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Classful addressing

Every host and router on the Internet has an IP address. which encodes its network number and host number. The Combination is unique. In principle no two machine on the Internet have the same IP address. It is important to note that an IP address does not actually refer to a host. It really refers to a network interface. So, if a host is on two networks, it must have two IP addresses. In practice, most hosts are on one network and thus have one IP address.

For several decades, IP addresses were divided into five categories/classes: class A, B, C, D and E.

				Range of Host addresses
A	1: 0	7: Network	24: Host	1.0.0.0 — 127.255.255.255 0 0000000 - 0 1111111
B	2: 10	14: Network	16: Host	128.0.0.0 - 191.255.255.255 10 000000 - 10 111111
C	3: 110	21: Network	8: Host	192.0.0.0 - 223.255.255.255 110 00000 - 110 11111
D	4: 1110	28: Multicast address		224.0.0.0 - 239.255.255.255 1110 0000 - 1110 1111
E	4: 1111	28: Reserved for future use		240.0.0.0 - 255.255.255.255 1111 0000 - 1111 1111

Class A, B, C and D allow for up to 2^7 networks with 2^{24} hosts, 2^{14} networks with 2^{16} hosts, 2^{21} networks with 2^8 hosts, respectively. and such Class D addresses are reserved for multicasting and addresses starts with 1110. Addresses begining with 1111 are reserved for future use. IP addresses are managed by a non-profit Corporation called ICANN - Internet Corporation for Assigned Names and Numbers to avoid conflicts.

special IP addresses

0000 - - - - - - - - - - - 0000		This host
00 - - - 00	Host	A host on this network
1111 - - - - - - - - - - - 1111		Broadcast on the local network
Network	1111 - - - - - - - - 1111	Broadcast on a distant network
127	Anything	Loopback

The IP address 0.0.0.0 is used by hosts when they are booted. The IP address with 0 as network number refer to the current network. This allows machines to refer to their own network without knowing its number. The IP address consists of all 1s refer to broadcasting on the local network, typically LAN. The addresses with proper network number and all 1s in the host field allow machine to broadcast to a distant LAN. Finally all IP addresses of the form 127.x.y.z are reserved for loopback testing. packet sent to that address are not put out onto the wire, they are processed locally and treated as incoming packets. this allows packets to be sent to the local network without the sender knowing its number.

Subnet masking: A class B address consists 14 bit for the network number and 16 bit for the host number. This fixed partitioning often creates IP address scarcity problem as networks grow. This is because a single address refers to one network not a collection of networks (LANs). Thus an university with many LANs may require multiple IP address which is difficult to get. This can be solve as follows:

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There can be a main router connected to the ISP and several LANs with is own router can be ~~[illegible]~~ connected to the main router. ~~[illegible]~~ This may be achiev as follows: Instead of 14 bits for network number and 16 bits for hosts, some bits may be taken away from host number to create a subset number. For example, an university with 35 department, it could use a 6-bit subnet number and a 10-bit host number allowing 64 LANs with 1022 (all 0s and all 1s are not available) host. To implement subnetting the main router needs a subnet mask to indicate the split between network ~~[illegible]~~ + subnet and host.

10	Network	Subnet	host

Subnet masks are also written in dotted decimal notation with a slash followed by the number of bits in the network + subnet part. For example, subnet mask 255.255.252.0 indicates 22 bit for network + subnet and ~~8~~ 10 bits for hosts. Alternatively, it can be written as /22 to indicate that the subnet mask is 22 bits long.

Outside the network, the subnetting is not visible, so allocating ~~[illegible]~~ a new subnet does not require contacting ICANN or change any external database.

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Consider an example of 3 subnets. The subnet1 starts at 130.50.4.1 subnet2 starts at 130.50.8.1 and subnet3 starts at 130.50.12.1.

subnet1:	10000010	00110010	000001	00	00000001
subnet2:	10000010	00110010	000010	00	00000001
subnet3:	10000010	00110010	000011	00	00000001

If a packet addressed to 130.50.15.6 arrives, it is ANDed with the mask 255.255.252.0/22 to give the address 130.50.12.0 = subnet 3.

Other than subnetting: (network, 0) tels how to get the distant network and (this_network, host) tels how to get to local host.

With subnetting: (this_network, subnet, 0) and (this_network, this_subnet, host) are used instead of (network, 0) and (this_network, host).

Thus a router on subnet k knows how to get to all other subnets and also how to get to all the ~~nodes~~ hosts on subnet k. It does not have to know the details of hosts on other subnets.

Classless InterDomain Routing: The basic idea is to allocate IP addresses in variable-sized blocks without regard to the classes. For example, if a site needs 2000 addresses, it is given a block of 2048 (2^{11}) addresses (nearest power of 2).

Each (5) routing table entry is extended by giving it a 32-bit mask. Thus there is now a single table ~~entry~~ for all networks consisting of an array of (IP address, subnet mask & outgoing line) triples. When a packet comes in, its destination IP address is first extracted. Then the routing table is scanned entry by entry masking the destination address and comparing it ~~to~~ the table entry looking for a match. If multiple entries match, the longest mask is used.

To understand the forwarding algorithm, ~~we~~ let us consider an example. ~~other~~ Suppose ~~to~~ several IP addresses are available starting at 194.24.0.0. Now suppose university 1 needs 2048 addresses. The addresses 194.24.0.0 through 194.24.7.255 (.. 00000000 00000000 / 00000111 11111111) ← 11-bit → can be assigned with mask 255.255.248.0 (..11111000 00000000).

Next suppose U2 asks for 4096 addresses. Since block of 4096 addresses must lie on a ~~4096~~ 12-bit boundary, they can not be given address starting at 194.24.8.0 (next address of 194.24.7.255). Instead, they get 194.24.16.0 through 194.24.31.255 (.. 0001 0000 00000000 / ..0001 1111 11111111) ← 12-bit → along with mask 255.255.240.0 (1111 0000 00000000).

Now suppose U3 asks for 1024 addresses and is assigned addresses 194.24.8.0 through 194.24.11.255 (000010 00 00000000 / 000010 11 11111111) along with the mask 255.255.252.0 (... 111111 00 00000000).

	First add	Last add	How many	written as
U1	194.24.0.0	194.24.7.255	2048	194.24.0.0/21
U3	194.24.8.0	194.24.11.255	1024	194.24.8.0/22
Available	194.24.12.0	194.24.15.255	1024	194.24.12.0/22
U2	194.24.16.0	194.24.31.255	4096	194.24.16.0/20

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The Routing tables are now updated. ~~with the three~~
Each entry contains a base address and a subnet mask.
as follows:

	194	24	0/8/16	0	Mask
U1 :	1100 0010	00011000	00000000 (0)	00000000	21-1s, 11-0s
U3 :	11000010	00011000	00001000 (8)	00000000	22-1s, 10-0s
U2 :	11000010	00011000	00010000 (16)	00000000	20-1s, 12-0s

19 ~~*~~ 13

Now Consider what happens when a packet comes in addressed to 194.24.17.4. This address will be ANDed with all three masks. for a possible match.

	194	24	17	4
	1100010	00011000	00010001	00000100
			11111000	00000000
Mask U1:	1111111	11111111	00010000	00000000
AND	11000010	00011000	00010000	0
	194	24	16	

This value does match with U2 base address.

The base addresses of U1, U3 and U2 have first 19 bits common. The same outgoing link then if all of them use the same outgoing link then they can be aggregated. So all three entries can be combined into a single entry: 194.24.0.0/19.

194 24
11000010 00011000 00000000 00000000.

with mask 11111111 11111111 11100000 00000000.

Q. A network on the Internet has a subnet mask of 255.255.240.0. What is the maximum number of hosts it can handle?

255 255 240 0
11111111 11111111 11110000 00000000. It has 12 bits for
20 ↓ 12
host number, So it can handle 2^{12} = 4096 host IDs.

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Q. A router has just received the following new IP addresses: 57.6.96.0/21, ~~57.6.104/21~~ 57.6.104.0/21, 57.6.112.0/21 and 57.6.120.0/21. If all of them use the same outgoing line, can they be aggregated? If so, to what? If not, why not?

Address/mask				
57.6.96.0/22	00111001	00000110	011 00000	00000000
57.6.104.0/21	00111001	00000110	011 01000	00000000
57.6.112.0/21	00111001	00000110	011 10000	00000000
57.6.120.0/21	00111001	00000110	011 11000	00000000
			19 | 13	

The first 19 bits are same for all the addresses. Since all of them uses the same next hop, they can be aggregated to

57.6.96.0/19 00111001 ; 00000110 ; 01100000 ; 00000000
57 6 96 0

Q. A router has the following CIDR entries in the routing table.

Address/mask	Next hop
135.46.56.0/22	Interface 0
135.46.60.0/22	Interface 1
192.53.40.0/23	Router 1
default	Router 2

For each of the following IP addresses, what does the router do if a packet with that address arrives?

a) 135.46.63.10

	10000111	00101110	00111111	00001010
AND.	11111111	11111111	11111100	00000000
	10000111	00101110	00111100	0
	135	46	60	

It matches with 135.46.60.0/22 and no other matches found, so it is forwarded to Interface 1.

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b) 135.46.57.14, After ANDing this with 255.255.252.0, we get 135.46.56.0 → and no other matche found. So it will be forwarded to Interface 0.

c) 135.46.52.2, After ANDing this with 255.255.252.0 (and also with 255.255.254.0) it becomes 135.46.52.0 so it does not matchs with any entry, so it is forwarded to default Router 2.

d) 192.53.40.7, After ANDing with 255.255.252.0, it becomes 192.53.40.0 and no other matche found, So it is forwarded to Router 1.

e) 192.53.56.7, After ANDing with 255.255.254.0 it becomes 192.53.56.0. So no matchs found, and thus forwarded to Router 2.

Q. Indicate whether each of the following subnet masks are valid or Invalid? for each invalid one, briefly indicate why it is invalid: a) 255.255.32.0
b) 255.255.224.0

Sol: 255.255.32.0 = 11111111 11111111 00100000 00000000
255.255.224.0 = 11111111 11111111 11100000 00000000

a) is invalid and b) is valid. A subnet mask should have a set of Contiguous bits all having 1 as the most significant bits (representing network+subnet part) followed by a set of Contiguous bits having value 0 (representing the host part).

Q. Indicate whether each of the following IP address is a valid host address. For each invalid one, briefly indicate why it is invalid: a) 197.15.136.64/26
b) 165.192.0.63/26
c) 106.178.35.255/20

(9)

a) 197.15.136.64/26 → invalid, host bits are all zeros.
.......01000000 Therefore, this is a network address

b) 165.192.0.63/26 → Invalid, hosts bits are all 1s.
.....00111111 Therefore, this is a broadcast address.

c) 106.178.35.255/20, Valid host address.
.....00100011 11111111

Q. For each of the following hosts, determine
a) subnet address
b) directed broadcast address
100.100.100.12/28 c) number of possible hosts on that subnet
d) maximum number of subnets, if same subnet mask is used for all subnet.

100	100	100	12
01100100	01100100	01100100	0000 1100

a) Find the most significant 28 bits. Set the remaining 4 bits to 0.

01100100 01100100 01100100 0000|0000
= 100.100.100.0/28

b) Set all the host ID bits to 1.

01100100 01100100 01100100 0000|1111
= 100.100.100.15/28

c) there are only 4 bits for host ID, so max possible hosts on a subnet = $2^4 - 2 = 14$ (all 0s and all 1s are not available)

d) This is a class A address (0 starting bit). By default net-ID has 1+7=8 bits. With subnetting it is extended to 28. So, 28-8=20 bits are available for subnet. So max is 2^{20}.