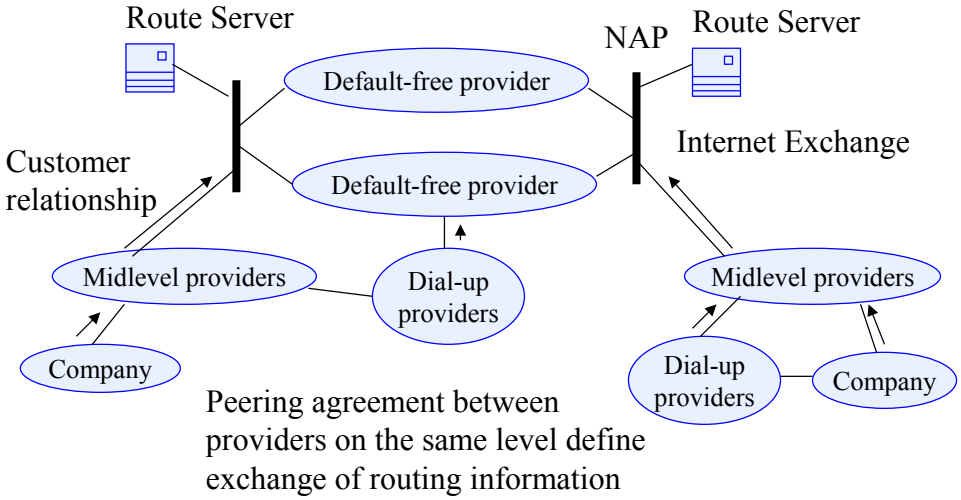
Introduction to exterior routing

Autonomous Systems

- AS – Autonomous System is a part of the Internet owned by a single organization.
- In an AS, usually one interior routing protocol is used
  - e.g. OSPF
- Exterior routing protocol are used between ASs
  - Currently Border Gateway Protocol version 4 (BGPv4) is used.
  - Not discussed in this course

Organization of the Internet as Autonomous Systems

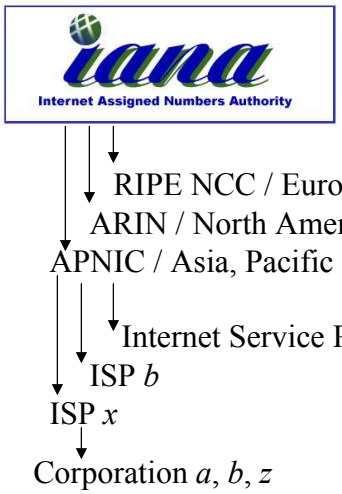


Peering agreement between providers on the same level define exchange of routing information

History of the Internet Core

…..1985 Arpanet
…..1987 NSFNET 56k lines
…..1992 NSFNET T1 lines (1.5M)
…. 1995 NSFNET T3 lines (24M)
1995 NSFNET decommissioned
1995… Commercial (UUNET,MCI, Sprint...

Internet Addresses are assigned by a hierarchy of registrars



- This model leads to provider addressing.
- Due to provider addressing, an IS needs to advertise shorter prefixes, leading to savings in routing table size in the backbone

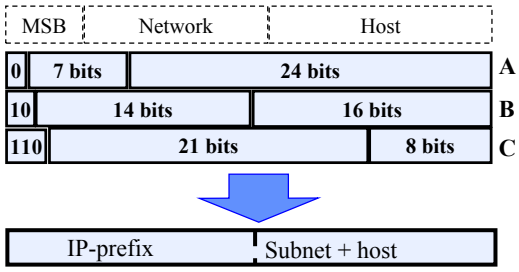
[http://www.iana.org/ipaddress/ip-addresses.htm]

CIDR - Classless Inter-Domain Routing

CIDR – Classless Inter Domain Routing

- Problems caused by the growth of the Internet
  - Not enough B-class addresses
    - Class A is too big, class C too small (256 addresses)
    - Only 16384 class B networks
  - Addresses in class B are used inefficiently
    - Class B is usually too big too (65534 addresses)
  - Growth of routing table size
- Internet growth has forced the adoption of CIDR address arithmetic to improve the efficiency of using IP address space.
- CIDR was adopted 1992

CIDR allows splitting 32-bit IP-addresses freely into prefix and tail



- A sequence of C class networks can be represented:

  194.51.120.0 - 194.51.127.255 =

  start = 194.51.120.0

  mask = 255.255.248.0

Repetition: address arithmetics

- Example

	192.24.134.23	address
AND	255.255.248.0	mask
	192.24.128.0	network
	192.24.143.23	address
AND	0.0.7.255	NOT (mask)
	0.0.6.23	host

network host (subnet+host)

11000000.00011000.10000110.00010111 address
11111111.11111111.11111000.00000000 mask

Repetition: address arithmetics

- Example

	192.24.134.23	address	
AND	255.255.248.0	mask	
	192.24.128.0	network	
	192.24.143.23	address	
AND	0.0.7.255	NOT (mask)	
	0.0.6.23	host	
	192.24.134.23	address	(alternative way)
–	192.24.128.0	network	
	0.0.6.23	host	

CIDR changes the way routes are advertised

- Rule 1:
  - Routing always looks for longest match address with the destination.
    → addresses of multi-homed networks can not be aggregated.
    (multi-homed network connects to many ASs.)
- Rule 2:
  - A network that aggregates a set of routes must delete packets that match with the aggregated prefix but with none of the network addresses that went into the aggregate. This helps to avoid loops.

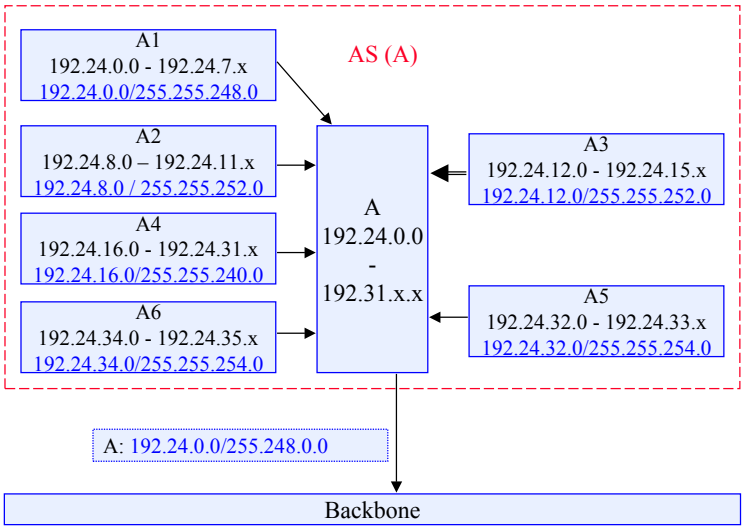
Example (1)

- Customers of the ISP
  - A1: ≤ 2048 addresses (8 class C networks)
  - A2: ≤ 1024 addresses (4 class C networks)
  - A3: ≤ 1024 addresses (4 class C networks)
  - A4: ≤ 4096 addresses (16 class C networks)
  - A5: ≤ 512 addresses (2 class C networks)
  - A6: ≤ 512 addresses (2 class C networks)

Example (2)

- Customers of the ISP
  - A1: ≤ 2048 addresses (8 class C networks)
    - 192.24.0 – 192.24.7 192.24.0.0 / 255.255.248.0
  - A2: ≤ 1024 addresses (4 class C networks)
    - 192.24.8 – 192.24.11 192.24.8.0 / 255.255.252.0
  - A3: ≤ 1024 addresses (4 class C networks)
    - 192.24.12 – 192.24.15 192.24.12.0 / 255.255.252.0
  - A4: ≤ 4096 addresses (16 class C networks)
    - 192.24.16 – 192.24.31 192.24.16.0 / 255.255.240.0
  - A5: ≤ 512 addresses (2 class C networks)
    - 192.24.32 – 192.24.33 192.24.32.0 / 255.255.254.0
  - A6: ≤ 512 addresses (2 class C networks)
    - 192.24.34 – 192.24.35 192.24.34.0/255.255.254.0

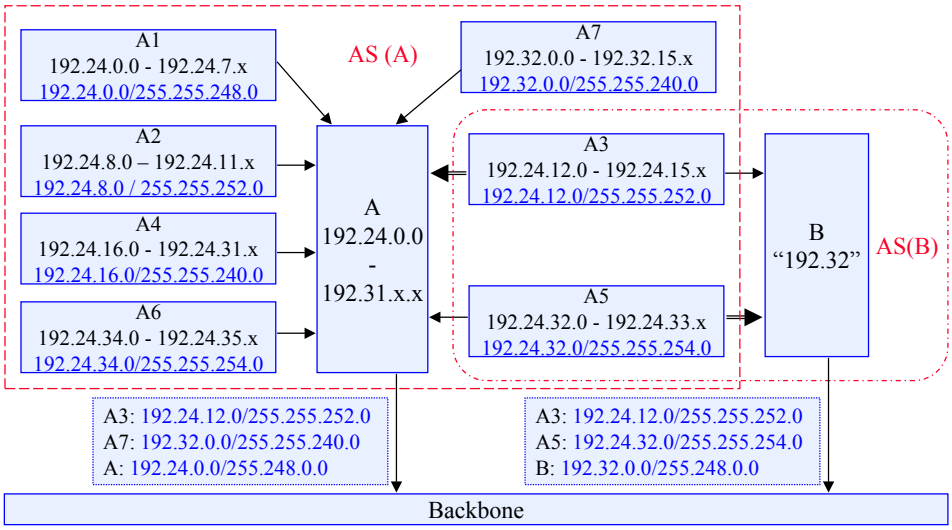
Example (3)



Example (4)

- Assuming that there is another AS (B)
  - Network 192.32.0.0 / 255.248.0.0
- A3 and A5 are attached to two ASs
  - A3 is primarily advertised through A
  - A5 is primarily advertised through B
- A7 has moved AS (B) → AS (A)
  - Network 192.32.0.0 / 255.255.240.0

Example (5)

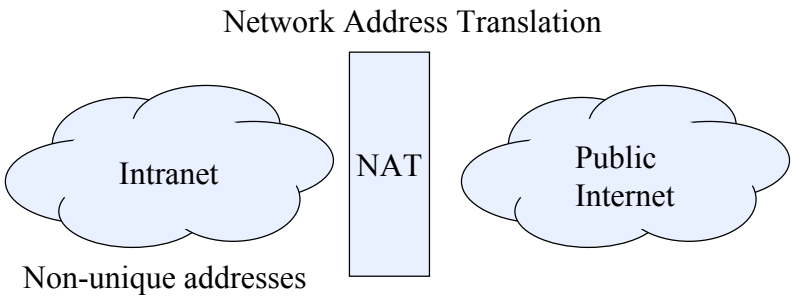


CIDR affects most routing protocols

Protocols that support CIDR

- Exterior protocols
  - Support: BGP-4
  - No support: EGP, BGP-3
- Interior protocols
  - Support: RIP-2, OSPF, E-IGRP
  - No support: RIP, IGRP

Network Address Translation (NAT) preserves address space and improves security



Non-unique addresses

- 10/8
- 172.16/12
- 192.168/16

⇒ Not routable in public Internet