TCP/IP

IP Addressing

minimum requirements (addressing) for communicating locally: (Physical segment/ same)

(IP Address)

Network ID	Host ID

+

[(subnet mask =) identify which portion of IP Address is the network ID and which portion is Host ID]

+

[(default gateway =) IP address of Router on the same physical segment)]

for remote access (different physical segments / subnet)

* All devices on the same physical segment share a common network ID.
* each physical segment has a unique network ID.

— IP addressing modes —

public:
- registered internet IP addresses
- can connect directly to the internet
- in the current organization, ARIN to ISP, ISP to companies

private:
- non-registered internet IP addresses
- RFC 1918 - 10.0.0.0
- cannot connect directly to internet
- need Network Address Translation (NAT) or proxy services to connect to internet (included in some routers, proxy servers or firewalls)

— IP address = — 32-bit binary number

11000000.10101000.01110001.00010011

11000000.10101000.01110001.00010011 (divided into 4, 8-bit octets)

192 . 168 . 113 . 19 (converted to decimal numbers)

(decimal range of an octet: 0-255)

— it contains the device's: Network ID and Host ID

ex: 192.176.11 . 201

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Classes of IP addressing :—

Class A = (Network ID . ~~Network~~ Host ID . Host ID . Host ID) = (1/127.---.---.---)

In Binary, any address that starts with a "0" in the first bit!

{ first address: 00000001.00000000.0000 0000.00000000 = 1.0.0.0
{ last address: 01111111. 00000000. 00000000. 00000000 = 127.0.0.0 (Loopback address)

✓ 1-126 = 126 possible class A Network IDs (because the last 127 is reserved for broadcast purposes)

✓ 256 * 256 * 256 = 16,777,216 (minus 2) ~~for~~ = 16777214 (number of host IDs)

(minus 2) ≡ { host IDs can not be all 1's (reserved for broadcast address)
" " " " " " 0's (" " "this network only" address

example:

33.0.0.1 — 33.0.0.255 (255 addresses)
33.0.1.0 — 33.0.1.255 (256 ")
33.0.255.0 — 33.0.255.255 (256 ") } A total of 65535 Addresses
33.1.0.0 — 33.1.255.255 (65536 addresses)
33.2.0.0 — 33.2.255.255 (65536 ")
33.255.0.0 — 33.255.255.254 (65535 addresses)

Class B = (Network ID . Network ID . Host ID . Host ID) = (128/191 .---.---.---)

In binary, any address that starts with a "10" in the first two bits of first octet

{ first address: 10000000. 00000000. 00000000. 00000000 = 128.0.0.0
{ last address: 10111111. 11111111. 00000000. 00000000 = 191.255.0.0

Class C = (Network ID . Network ID . Network ID . Host ID) = (192 - 223 . ...)

In binary, any address that start with "110" in first three bits of first octet.

first address: 110 00000 . 0000 0000 . 00000000 . 0000 0000 = 192.0.0.0

last address: 110 11111 . 1111 1111 . 11111111 . 11111111 = 223.255.255.0

Class D & E : (reserved)

Class D = { used by Multicast applications
shared addresses
224.0.0.0 — 239.255.255.255 }

Class E = { experimental
240.0.0.0+ }

= What makes up a Subnet Mask (SNM)?

In binary, 1's represent what portion of IP address is the Network ID.

0's represent what portion of IP address is the Host ID.

for example:

207.23.106.99 (class C address)

⇒ Network. Network. Network. Host

⇒ 11111111. 11111111. 11111111. 00000000

⇒ 255. 255. 255. 0 (subnet mask)

similarly, class B subnet mask = 255.255.0.0

class A " " = 255.0.0.0

= ARP (Address Resolution Protocol)

example. RFC 826

- Maps a MAC (Hardware) (Physical) Address to a destination Host's or router's IP Address.

Source (computer) Host retrieves — (obtains) MAC address from cache or with a local broadcast.

- ~~MAC address places in the~~
- Host places MAC address in the address field of data-link frame (Ethernet, TokenRing, etc.)

* MAC/Physical/Hardware address is a unique address, 6 byte address (in most cases), burnt into network interface card by the manufacturer of network interface card

= local or Remote algorithm =

Before the data can be transferred over the network, a TCP connection must be established/setup -

- IP address of destination computer is needed and that is obtained by (DNS, WINS, Broadcast, etc.) server/site.
- once IP address is obtained, it is analyzed to determine if it is local or remote, by source host
  - ≒ comparing destination's network ID to its (source Host) network ID with subnet mask

if (destination host's network ID = Source Host's network ID)
then [it is local (same physical segment/subnet)]
and [further, it checks whether destination host's MAC address is in its cache. If not, it starts a local broadcast to obtain it and cached it for reuse.]

else it is remote
source host checks its local route table for a special route to the network of destination host, if there is, the source computer checks its ARP cache for a cached MAC address of the router associated with the router in local route table.
and if router's MAC address is not in cache, a local broadcast is initiated to obtain routers MAC address and it is cached for reuse.

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to obtain MAC address from remote host—

if there is no special route in the source host's local route table, source computer checks its ARP cache for a cached MAC address of the default gateway.

if it is not there, a local broadcast is initiated to obtain and cache it for reuse.

= Why custom subnet masks?

- All devices/hosts on the same physical segment must have the same network ID.

to correctly address multiple physical segments, we must divide the single network ID into sub-networks or "subnets", and these are created with custom subnet masks.

((a subnet is a portion or subdivision of the IP addresses that are associated with an assigned network ID.))

((The range of IP addresses included in a subnet is determined by the subnet mask.))

= Why subnets?

- hardware specifications (standard, vendor, ...)
- network performance
- geographic
- different topologies
- routers

= Creation of Subnet IDs =

example: (Network ID . Network ID . Host ID . Host ID) → default SNM

⇒ Network . Network . SN-ID . Host) → custom SNM

(subnet ID)

- each physical segment of network has a unique subnet-ID and the subnet ID is common to all hosts on a physical segment
- each host on the network has a host ID unique to its subnet ID
- choose (custom) subnet mask that creates the number of:
  - subnet-IDs >= physical segments
  - Host IDs per subnet-ID >= Hosts per physical segment

example: 152.77.0.0 { with 5 physical segments that each have a maximum of 5000 host on each segment

Net . Net . Host . Host

↳ 11111111 . 11111111 . 00000000 . 00000000

↳ Net . Net . SNID Host . Host → Custom SNM

			SNM	#of SN-IDs	#of Hosts/SN ID
11111111 .	11111111 .	10000000 .	00000000	SNM	#of SN-IDs	#of Hosts/SN ID
		10000000	00000000	128	2-2=0	32768-2
		11000000	00000000	192	4-2=2	16384-2
OK →		11100000	00000000	224	8-2=6	8192-2
		11110000	00000000	240	16-2=14	4092-2
		11111000	00000000	248	32-2=30	2048-2

use a custom subnet mask of

⇒ 255 . 255 . 224 . 0 (all devices)

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== One bits in a subnet mask =

- the 'one' bits must be contiguous, left to right in SNM, no embedded zeros

ex:' 1111 1111. 11111111. 1111 0000. 00000000 (OK)
1111 1111. 11111111. 1100 1100. 00000000 (wrong)

- subnet masks are expressed as a "/20" or some other "/number" alternatively.

ex:- for (152.77.32.0/20) ~~=~~

here, the "/20" = the number of '1' bits in SNM

so, in SNM, it will be (11111111.11111111.1111 0000.0000 0000) ⇒
(20 '1's)

⇒ ⇒ (255.255. 240. 0)

= (Minus 2) ! = why ? =

- { * the first host address is "zeros" i.e., all address is zeros.
* the last " " "ones" i.e., all " " ones. }

(both are invalid.)

- number of subnets

[don't (minus 2) if all hardware & software supports RFC 1812]

(All current stuffs (devices & S/w) have RFC 1812 now.

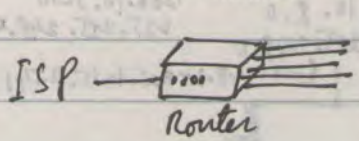
ex:

= determining (Subnet IDs) SNM = 224 ⇒

152.77.0.0 Network Address

255.255.224.0 Custom SNM

1110 0000. 00000000 (Subnet mask) SNID/Host ID (last 2 octets-Binary)	Subnet ID (decimal conversion)
000 00000. 0000 0000 (invalid)	152.77.0.0
001 00000. 0000 0000 (First SNID)	152.77.32.0
010 . . . . . (Second ")	152.77.64.0
011 - - - - - - - - (III "	152.77.96.0
100 - - - - - (IV ")	152.77.128.0
101 - - - - - (V ")	152.77.160.0
110 - - - - - (VI ")	152.77.192.0
111 - - - - - ( ) invalid	152.77.224.0



152.77.0.0 / 255.255.224.0

255.255.1110 0000.00000000	subnet mask	IP Address
152.77.00100000.00000000	First subnet ID	152.77.32.0
152.77.00100000.00000001	First Host ID	152.77.32.1
152.77.00100000.00000010	second Host ID	152.77.32.2
. . . . .	. . . . .	. . . . .
152.77.00111111.11111110	Last Host ID	152.77.63.254
152.77.01000000.00000000	second subnet ID	152.77.64.0
152.77.01000000.00000001	First Host ID	152.77.64.1
. . . . .	. . . . .	. . . . .
152.77.01011111.11111110	Last Host ID	152.77.95.254
	Third subnet ID	

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CIDR (Classless Interdomain Routing) is used —

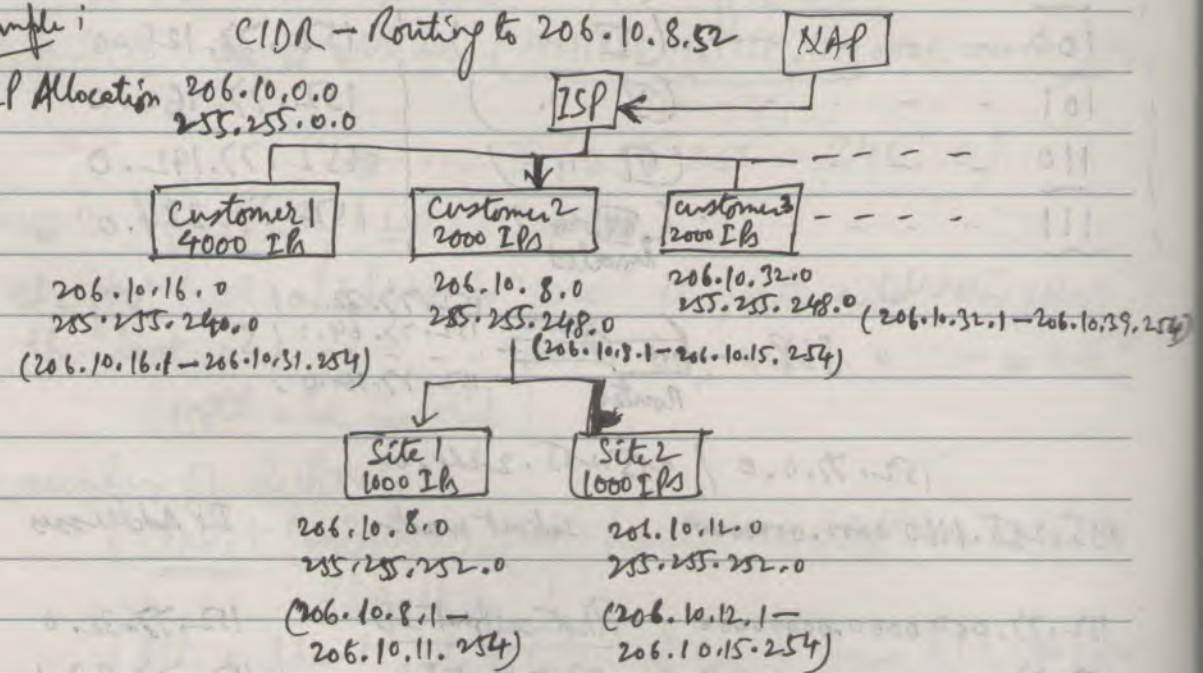
→ due to inefficient use of IP address space, proliferation of routes

~~forgets~~ * A large number of networks are represented/summarized as a single route.

= Classless numbering =

- forgets address classes (A, B, C)
- everything depends on the subnet mask (subnetting)
- one hop at a time

example:

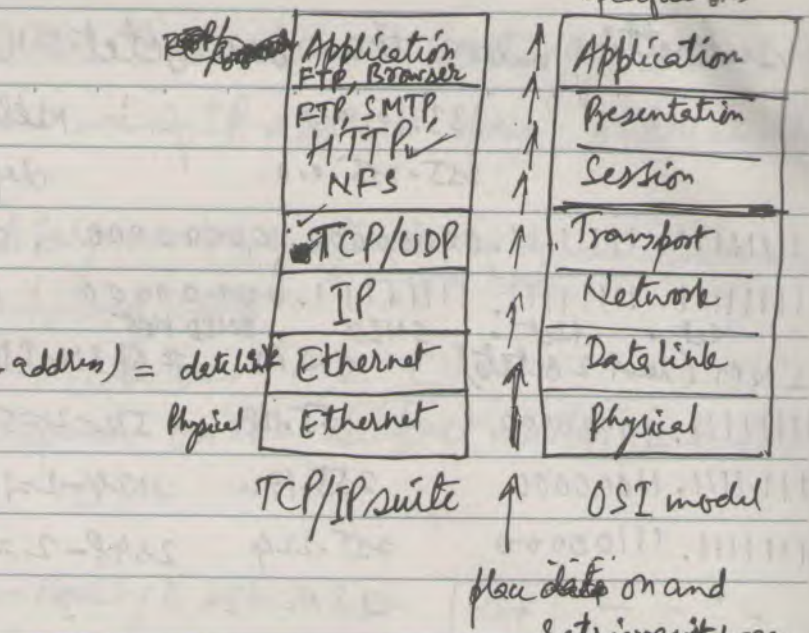


= subnetting more than one octet: Class B chart = (example)

133.10.0.0	Network address
255.255.0.0	default SNM
11111111.11111111.00000000.00000000	SNM (Binary)
11111111.11111111.11111111.00000000	Custom SNM

SNM (last 2 octets)	Net. Net. SNID SNID Host SNM	# of SN-IDs	# of Hosts per SN-ID
11111111.10000000	255.128	512-2=510	128-2=126
11111111.11000000	255.192	1024-2=1022	64-2=62
11111111.11100000	255.224	2048-2=2046	32-2=30
. . .	. . .	. . .	. . .
11111111.11111110	255.254	invalid	
11111111.11111111	255.255	invalid	

Open systems Interconnect (OSI) model - ISO specifications



✓ physical layer: specification for physical components of network (i.e. cabling, interconnection methods, distances)

✓ data link layer:- media Access control (MAC / hardware) and logical link control (LLC),
- address network devices (MAC address)
- place data in a data frame (packet)
- gives the data bits to NIC card (MAC)
- controls the NIC's access to the media (MAC)
- detects transmission errors (LLC)

example: NIC card and driver

network layer:- network addressing
- move packets between different networks - routing

example: TCP/IP software

Transport layer:- receives data from application and segments it ✓
- can provide transmission error detection and correction

example: → TCP/IP software

Session layer:- manage and track user sessions (ongoing communication)

Presentation layer:- make sure the receiving station can read the transferred data (data formatting)

Application layer:- gives end-user application access to network resources

(TCP/IP) Internet suite of protocols

Application
Transport
Internet
Network

internet/DOD model

protocols = - ARP (address resolution protocol) (used to discover MAC address)
- IP (internet protocol) (provides addressing and routing), (connectionless)
- TCP (transmission control protocol) provides (three way handshake) (agreement/acknowledgement) connection-oriented, reliable data delivery
- UDP (user datagram protocol) provids connection-less data delivery
- DNS (domain naming servers) protocol, retrieves IP address when user enter URLs.
- HTTP (hyper text transfer protocol) provides web browsing
- HTML (protocol provides page formatting)
- others: ICMP, SMTP, POP3, DHCP, FTP, SNMP, BGP, RIP, etc.

{Ethernet / (IEEE 802.3)} = (LAN technology for transferring data 10 Mbs to 1 Gbs.) = (OSI model's physical and data link layers specifications)
- connectionless

(calling & connection) x Baseband = 10 Mbs
eg. 10 Base 5 = 10 Mbs Base 5

ethernet interconnection methods: Bus (cheap, but not fault tolerance)

ethernet interconnection method: star (more expensive but fault tolerant uses hubs

ethernet addressing (MAC/hardware/NIC addressing)
- 6 byte address:
  - first 3 bytes are organization unique identifier (OUI) assigned by to manufacturer

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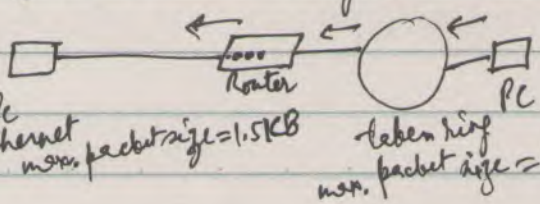
IP packet fragmentation = a single IP packet can be subdivided by a router into multiple packets during data transmission to accommodate destination network (which is determined by data link layer)



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Ports – a method for applications to identify themselves to the TCP and UDP programs.

(multiple applications use the same TCP program)
e.g., DNS, FTP, webserver, etc...

✓ (each application is assigned a unique port number by TCP)

(possible 65536 port numbers)

Server side ports = (RFC1700 reserves the first 1000 port numbers for server side applications)

e.g.: webserver port 80
DNS port 53
SMPT port 25

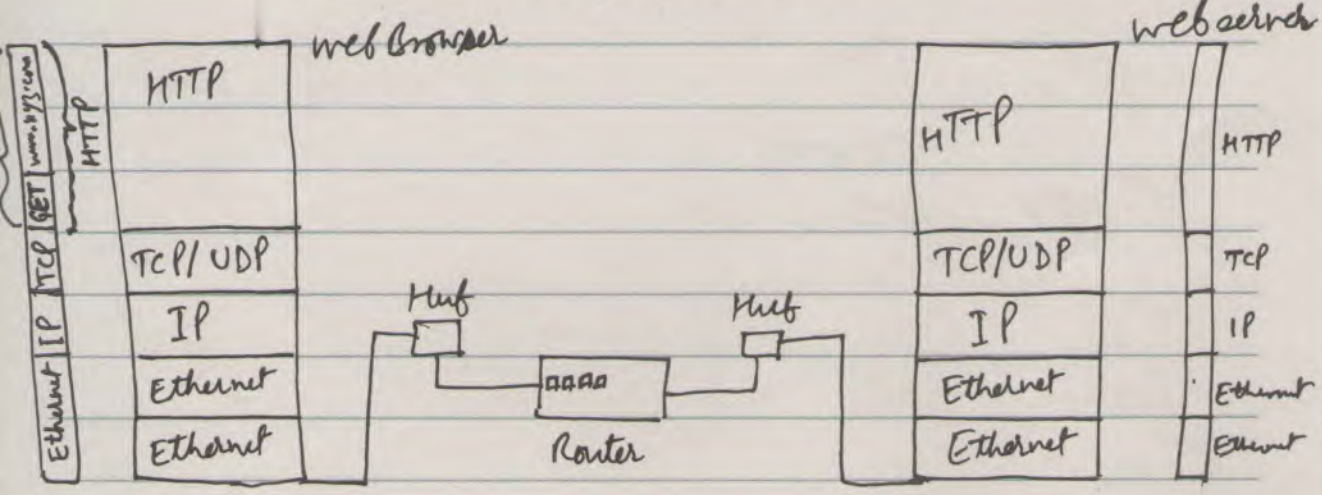
client side ports = (numbers assigned to client network applications as they initialize)

– (starting at 1024)

OSI Computer : Building packets

client	OSI	TCP/IP	Server
web browser (HTTP/HTML)	APPLICATION	HTTP/HTML	web server (HTTP/HTML)
	Presentation		
	Session		
TCP/IP Software	Transport	TCP/IP	TCP/IP Software
TCP/IP Software	Network	IP	"
NIC Card & Driver	data link	ethernet	NIC card & Driver
" "	physical	ethernet	NIC card driver

end to end communication



Network commands =

① ipconfig /all

② tracert 142.58, 224.88

(tracing route to ...)

Web Server (Serving dynamic web pages)