01/20/2004

CIS 456, Open Systems Networking.

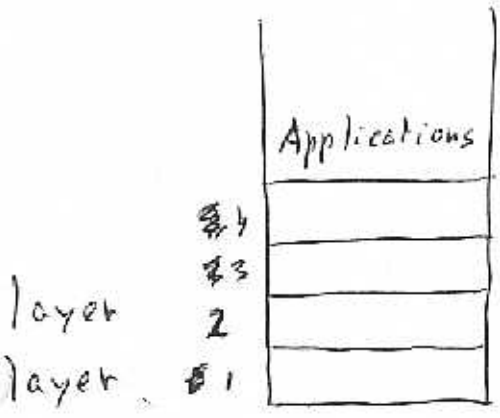
The name of this course dates back to the time that OSI (Open Systems Interconnection) was thought to be the Future.

No more!

OSI "disappeared",

TCP/IP won. (more later).

Some of the language of OSI stuck:



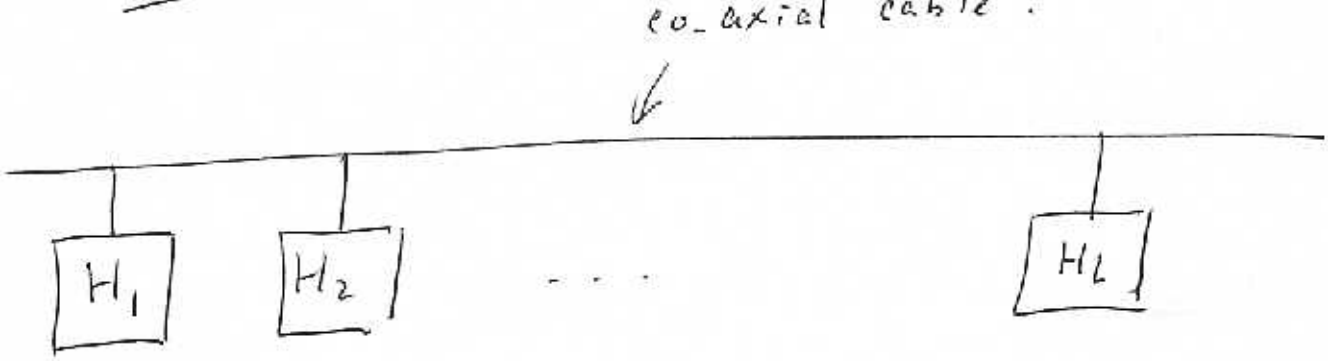
In this course we concentrate on layers 3 and 4, plus some applications (WWW).

We use ethernet as recurrent example of a Data Link Layer protocol.

(There are more: take CIS 451).

Ethernet :

I: Old :



$H_1, H_2, \ldots, H_L$: Hosts (= Computers).

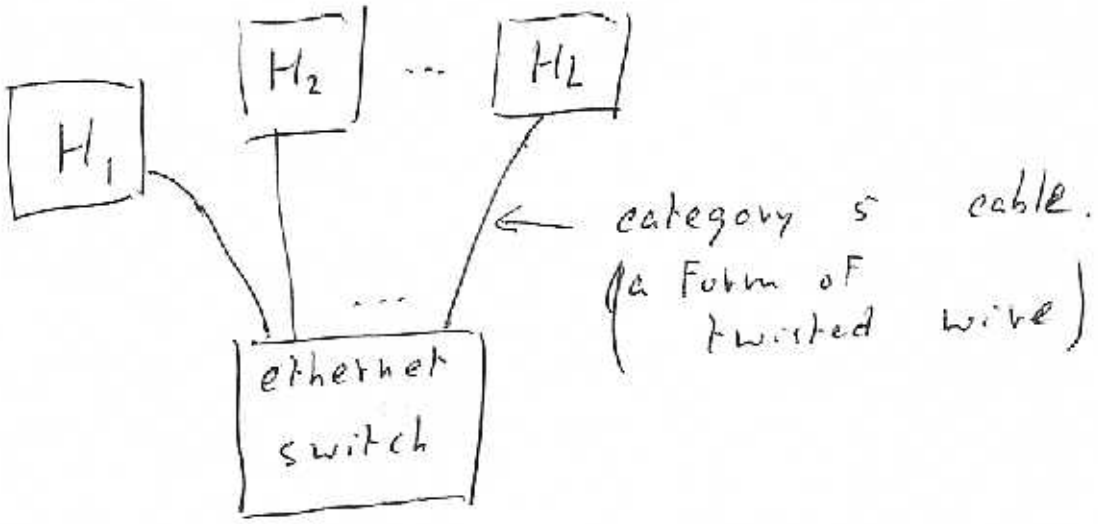
(Using CSMA_CD :
Carrier Sense Multiple Access,
with Collission Detection,
see CIS 451).

In this course you do not need to know CSMA_CD.
(But it does not hurt: is a good investment).

Any station sends: All hear it.
(Needs method to handle collissions).
(Re_transmission, Exponential BackoFF, etc.)

ethernet,

II : now (mostly)



Any host sends:

ethernet switch receives,

Forwards to { All / Some / one / none? } other hosts.

No collisions!

To keep language simple, we pretend we are in the situation of co-axial cable.

III. 6 bit ethernet.

"Similar to II (ethernet switch)"

but now ~~two~~ either more complicated twisted wire, or optical fiber.

In ~ ~~25~~ 30 years, ethernet moved from

~ 3 Mbit/sec, shared, to

~ 1000 Mbit/sec, switched.

Why do we still call it ethernet?

What is it that remained constant?

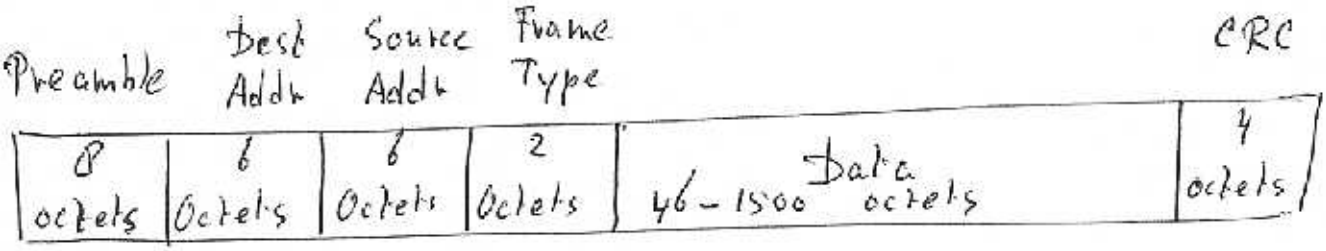
The ethernet Frame layout.

(Language: ethernet Frame
IP packet).

IF Host x wants to send Data to Host y:

It encapsulates the data in an ethernet Frame:

((Comer, p 30)



Preamble: 8 octets = 64 bits.
Used to get clocks in synch., etc.
"Here comes a Frame".

Ethernet Addresses.

Every ethernet card has a "baked in" 6 Byte, 48 bit, ethernet address.

Baked in by the manufacturer.

IEEE hands "batches of addresses" to manufacturers.

48 bits:

There are (in principle)

$2^{48} = 2.8 * 10^{14}$ different ethernet addresses.

(Not all are legal!)

About $\frac{2.8 * 10^{14}}{6 * 10^{9}} \approx 4.7 * 10^{4}$ For every human on the planet.

This is the unicast address of the network card.

The "physical address" of the host.

Frame Type.

often called "ether type".

2 octets. = 16 bits

Describes the type of data carried.

E.g. if the Frame type Field contains

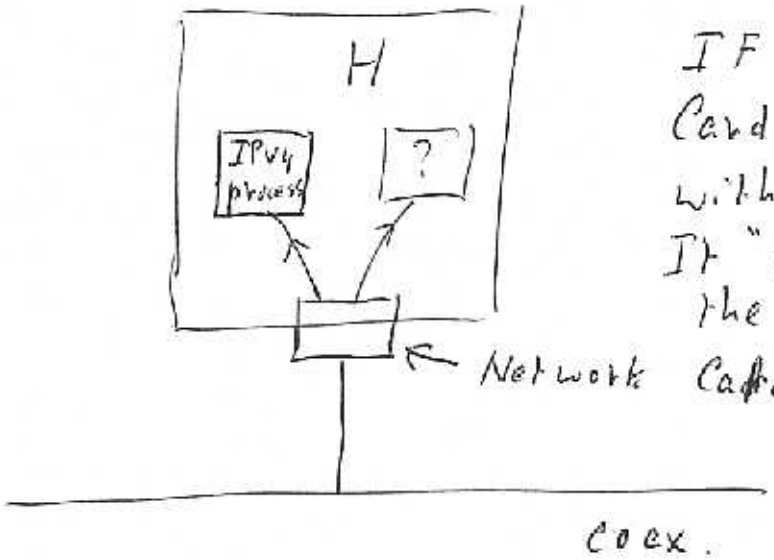
0000 1000 0000 0000 = 0800 = 2048,

bits Hexadec decimal

that means the data is an

IP v 4 (IP version 4) packet.

Related to Layering:



IF the Network Card receives a Frame with Frametype 0800, It "knows" it must give the packet to the IP v 4 Software.

CRC :
Cyclic Redundancy Check.
This is an error-detecting scheme.

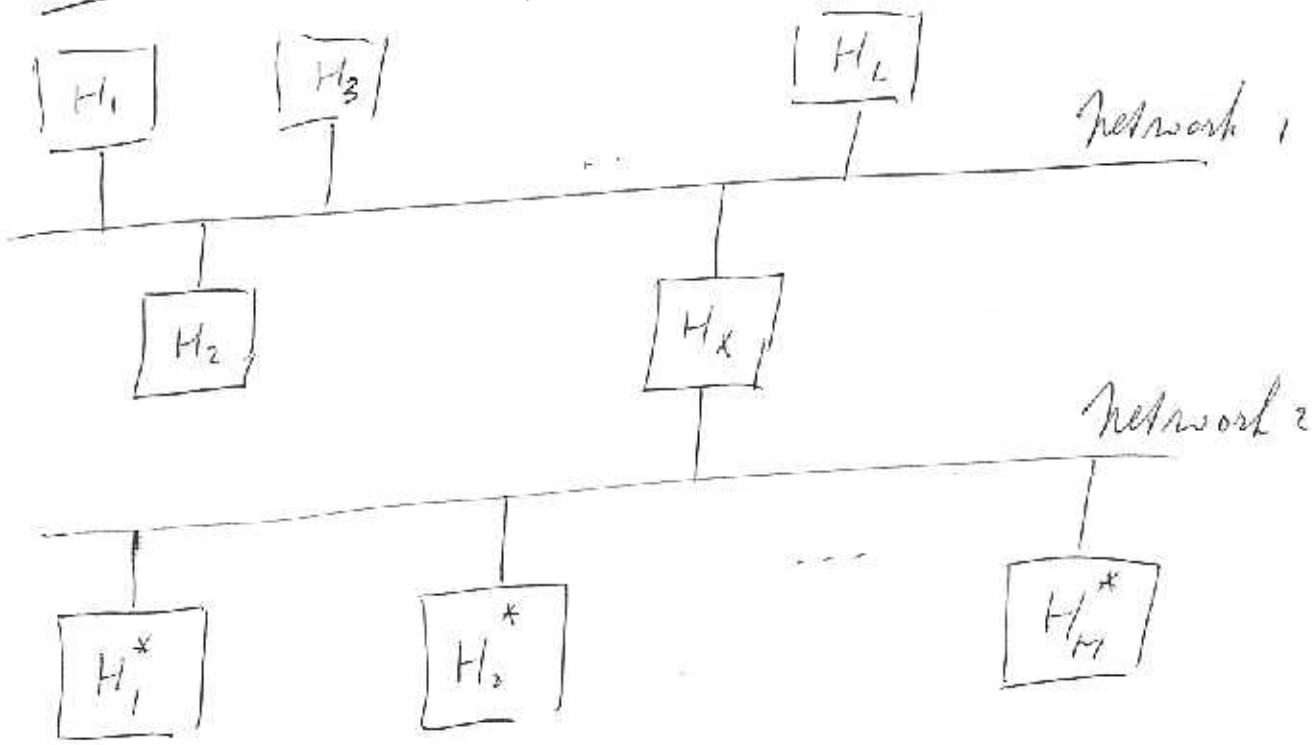
IF Frame gets damaged in transit:
Receiver checks CRC, detects error,
discards Frame.

Data: 46 - 1500 Bytes.
IF the "real data" is less than
46 Bytes: Use padding.

How does the receiver know there
is padding?
In case of IP: the IP Header.
There is an older method, also.

Addresses are addresses of Inter Faces.

Not of Computers



H_1 etc. : has one address on Network 1

H_1^* etc has one address on Network 2.

H_X has Two addresses:

one on network 1

one on network 2.

H_X is dual ported.

Why dual ported?

E.g.

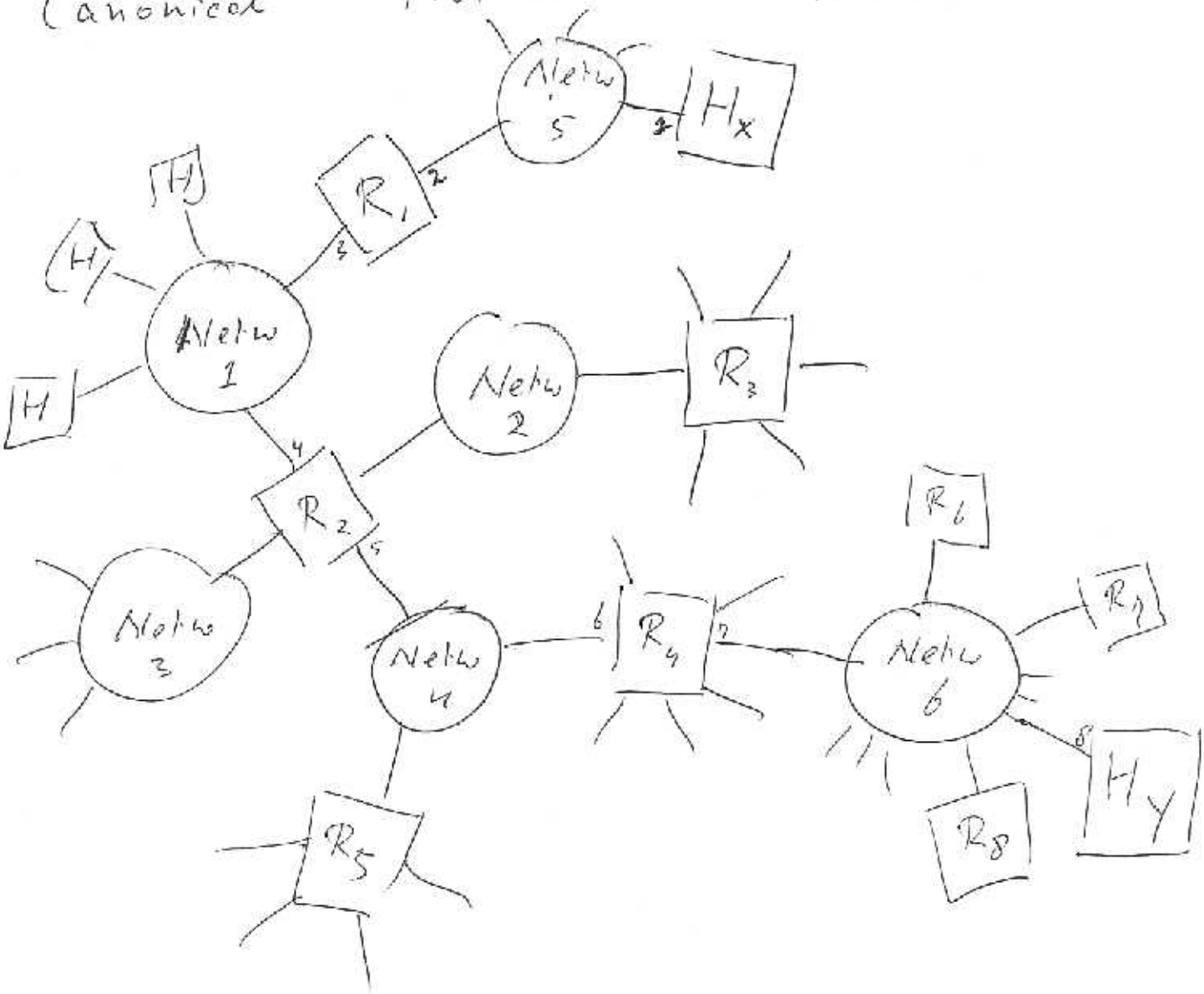
A printer (network printer) may very well be dual ported:
Computers (customers) from 2 networks can use it.

Storm here 01/23/2004

Other example?
What if H_1 has data it wants to send to H_1*?

H_X (IF so configured!) can act as router.

"Canonical" Picture of Internet:



etc.

R_5: Has 5 Interfaces.

5 IP addresses.
("on different networks").

~~each~~ 5 physical addresses.
(could be same!!) ← very unlikely!
(if ethernets: all different!).

H_x has data to send to H_y.

H_x : Source

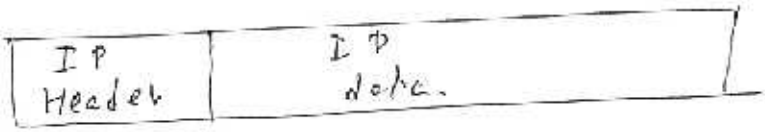
H_y : Destination.

H_x puts data in an

IP packet.

(Internet Protocol).

With an IP packet Header.



The IP Header contains:

IP address of H_x (IP Source Address)

IP address of H_y (IP dest. Addr)

These are the Logical Addresses.

(IP Header contains more: Later).

H_x finds router that can forward the packet (R_1)

H_x stuffs IP packet inside "LAN Frame" (think ethernet). ("LAN wrapper").

with physical source address 1

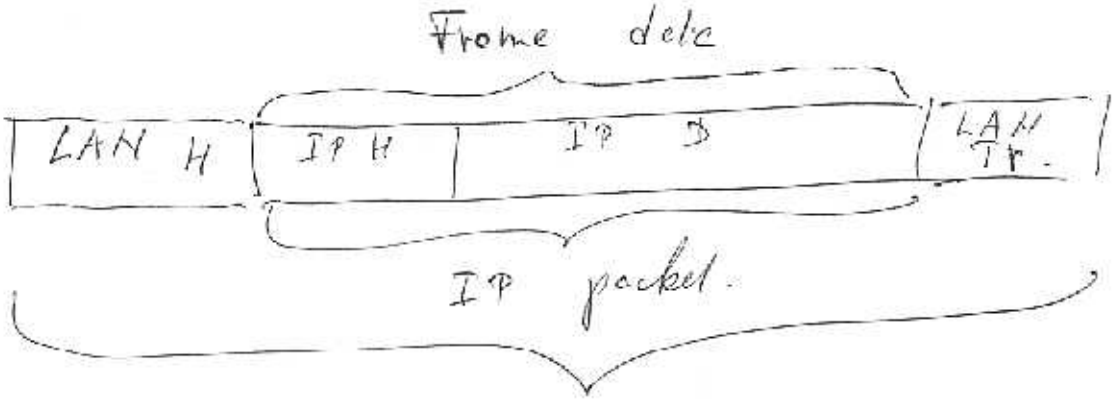
dest. " 2.

R_1 finds other router that can forward the IP packet. (How?).

LAN frames. R_1: $3_2 \Rightarrow 4$.

etc.

R_2 $5 \Rightarrow 6$ R_4: $7 \Rightarrow 8$ Delivery.



Frame.

Questions.

(1) How does H_x know which router to send the packet to?

(2) Once A knows about R_1:
How does it get the physical address?

etc.

Similar:

(3) How does R_i know which router (R_{i+1}) to forward to?

(4) How does it know the physical address to forward to?

On the way From R_i to R_{i+1}:

IP packet has IP source address "H_x", } Logical
IP dest address "H_y". } Addresses

LAN Frame has source address "R_i", } Physical
dest. address "R_{i+1}". } Addresses.

Remember:

Ethernet Addresses are globally unique.

But:

Have no structure.

Can not be used for routing external to "LAN" (how many).

Many other LANs:

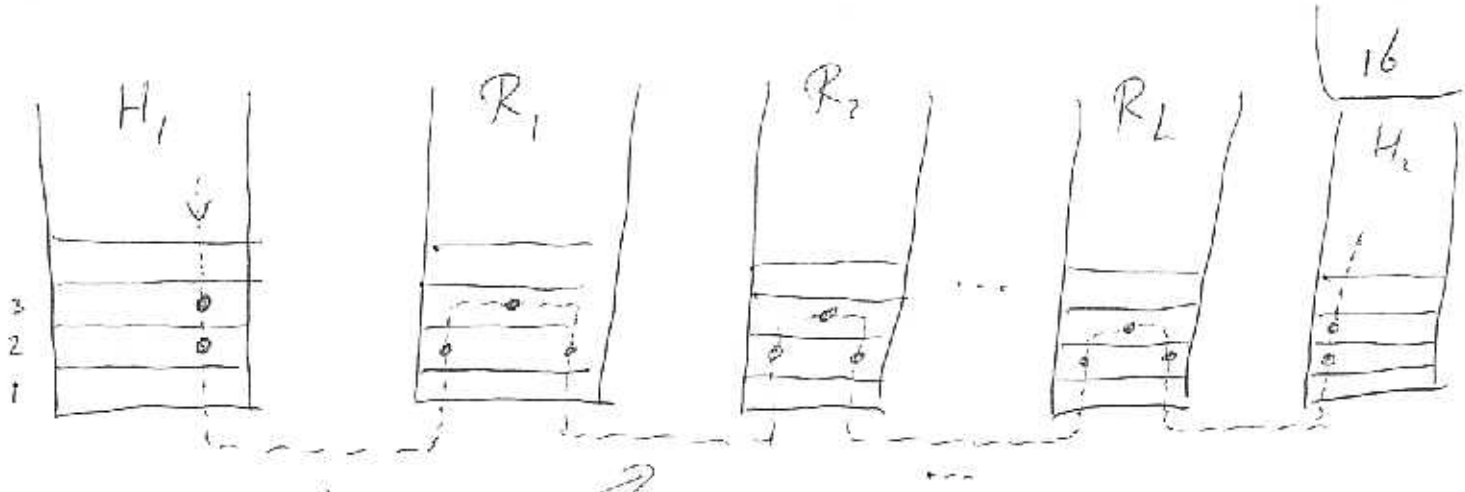
physical addresses are not globally unique.

Can not be used for routing external to LAN.

LAN Header, Trailer,

Have Local meaning only!

Link Layer.



Different (New) LAN - wrapper.
("Frame", think ethernet)

Same ~~IP~~ IP Packet.
(Almost same: ~~there is~~ Routers make minor changes).

Internet Addresses.

Internet Addresses have structure.

Old structure: Class Full Addresses.

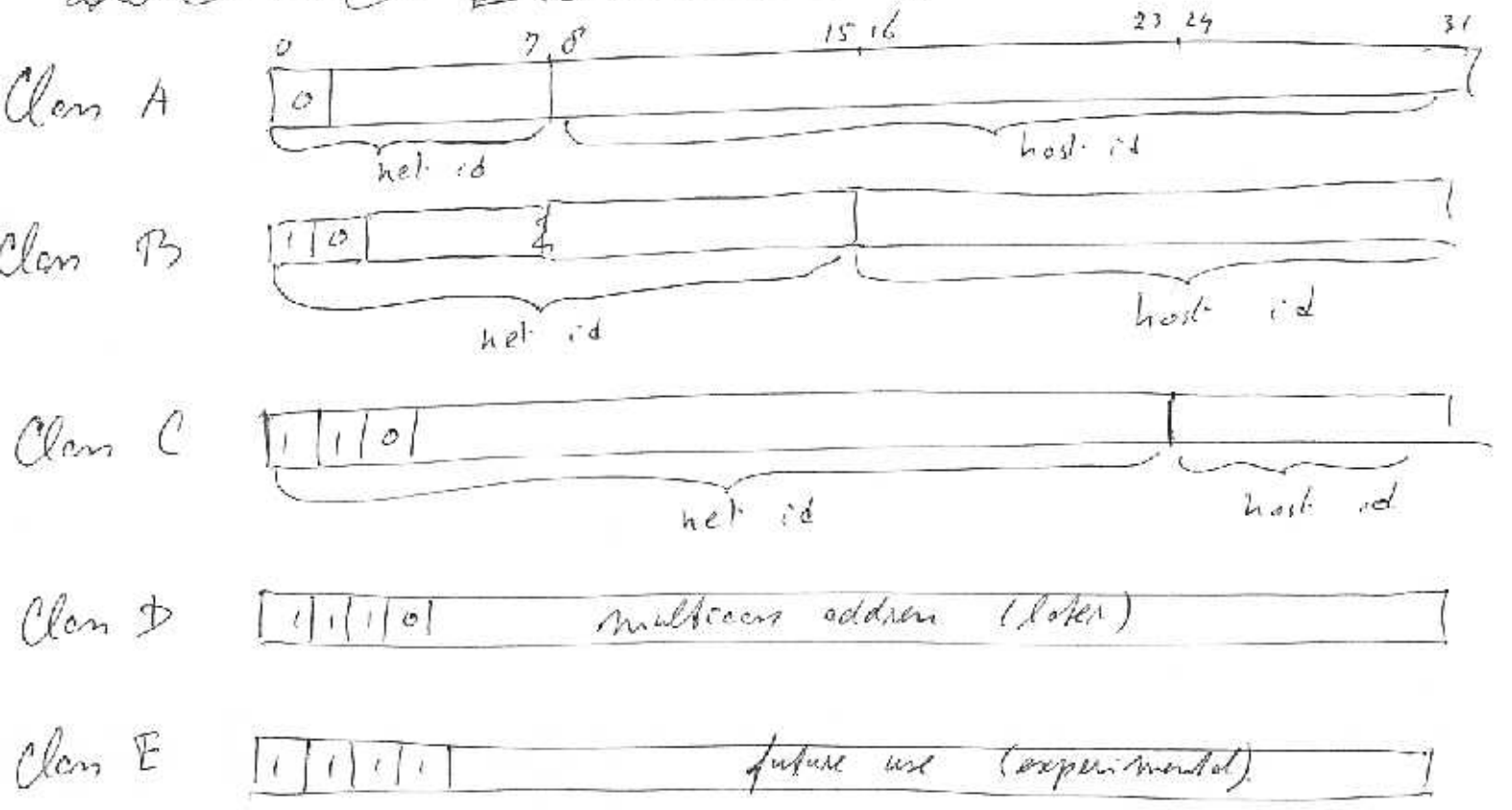
Comer, p 64.

All Internet Addresses are 32 bits long, consist of

net work part host part.

But the break-down is not always the same.

Old:



Class full Addresses are ~~Self~~ Self-identifying:

You can see (from the address) which part is network id, host id.

~~Class A~~:

Dotted Decimal Notation:

aFs1:

aFs1.njit.edu

alizarin.njit.edu

128.235.204.81.

1000 0000 . 1110 1011 . 1100 1100 . 0100 0001

128 235 204 81

235 = 128 + 64 + 32 + 8 + 2 + 1 (192, ~~224~~ 232)

204 = 128 + 64 + 8 + 4 (192)

81 = 64 + 16 + 1

IF we believe this is a class Full address:

Must be class B.

Net_id: 1000 0000 . 1110 1011

128 235

Host_id 1100 1100 . 0100 0001

204 81.

Indeed:
NSIT "owns" the whole address space 128.235.0.0/16.
(all addresses that have the same first 16 bits as 128.235.0.0).

Structure:

So, if any router in the world sees an IP packet with a dest. addr. that starts with 12.8.235, it "knows" the packet is for NSIT. (Some computer in NSIT).

Exceptions:

Addresses in 127.0.0.0/8
(0 111 1111. anything. anything. anything)
are "loop back addresses".
are <u>not</u> allowed in Internet!

Comer p 172.

Private Addresses:

10.0.0.0/8	0000 1010 { anything	(A?)
172.16.0.0/12	1010 1100 . 0001 { anything	(B?)
192.168.0.0/16	1100 0000 . 1010 1000 { anything	(C?)
169.254.0.0/16	1010 1001 . 1111 1110 { anything	(B?)

are <u>private</u> addresses.
Anybody can use them in a private network.

E.g. my Internet Lab: we use 10.0.0.0/8.

How do we prevent confusion?
NAT: Network Address Translation.
(Not in this class?)
(Ch. 20)(?)

Under "Class Full Addressing", addresses are <u>self-identifying</u>.
Once you see the address, you know what part is network ID, what part is Host ID.

Other special meanings:

all zeros : "this".
all one : "all".

p 71.

Example:

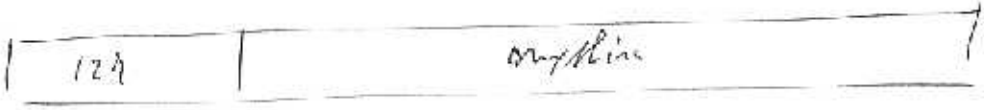
32 zeros.
"this host, on this network".
source address only.
Used by computer that does not know its own IP address.

Host on this net.
(when?)

"limited broadcast"

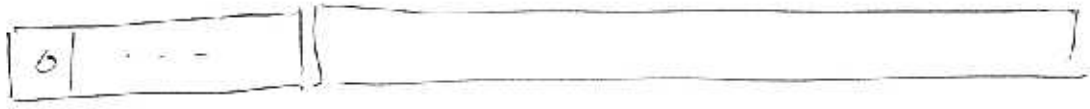
"all hosts on this net.
(illogical!)

directed broadcast



loop-back.

01 1

Class A: 

There can be $2^7 - 2$ different class A networks.

$$\begin{pmatrix} net & 11\cdots1 \\ net & 00\cdots0 \end{pmatrix}$$

$= 128 - 2 = 126.$

Each has $2^{24} - 2 = 16,777,216 - 2 = 16,777,214$ possible addresses.

Class B: 

$2^{14} - 2 = 16,384 - 2 = 16,382$ networks.

each $2^{16} - 2 = 65,536 - 2 = 65,534$ host addresses.

Class C: 

$2^{24} - 2 = 16,777,214$ different networks

each $2^8 - 2 = 256 - 2 = 254$ host addresses.

Did not make sense!

(1) Can you think of a single "LAN" that has 16 M Hosts? or even 64 K Hosts?..

(2) Can you think of a single company that needs 16 M addresses? (Any?) or 64 K addresses! (yes, quite a few, not 16 K? companies).

Many companies need several times 254 addresses: give them a whole class B space? Not enough class B networks.

Does "Network" stand for "Company"? Confusing!

Result of Class Full Addressing:

A company that needs 800 addresses asks for a class B address space.

Waste of Address space.

~ 1995 ~~1997~~: We (thought we) were running out of address space.

Partial Solution: CIDR

Classless Inter-Domain Routing.

Comer, p 165.

Example:

128.235.0.0/16 : The "set of all addresses that have the same first 16 bits as 128.235.0.0.

1000 0000 1110 1011 { anything.

(NJIT).

Internally, NJIT is Further sub-divided in sub-nets.

e.g.

128.235.32.0/22

1000 0000 . 1110 1011 . 0010 00 { anything

22 bits — 10 bits — 1022 host-ids

Also

~~128.235.32.0/22~~

~~1000 0000 . 1110 1011 . 1100 11~~

128.235.204.0/22

1000 0000 . 1110 1011 . 1100 11 { anything

22 bits — 10 bits — 1022 host-ids

There are more.

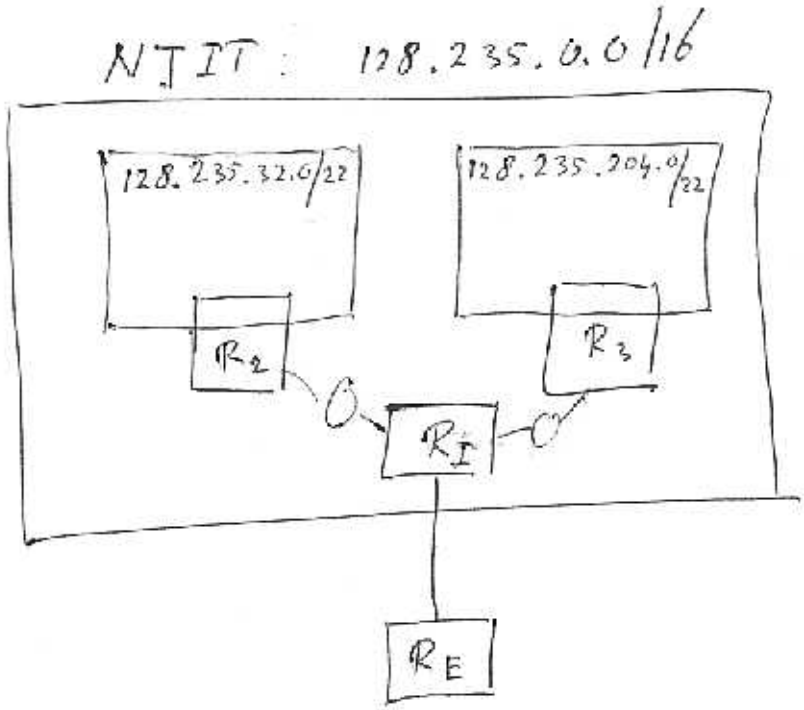
Not necessarily all of length 22.

Indeed: (Found later).

128.235.223.0/24

1000 0000 . 1110 1011 . 1101 1111 { anything

24 bits — 8 bits — 254 host-ids.



Outside NJIT:

Any Router that sees a destination IP address inside 128.235.0.0/16 "knows" the packet is For NJIT: does not look Further.

Inside NJIT, Routers Look Further: which sub-network?

[redacted]

More about

Super- Netting,

Sub - Netting,

CIDR,

Later

(Comer, Ch. 10).