IPv6 Courses

December 20, 2010

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G6

- Group of IPv6 actors in France (researchers, engineers...)
- Academic & industrial partners
  - CNRS, Institut TELECOM, INRIA, Universities...
  - AFNIC, 6Wind, Bull...
- Launched in 1995 by:
  - Alain Durand
  - Bernard Tuy
- Is today a legal association under French Law (1901)
  - Laurent Toutain, President
- For further information: http://www.g6.asso.fr/

G6Charter

- Share experience gained from IPv6 experimentations and deployment
- Spread IPv6 information
  - Tutorials and trainings (ISPs, Engineers, netadmins...)
  - Online book (in French), "IPv6, Théorie et pratique": http://livre.g6.asso.fr/
- Initiate research activities around IPv6
- Active in RIPE & IETF working groups
- Promotion of IPv6: French Task Force

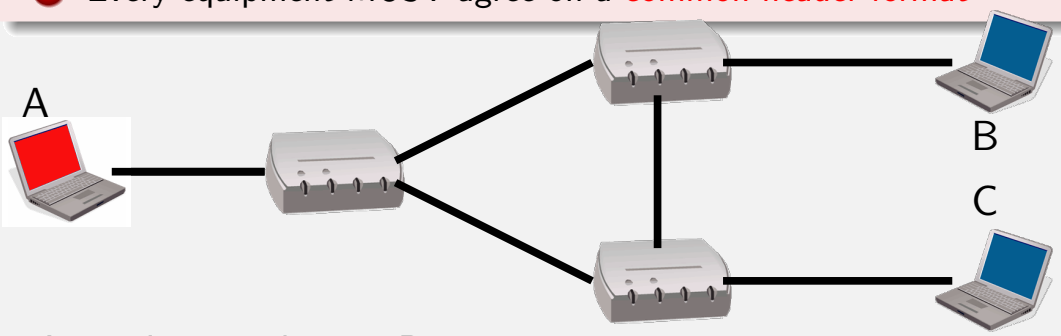
Hypertext Symbols

- Several symbols are used in this document:
  - All RFCs and Internet Drafts are hypertext links.
    - Check that there is no more recent version of the document.
  -  is a link to a *Techniques de l'Ingénieur* article on the subject (in French, access may be restricted).
  -  is a link to the online edition of *IPv6, Théorie et Pratique* (in French)
  - W is a link to other information on the web.
- Material concerning IPv6 is taken from the G6 tutorial and copyrighted from G6.

What Is A Datagram

Definition

1. Every packet is processed separately
2. No state in the network
3. Destination address MUST be repeated in each packet
4. Every equipment MUST agree on a common header format



A sends a packet to B

What Is A Datagram

Concepts
Datagram
Addresses
Facts on Addresses

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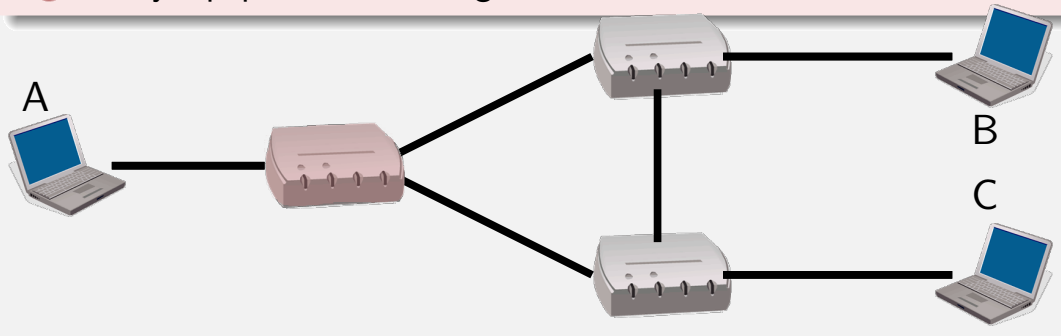

The first router looks at the header to find the exit interface

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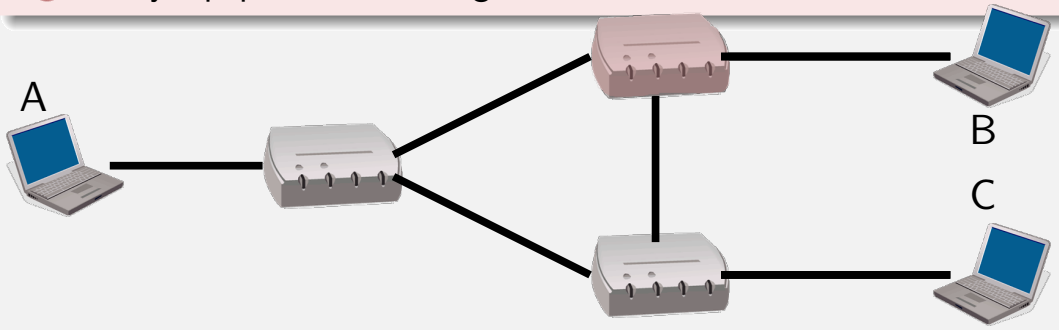

The second router looks at the header to find the exit interface

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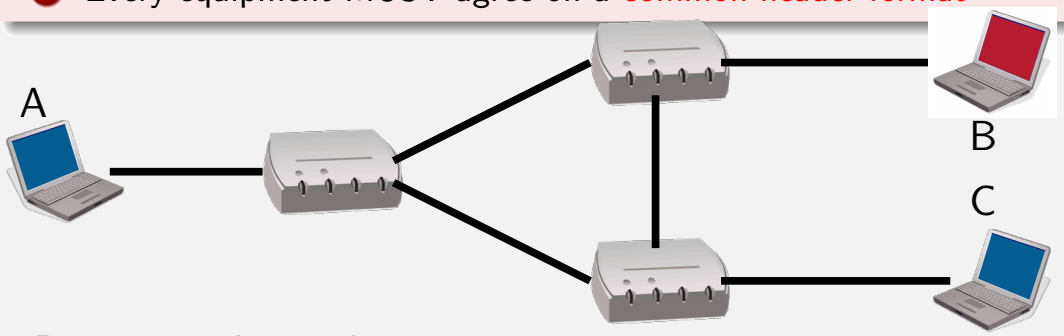
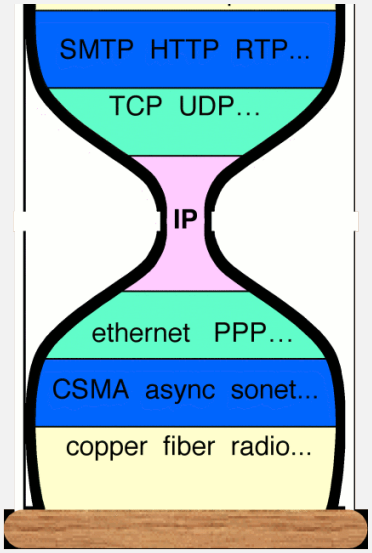


B accepts the packet

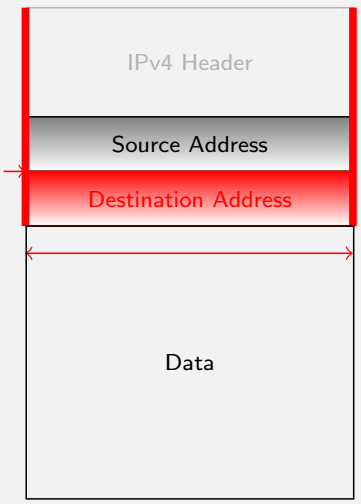
IP Layer



- IP is kept simple
  - Forwards packet towards destination
- IP on everything
  - Adapt IP protocol on every layer 2
- Everything on IP
  - Write applications to use IP layer (through L4: TCP, UDP)
- IP must facilitate network interconnection
  - Avoid ambiguities on addresses

W http://www.ietf.org/proceedings/01aug/slides/plenary-1/index.html Steve deering, Watching the Waist of the Protocol Hourglass, IETF 51, London

Destination Address Processing



The destination address must be easily accessible:

- Fixed location
- Fixed size
- Aligment in memory

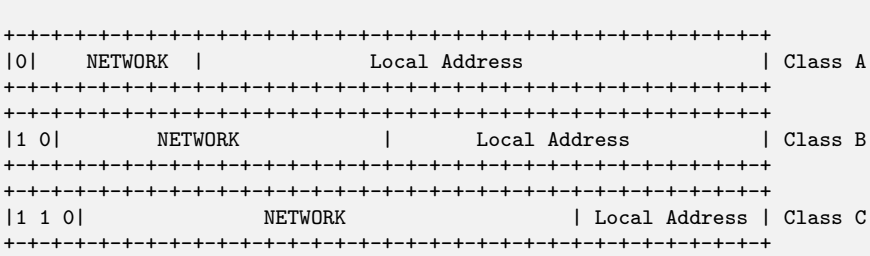
RFC 791 (Sept 1981)

`Addresses are fixed length of four octets (32 bits)`

Concepts

Addresses

IPv4 address allocation (originally)



- The address is split into two parts:
  - Network part
  - Host part
- Initially the boundary was given by a prefix
  - 3 boundaries called classes
  - 1 class (D) for mutlicast added later
  - 1 class (E) reserved (never used)
- An authority used to give unique prefix to sites
- This plan was developed to guarantee address uniqueness

Facts on Addresses

Historical view

Historical facts

- 1983 : Research network for about 100 computers
- 1992 : Commercial activity
  - Exponential growth
- 1993 : Exhaustion of the class B address space
  - Allocation in the class C space
  - Require more information in routers memory
- Forecast of network collapse for 1998!
  - 1999 : Bob Metcalfe ate his Infoworld 1995 paper where he made this prediction

Emergency Measures: Better Addresses Management

RFC 1517 - RFC 1520 (Sept 1993)

- Ask the internet community to give back allocated prefixes (RFC 1917)
- Re-use class C address space
- CIDR (Classless Internet Domain Routing)
  - network address = prefix/prefix length
  - less address waste
  - recommend aggregation (reduce routing table length)
- Introduce private prefixes (RFC 1918)

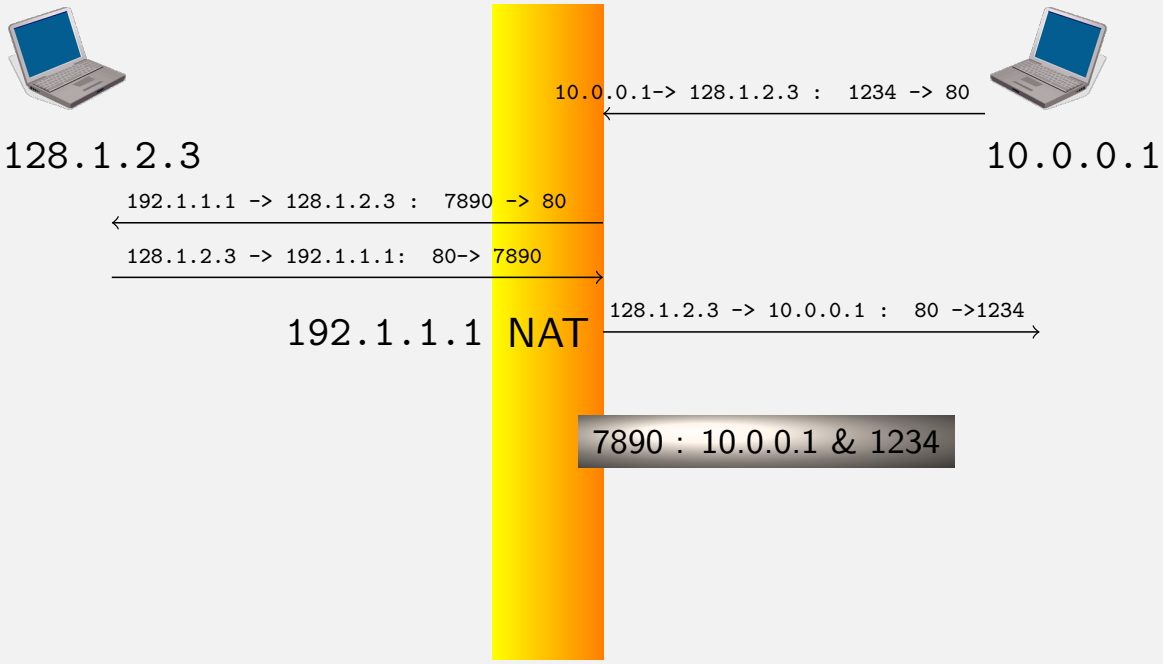
Facts on Addresses

NAT

Emergency Measures: Private Addresses (RFC 1918 BCP)

- Allow private addressing plans
- Addresses are used internally
- Similar to security architecture with firewalls
- Use of proxies or NAT to go outside
  - RFC 1631, RFC 2663 and RFC 2993
- NAPT is the most commonly used of NAT variations

How NAT with Port Translation Works



NAT Impact

first consequence

The application does not know its public name.

second consequence

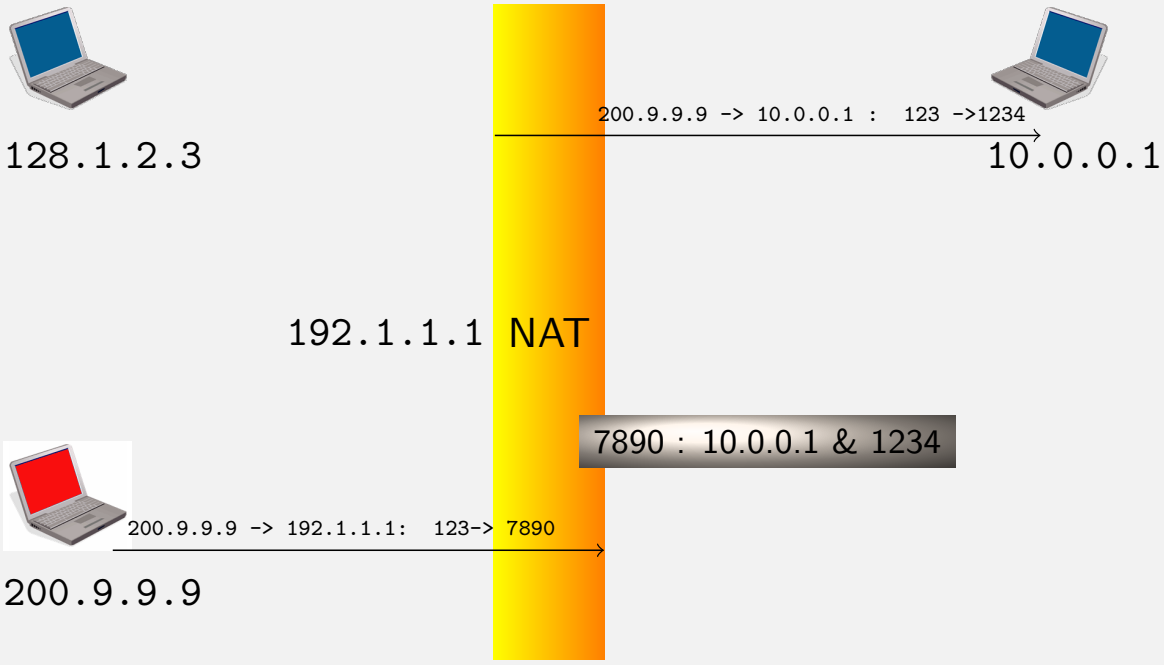
It is difficult to contact a NATed equipment from outside

- Security feeling
- Solutions for NAT traversal exist

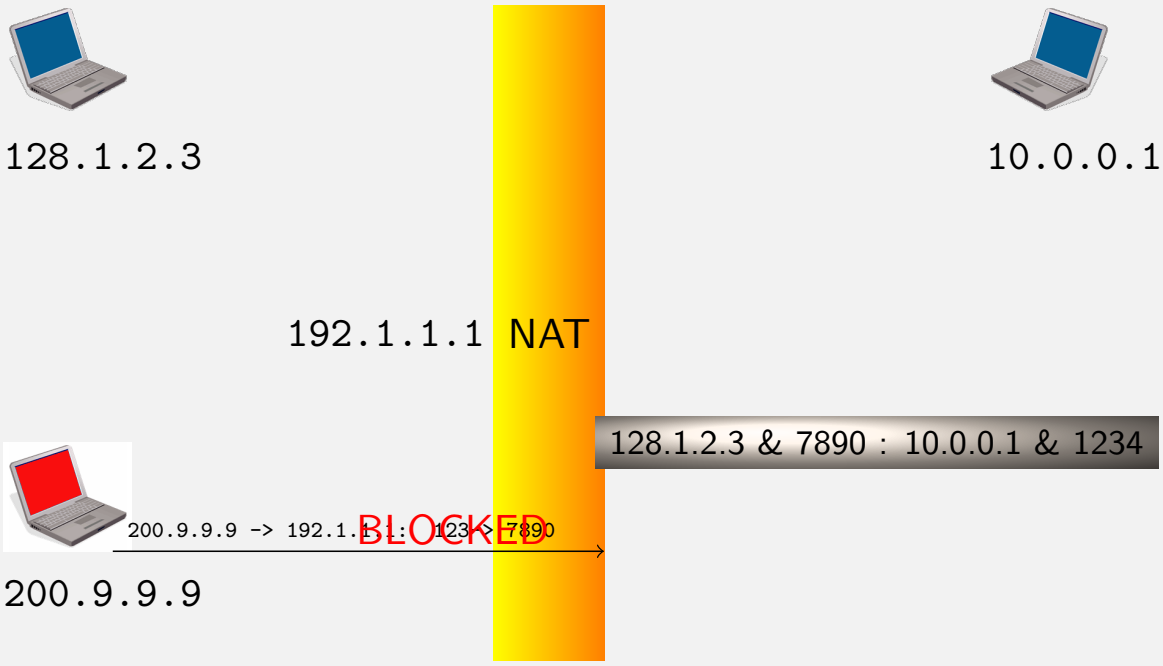
third consequence

There is no standardized behavior for NAT yet

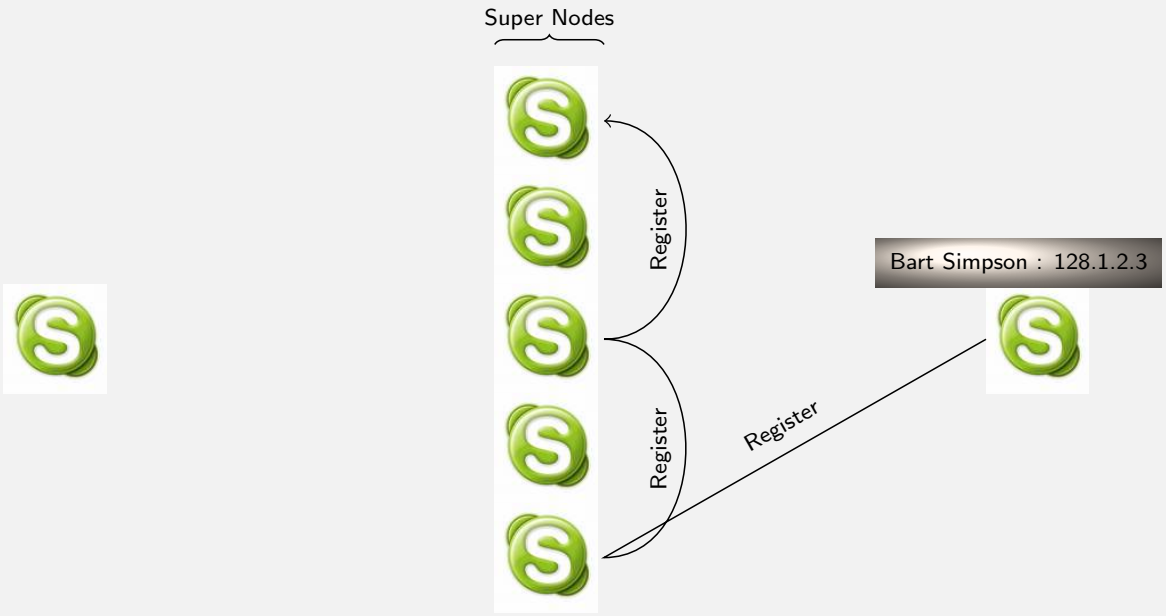
Conic NAT



Restricted NAT



NAT Traversal and Peer To Peer



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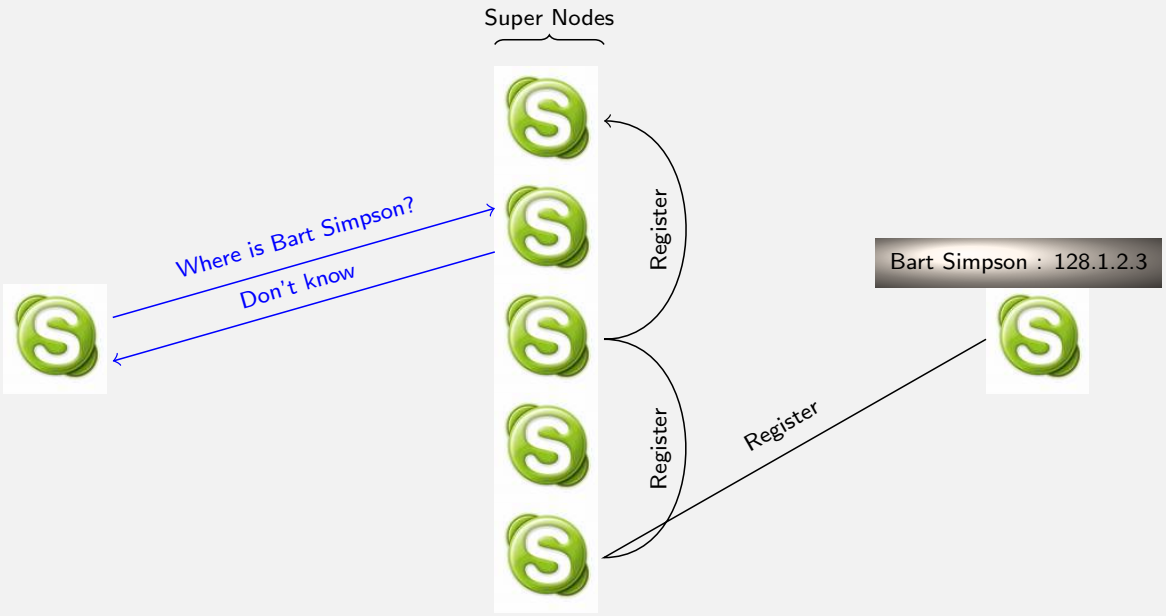

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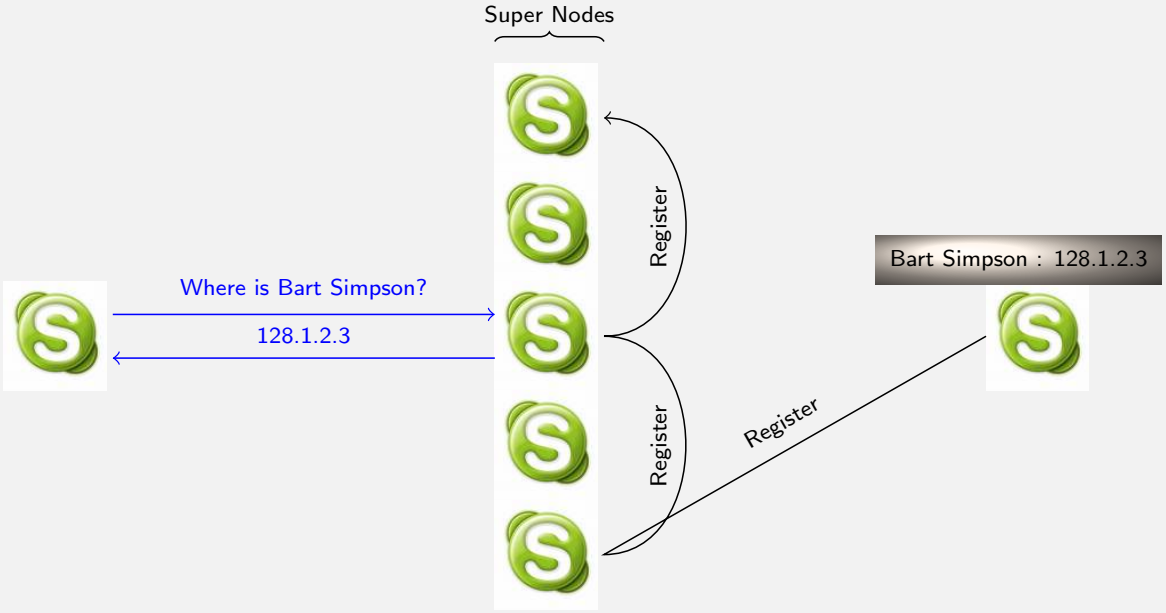

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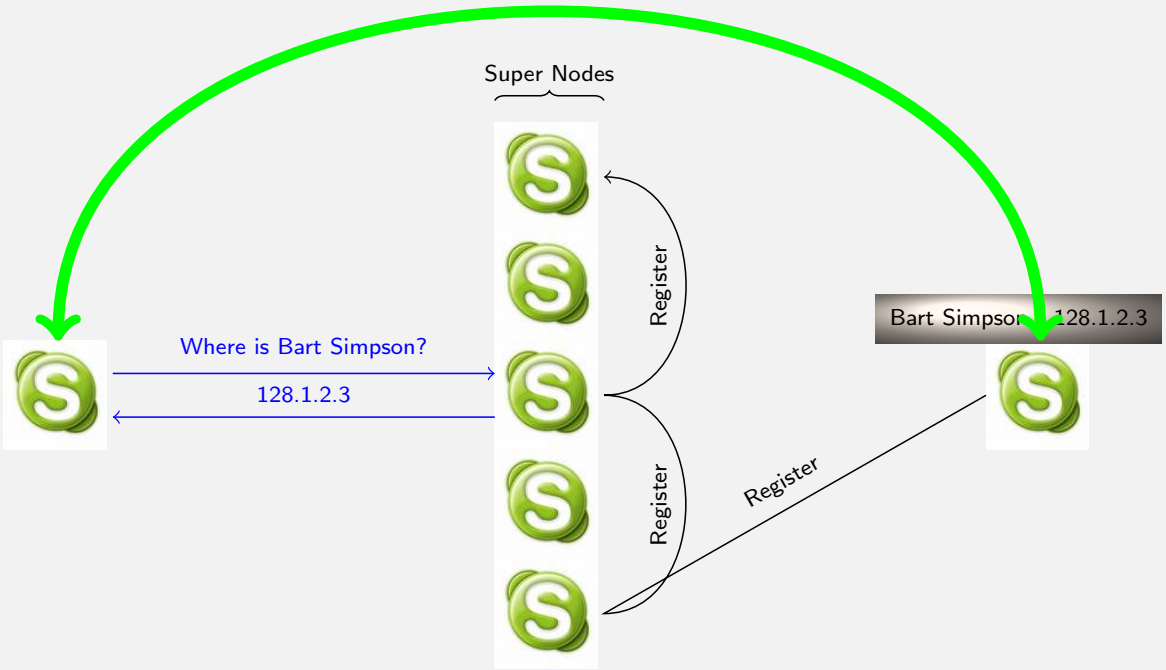

©G6 Association December 20, 2010 22 / 39

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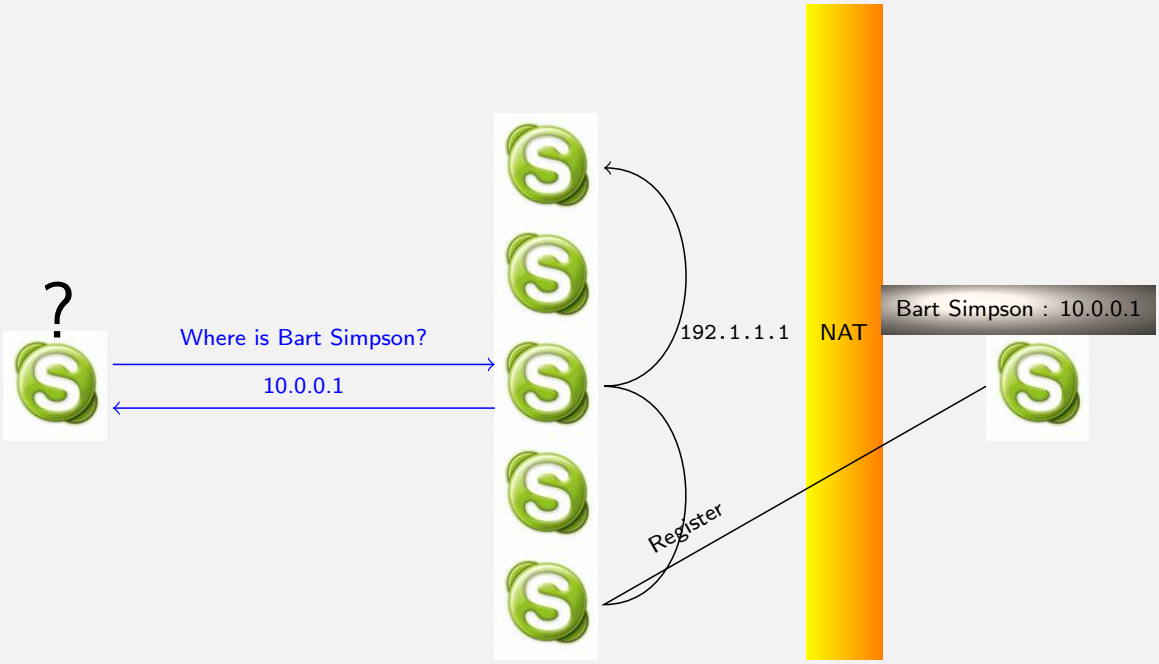

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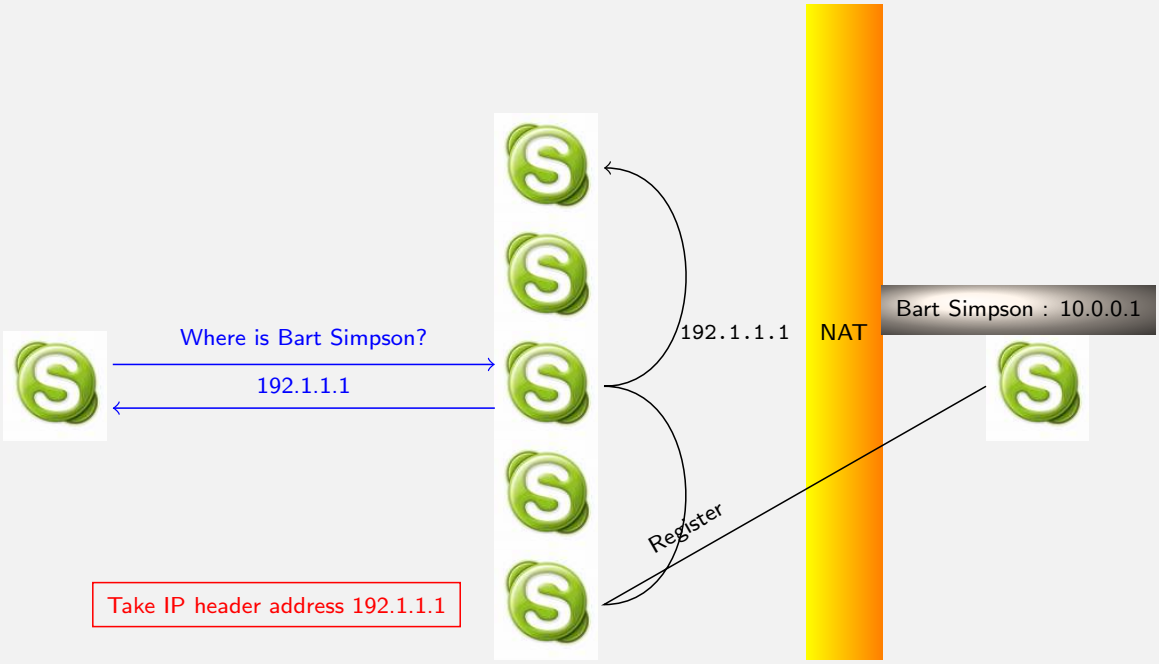

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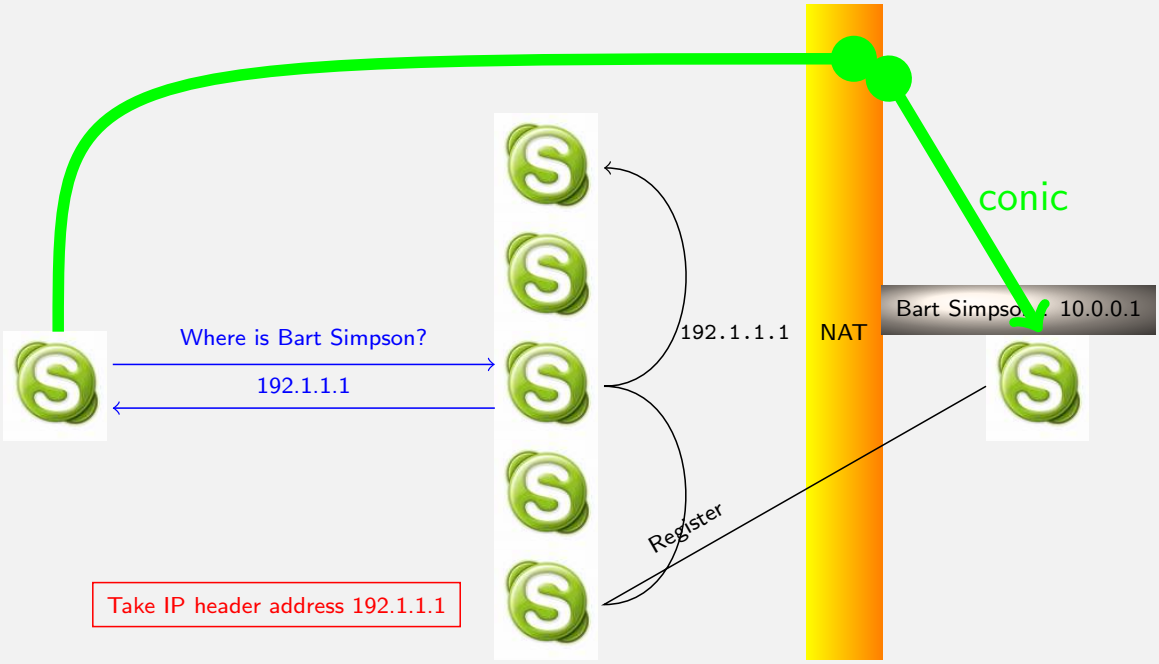

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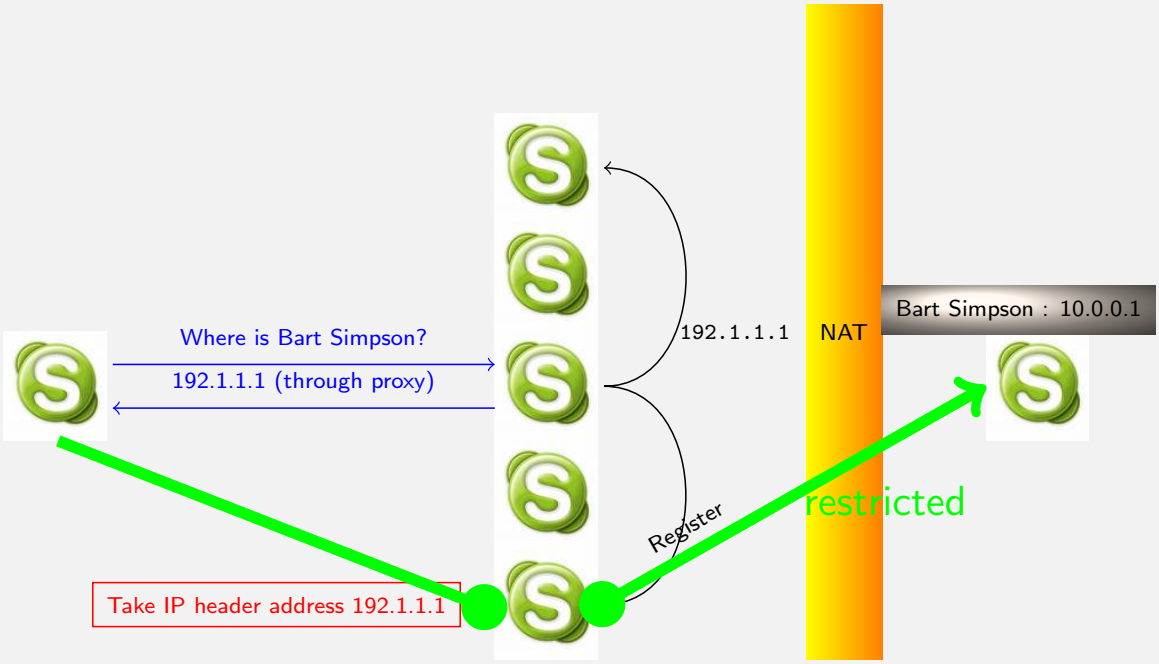


Facts on Addresses

Prefixes delegation

What Has Changed

Classful Addressing

1. Ensure uniqueness
2. Facilitate administrative allocation
   - One central entity

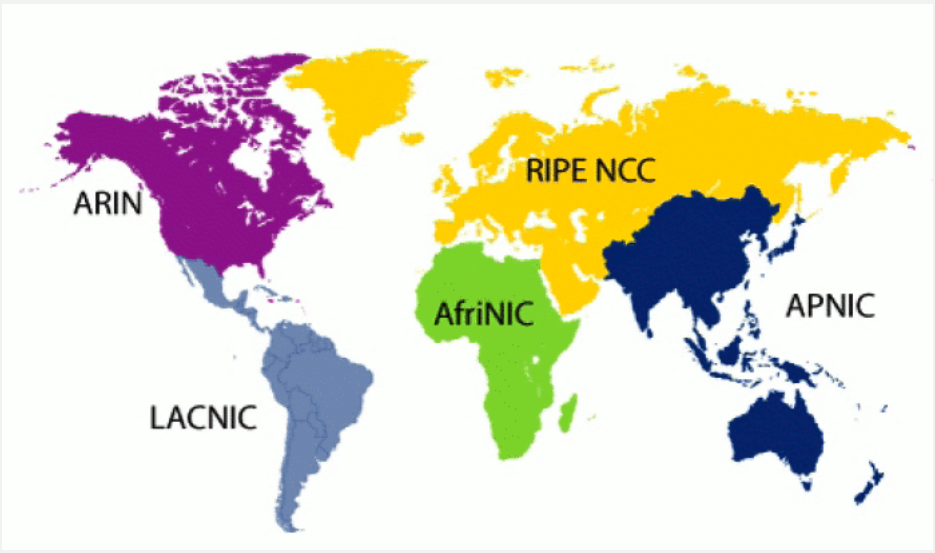
Class-Less (CIDR)

1. Facilitate administrative allocation (hierarchical)
   - Nowadays 5 regional entities
2. Facilitate host location in the network
3. Allocate the minimum pool of addresses

CIDR Administrative Point of View

- A hierarchy of administrative registries
  - IANA/ICANN at the top
- 5 Regional Internet Registries (RIR)
  - APNIC (Asia Pacific Network Information Centre)
  - ARIN (American Registry for Internet Numbers)
  - LACNIC (Regional Latin-American and Caribbean IP Address Registry)
  - RIPE NCC (Réseaux IP Européens - Network Coordination Center)
    - Europe, Middle east.
  - AfriNIC (Africa)
- Providers get prefixes allocation from RIR

RIR Regions



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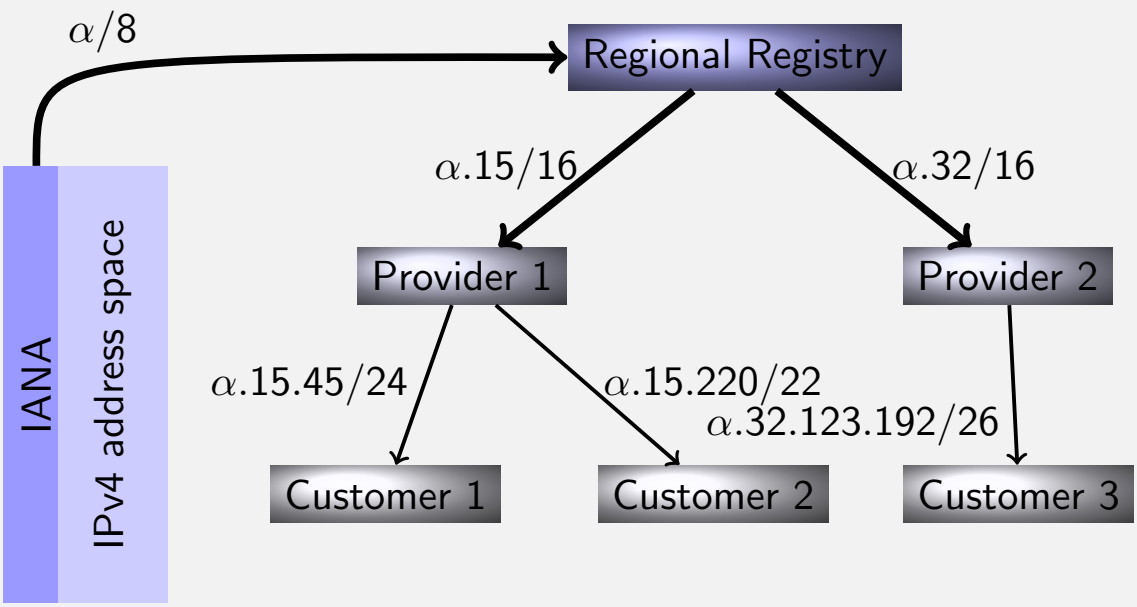
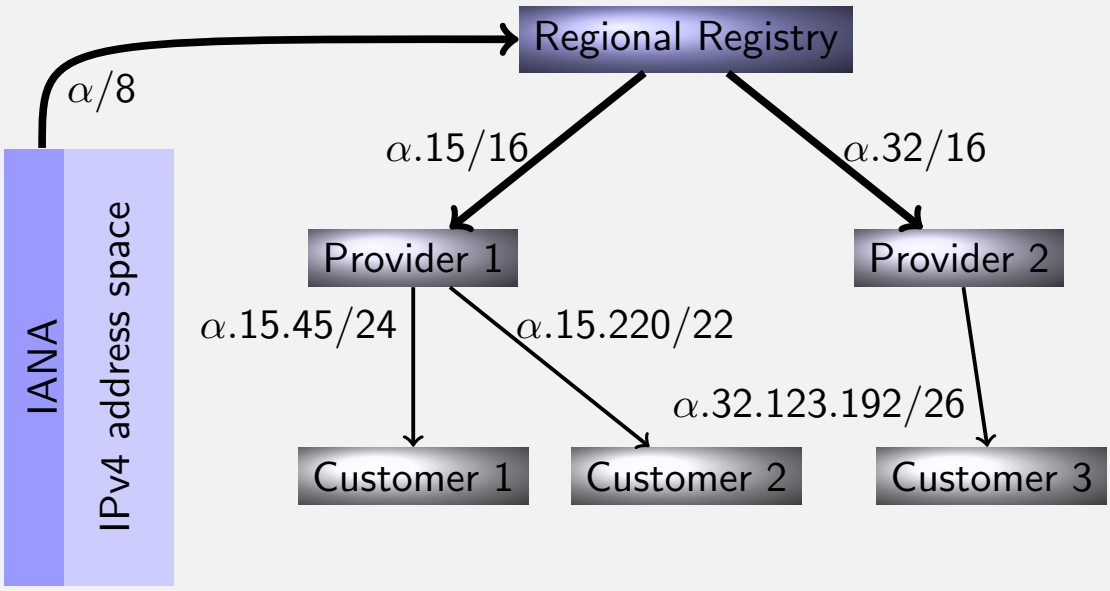


http://www.iana.org/assignments/ipv4-address-space for allocated blocks

Core Network Routing Table



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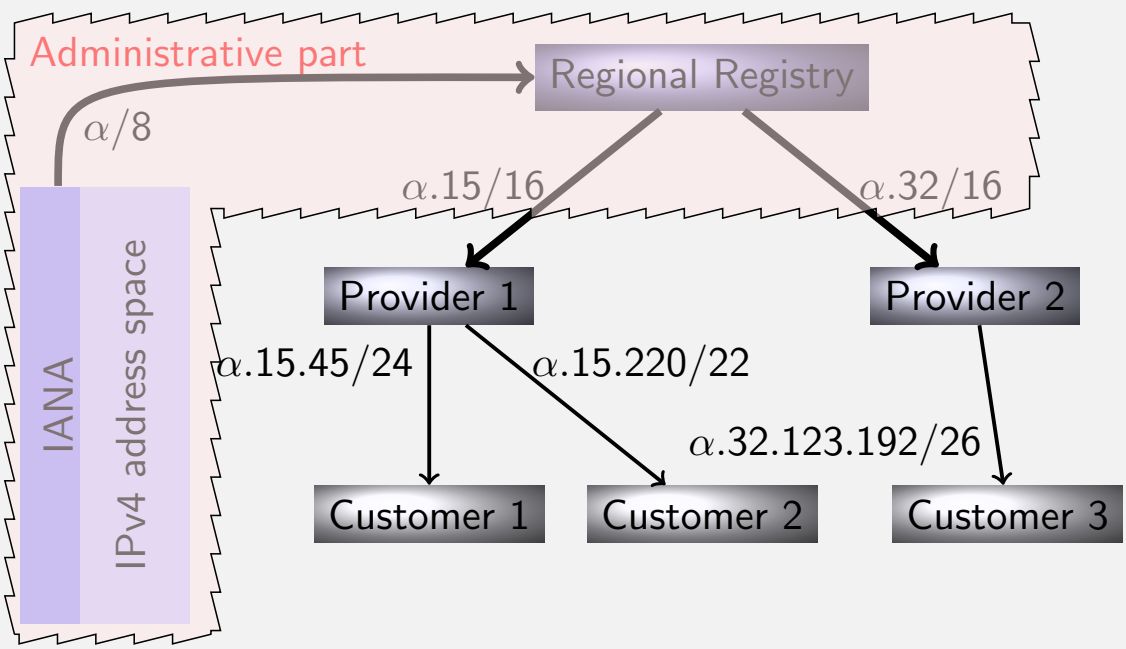

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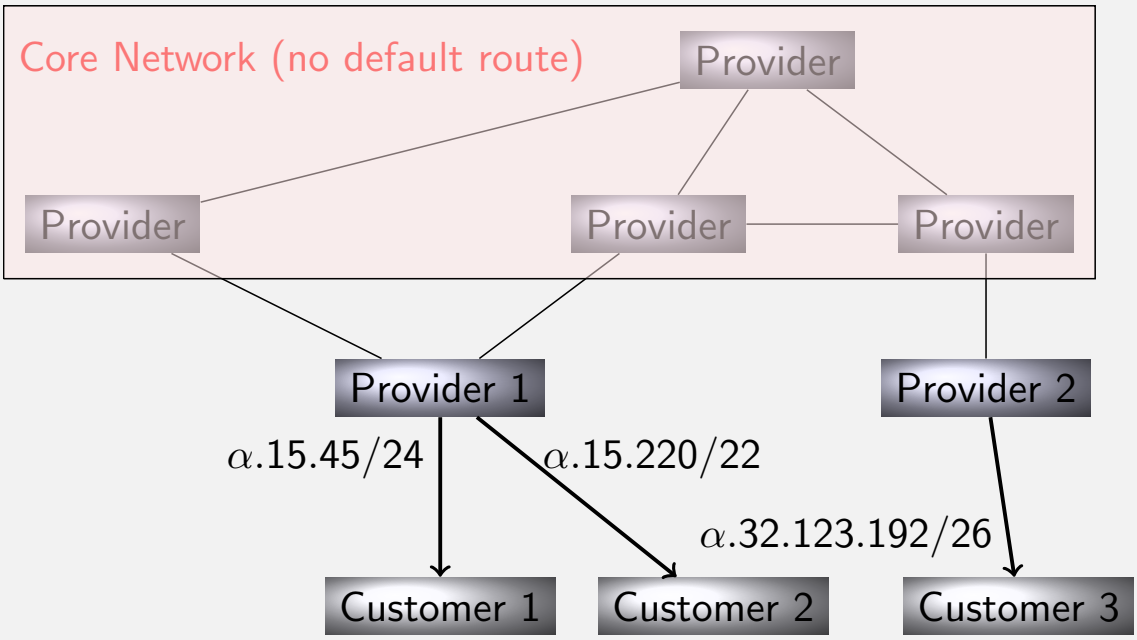

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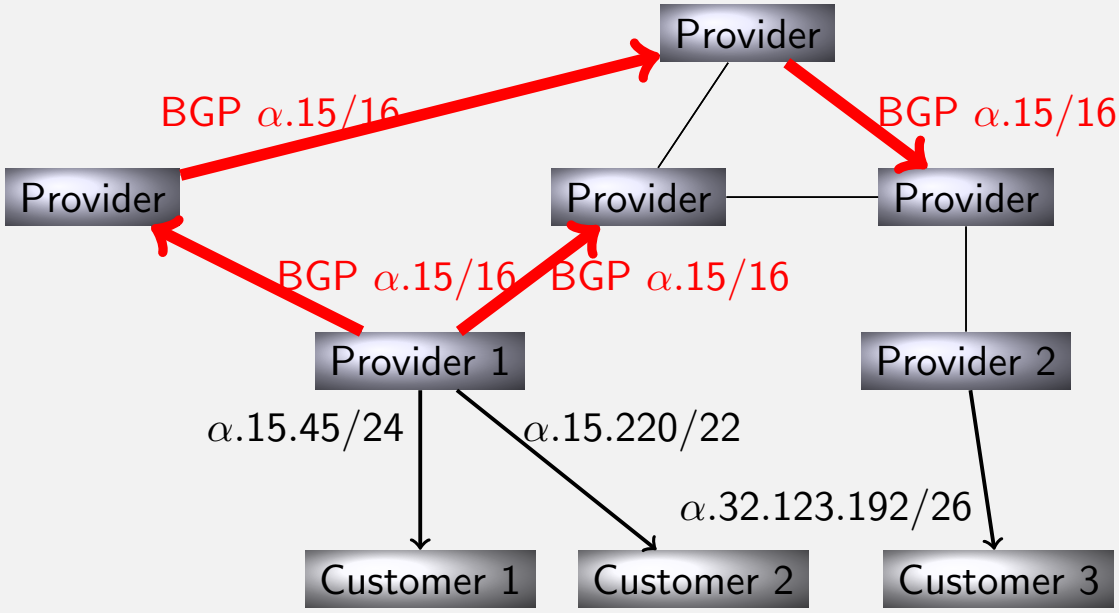
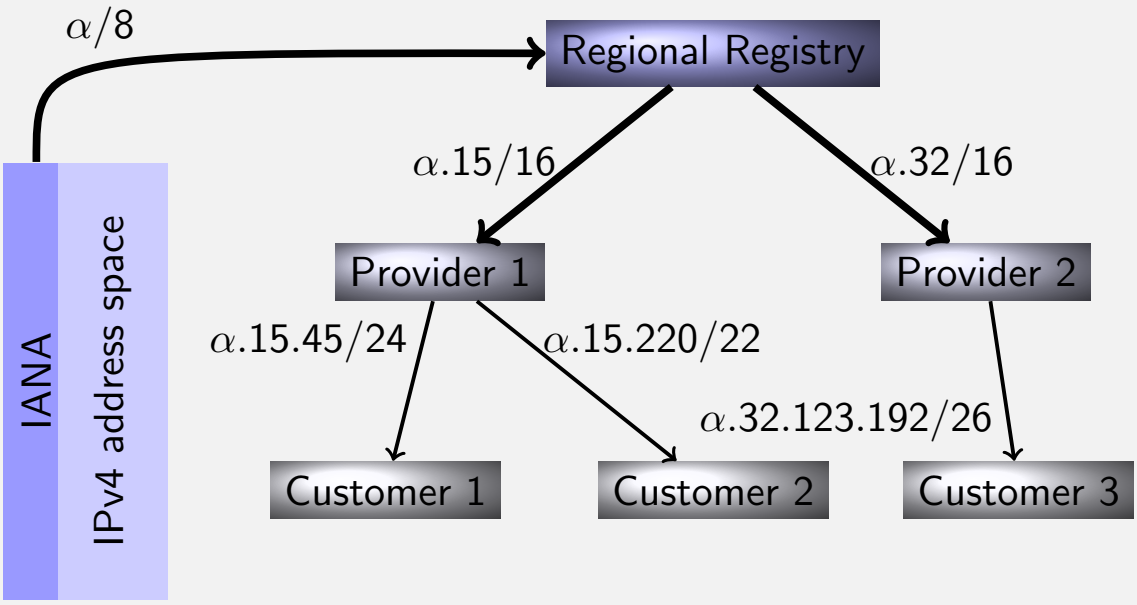


Access Provider Change: Difficult



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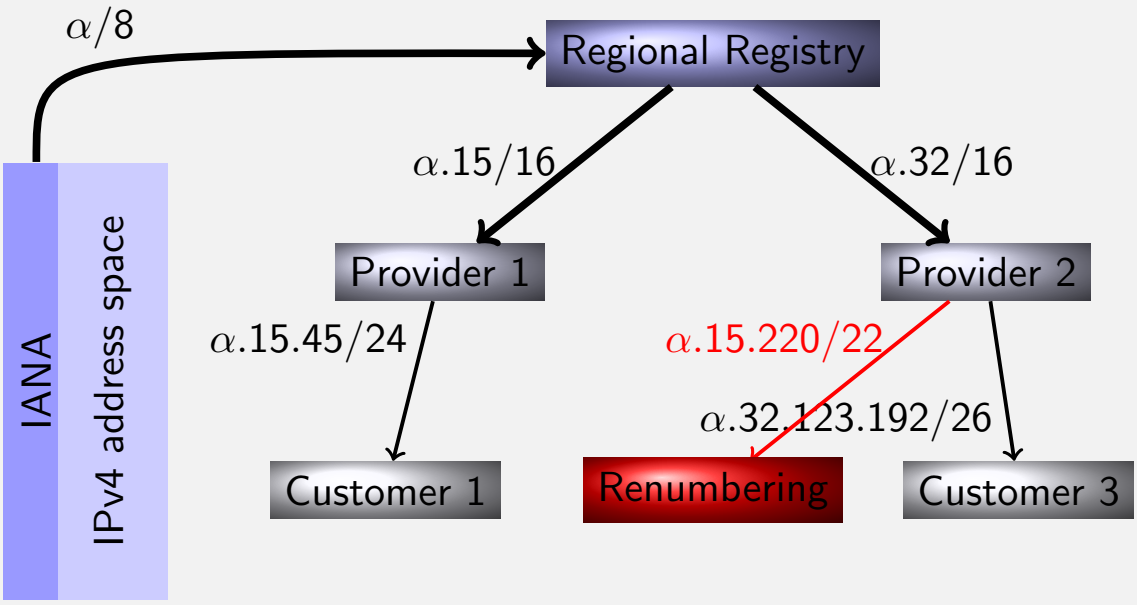
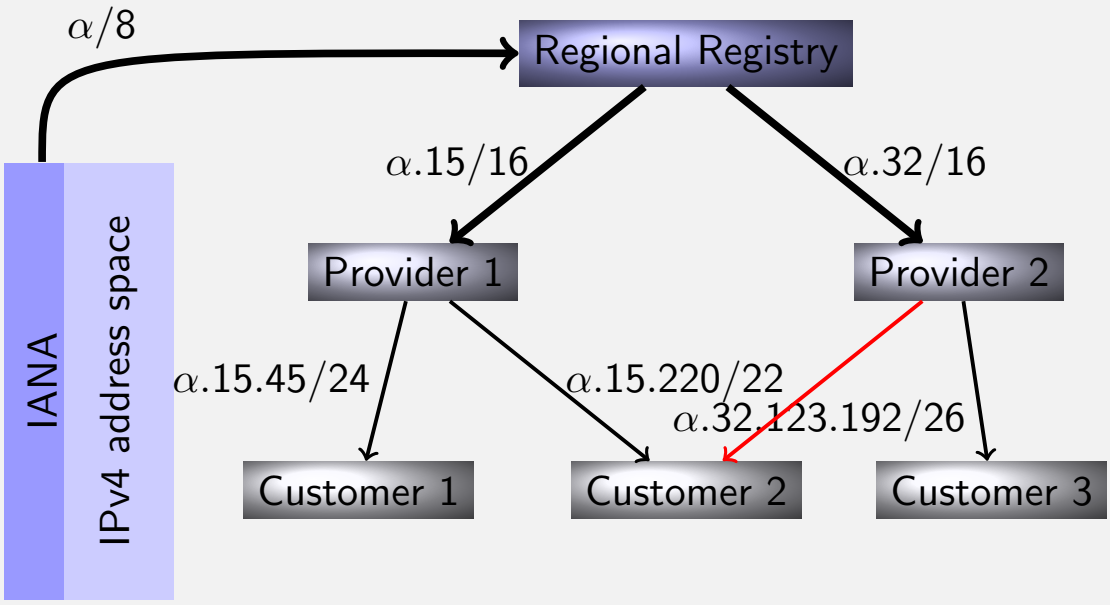


Multi-homing: Difficult



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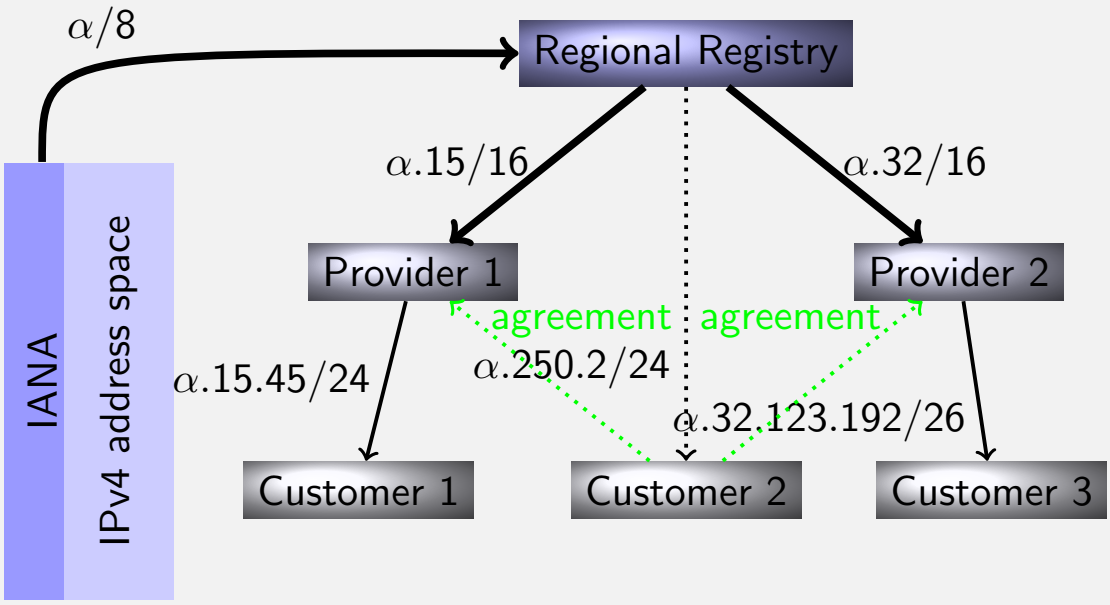
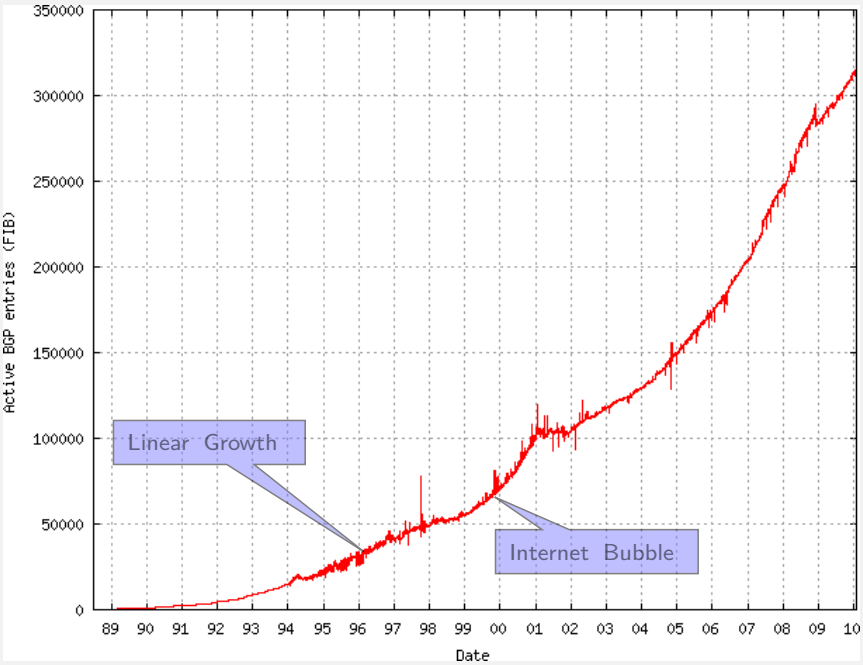


Prefix usage in Feb. 2010



http://www.cidr-report.org/as2.0

Prefix

- CIDR can be viewed as an extension of the netmask concept
- It is called classless since IP addresses are no longer interpreted as belonging to a given Class (A, B, C) based on the value of the 1-4 leading bits
- The prefix length must be added to the 32 bit word to indicate what is the network part.
  - Lookup complexity in the FIB (Forwarding Information Base) is increased:
  - Best prefix match rule

HD-Ratio

- How do define if a customer/provider needs more block ?
- In a hierarchical addressing plan every single prefix cannot be allocated
- High Density Ratio gives occupation of an addressing plan

Definition [RFC 3194]

$$HD = \frac{\log(\text{number of allocated objects})}{\log(\text{maximum number of allocatable objects})}$$

Current HD-Ratio is 0.94! http://www.ripe.net/docs/ipv6policy.html

BGP routing table analysis

Some studies show factors inflating IPv4 BGP routing table

AS Multi-homing

Connection to several AS for fault tolerance

- Subset of the announced prefixes can be announced to other ASes
- Add 20% to 30% prefixes to routing table

Load Balancing

Split traffic between different ASes

- announce different subset to ASes
- Add 20% to 25% prefixes to routing table

BGP routing table analysis

Failure to aggregate

Provider may announce shorter prefixes

- Bad tuning of aggregation rules
- Generate overload of 15% to 20%

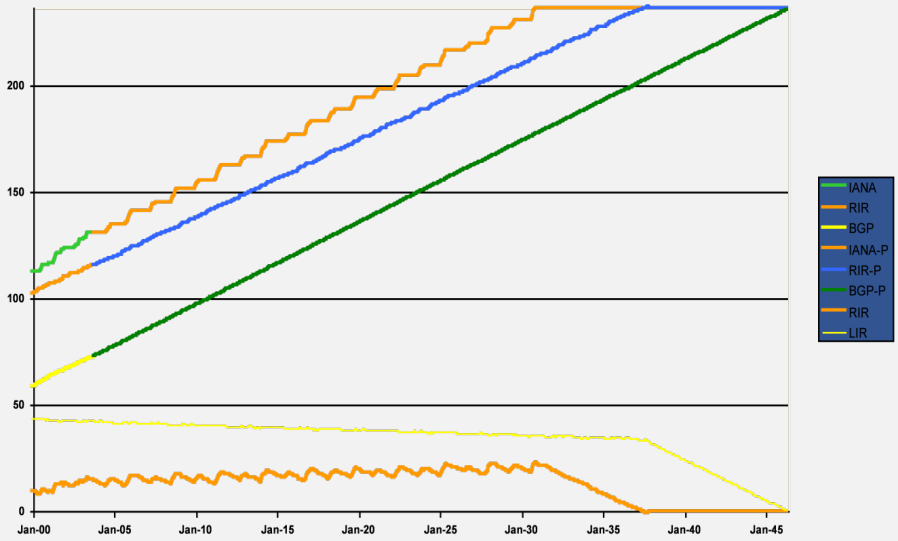
Address fragmentation

Ideally one prefix per provider but

- Historical classfull prefixes
- Blocks are requested sequentially
- Fragmentation contributes to more than 75% of the routing table size

T.Bu, Lixin Gao, and Don Towsley, On Characterizing Routing Table Growth, GlobalInternet 2002
http://www-unix.ecs.umass.edu/~ lgao/globalinternet2002_tian.pdf

Exhaustion of IPv4 Prefix Pool



Projected Exhaustion Date (December 2010)

- IANA Unallocated Address Pool Exhaustion: March 2011
- RIR Unallocated Address Pool Exhaustion: December 2011

http://www.potaroo.net/tools/ipv4/

Addresses versus Packet Format