COMPUTER SYSTEMS FUNDAMENTALS
(4COSC004W)

Lecture: Week 12. Part 3

Contact details

- Module Leader:

This week's lecture

- Network topologies
  - *Physical & Logical*

- Types of network

- Network components

- Network Collisions
  - *Avoidance*

- Network Infrastructure

- IP Addressing
  - *Calculations*
  - *Masking*
  - *Classless & Classful systems*

- Subnetting calculations

NETWORKS III

IP Addressing ; Networking calculations

IP ADDRESSING

IP Addresses:

- Unique Identification of:
  - *Network Host*
    - Source
    - Destination

- Identifies machine's connection to a network

- Moving to another network requires change of IP address

- Assigned by authorities such as:
  - *RIPE (Regional Internet Registry for Europe)*
  - *ARIN (American Registry for Internet Numbers)*
  - *LIR (Local Internet Registries)*

- TCP/IP uses unique 32-bit address
  - *Transmission Control Protocol / Internet Protocol*

IP Addressing, limitations

- IPv4
  - *32 bit address*
  - *Broken into 4 groups of 8 bits*
  - *2^{32} addresses in total*
  - *4,294,967,296*
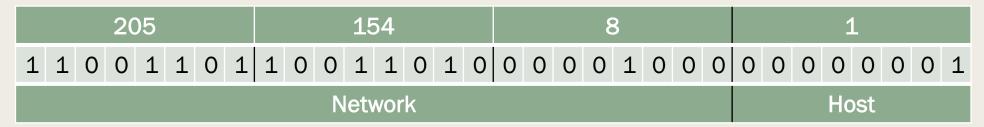 - *~2 addresses for every 3 persons on Earth*

- IPv6
  - *128 bit address*
  - *Broken into 12 groups of 8 bits*
  - *2^{128} addresses in total*
  - *~3.4×10^{38}*
  - *~5×10^{28} addresses per persons on Earth*

Basic structure of an IP v4 address

■ 32-bit number (4 octet number ; octet = 8 bits)

   – *Decimal representation:*

      ■ 133.27.168.125

   – *Binary representation:*

      ■ 10001010.00011011.10101000.01111101

   – *Hexadecimal representation:*

      ■ 85.1B.A2.7D

Anatomy of an IP Address:

■ Hierarchical Division in IP Address:

– *Network Part (Prefix)*

■ Describes which physical network

– *Host Part (Host Address)*

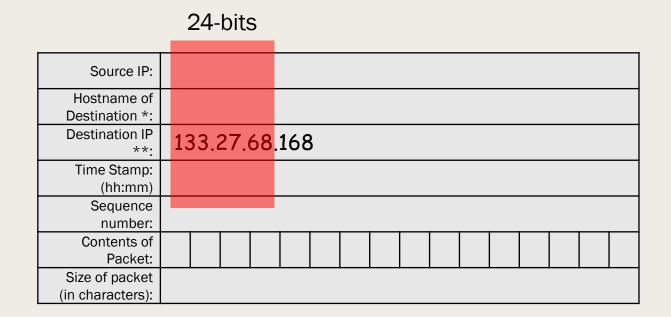■ Describes which host on that network

205	154	8	1
1 1 0 0 1 1 0 1	1 0 0 1 1 0 1 0	0 0 0 0 1 0 0 0	0 0 0 0 0 0 0 1
Network			Host

■ Boundary can be anywhere

– *Very often NOT at a multiple of 8 bits*

IP calculations terminology:

■ Network Address:

  – *Identifies this network*

■ Broadcast Address:

  – *Special IP address used to send a message to all the hosts on this network*

■ Valid Host Address:

  – *And IP address that can be allocated to a host in this network*

Identifying if an IP address is in your domain (network):

■ Network mask

24-bits

Source IP:		
Hostname of Destination *:		
Destination IP **:	133.27.68.168	
Time Stamp: (hh:mm)		
Sequence number:		
Contents of Packet:		
Size of packet (in characters):		

Three flavours of Network Masks:

- CIDR
  - *Classless Inter-Domain Routing*
  - *Network Prefix*
  - *192.168.1.0/24*
- Network Mask
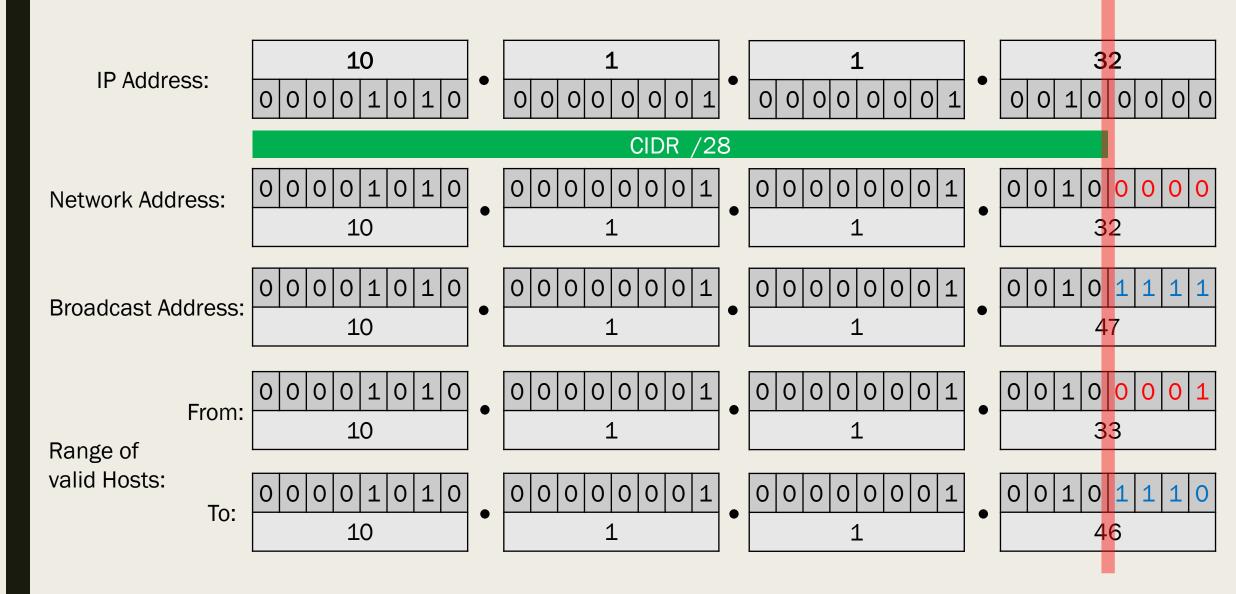 - *Bitmask*
  - 255.255.255.0
- Classful systems

Classless Addressing

■ Internet routing and address management today is classless

■ CIDR = Classless Inter-Domain Routing

■ VLSM = Variable–Length Subnet Masks

Process of Networking calculations:

O   Work out the CIDR

- *The number of bits of the Network Mask*

1.   Convert the whole IP address into Binary

2.   Network Address is calculated by:

- *Any bits to the left of the Mask, followed by all zero's there after*

- *Convert these 4 octet Binary values to Decimal*

3.   Broadcast Address is calculated by:

- *Any bits to the left of the Mask, followed by all one's there after*

- *Convert these 4 octet Binary values to Decimal*

4.   The Network Address and Broadcast Address envelop the range of addressable host IP addresses

- *From the address immediately after the Internet Address*

- *To the address immediately before the Broadcast Address*

Network 10.1.1.32/28

IP Address:

10		1		1		32
0 0 0 0 1 0 1 0	•	0 0 0 0 0 0 0 1	•	0 0 0 0 0 0 0 1	•	0 0 1 0 0 0 0 0

CIDR /28

Network Address:

0 0 0 0 1 0 1 0	•	0 0 0 0 0 0 0 1	•	0 0 0 0 0 0 0 1	•	0 0 1 0 0 0 0 0
10		1		1		32

Broadcast Address:

0 0 0 0 1 0 1 0	•	0 0 0 0 0 0 0 1	•	0 0 0 0 0 0 0 1	•	0 0 1 0 1 1 1 1
10		1		1		47

Range of valid Hosts:

From:

0 0 0 0 1 0 1 0	•	0 0 0 0 0 0 0 1	•	0 0 0 0 0 0 0 1	•	0 0 1 0 0 0 0 1
10		1		1		33

To:

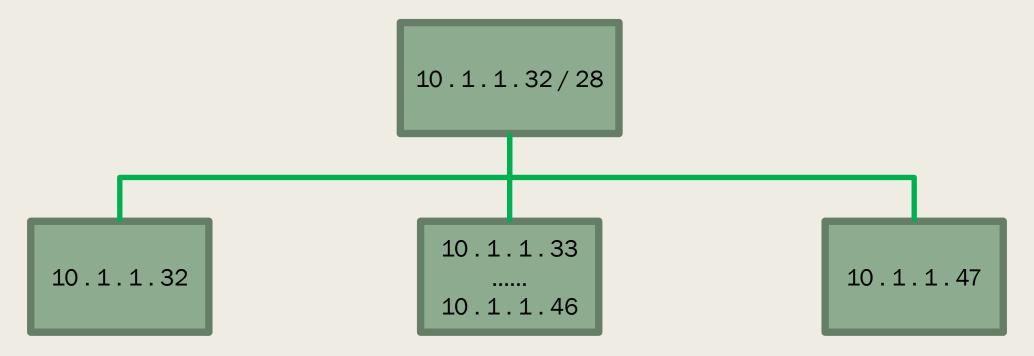| 0 0 0 0 1 0 1 0	•	0 0 0 0 0 0 0 1	•	0 0 0 0 0 0 0 1	•	0 0 1 0 1 1 1 0
10		1		1		46

Network address & Broadcast address

■ IP Address with subnet mask defines the range of addresses in the block:
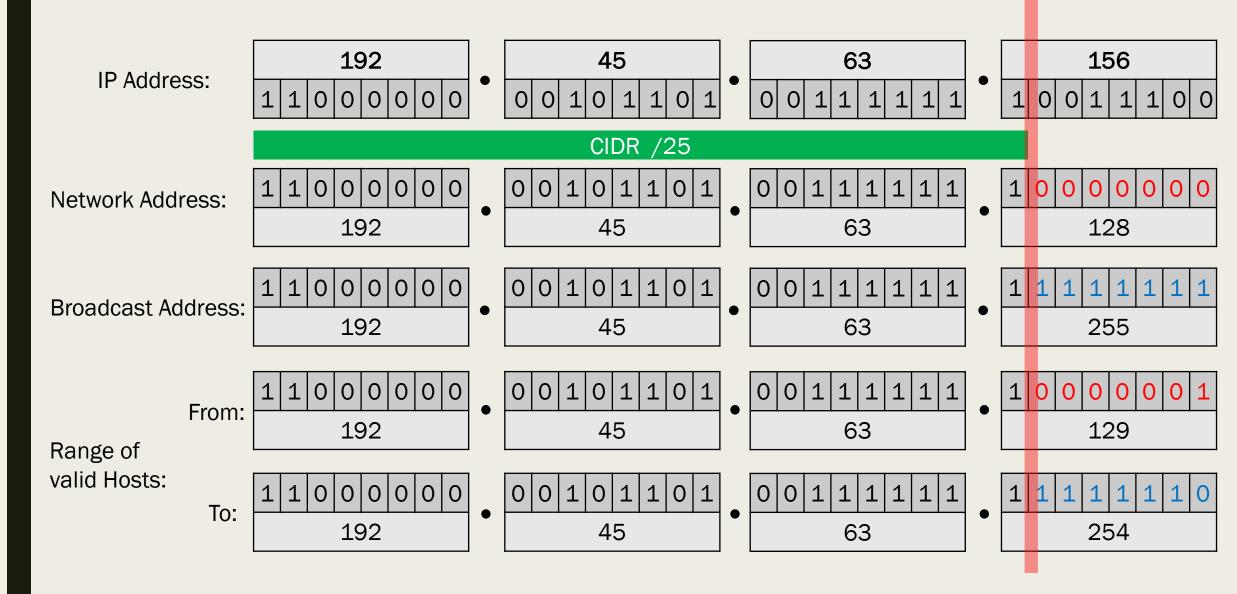
  - *10.1.1.32/28 (subnet mask 255.255.255.240)*

IP Address:	00001010 •	00000001 •	00000001 •	00100000
Net Mask:	11111111 •	11111111 •	11111111 •	11110000
Network Ad:	00001010 •	00000001 •	00000001 •	00100000
	10 •	1 •	1 •	32
Broadcast Ad:	00001010 •	00000001 •	00000001 •	00101111
	10 •	1 •	1 •	47

■ 10.1.1.32   Network Address (AND operation)

■ 10.1.1.47   Broadcast Address

  - *Total of 16 addresses in this subnet; ....0000 to 1111*

■ 14 assignable addresses: 10.1.1.33 to 10.1.1.46

Network 10.1.1.32/28

Host: 192.45.63.156/25

	192	45	63	156
IP Address:	1 1 0 0 0 0 0 0	0 0 1 0 1 1 0 1	0 0 1 1 1 1 1 1	1 0 0 1 1 1 0 0

CIDR /25

	192	45	63	128
Network Address:	1 1 0 0 0 0 0 0	0 0 1 0 1 1 0 1	0 0 1 1 1 1 1 1	1 0 0 0 0 0 0 0

	192	45	63	255
Broadcast Address:	1 1 0 0 0 0 0 0	0 0 1 0 1 1 0 1	0 0 1 1 1 1 1 1	1 1 1 1 1 1 1 1

Range of valid Hosts:

	192	45	63	129
From:	1 1 0 0 0 0 0 0	0 0 1 0 1 1 0 1	0 0 1 1 1 1 1 1	1 0 0 0 0 0 0 1

	192	45	63	254
To:	1 1 0 0 0 0 0 0	0 0 1 0 1 1 0 1	0 0 1 1 1 1 1 1	1 1 1 1 1 1 1 0

Host: 192.45.63.156   255.255.255.128

	192		45		63		156
IP Address:	1 1 0 0 0 0 0 0	•	0 0 1 0 1 1 0 1	•	0 0 1 1 1 1 1 1	•	1 0 0 1 1 1 0 0

	255		255		255		128
Net mask:	1 1 1 1 1 1 1 1	•	1 1 1 1 1 1 1 1	•	1 1 1 1 1 1 1 1	•	1 0 0 0 0 0 0 0

Network Address:	1 1 0 0 0 0 0 0	•	0 0 1 0 1 1 0 1	•	0 0 1 1 1 1 1 1	•	1 0 0 0 0 0 0 0
	192		45		63		128

Broadcast Address:	1 1 0 0 0 0 0 0	•	0 0 1 0 1 1 0 1	•	0 0 1 1 1 1 1 1	•	1 1 1 1 1 1 1 1
	192		45		63		255

Range of valid Hosts:

From:	1 1 0 0 0 0 0 0	•	0 0 1 0 1 1 0 1	•	0 0 1 1 1 1 1 1	•	1 0 0 0 0 0 0 1
	192		45		63		129
To:	1 1 0 0 0 0 0 0	•	0 0 1 0 1 1 0 1	•	0 0 1 1 1 1 1 1	•	1 1 1 1 1 1 1 0
	192		45		63		254

Classful networking systems:

■ Networks classed by size:

■ Class A networks (large):

- *8 bits network, 24 bits host (/8 , 255.0.0.0)*

- *First byte in range 0-126*

■ Class B Network (medium)

- *16 bits network, 16 bits host (/16 , 255.255.0.0)*

- *First byte in range 128-191*

■ Class C network (small)

- *24 bits network, 8 bits host (/24 , 255.255.255.0)*

How to determine what class it is:

- Just look at the IP address:
  - *Class A: 1.0.0.0 to 126.255.255.255*
    - Binary: 0xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
      - *16,777,214 hosts*
  - *Class B: 128.0.0.0 to 191.255.255.255*
    - Binary: 10xxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
      - *65,534 hosts*
  - *Class C: 192.0.0.0 to 223.255.255.255*
    - Binary: 110xxxxxxxxxxxxxxxxxxxxxxxxxxxxx
      - *254 hosts*
  - *Class D: (multicast) 224.0.0.0 to 239.255.255.255*
    - Binary: 1110xxxxxxxxxxxxxxxxxxxxxxxxxxx
  - *Class E: (reserved) 240.0.0.0 to 255.255.255.255*
    - Binary: 1110xxxxxxxxxxxxxxxxxxxxxxxxxxx

Class table

Class:	Host address range (Den):	Binary (first byte):	CIDR:	Network mask: (den)
A	1.0.0.0 to 126.255.255.255	0#######	/8	255.0.0.0
B	128.0.0.0 to 191.255.255.255	10######	/16	255.255.0.0
C	192.0.0.0 to 223.255.255.255	110#####	/24	255.255.255.0
D	224.0.0.0 to 239.255.255.255	1110####		(multicast)
E	240.0.0.0 to 255.255.255.255	1111####		(reserved)

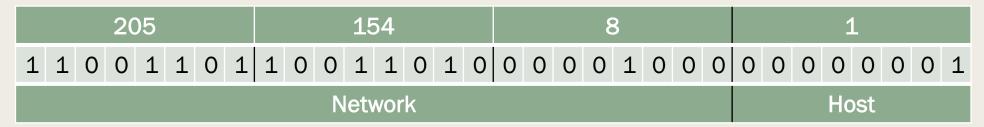# Implied Netmasks of Classful Addresses

- *Natural* or *Implied* prefix length or netmask:
  - *Class A: prefix length /8 (netmask: 255.0.0.0)*
  - *Class B: prefix length /16 (netmask: 255.255.0.0)*
  - *Class C: prefix length /24 (netmask: 255.255.255.0)*
- Old routing systems often used implied netmasks
- Newer routing systems use explicit masking

Addressing in Internetworks

■ More than one physical network

■ Different locations

■ Larger numbers of computers

■ Need structure in IP address:

- *Network part identifies which network in the internetwork (eg. The Internet)*

- *Host part identifies host on that network*

Address structure revisited:

- Hierarchical Division in IP Address:
  - *Network Part (Prefix)*
    - Describes which physical network
  - *Host Part (Host Address)*
    - Describes which host on that network

205	154	8	1
1 1 0 0 1 1 0 1	1 0 0 1 1 0 1 0	0 0 0 0 1 0 0 0	0 0 0 0 0 0 0 1
Network			Host

- Boundary can be anywhere
  - *Very often NOT at a multiple of 8 bits*

Network masks:

■ Define which bits are used to describe the Network and which for the Hosts

■ Different Representations:
- *Decimal Dot Notation: 255.255.224.0*
- *Binary: 11111111 11111111 11100000 00000000*
- *Hexadecimal: 0xFFFE000*
- *CIDR : /19*

SUBNETTING

Subnetting calculations:

Maximum number of subnets

Maximum number of hots per subnet

Traditional Subnetting of Classful Networks:

■ Old routing systems allowed a classful network to be divided up into subnets:

– *All subnets (of one classful network) must be the same size –same netmask*

– *Subnets cannot be subdivided further*

■ None of these restriction apply in modern systems

Class table

Class:	Host address range (Den):	Binary (first byte):	CIDR:	Network mask: (den)
A	1.0.0.0 to 126.255.255.255	0#######	/8	255.0.0.0
B	128.0.0.0 to 191.255.255.255	10######	/16	255.255.0.0
C	192.0.0.0 to 223.255.255.255	110#####	/24	255.255.255.0
D	224.0.0.0 to 239.255.255.255	1110####		(multicast)
E	240.0.0.0 to 255.255.255.255	1111####		(reserved)

The network 193.21.85.0/27
- Maximum number of subnets
- Maximum number of hosts per subnet

■ Assume the Network mask is classful

– *193 is Class C (Network Mask /24)*

■ We are told that the Subnet Mask is /27

■ Bits available for the Subnets: 27 – 24 = 3

– Maximum number of subnets:

– $2^3 = 8$

■ Bits available for the hosts per subnet: 32 – 27 = 5

– *Maximum number of hosts per subnet:*

– $2^5 - 2 = 30$

The network 193.21.85.0/26
- Maximum number of subnets
- Maximum number of hosts per subnet

- **■** Assume the Network mask is classful

  - – *193 is Class C (Network Mask /24)*

- **■** We are told that the Subnet Mask is /26

- **■** Bits available for the Subnets: 26 – 24 = 2

  - – Maximum number of subnets:

  - – $2^2 = 4$

- **■** Bits available for the hosts per subnet: 32 – 26 = 6

  - – *Maximum number of hosts per subnet:*

  - – $2^6 - 2 = 62$

The network 171.21.0.0/22
- Maximum number of subnets
- Maximum number of hosts per subnet

- Assume the Network mask is classful

  - *171 is Class B (Network Mask /16)*

- We are told that the Subnet Mask is /22

- Bits available for the Subnets: 22 – 16 = 6

  - Maximum number of subnets:

  - $2^6 = 64$

- Bits available for the hosts per subnet: 32 – 22 = 10

  - *Maximum number of hosts per subnet:*

  - $2^{10} - 2 = 1022$

Special IP addresses:

- All 0's in the host part:
  - *Network Address*

- All 1's in the host part
  - *Broadcast Address*

- 127.0.0.0/8: Loopback address
  - *127.0.0.1 - localhost*

- 1.#.#.# : Reserved for experimental purposes

- 0.0.0.0 : Special purposes
  - *Invalid, un-known or non-applicable target*

What we have covered in this video:

- IP Addressing

- Network Calculations
  - *Network Address*
  - *Broadcast Address*
  - *Range of Valid Hosts*

- Subnetting Calculations
  - *Maximum number of subnets*
  - *Maximum number of hosts per subnet*

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