CMP3214 Computer Communication Networks

Lecture 6

Internet Protocol

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Internet Protocol

- IPv4 defined in 1981 as RFC 791.
- Limited address space of 4.3 billion addresses (2^{32}) is now telling which is forcing change to IPv6 with its $3.4x10^{38}$ addresses (21^{28}).
  - 0.0.0.0/0 Default address
  - 127.0.0.1/32 Localhost

Internet Protocol classes, A, B and C

- **Class A** (network.host.host.host):
  - 1.0.0.1 to 127.255.255.254
  - 126 networks, 16 million nodes.
  - The binary standard is: 0 + 7 network bits + 24 node bits.
- **Class B** (network.network.host.host):
  - 128.0.0.1 to 191.255.255.254
  - 16K networks, 65K nodes
  - The binary standard is 10 + 14 network bits + 16 node bits.
- **Class C** (net.net.net.host):
  - 192.0.0.1 to 223.255.255.254
  - 2 million of networks, 254 nodes.
  - The binary standard is 110 + 21 network bits + 8 node bits.

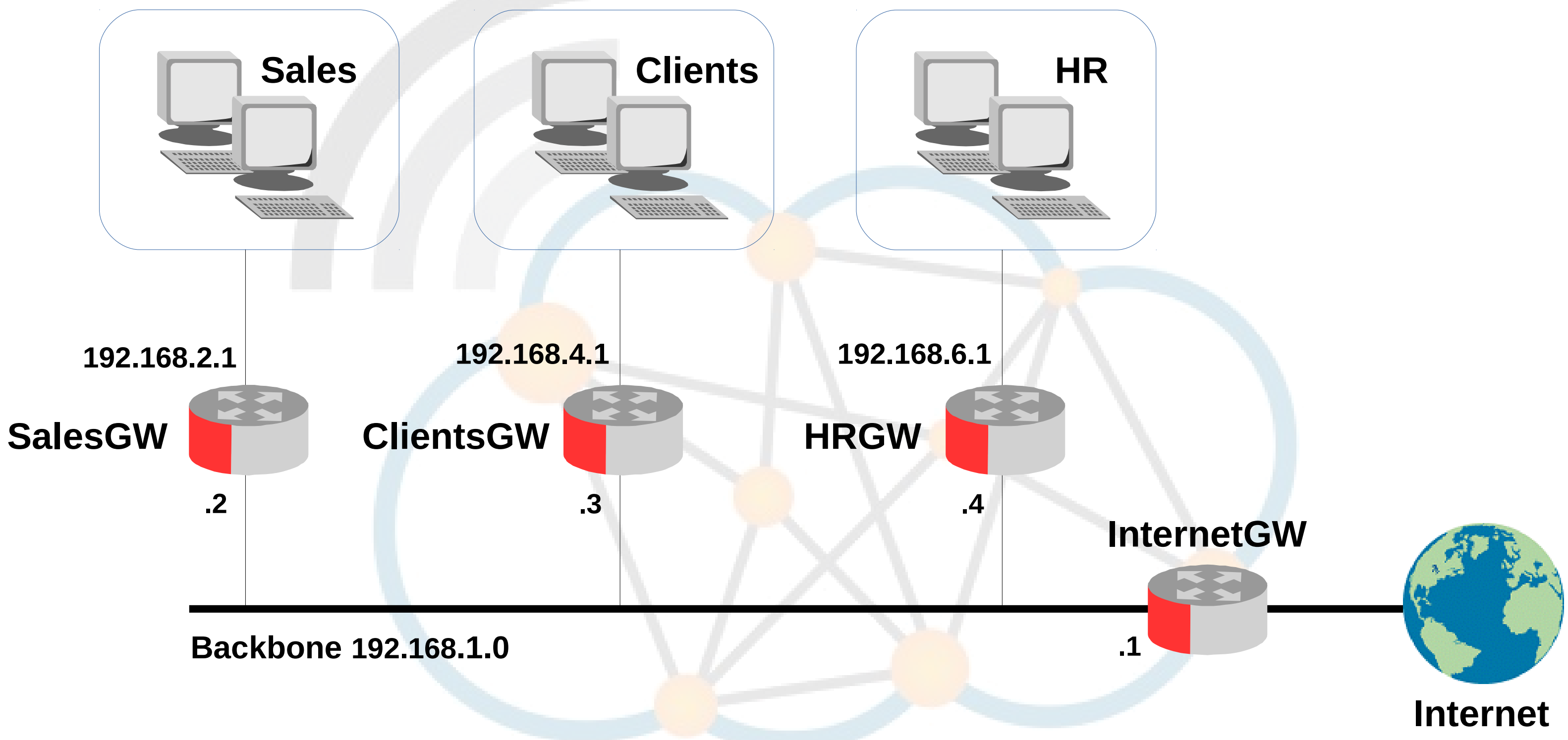
Internet Protocol classes, D and E

- **Class D**
  - 224.0.0.1 to 239.255.255.255
  - Reserved for Multicast
- **Class E**
  - 240.0.0.1 to 255.255.255.255 reserved for experimental purposes.

Private networks

- **Class A** - 10.0.0.0 to 10.255.255.255
- **Class B** - 172.16.0.0 to 172.31.0.0
- **Class C** - 192.168.0.0 to 192.168.255.0.

Routing



Sales
Clients
HR
192.168.2.1
192.168.4.1
192.168.6.1
SalesGW
ClientsGW
HRGW
.2
.3
.4
InternetGW
Backbone 192.168.1.0
.1
Internet

Routing – SalesGW Routing table

Address	Mask	Gateway	Interface
192.168.1.0	255.255.255.0 /24	-	eth1
192.168.4.0	255.255.255.0 /24	192.168.1.2	eth1
192.168.6.0	255.255.255.0 /24	192.168.1.3	eth1
0.0.0.0	0.0.0.0	192.168.1.1	eth1
192.168.2.0	255.255.255.0 /24	-	eth0

IPv4 Subnetting

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Subnetting

10010110.11010111.**0001**0001.01100010	150.215.017.098	IP Address
11111111.11111111.**1111**0000.00000000	255.255.240.000	Subnet Mask
10010110.11010111.00010000.00000000	150.215.016.000	Network address

$2^4 - 2 = 14$

The 14 possible subnets:

150.215.0.0, 150.215.16.0, 150.215.32.0,
150.215.64.0, 150.215.80.0, 150.215.96.0,
150.215.112.0, 150.215.128.0, 150.215.144.0,
150.215.160.0, 150.215.176.0, 150.215.192.0,
150.215.208.0, 150.215.224.0

Calculate the network of 150.215.17.9/20

Step 1: Indentify “**Interesting Octet**”.

			Interesting Octet	
Subnet mask	255	255	240	0
IP Address	150	215	17	9

Calculate the Network Components

Step 2: Indentify “**Subnet differentiator**”.

			Interesting Octet	
Subnet mask	255	255	240	0
IP Address	150	215	17	9

256 – 240 = 16

Calculate the Network Components

Step 3: Generate a possible subnet list.

			Interesting Octet	
Subnet mask	255	255	240	0
IP Address	150	215	17	9

256 – 240 = 16

0
16
32
48
64
80
96
112
128
144
160
176
192
208
224
240
256

Calculate the Network Components

Step 4: Drop down left hand side octets.

			Interesting Octet	
Subnet mask	255	255	240	0
IP Address	150	215	17	9
	↓	↓		
Resident Network	150	215		
Broadcast Address	150	215		
First Address	150	215		
Last Address	150	215		

Calculate the Resident Network

Step 1: Make the right side octets zero.

		Interesting Octet		
Subnet mask	255	255	240	0
IP Address	150	215	17	9
Resident Network	150	215		0
Broadcast Address	150	215		
First Address	150	215		
Last Address	150	215		

← Make zero

Calculate the Resident Network

Step 2: Select nearest (lower) subnet.

			Interesting Octet	
Subnet mask	255	255	240	0
IP Address	150	215	17	9
Resident Network	150	215	16	0
Broadcast Address	150	215		
First Address	150	215		
Last Address	150	215		

0
16
32
48
64
80
96
112
128
144
160
176
192
208
224
240
256

Calculate the Broadcast Address

Step 1: Make the right octet "**255**".

			Interesting Octet	
Subnet mask	255	255	240	0
IP Address	150	215	17	9
Resident Network	150	215	16	0
Broadcast Address	150	215		255 ← Make "255"
First Address	150	215		
Last Address	150	215		

Calculate the Broadcast Address

Step 2: Add the subnet differentiator & the interesting octet from the resident network and subtract "**1**".

			Interesting Octet	
Subnet mask	255	255	240	0
IP Address	150	215	17	9
Resident Network	150	215	16	0
Broadcast Address	150	215	31	255
First Address	150	215		
Last Address	150	215		

$$16 + 16 - 1 = 31$$

Calculate the first address

Step 1: Copy resident network interesting octet to the first address interesting octet.

			Interesting Octet	
Subnet mask	255	255	240	0
IP Address	150	215	17	9
Resident Network	150	215	16	0
Broadcast Address	150	215	31	255
First Address	150	215	16	
Last Address	150	215		

Calculate the first address

Step 2: Add "**1**" to the last octet from the resident network and put in the last octet of the first address.

			Interesting Octet	
Subnet mask	255	255	240	0
IP Address	150	215	17	9
Resident Network	150	215	16	0
Broadcast Address	150	215	31	255
First Address	150	215	16	1
Last Address	150	215		

$$\begin{array}{r} 0 \\ +\ 1 \\ \hline 1 \end{array}$$

Calculate the last address

Step 1: Copy the left interesting octet from the broadcast address to the interesting octet in the last address.

			Interesting Octet	
Subnet mask	255	255	240	0
IP Address	150	215	17	9
Resident Network	150	215	16	0
Broadcast Address	150	215	31	255
First Address	150	215	16	1
Last Address	150	215	31	

Calculate the last address

Step 2: Subtract "**1**" from the last octet from the broadcast address and put in the last octet of the last address.

		Interesting Octet		
Subnet mask	255	255	240	0
IP Address	150	215	17	9
Resident Network	150	215	16	0
Broadcast Address	150	215	31	255
First Address	150	215	16	1
Last Address	150	215	31	254

$$255 - 1 = 254$$

Network of 150.215.17.9/20

			Interesting Octet	
Subnet mask	255	255	240	0
IP Address	150	215	17	9
Resident Network	150	215	16	0
Broadcast Address	150	215	31	255
First Address	150	215	16	1
Last Address	150	215	31	254

Subnetting

Breakdown 192.168.1.0/27 to show all its possible subnets

256 - 224 = 32

				Interesting Octet	
Subnet mask	255	255	255	224	
Network	192	168	1	0	Zero Subnet
Subnet 1	192	168	1	32	
Subnet 2	192	168	1	64	
Subnet 3	192	168	1	96	
Subnet 4	192	168	1	128	
Subnet 5	192	168	1	160	
Subnet 6	192	168	1	192	
	192	168	1	224	Broadcast Subnet
	192	168	1	256	

- Subnet bits
  - 27 – 24 = 3
- No. of Subnets
  - $2^3 - 2 = 6$
- How many hosts/subnet:
  - $2^5 - 2 = 30$

Note: Some routers will allow the use the top and bottom subnet in reality however technically this is incorrect.

Subnetting

- Subnet bits
  - $20 - 16 = 4$
- No. of Subnets
  - $2^4 - 2 = 14$
- How many hosts/subnet:
  - $2^{12} - 2 = 4094$

Breakdown 172.1.0.0/20 to show all its possible subnets

256 - 240 = 16 (Interesting Octet)

			Interesting Octet		
Subnet mask	255	255	240	0	
Network	172	1	0	0	Zero Subnet
Subnet 1	172	1	16	0	
Subnet 2	172	1	32	0	
Subnet 3	172	1	48	0	
Subnet 4	172	1	64	0	
Subnet 5	172	1	80	0	
Subnet 6	172	1	96	0	
Subnet 7	172	1	112	0	
Subnet 8	172	1	128	0	
Subnet 9	172	1	144	0	
Subnet 10	172	1	160	0	
Subnet 11	172	1	176	0	
Subnet 12	172	1	192	0	
Subnet 13	172	1	208	0	
Subnet 14	172	1	224	0	
	172	1	240	0	Broadcast Subnet
	172	1	256	0	

Binary method – worked examples

Standard class C (/24) network /24 (255.255.255.0) from the network 195.1.1.0/24

Network: 195.1.1.0/24
Interesting octet: 4th
NW: 0000000 (.0)

Net: 00000000 (0) → 195.1.1.0/24
IP1: 00000001 (1) → 195.1.1.1/24
IP2: 00000010 (2) → 195.1.1.2/24
IP254: 11111110 (254) → 195.1.1.254/24
BC: 11111110 (255) → 195.1.1.255/24

Binary method – worked examples

Subnetted /20 from /16

/20 (255.255.240.0) from the network 191.2.192.0/16

```
Network: 191.2.192.0/20
Interesting octet: 3rd
Mask: 11110000
NW: 1100 | 0000 .0 (192.0)
```

```
Net:    1100 | 0000 (192) .0   → 191.2.192.0/20
IP1:    1100 | 0000 (193) .1   → 191.2.192.1/20
IP2:    1100 | 0010 (2)   .2   → 191.2.192.2/20
IP254:  1100 | 1111 (207) .254 → 191.2.207.254/20
BC:     1100 | 1111 (207) .255 → 191.2.207.255/20
```

Binary method – worked examples

Interlink /30 (255.255.255.252) from 197.77.203.0/24

```
Network: 197.77.203.0/30,
Interesting octet, 4th
Mask: 1111100
NW: 000000 | 00 (0)

Net: 000000 | 00 (0)  → 197.77.203.0/30
IP1: 000000 | 01 (1)  → 197.77.203.1/30
IP2: 000000 | 10 (2)  → 197.77.203.2/30
BC : 000000 | 11 (3)  → 197.77.203.3/30
```

Binary method – worked examples

Host route /32 (255.255.255.255) from 10.0.0.0/8

```
10.0.0.1/32, Interesting octet, 4th
Mask:11111111

Net: 00000001 (0) → 10.0.0.1/32
IP1: 00000001 (0) → 10.0.0.1/32
BC : 00000001 (0) → 10.0.0.1/32
```

CIDR / VLSM

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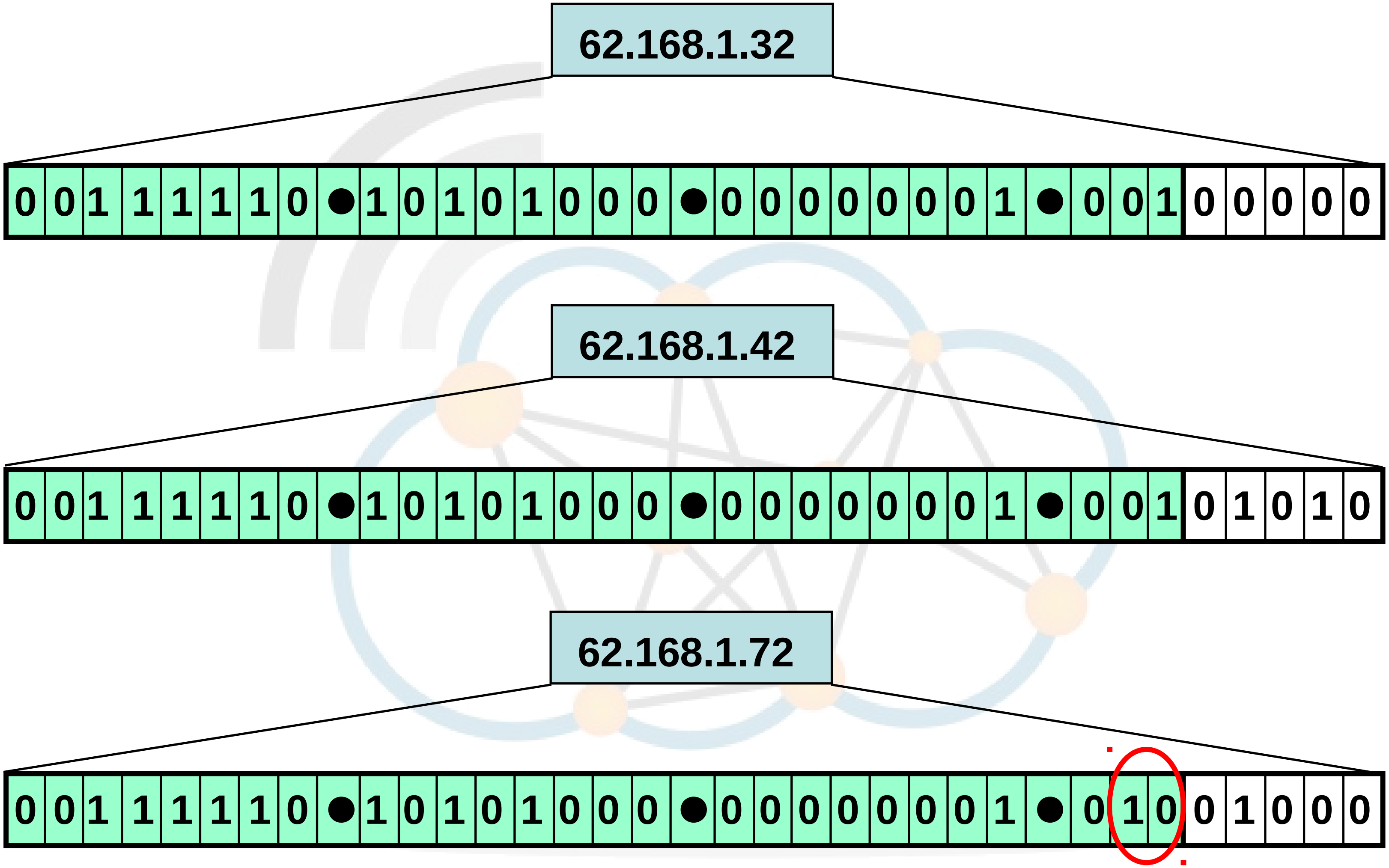
CIDR blocks



- 62.168.1.42 in 62.168.1.32/27 but 62.168.1.72 is not.

Assignment of CIDR blocks

- IANA issues to RIRs large, short-prefix CIDR blocks.
- RIRs subdivide these blocks and issue them publicly.
- Large ISPs obtain CIDR blocks from a RIR
  - Subdivide them for their subscribers.
- Networks served by a single ISP are encouraged by IETF to obtain IP address space from their ISP.
- Networks served by multiple ISPs often obtain independent CIDR blocks directly from the RIR.

Variable Length Subnet Masks (VLSM)

- CIDR uses VLSM to allocate IP addresses to subnets according to individual need, rather than some general network-wide rule.
- Network/host division can occur at any bit boundary in the address.
- The process can be recursive, with further subdivision into even smaller portions.
- CIDR/VLSM network addresses are now used throughout the public Internet and in large private networks.

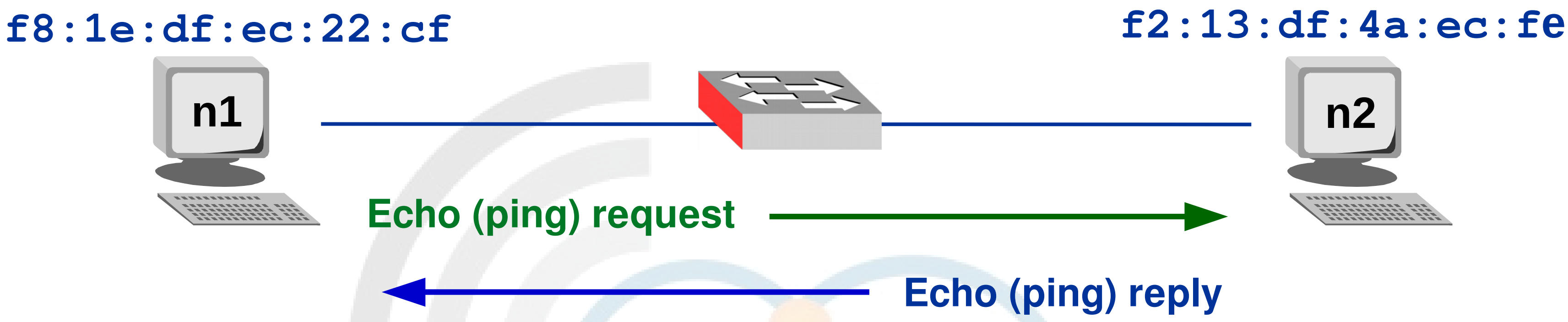
Prefix aggregation

- Another benefit of CIDR is the possibility of routing prefix aggregation (Supernetting / route summarisation)
  - Sixteen contiguous /24 networks as a single /20 route.
  - Two aligned contiguous /20s aggregated to a /19, etc..
  - Significant reduction in the number of routes advertised over the Internet
    - Preventing 'routing table explosions'.
- ISPs on the public Internet will typically not route anything smaller than a /19 prefix, effectively preventing small networks from Internet routing without going through a routing aggregator such as an ISP.

Internet Control Message Protocol

- Echo Reply
- Echo request
- Destination Unreachable
- Redirect Message
- Router Advertisement
- Router Solicitation
- Time Exceeded
- Parameter Problem
- Timestamp
- Timestamp Reply

Internet Control Message Protocol



Frame 1: 100 bytes on wire (800 bits)
Ethernet II
  Src f8:1e:df:ec:22:cf
  Dst f2:13:df:4a:ec:fe
Internet Protocol Version 4
  Src: 192.168.10.2
  Dst: 192.168.10.1
Internet Control Message Protocol
  Type: **8 (Echo (ping) request)**
  Code: 0
  Checksum: 0x381e [correct]
  Identifier (BE): 19292 (0x4b5c)
  Identifier (LE): 23627 (0x5c4b)
  Sequence number (BE): 1 (0x0001)
  Sequence number (LE): 256 (0x0100)
  Data (48 bytes)

Frame 2: 100 bytes on wire (800 bits)
Ethernet II
  Src f2:13:df:4a:ec:fe
  Dst f8:1e:df:ec:22:cf
Internet Protocol Version 4
  Src: 192.168.10.1
  Dst: 192.168.10.4
Internet Control Message Protocol
  Type: **0 (Echo (ping) reply)**
  Code: 0
  Checksum: 0x401e [correct]
  Identifier (BE): 19292 (0x4b5c)
  Identifier (LE): 23627 (0x5c4b)
  Sequence number (BE): 1 (0x0001)
  Sequence number (LE): 256 (0x0100)
  Data (48 bytes)

Thank You

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