Networking Technologies and Applications

Rolland Vida
BME TMIT

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Subnetting Example

- An organization with 4 departments has the following IP address space: 10.2.22.0/23. As the systems manager, you are required to create subnets to accommodate the IT needs of 4 departments. The subnets have to support to 200, 61, 55, and 41 hosts respectively. What are the 4 **subnet network** numbers?

- Solution:
  - 10.2.22.0/24 (256 addresses > 200)
  - 10.2.23.0/26 (64 addresses >61)
  - 10.2.23.64/26 (64 addresses > 55)
  - 10.2.23.128/26 (64 addresses > 41)

10.2.22.0/23 = 10.2.00010110.00000000/23
10.2.22.0/24 = 10.2.00010110.00000000/24
10.2.23.0/26 = 10.2.00010111.00000000/26
10.2.23.64/26 = 10.2.00010111.01000000/26
10.2.23.128/26 = 10.2.00010111.10000000/26
10.2.23.192/26 = 10.2.00010111.11000000/26

CIDR and Address assignments

- IANA – Internet Assigned Numbers Authority
  - The RIRs get short prefix CIDR blocks
    - Regional Internet Registries
  - E.g., 62.0.0.0/8 assigned to RIPE NCC
    - Réseaux IP Européens Network Coordination Centre
- RIRs fragment and redistribute parts of the address space
  - Backbone ISPs obtain large blocks of IP address space and then reallocate portions of their address blocks to their customers.

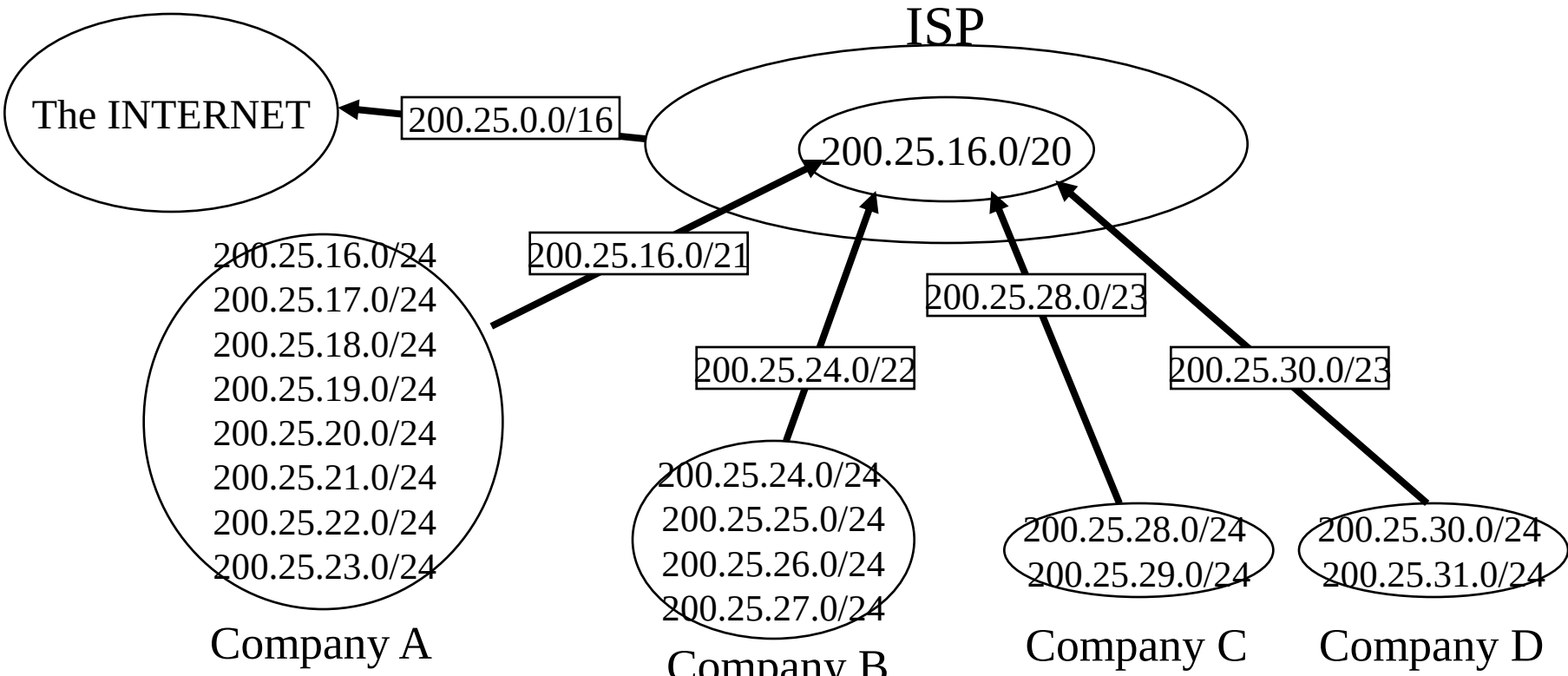
Example:

- Assume that an ISP owns the address block 206.0.64.0/18, which represents 16,384 ($2^{32-18}=2^{14}$) IP host addresses
- Suppose a client requires 800 host addresses
  - $512=2^9<800<1024=2^{10}$ -> 32-10 = 22,
  - Assigning a /22 block, i.e., 206.0.68.0/22 -> gives a block of 1,024 (2^{10}) IP addresses to client.

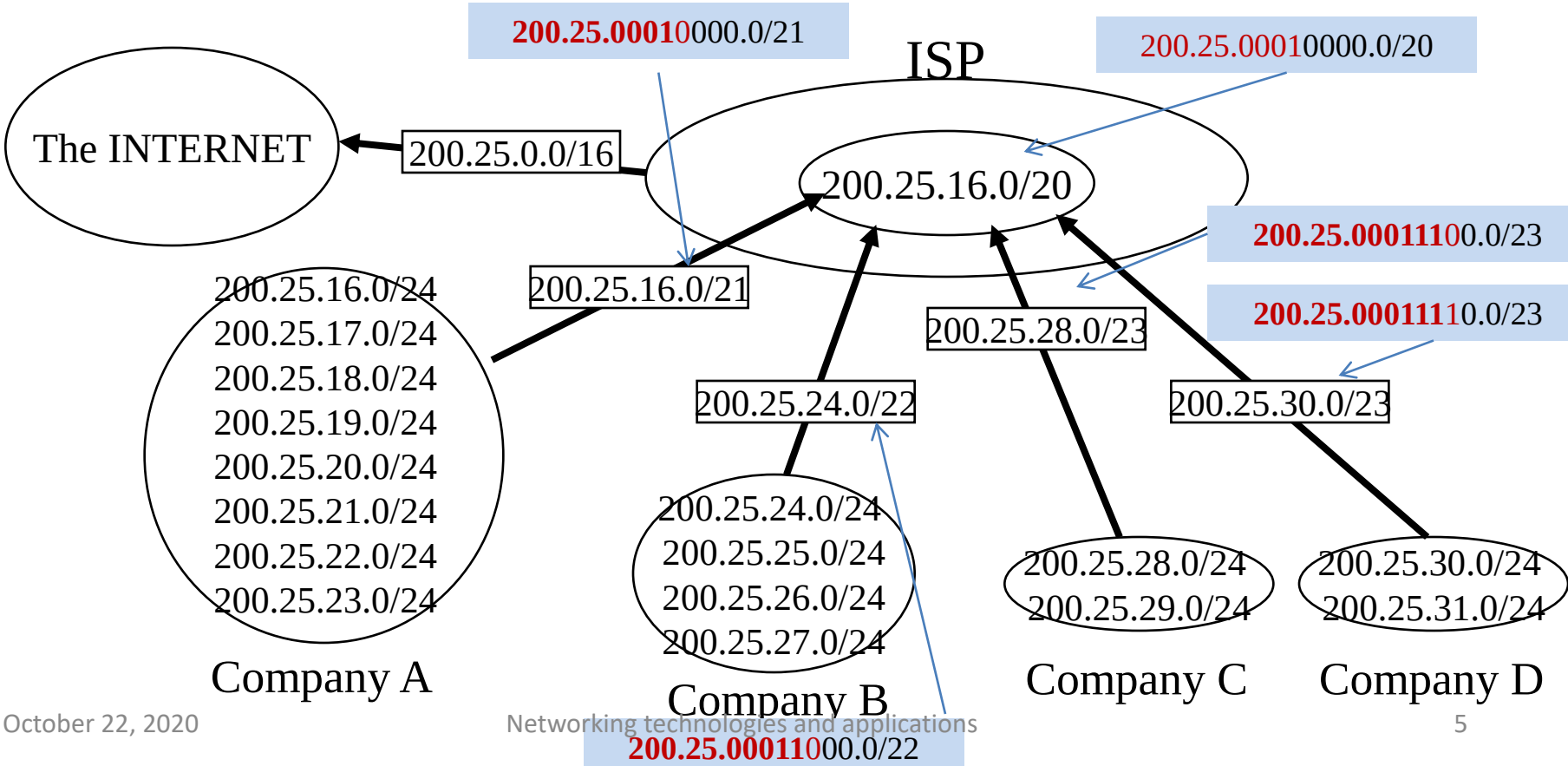
01000000

01000100

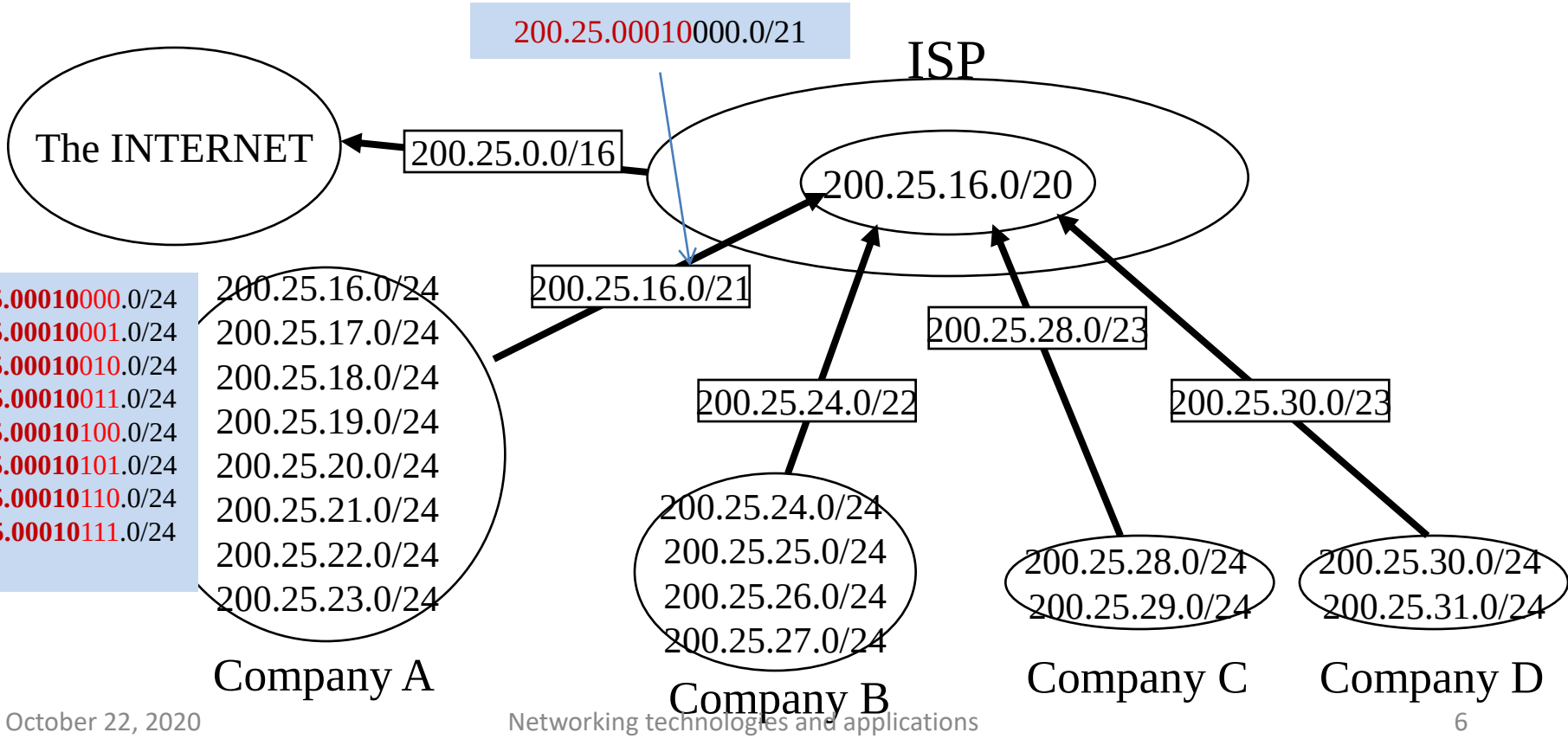
CIDR example



CIDR example



CIDR example



CIDR and Routing

- **Longest prefix match**: Routing table lookup finds the routing entry that matches the longest prefix

E.g., What is the outgoing interface for destination IP address: 128.143.137.0?

Prefix	Interface/outgoing link
128.143.128.0/17	interface #1
128.128.0.0/9	interface #2
128.0.0.0/4	interface #5

Routing table

CIDR and Routing

128.143.128.0/17 = 10000000.10001111.10000000.00000000/17
128.128.0.0/9 = 10000000.10000000.10000000.00000000/9
128.0.0.0/4 = 10000000.10000000.10000000.00000000/4

128.143.137.0 = 10000000.10001111.10001001.00000000

E.g., What is the outgoing interface for destination IP address: 128.143.137.0?

Prefix	Interface/outgoing link
128.143.128.0/17	interface #1
128.128.0.0/9	interface #2
128.0.0.0/4	interface #5

Routing table

CIDR and Routing

- **Aggregation** of routing table entries:
  - 128.143.0.0/16 and 128.142.0.0/16 can be represented as 128.142.0.0/15 at a router.
    - 143 = 10001111 142 = 10001110.

Compressing routing tables

How can we compress the below routing table using CIDR?

DestNet	NetMask	Interface
194.100.0.0	255.255.255.0	I1
194.100.1.0	255.255.255.0	I1
194.100.2.0	255.255.254.0	I1
194.100.4.0	255.255.252.0	I1
194.100.8.0	255.255.248.0	I1
194.100.48.0	255.255.240.0	I1
194.100.64.0	255.255.240.0	I1

Compressing routing tables

DestNet	NetMask	IF
194.100.0.0	255.255.255.0	I1
194.100.1.0	255.255.255.0	I1
194.100.2.0	255.255.254.0	I1
194.100.4.0	255.255.252.0	I1
194.100.8.0	255.255.248.0	I1
194.100.48.0	255.255.240.0	I1
194.100.64.0	255.255.240.0	I1

- 194.100.0.0/24 -> from 194.100.0.0 to 194.100.0.255 (#256)
- 194.100.1.0/24 -> from 194.100.1.0 to 194.100.1.255 (#256)
- 194.100.2.0/23 -> from 194.100.2.0 to 194.100.3.255 (#512)
- 194.100.4.0/22 -> from 194.100.4.0 to 194.100.7.255 (#1024)
- 194.100.8.0/21 -> from 194.100.8.0 to 194.100.15.255 (#2048)
- Continuous address spaces, the first 20 bits match, 4096 addresses
  - With CIDR 194.100.0.0/20

194.100.00000000.0/20

- 194.100.48.0/20 -> from 194.100.48.0 to 194.100.63.255 (#4096)
- 194.100.64.0/20 -> from 194.100.64.0 to 194.100.79.255 (#4096)

194.100.00110000.0/20
194.100.01000000.0/20

- Continuous address space, but 48 -> 00110000, 64 -> 01000000, the first 19 bits do not match, we cannot aggregate into a /19 address

Compressing routing tables

DestNet	NetMask	IF
194.100.0.0	255.255.255.0	I1
194.100.1.0	255.255.255.0	I1
194.100.2.0	255.255.254.0	I1
194.100.4.0	255.255.252.0	I1
194.100.8.0	255.255.248.0	I1
194.100.48.0	255.255.240.0	I1
194.100.64.0	255.255.240.0	I1

- Compressed CIDR routing table

DestNet	IF
194.100.0.0/20	I1
194.100.48.0/20	I1
194.100.64.0/20	I1

Compressing routing tables

How can we compress the below routing table with CIDR

DestNet	NetMask	IF
200.0.0.0	255.255.192.0	A
200.0.64.0	255.255.192.0	A
200.0.128.0	255.255.128.0	A
200.1.0.0	255.255.0.0	A
193.0.2.0	255.255.255.0	B
193.0.3.0	255.255.255.0	B
193.0.4.0	255.255.255.0	B
193.0.5.0	255.255.255.0	B

Compressing routing tables

DestNet	NetMask	IF
200.0.0.0	255.255.192.0	A
200.0.64.0	255.255.192.0	A
200.0.128.0	255.255.128.0	A
200.1.0.0	255.255.0.0	A
193.0.2.0	255.255.255.0	B
193.0.3.0	255.255.255.0	B
193.0.4.0	255.255.255.0	B
193.0.5.0	255.255.255.0	B

- 200.0.0.0/18 -> from 200.0.0.0 to 200.0.63.255 (#16384)
- 200.0.64.0/18 -> from 200.0.64.0 to 200.0.127.255 (#16384)
- 200.0.128.0/17 -> from 200.0.128.0 to 200.0.255.255 (#32768)
- 200.1.0.0/16 -> from 200.1.0.0 to 200.1.255.255 (#65536)
- Continuous address spce, first 15 bits match, 131072 addresses
  - With CIDR 200.0.0.0/15

- 193.0.2.0/24 -> from 193.0.2.0 to 193.0.2.255 (#256)
- 193.0.3.0/24 -> from 193.0.3.0 to 193.0.3.255 (#256)
- 193.0.4.0/24 -> from 193.0.4.0 to 193.0.4.255 (#256)
- 193.0.5.0/24 -> from 193.0.5.0 to 193.0.5.255 (#256)
- 193.0.2.0 and 193.0.3.0 continuous, first 23 bits match -> 193.0.2.0/23
- 193.0.4.0 and 193.0.5.0 continuous, first 23 bits match -> 193.0.4.0/23

Compressing routing tables

- Compressed CIDR routing table

DestNet	IF
200.0.0.0/15	A
193.0.2.0/23	B
193.0.4.0/23	B

DestNet	NetMask	IF
200.0.0.0	255.255.192.0	A
200.0.64.0	255.255.192.0	A
200.0.128.0	255.255.128.0	A
200.1.0.0	255.255.0.0	A
193.0.2.0	255.255.255.0	B
193.0.3.0	255.255.255.0	B
193.0.4.0	255.255.255.0	B
193.0.5.0	255.255.255.0	B

Problems with Classful IP Addresses

Problem 5. The Internet is going to outgrow the 32-bit addresses

- **Fix #3: IP Version 6**