

IP Addresses & Subnets

Internetworking – M30233

Lecture 2

IP Addresses & Subnets

- ▶ IP protocol
- ▶ IP functions
- ▶ IP notation methods
- ▶ IP address structure
- ▶ IP addressing
- ▶ Subnetting

Layer 3 functionalities

- ▶ This layer handles the routing of the data by delivering it to the correct destination
- ▶ Layer 3 functionalities are spread all over the network
 - In ad hoc hardware – routers
 - In your PC – routing software by Operating System

The Internet Protocol (IP)

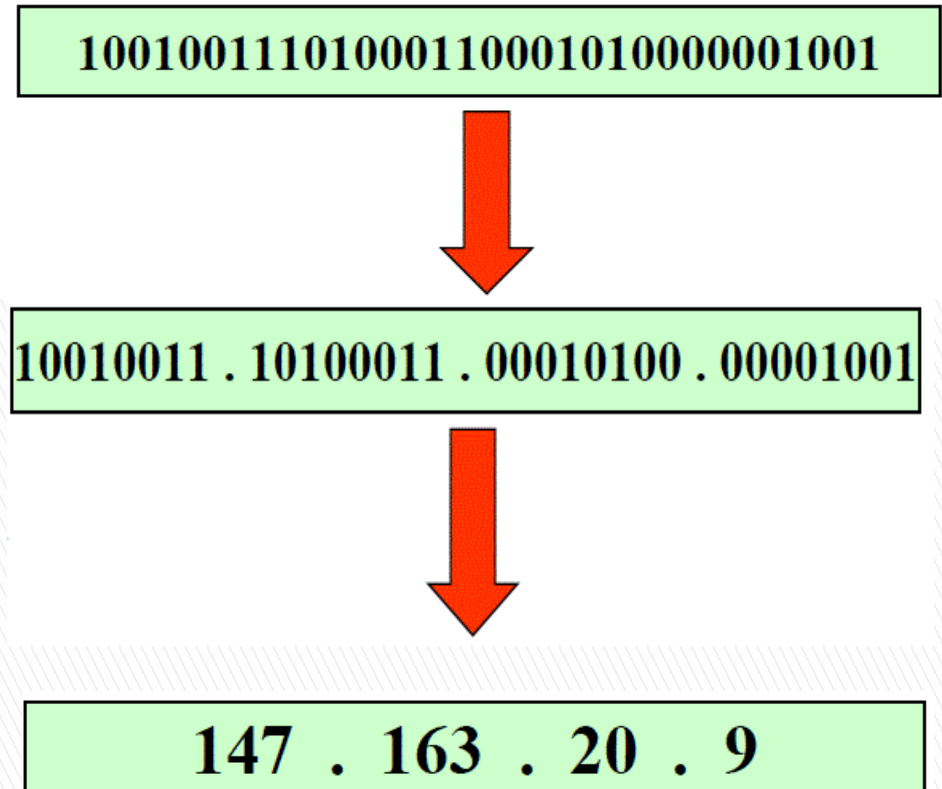
- ▶ Connectionless
 - Delivering datagrams
- ▶ Best effort
- ▶ Unreliable
 - No guarantee of orderly delivery
 - Error-handling algorithm?
 - Buffer is full → discard
 - Error check failed → discard

IP functions

- ▶ When transmitting:
 - Encapsulates data from transport layer into datagrams
 - Prepare header (src & dest addresses, etc)
 - Apply routing algorithm
 - Forward datagram to network interface card
- ▶ When receiving:
 - Check validity of incoming datagrams
 - Read header
 - Check if forwarding is needed
 - If yes → send to appropriate network interface
 - If no → pass payload to next upper layer

IP Address

- ▶ 32 bit string
 - System notation
- ▶ Dotted notation
 - 4 x 1 byte (8 bits)
 - **Each byte** = 0:255 integer
 - 1492.14.2.0 is not an IP address!
 - Intended for humans



Notation conversion

- ▶ From binary to decimal
 - E.g. 10101100.11011001.10101001.01010011

Binary	128	64	32	16	8	4	2	1	Decimal
10101100	1	0	1	0	1	1	0	0	172
11011001	1	1	0	1	1	0	0	1	217
10101001	1	0	1	0	1	0	0	1	169
01010011	0	1	0	1	0	0	1	1	83

- ▶ 172.217.169.83 (mail.myport.ac.uk)

Notation conversion

- ▶ Decimal to binary

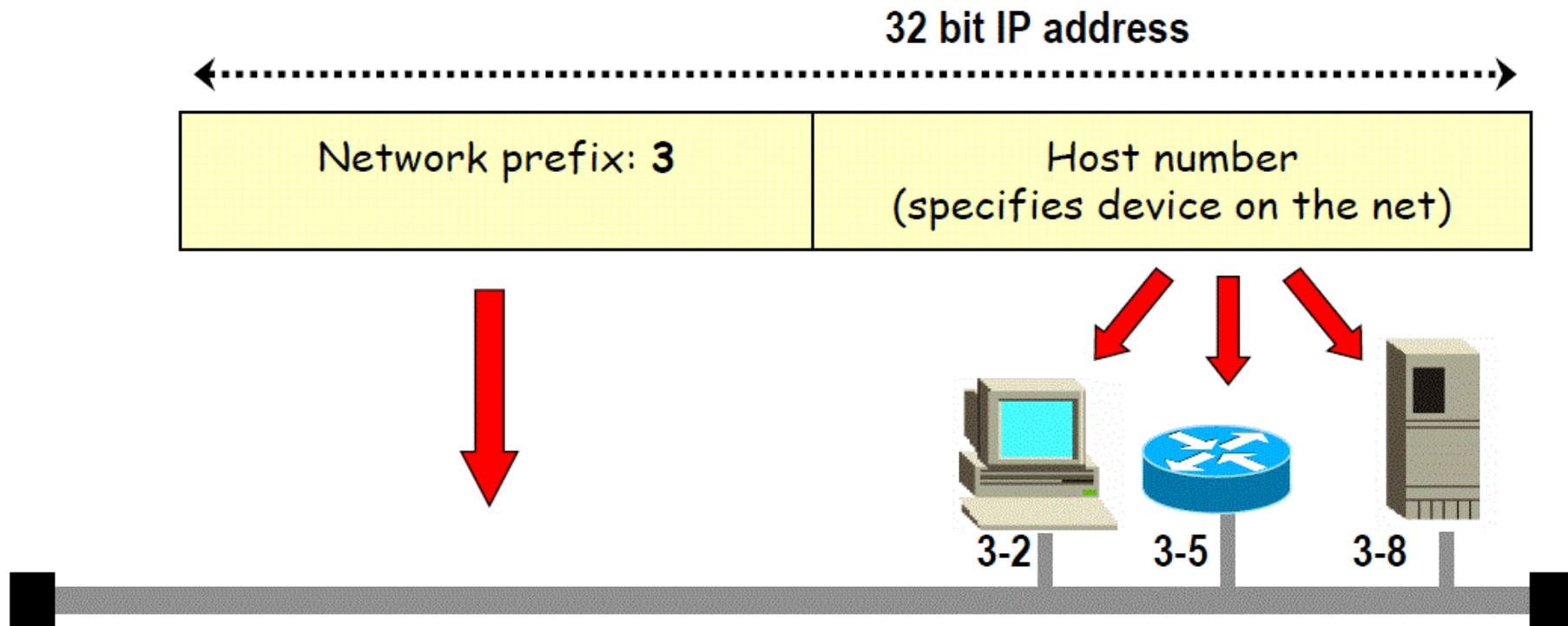
- E.g. 194.168.4.100

Decimal	128	64	32	16	8	4	2	1	Binary
194	1	1	0	0	0	0	1	0	11000010
168	1	0	1	0	1	0	0	0	10101000
4	0	0	0	0	0	1	0	0	00000100
100	0	1	1	0	0	1	0	0	01100100

- cache1.service.virginmedia.net

IP Address Structure

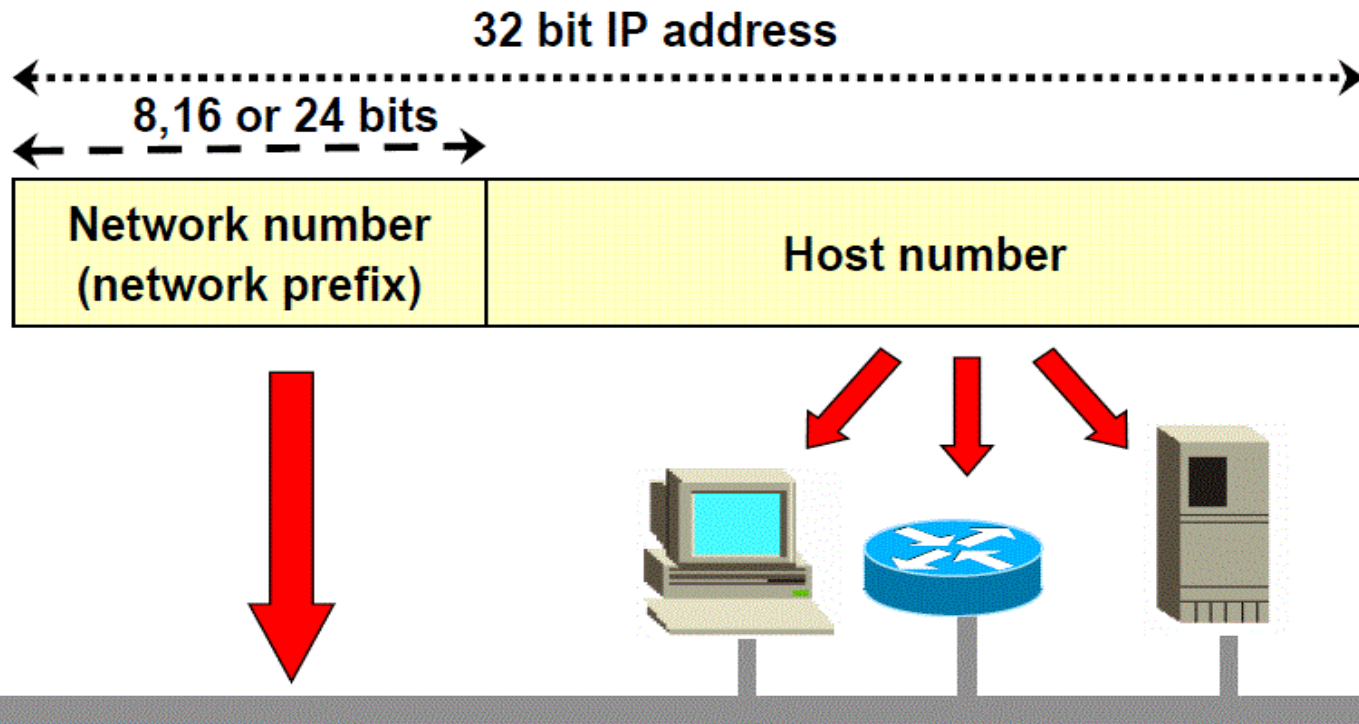
- ▶ It is portioned into two fields



Host Addresses
3-8 means: host 8 on network 3

Classful IP Addressing

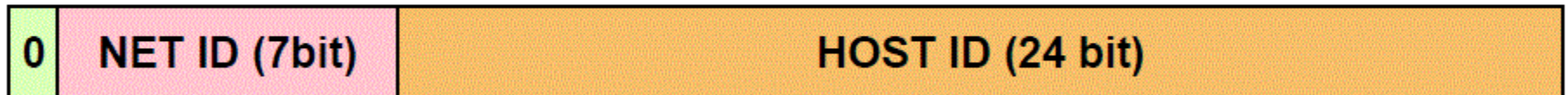
- ▶ It is portioned into two fields
 - Network ID can be 8,16 or 24 bits in length



IP Address Classes – primary

- ▶ Three standardised classes

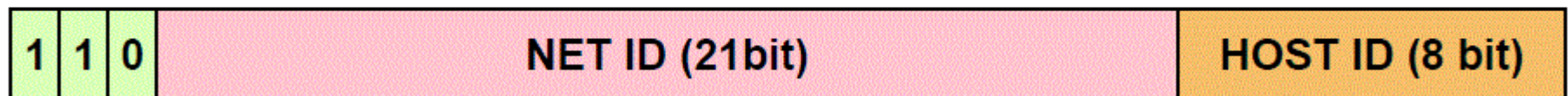
Class A - /8 network prefix



Class B - /16 network prefix



Class C - /24 network prefix

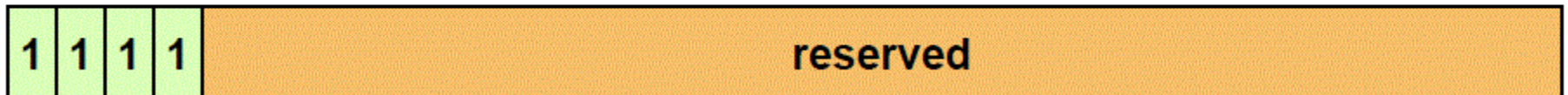


IP Address Classes – extra

Class D: IP multicasting



Class E: reserved for experimental use



IP Address – Decimal Ranges

Address Class	Dotted Decimal ranges
Class A	1.xxx.xxx.xxx through 126.xxx.xxx.xxx
Class B	128.0.xxx.xxx through 191.255.xxx.xxx
Class C	192.0.0.xxx through 223.255.255.xxx
Class D (mcast)	224.xxx.xxx.xxx through 239.xxx.xxx.xxx
Class E (exper)	240.xxx.xxx.xxx through 255.xxx.xxx.xxx

Class A network 127.xxx.xxx.xxx is not part of the list – Why?

There's no place like

127.0.0.1

IP Address – Decimal Ranges

▶ Examples:

- Class A – Default subnet mask = 255.0.0.0
 - 10.25.24.2
 - Network ID = 8 bits & Host ID = 24 bits
- Class B – Default subnet mask = 255.255.0.0
 - 148.97.52.23
 - Network ID = 16 bits & Host ID = 16 bits
- Class C – Default subnet mask = 255.255.255.0
 - 198.167.42.85
 - Network ID = 24 bits & Host ID = 8 bits

Addressing Networks

- ▶ When you refer to a network address then all host ID bits equal to 0
- ▶ Examples:
 - Class A IP address = 12.25.89.124
 - Network address = 12.0.0.0
 - Class B IP address = 132.15.223.17
 - Network address = 132.15.0.0
 - Class C network = 197.211.12.88
 - Network address = 197.211.12.0

Subnetting

- ▶ IPv4 provides 2^{32} IP addresses
 - 4.294.967.296 (theoretical) maximum
- ▶ A class C network provides $(2^8 - 2)$ assignable host addresses – 254
- ▶ A class B network provides $(2^{16} - 2)$ assignable host addresses – 65534
- ▶ A class A network provides $(2^{24} - 2)$ assignable host addresses – 16.777.214

Usable host addresses

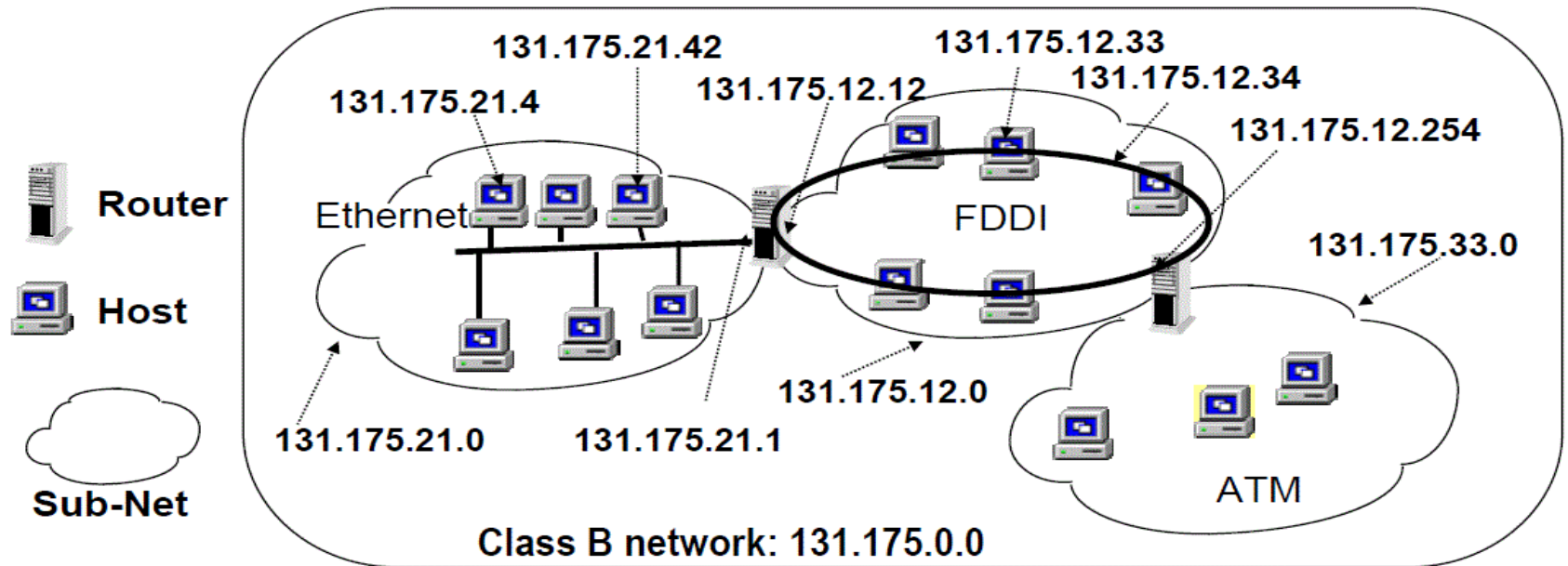
- ▶ The x-2 rule
- ▶ You have been assigned a Class B network address
→ 128.147.0.0
 - IP range: 128.147.0.0 – 128.147.255.255
 - Total addresses available = 65536
 - First assignable address = 128.147.0.1
 - Last assignable address = 128.147.255.254
 - Total assignable addresses = 65534
- ▶ Why do we have to deduce 2 from the total addresses?
 - 128.147.0.0 is the network address – not assignable
 - 128.147.255.255 is the network's broadcast address – not assignable

Subnetting – Why?

- ▶ If you have been assigned a Class B network address...
- ▶ Is it possible to accommodate 65534 hosts on one single physical network?
 - What about management?
 - What about performance?
 - Waste of IP addresses?

Subnetting – Hierarchy

- ▶ Divide one big network into several subnetworks
- ▶ Each subnet = a physical network



- ▶ Solution?
 - We can use the third byte 131.175.X.0 as subnet identifier!

Subnetting – Hierarchy

- ▶ Network administrator asks for a classful network address – e.g. 128.147.0.0 – Class B
- ▶ Create subnetworks within the main network
 - Subnet #1 = 128.147.8.0
 - Subnet #2 = 128.147.12.0



- Subnet #N = 128.147.x.0
- ▶ Flexible for administrator –> Create smaller, manageable networks
- ▶ Subnetworks do not require extra routing –> one entry in core router

Subnetting – Example

- ▶ Class B without subnetting



- ▶ Class B with subnetting



- ▶ You reserve host ID bits for subnetting
- ▶ The reserved bits are called Subnet ID.

Subnet Address and Mask

- ▶ Host IP address
 - 148.197.9.18 -> 10010100.11000101.00001001.00010010
- ▶ Class B network with default subnet mask:
 - 255.255.0.0 -> 11111111.11111111.00000000.00000000
- ▶ Custom subnet mask (when subnetting)
 - Longer than default class mask. Decided by network admin.
 - Tells where the new boundary between networkID-hostID is
- ▶ Example: class B address with a 5 bit subnet ID
 - Subnet mask = /21 ->
 - 255.255.248.0 -> 11111111.11111111.11111000.00000000
 - Network ID = 148.197.0.0 (B class)
 - New (sub)network ID =
10010100.11000101.00001000.00000000 -> 148.197.8.0/21

Class B subnetting – example

- ▶ Class B address = /16 network prefix
 - Network address = 148.197.0.0
 - Default subnet mask = 255.255.0.0 = 16 bits long
 - Host ID = 16 bits long
- ▶ You can create subnets by extending the network ID with bits you reserve from the Host ID
 - Custom subnet mask = 255.255.**255**.0 (extended by 8 bits)
 - Subnet ID = 8 bits long $\rightarrow 2^8$ (256) number of subnets
 - New Host ID = 8 bits long $\rightarrow 2^8 - 2$ number of (useable) hosts per subnet

Class C subnetting – example (1)

- ▶ You have been assigned a Class C network.
 - 193.1.1.0/24
 - Network ID = 24 bits & Host ID = 8 bits
 - Total number of hosts = $2^8 = 256$
 - Number of usable hosts = $256 - 2 = 254$
 - You are asked to create 8 new subnets within the Class C network

Class C subnetting – example (2)

- 193.1.1.0/24
 - Network ID = 24 bits & Host ID = 8 bits
 - You are asked to create 8 new subnets within the Class C network
- ▶ The rule $2^x \geq y$ defines how many bits you reserve from the Host ID
 - You need 8 subnets $\rightarrow 2^x \geq 8 \rightarrow x=3$ bits to reserve
 - You reserve 3 bits from the Host ID
 - (new)Host ID = 5 bits. How many host IP addresses per subnet?
 - Total number of IP address = $2^5 = 32$ addresses per subnet
 - Usable host addresses = $32 - 2 = 30$ per subnet

Class C subnetting – example (2)

- ▶ Why do we need to deduce 2 addresses for every newly created subnet?
 - The first IP address within each subnet is the subnet address – all (new)Host ID bits equals to 0
 - The last IP address within each subnet is the subnet's broadcast address – all (new)Host ID bits equals to 1
 - Every other IP address is a usable address – can be assigned to a host
 - *See next slide for subnet address...*

Class C subnetting – example (2)

Subnet # 0	11000001.00000001.00000001. 000 00000	193.1.1.0/27
Subnet # 1	11000001.00000001.00000001. 001 00000	193.1.1.32/27
Subnet # 2	11000001.00000001.00000001. 010 00000	193.1.1.64/27
Subnet # 3	11000001.00000001.00000001. 011 00000	193.1.1.96/27
Subnet # 4	11000001.00000001.00000001. 100 00000	193.1.1.128/27
Subnet # 5	11000001.00000001.00000001. 101 00000	193.1.1.160/27
Subnet # 6	11000001.00000001.00000001. 110 00000	193.1.1.192/27
Subnet # 7	11000001.00000001.00000001. 111 00000	193.1.1.224/27

Remember, the rule of $2^x \geq y$ can be applied when you need to create subnets based on the number of required host addresses per subnet

Custom Subnet mask values

128	64	32	16	8	4	2	1	
1	0	0	0	0	0	0	0	= 128
1	1	0	0	0	0	0	0	= 192
1	1	1	0	0	0	0	0	= 224
1	1	1	1	0	0	0	0	= 240
1	1	1	1	1	0	0	0	= 248
1	1	1	1	1	1	0	0	= 252
1	1	1	1	1	1	1	0	= 254
1	1	1	1	1	1	1	1	= 255

Special Addresses

- ▶ When Host ID is all 1s -> **broadcast address** for this network
 - 134.86.255.255 = Broadcast address for network 134.86.0.0
- ▶ **0.0.0.0** -> This host on this network (reserved)
- ▶ **127.x.x.x** used for loopback
 - 127.0.0.1 = localhost (same for every PC)
- ▶ When address is all 1s -> limited broadcast
 - **255.255.255.255** -> all nodes on this local network

Private IP addresses (RFC 1918)

- ▶ Can be used by private organisations not connected to the Internet
 - No need to ask assignment by IANA or InterNIC
 - Internet connectivity? → use NAT (Network Address Translator)

IANA-Allocated, Non-Internet Routable, IP Address Schemes

Class	Network Address Range
A	10.0.0.0 - 10.255.255.255
B	172.16.0.0 - 172.31.255.255
C	192.168.0.0 - 192.168.255.255

▶ Next Week

- Classless Inter-Domain Routing – CIDR