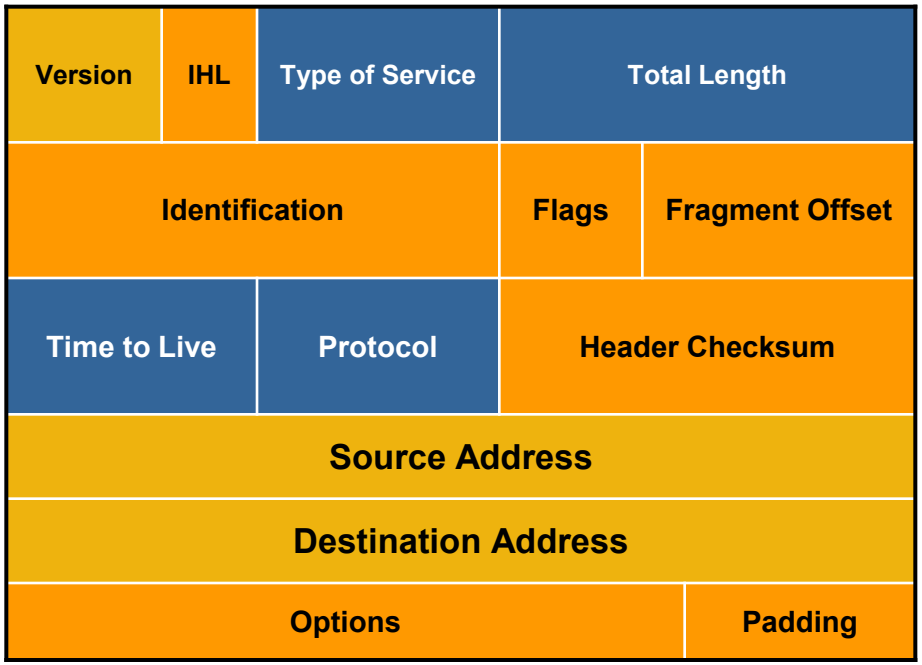
- Simpler and more efficient header:
  - 64-bit aligned fields and fewer fields
  - Hardware-based efficient processing
  - Improved routing efficiency, performance, and forwarding rate scalability

IPv6 Header

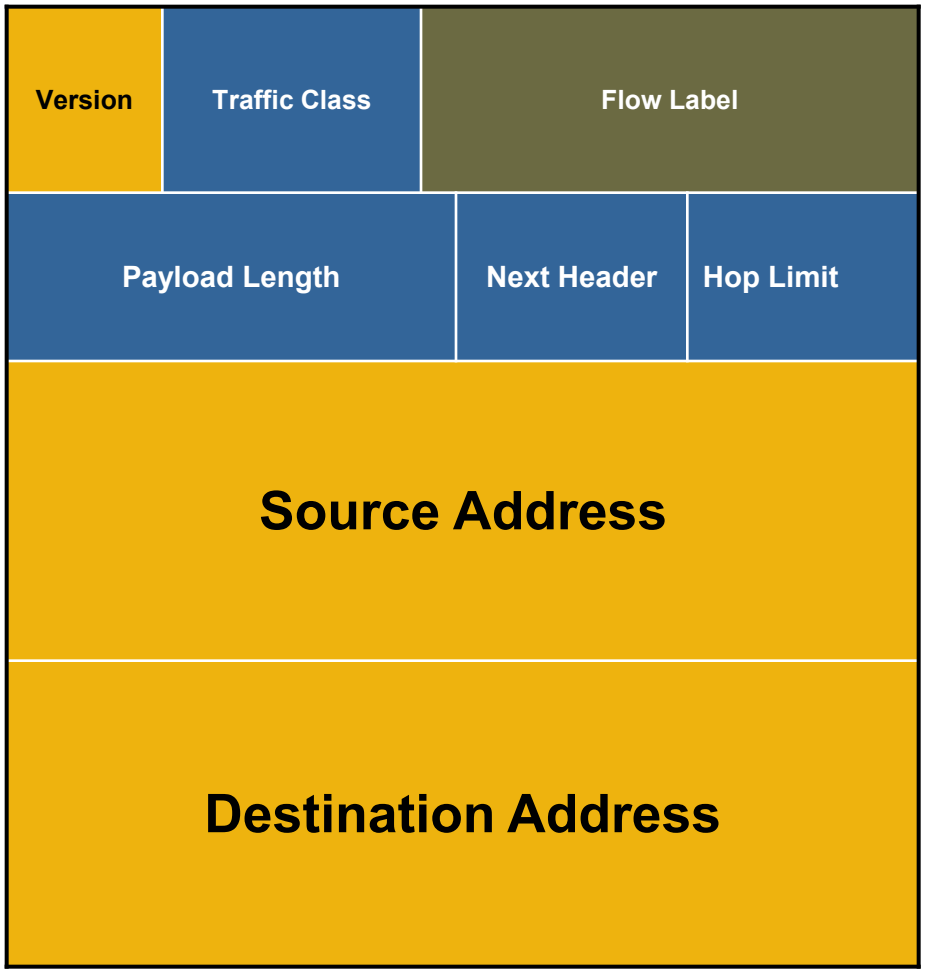


IPv4 and IPv6 Header

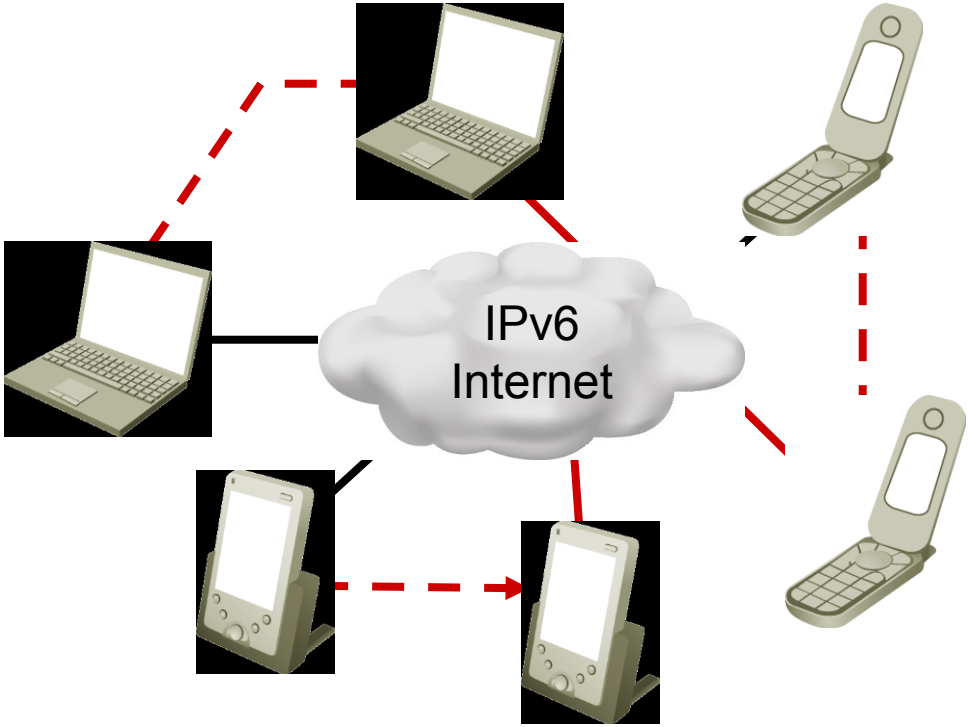
IPv4 Header



IPv6 Header

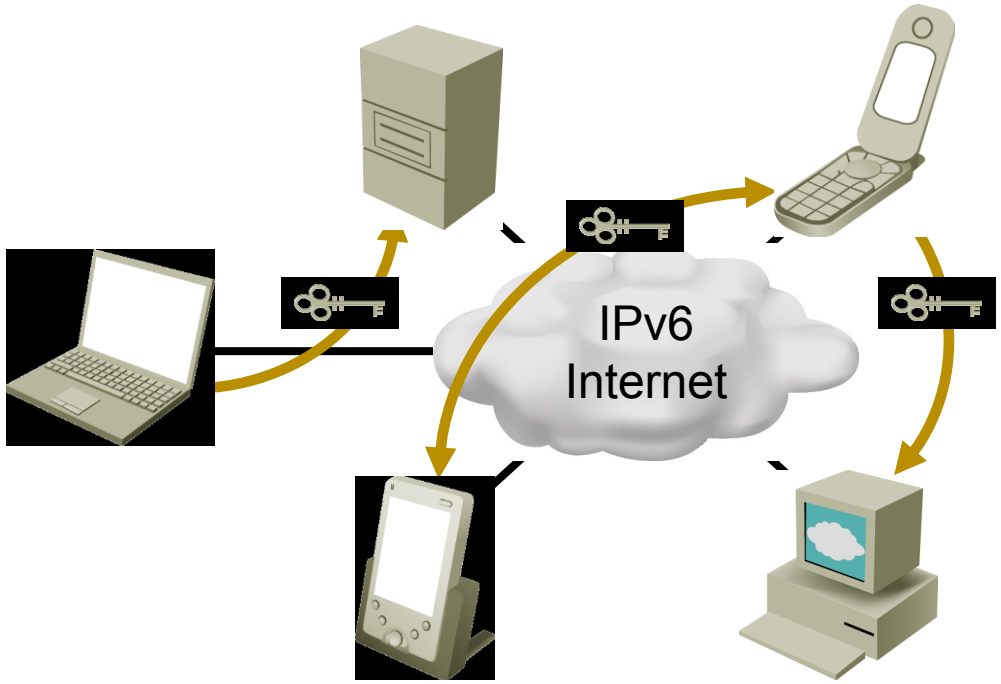


Mobility



- **Mobility:**
  - Mobile devices are fully supported while moving.
  - Mobility is built-in with IPv6.
    - Any node can use it.
  - Efficient routing means performance for end users.

Security



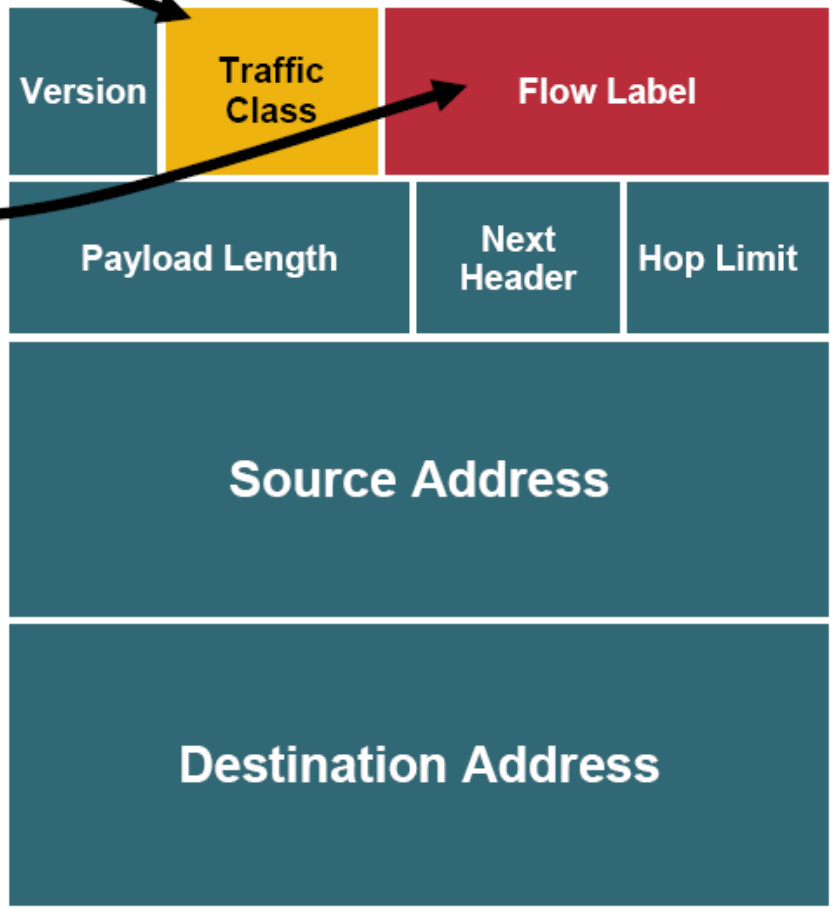
- **Security:**
  - End-to-end network security (integrity, authentication, confidentiality)
  - Inherent (built-in) with IPv6
    - Usable by any node

Quality of Service: Not a New Feature

- QoS
  - QoS has been mentioned as an IPv6 feature—in fact IPv6 currently does QoS the same way as IPv4.
  - IPv6 uses Traffic Class field in same manner as IPv4.
  - There is no difference between QoS protocols and methods in IPv4 and IPv6.
  - The IPv6 flow label can be used for QoS devices to identify specific flows.
  - The flow label itself is not currently specified as a QoS feature.

IPv6 QoS Support

- **IPv6 traffic class**
  - Exactly the same as TOS field in IPv4
- **IPv6 Flow Label (RFC 3697)**
  - A new 20-bit field in the IPv6 basic header which:
    - Labels packets belonging to particular flows
    - Can be used for special sender requests
  - Per RFC, Flow Label must not be modified by intermediate routers
- **Keep an eye out for work being doing to leverage the flow label**



Address Representation

- Format:
  - x:x:x:x:x:x:x:x, where *x* is a 16-bit hexadecimal field
    - 2001:0DB8:010F:0001:0000:0000:0000:0ACD
    - Case-insensitive
  - Leading zeros in a field are optional.
    - 2001:DB8:10F:1:0:0:0:ACD
  - Successive fields of 0 are represented as :: but only once in an address.
    - 2001:DB8:10F:1::ACD

Address Representation (Cont.)

- In a URL, the address is enclosed in brackets.
  - http://[2001:DB8:1003::f]:8080/index.html
  - Cumbersome for users
  - Mostly for diagnostic purposes
  - Use fully qualified domain names

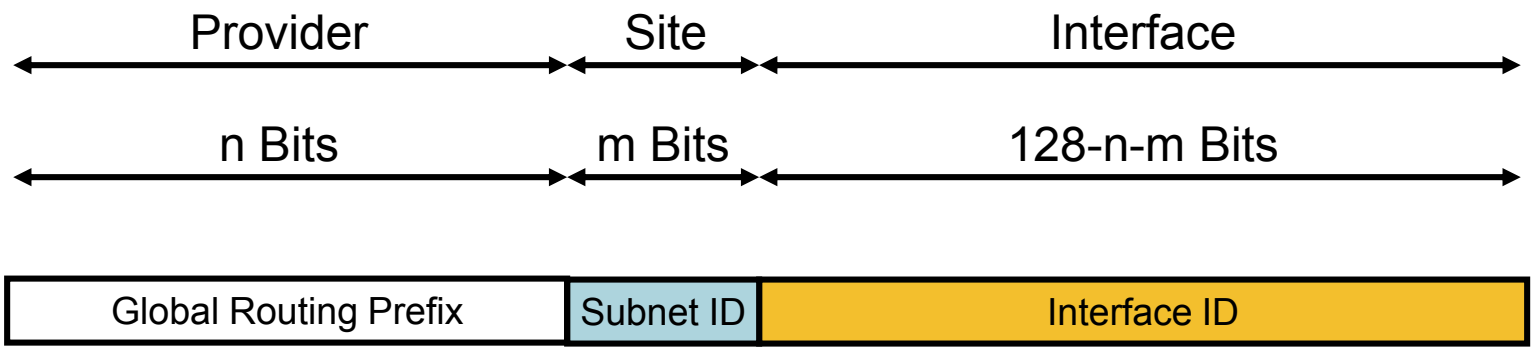
Address Types

- Unicast
- Multicast
- Anycast

Unicast

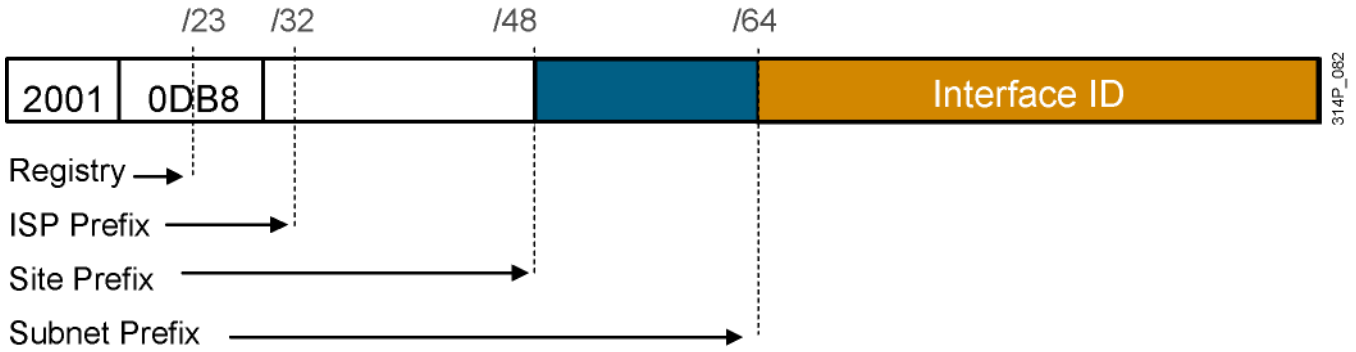
- Unicast addresses are used in a one-to-one context.
- IPv6 unicast addresses:
  - Global unicast addresses
  - Link-local addresses
  - Unique local addresses
  - Special-purpose unicast
    - Unspecified
    - Loopback
    - IPv4-mapped

Global Unicast Addresses



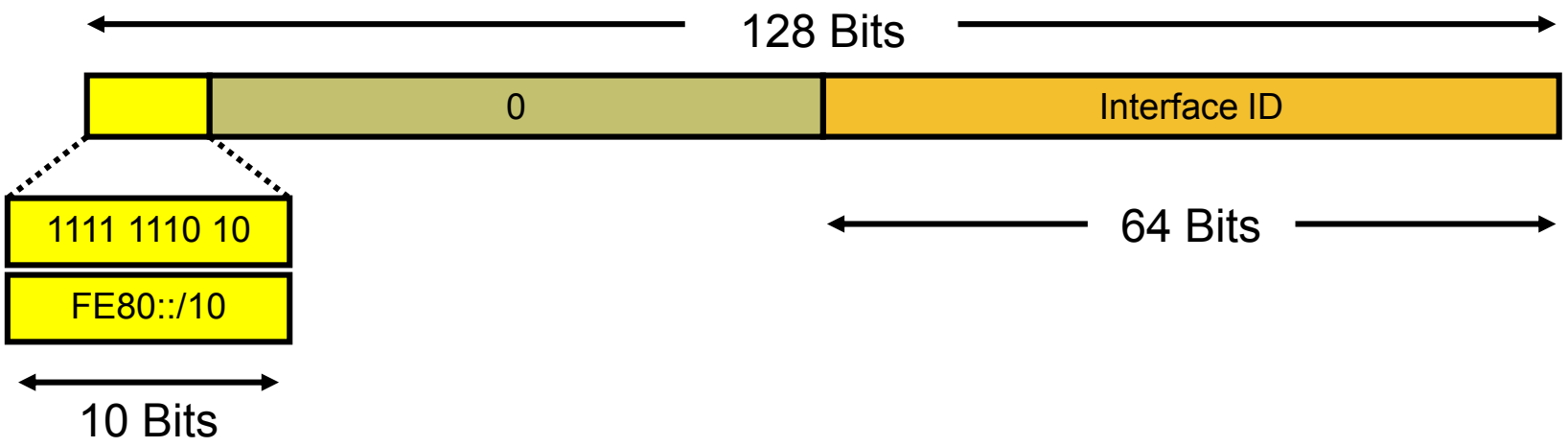
- **Global unicast addresses are addresses for generic use of IPv6.**

IPv6 Global Unicast Addresses



- IPv6 has the same address format for global unicast and for anycast addresses.
  - Uses a global routing prefix—a structure that enables aggregation upward, eventually to the ISP.
  - A single interface may be assigned multiple addresses of any type (unicast, anycast, multicast).
  - Every IPv6-enabled interface contains at least one loopback (::1/128) and one link-local address.
  - Optionally, every interface can have multiple unique local and global addresses.

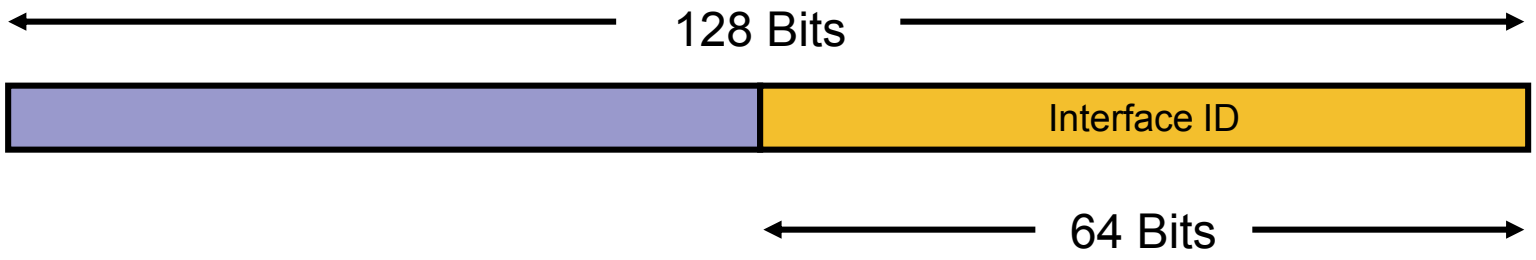
Link-Local Addresses



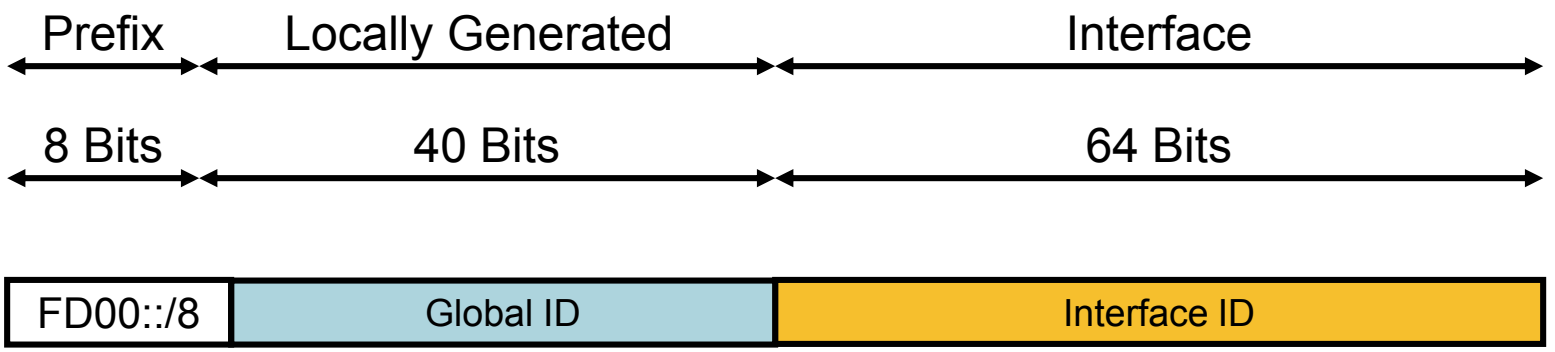
- **Link-local addresses:**
  - **Have a scope limited to the link**
  - **Are automatically configured with the interface ID**

Interface Identifiers

- Used to identify interfaces on a link
  - Must be unique on that link
  - Can be globally unique
- Unicast addresses may have a 64-bit interface ID.
  - Interface ID constructed in modified EUI-64 format



Unique Local Unicast Addresses



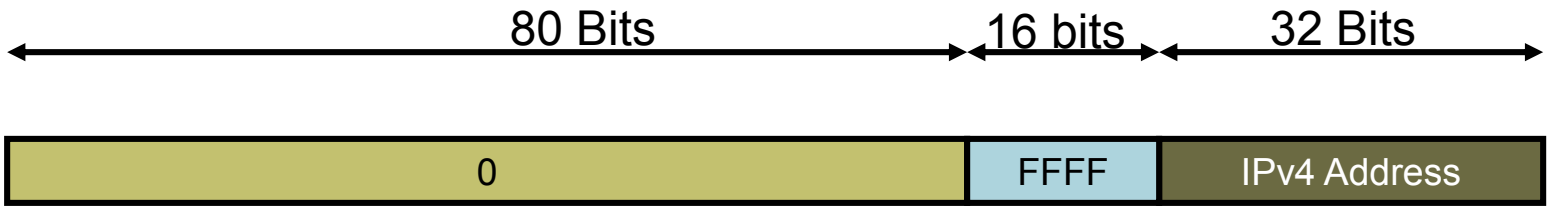
- **Unique local unicast addresses are addresses for local use only.**

Unspecified and Loopback Address

- Unspecified address:
  - 0:0:0:0:0:0:0:0
  - Placeholder if no IPv6 address is available (DHCP Request, DAD)
- Loopback address:
  - 0:0:0:0:0:0:0:1 (::1)
  - 127.0.0.1 in IPv4

IPv4-Mapped Address

- Representation of IPv4 addresses as IPv6 host addresses
- Use in MPLS, 6PE and 6VPE

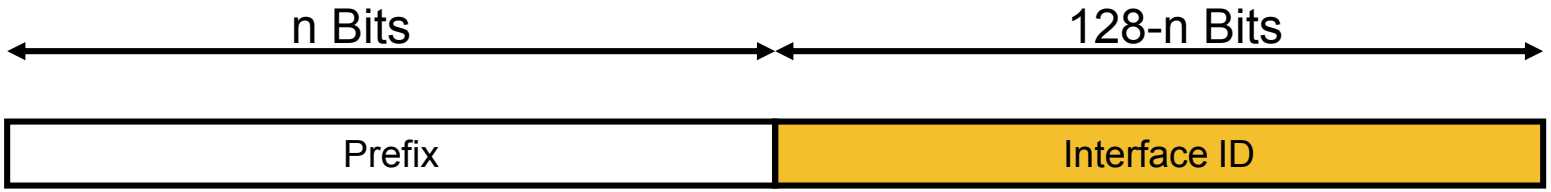


0:0:0:0:0:FFFF:192.0.2.100

= ::FFFF:192.0.2.100

= ::FFFF:C000:0246

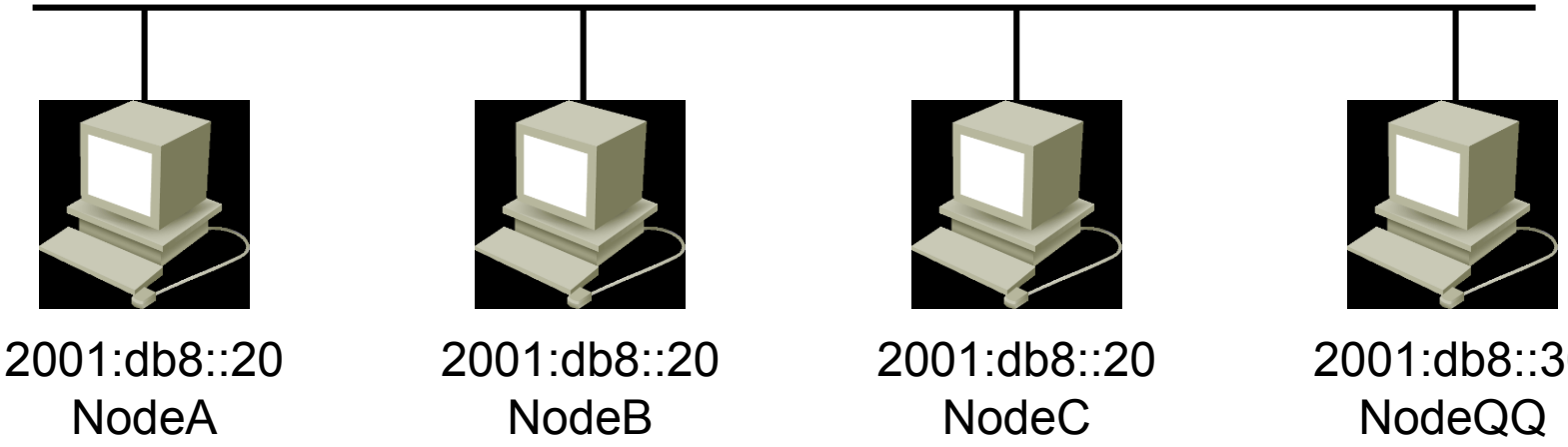
Anycast Addresses



- **Anycast:**
  - **Used in the context of one-to-nearest**
  - **Assigned to more than one interface**
  - **Allocated from the unicast address space**

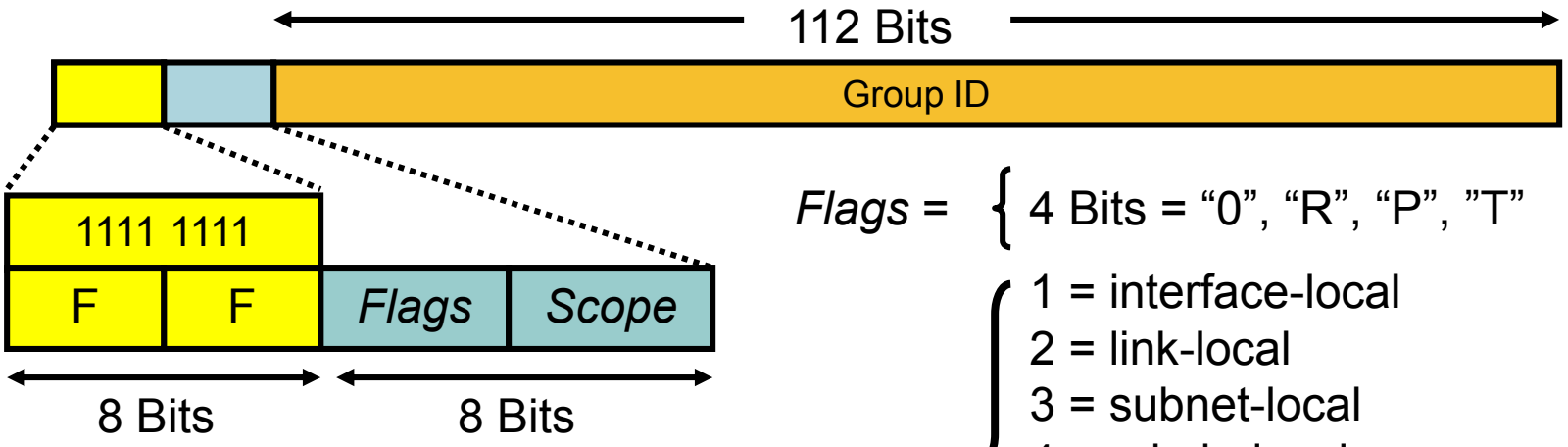
Anycast Addresses: LAN

- **Nearest anycast address is whichever host is put into NodeQQ neighbor cache first.**

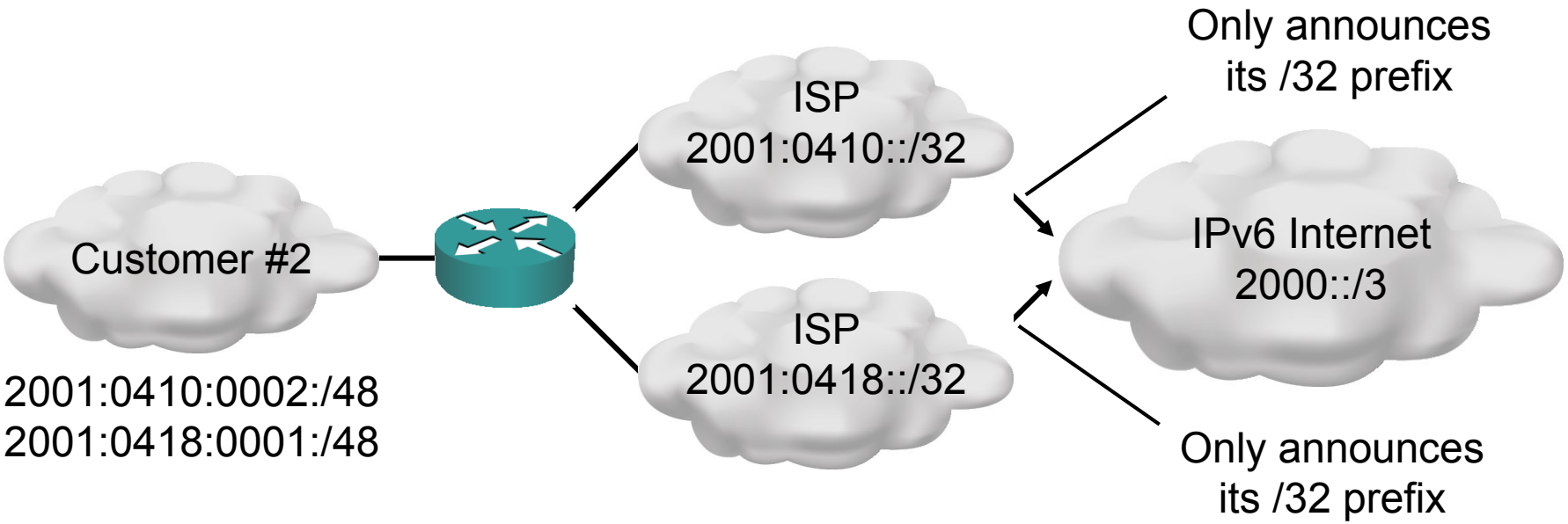


IPv6 Multicast Address

- Addressing: One to Many (group address)
- Multicast Scope new by IPv6



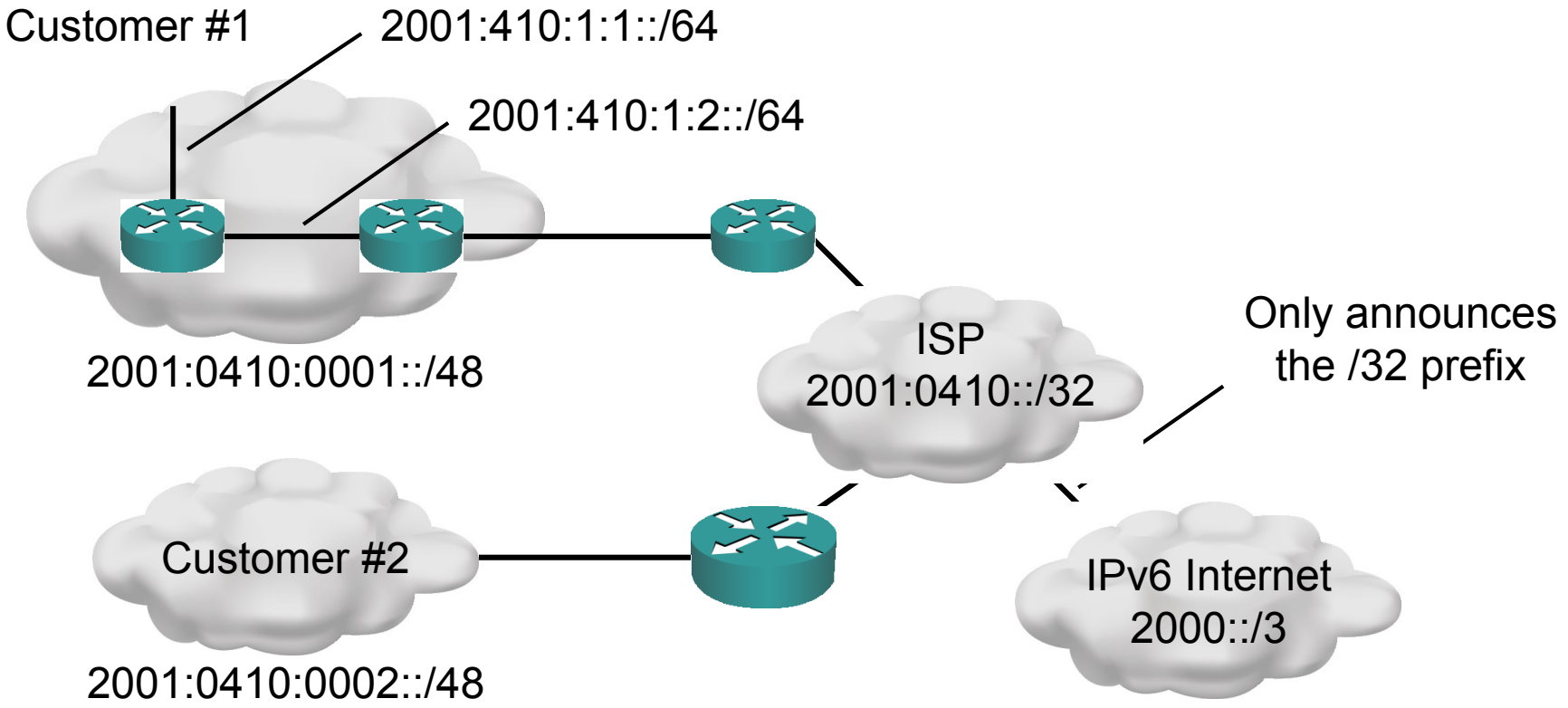
Multiple Addresses



Larger address space:

- Multiple simultaneous addresses for hosts and networks
- Support of multihoming

Aggregation



Larger address space:

- Aggregation of prefixes announced in global routing table
- Efficient and scalable routing

DNS

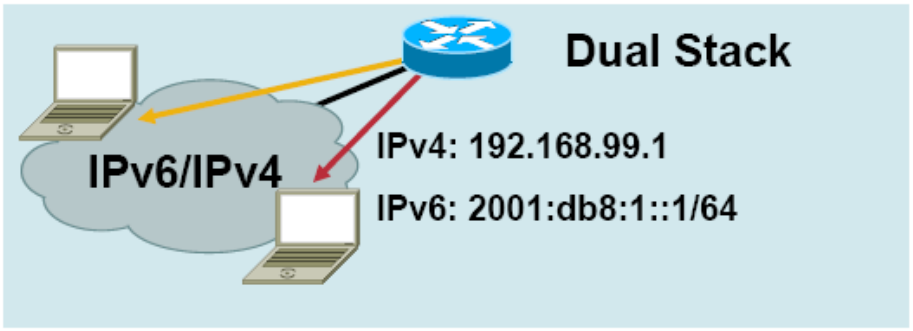
- IPv6 update required by the DNS server and client
- DNS tree structure is identical to IPv4
  - Root DNS Server (13 of 13 IPv6)
  - Top Level Domain DNS Server
  - DNS Server for each domain
- IPv6 use AAAA Record, IPv4 A Record

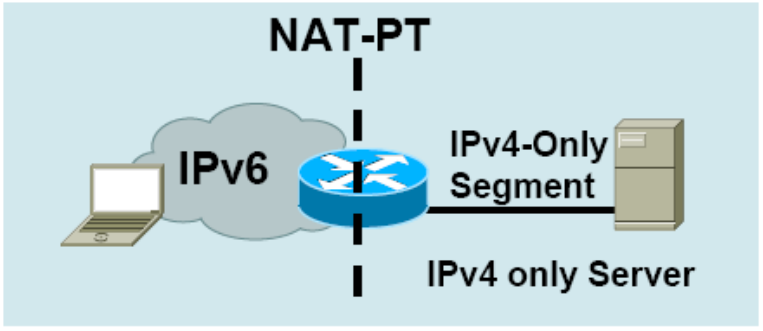
PC5.gk.at	AAAA	2001:db8:800:3abc:cc5::55b1
PC9.gk.at	A	192.168.7.187

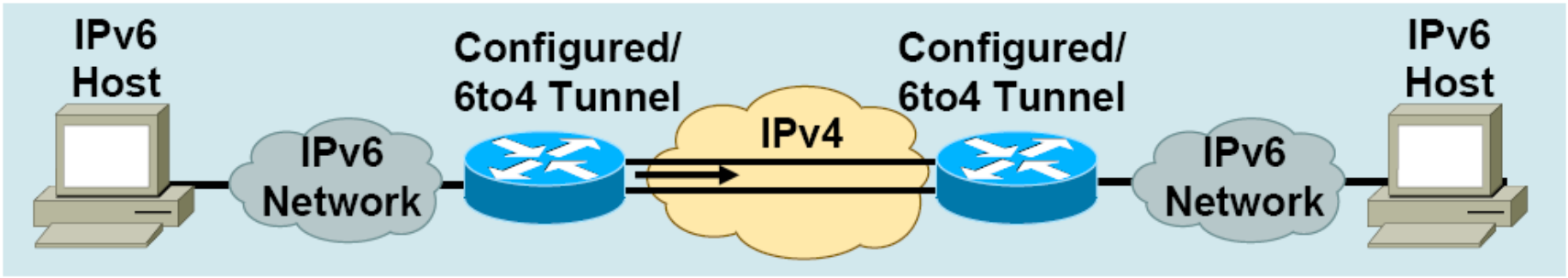
Routing with IPv6

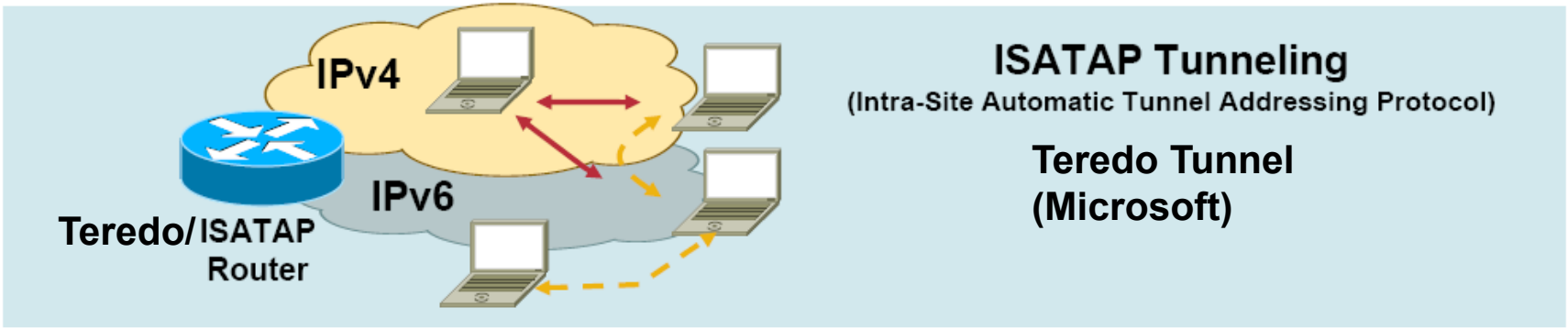
- RIPng
- OSPFv3
- Cisco EIGRP
- Integrated IS-IS
- Multiprotokoll BGP, MP-BGP

IPv6 Enterprise Deployment

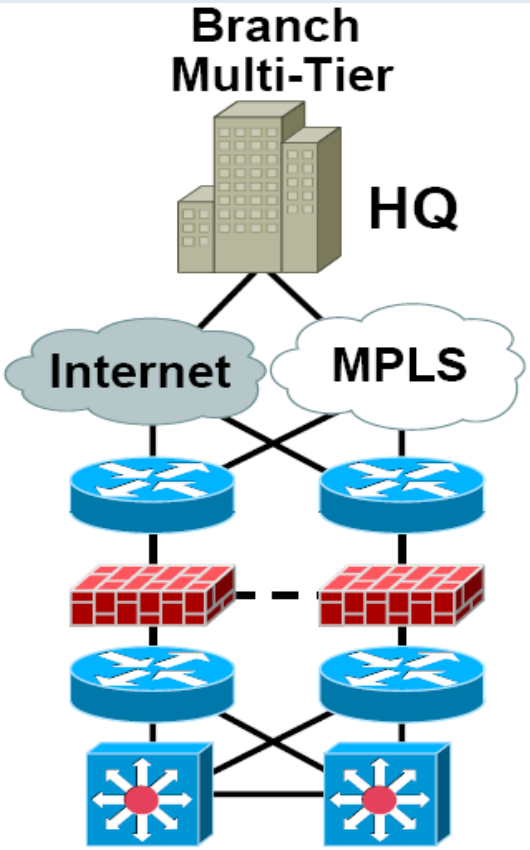




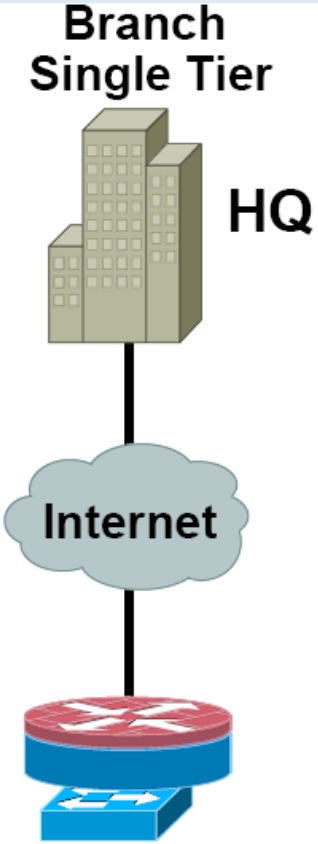




IPv6 in the Branch



Dual-Stack
IPSec VPN or
MPLS (6PE/6VPE)
Firewall (IPv4/IPv6)



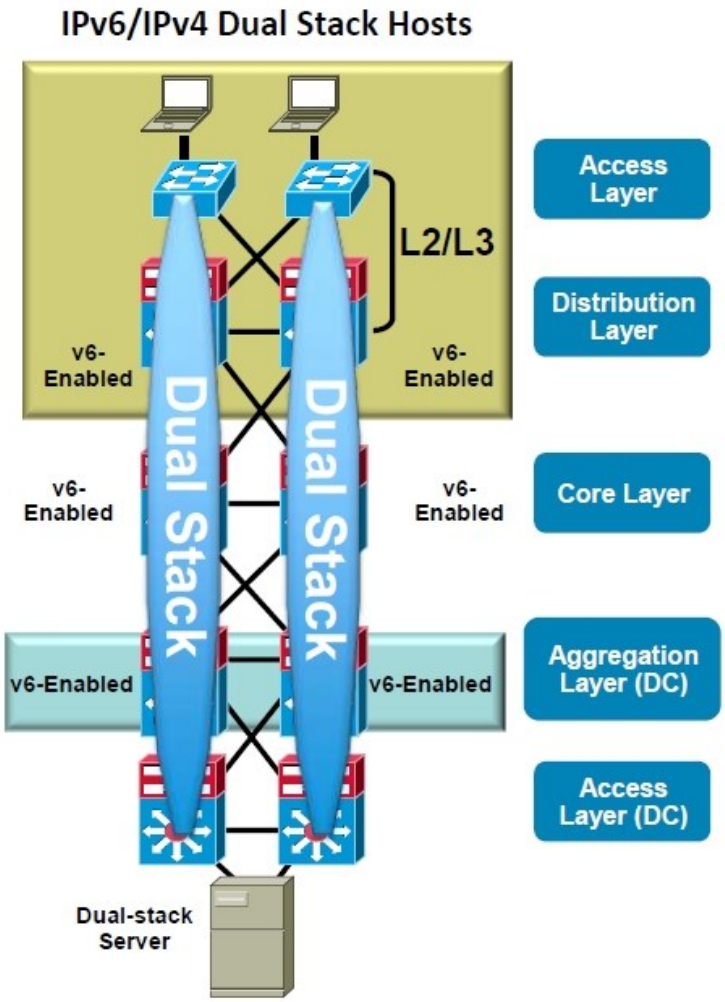
Dual-Stack
IPSec VPN (IPv4/IPv6)
IOS Firewall (IPv4/IPv6)
Integrated Switch

Campus IPv6 Deployment

- DUAL STACK, die offensichtliche Option
  - Performance, Security, QoS, Multicast
  - IPv6 in Hardware in Multilayer Switches
- HYBRID, Dual Stack wo möglich, der Rest wird getunnelt
  - PRO: Unterstützt das vorhandene Design und Equipment (traditioneller L2/L3, Routing)
  - CON: Tunnel (besonders ISATAP) verursachen unnatürliche Dinge (Core Layer wird zum Access Layer) und unterstützt keine IPv6 Multicast

Campus IPv6 Deployment Optionen Dual Stack IPv4/IPv6

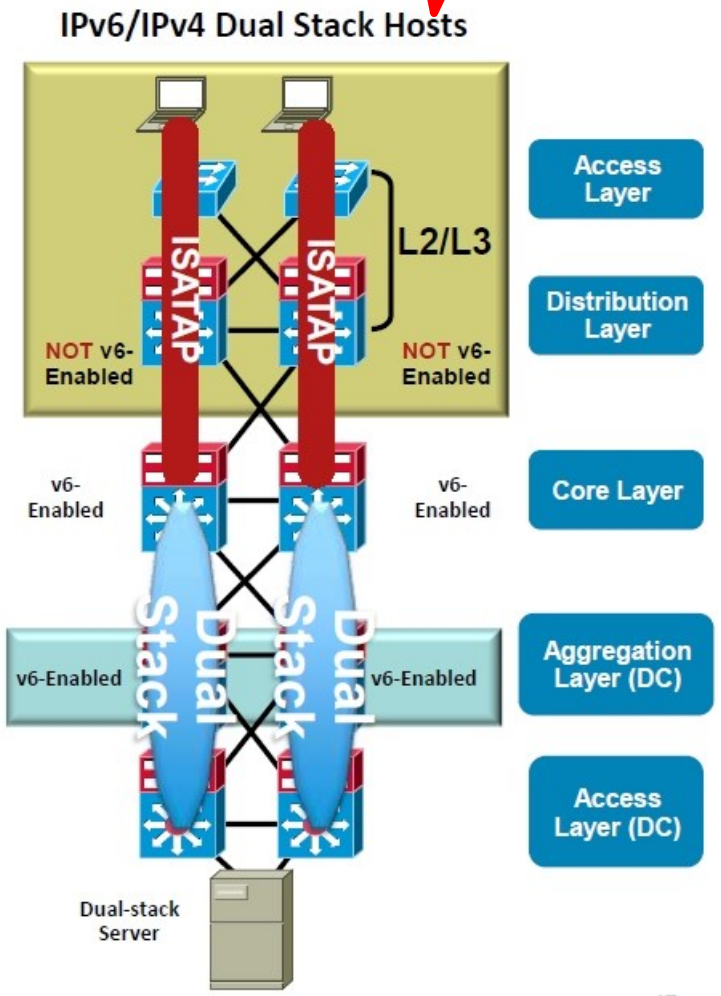
- #1 Voraussetzung: Switching und Routing Komponenten müssen IPv6 in Hardware unterstützen
- IPv6 ist transparent auf L2 Switches, aber…
  - IPv6 Management (SSH, Telnet)
  - L2 Multicast: MLD Snooping
- Gleichen Routing Protokolle wie bei IPv4 benutzen



Campus IPv6 Deployment Optionen: Hyprid Model

Nur wenn Dual Stack nicht geht

- IPv6 Connectivity via
  - Dual Stack
  - Configured Tunnels: L3-to-L3
  - ISTAP: Host-to-L3
- Unterstützt vorhandenes Netzwerk/Infrastruktur
- Natürliche Entwicklung zu Dual-Stack
- Tunnel bis zum Core Layer, suboptimal
- ISATAP generiert flaches Netz
  - Alle Hosts im selben Tunnel sind Peers



Dual Stack, Vorteile und Nachteile

- Vorteile:
  - Relativ einfach einzusetzen
  - Beinhaltet weitere IPv4 Unterstützung
  - Breite Unterstützung Hardware und Applikationen
- Nachteile:
  - Doppelte Arbeit für fast alle Services
    - Zwei Routing Protokolle = zwei Routing Tables, zwei Routing Prozesse (Ausnahme: Integrated IS-IS)
    - Zwei DNS Server
    - Zwei DHCP Server
    - Security

Tunnel, Vorteile und Nachteile

- Vorteile:
  - Niedrige Kosten wenn nicht Performance wichtiger Faktor ist
  - Einfach zur Kopplung von IPv6 Inseln (WAN)
  - IPv6 Verbindungen über vorhandener IPv4 Infrastruktur
- Nachteile:
  - Tunnel Overhead, MTU und Delay (Ein- und Auspacken)
  - Komplexes Management
  - Tunnel Interfaces sind immer up, Link Failure Erkennung

Übersetzung, NAT64, Vorteile und Nachteile

- Vorteile sind Kommunikation mit traditionellen Applikationen die niemals IPv6 unterstützen werden
- NAT hat mehrere Nachteile
  - Ende-zu-Ende Security geht verloren (IPsec)
  - Applikationen die L3 Adressen oder Ports im Payload verwenden können Probleme bekommen (SIP, FTP)
  - Single Point of Failure
- Evtl. Proxies als Alternativen
  - Application Layer Gateways ALG
  - Benötigt Unterstützung der Applikation

Galileo Big Picure


Q & A