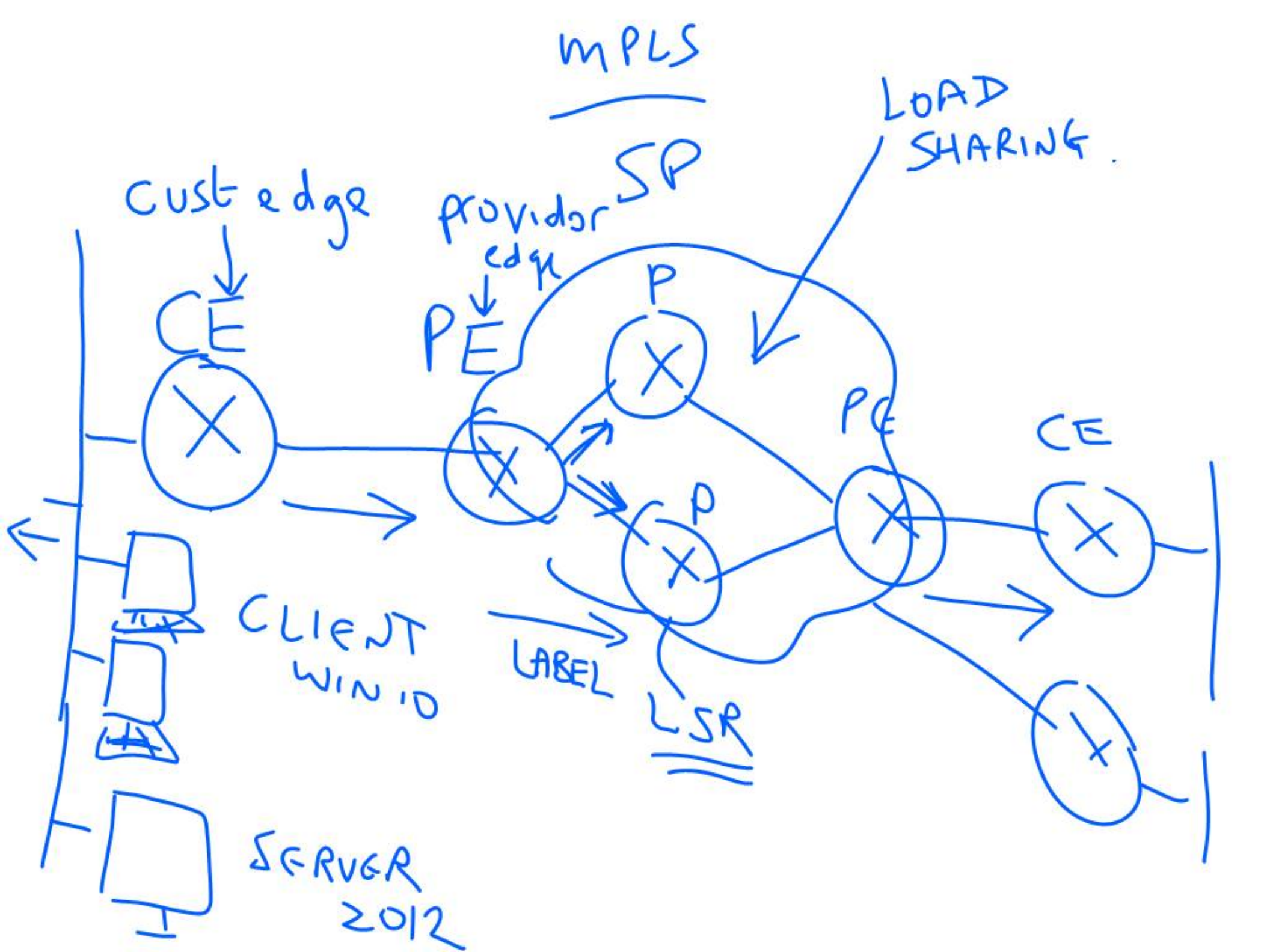
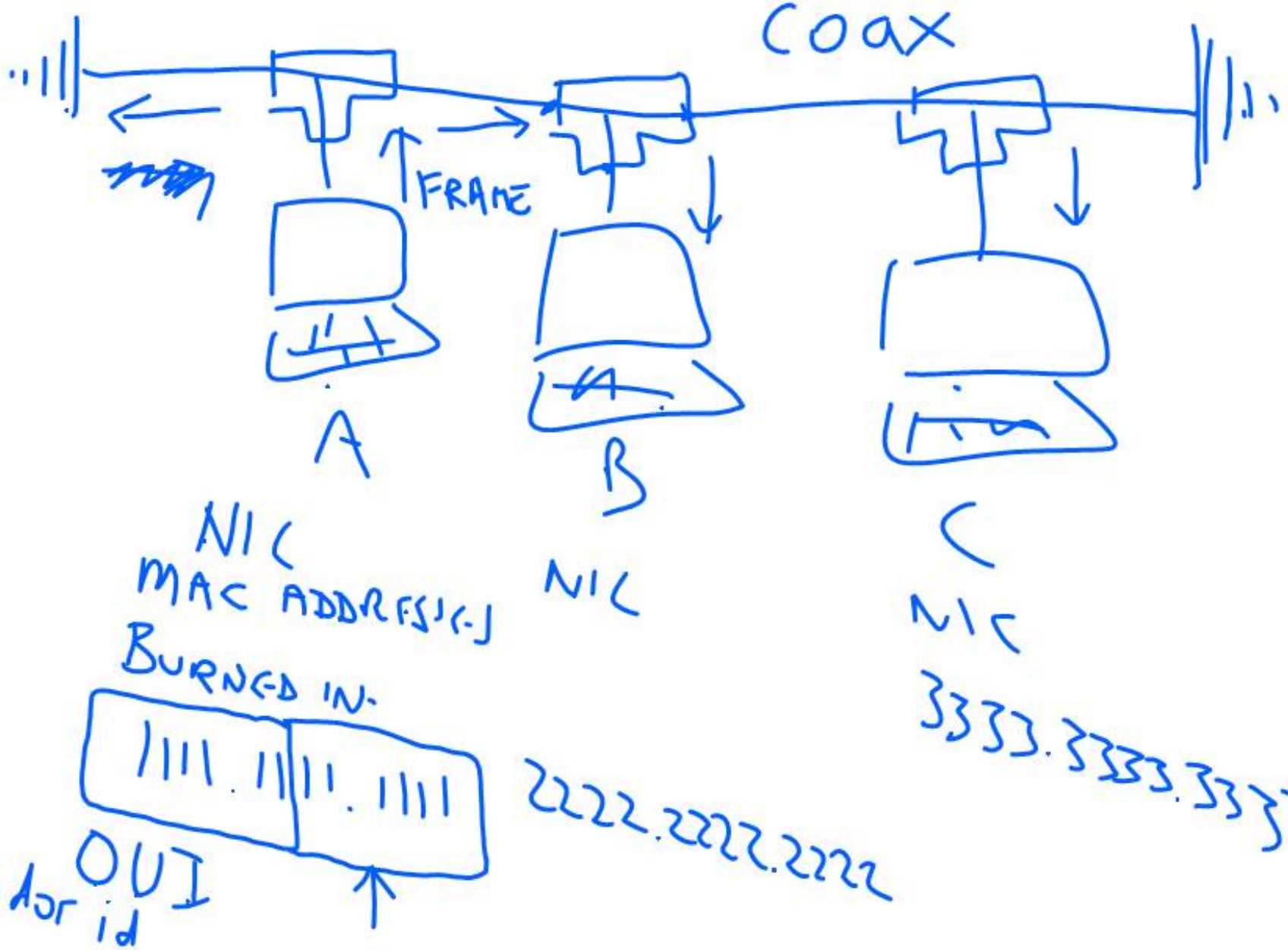
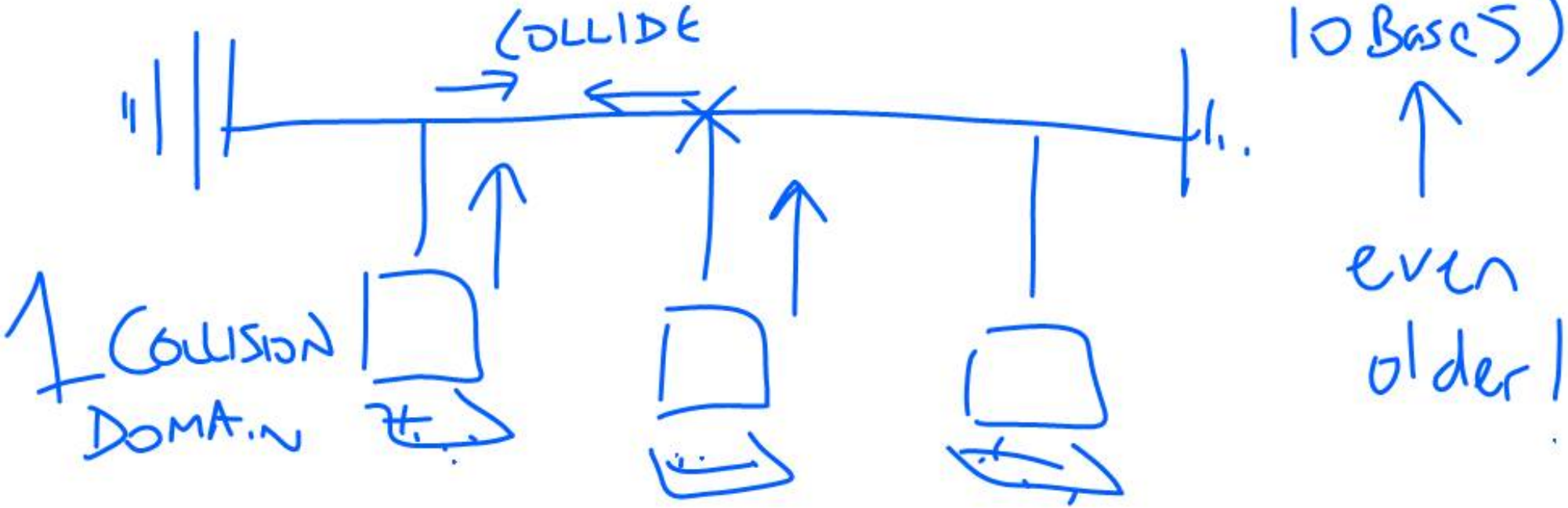

MPLS
LOAD SHARING.
SP
Cust edge
providor edge
CE
PE
P
P
PE
CE
CLIENT WIN 10
LABEL
LSR
SERVER 2012

10Base2 (old!)


Coax
FRAME
A
B
C
NIC
MAC ADDRESS
BURNED IN
NIC
NIC
1111.11
11.1111
OUI
vendor id
2222.2222.2222
3333.3333.3333

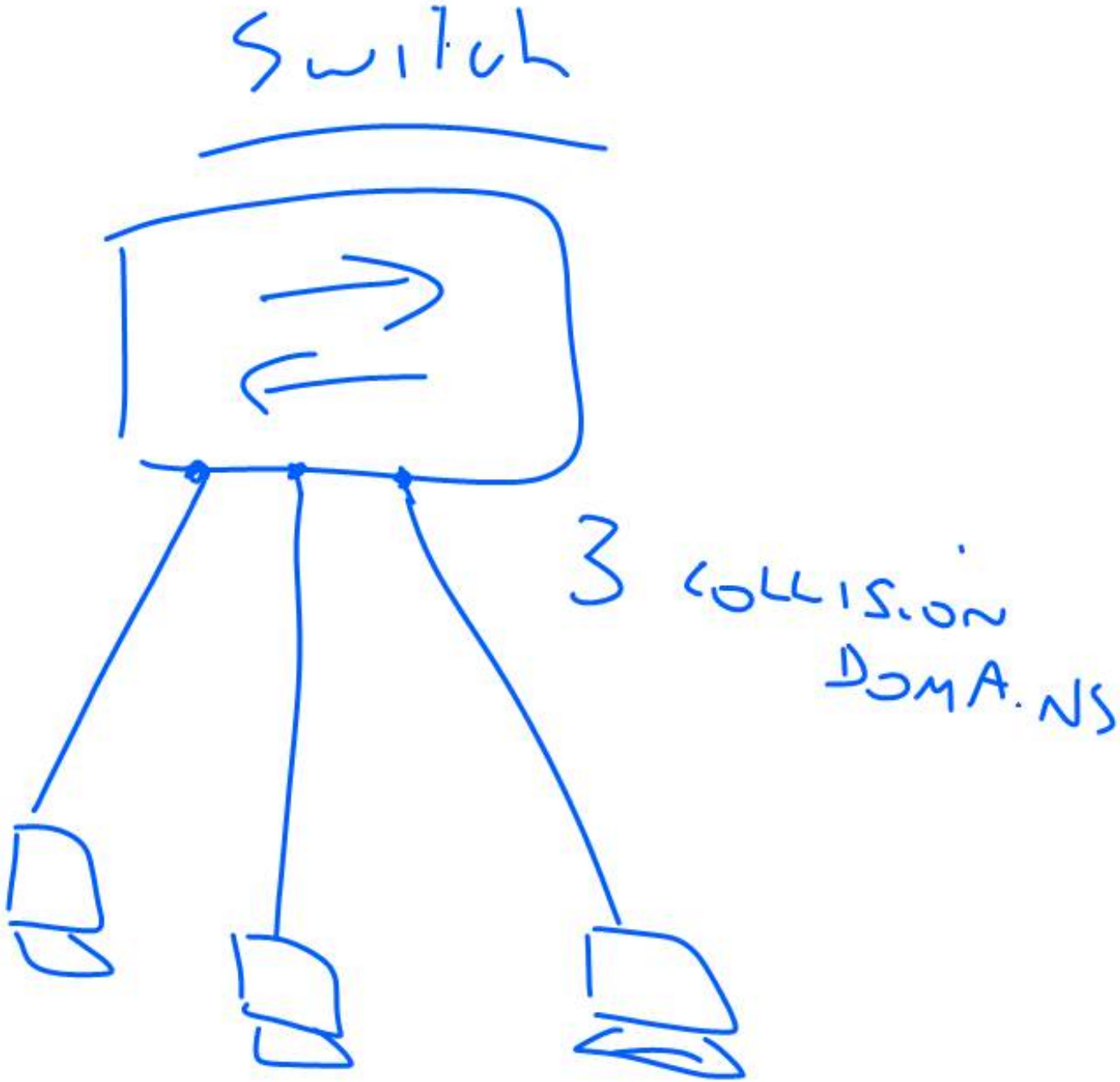
Speed — 10Base2 — Thinnet (Thicknet 10Base5)



Carrier Sense Multiple Access Collision Detection

CSMA/CD

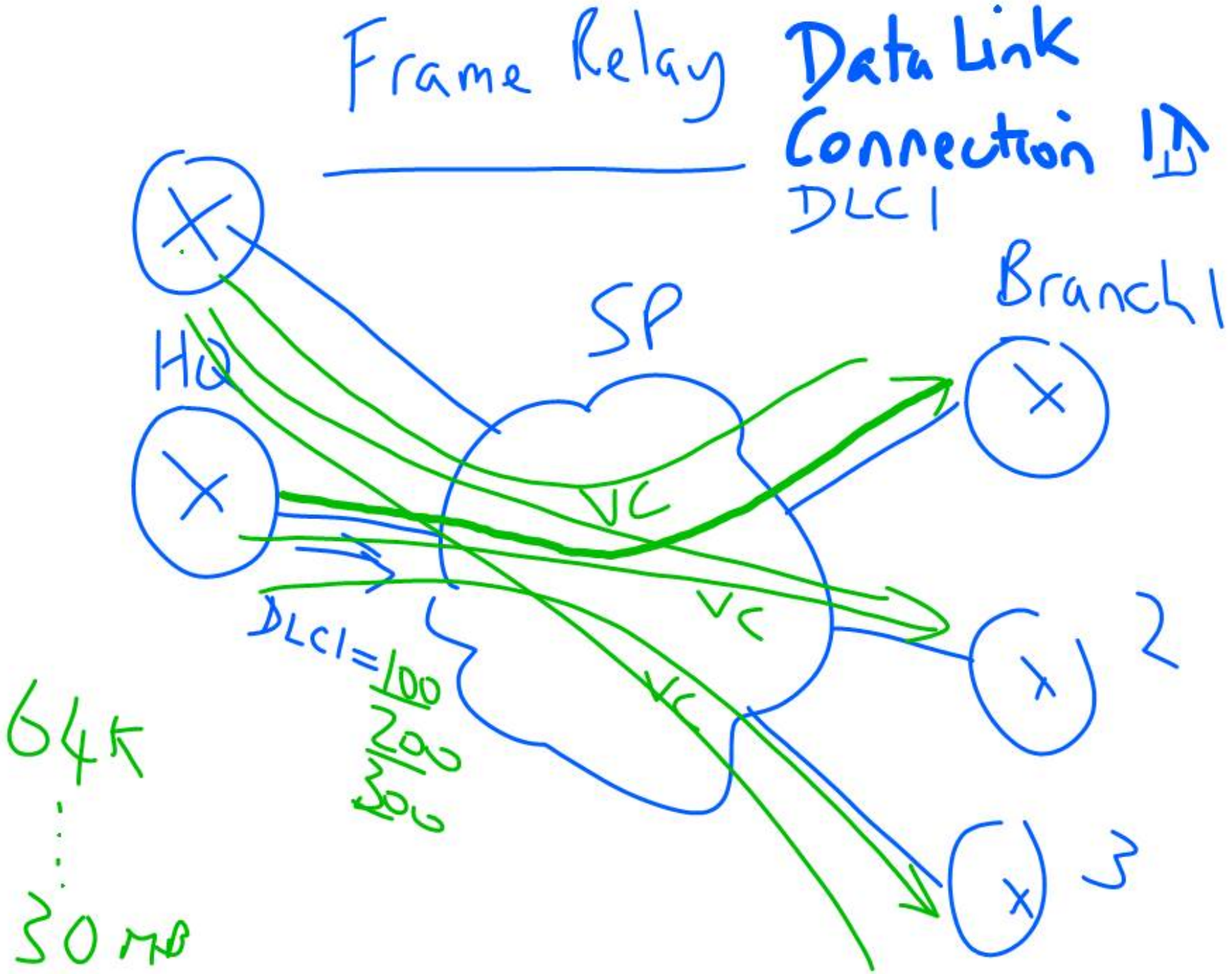
HUB (OLD!)

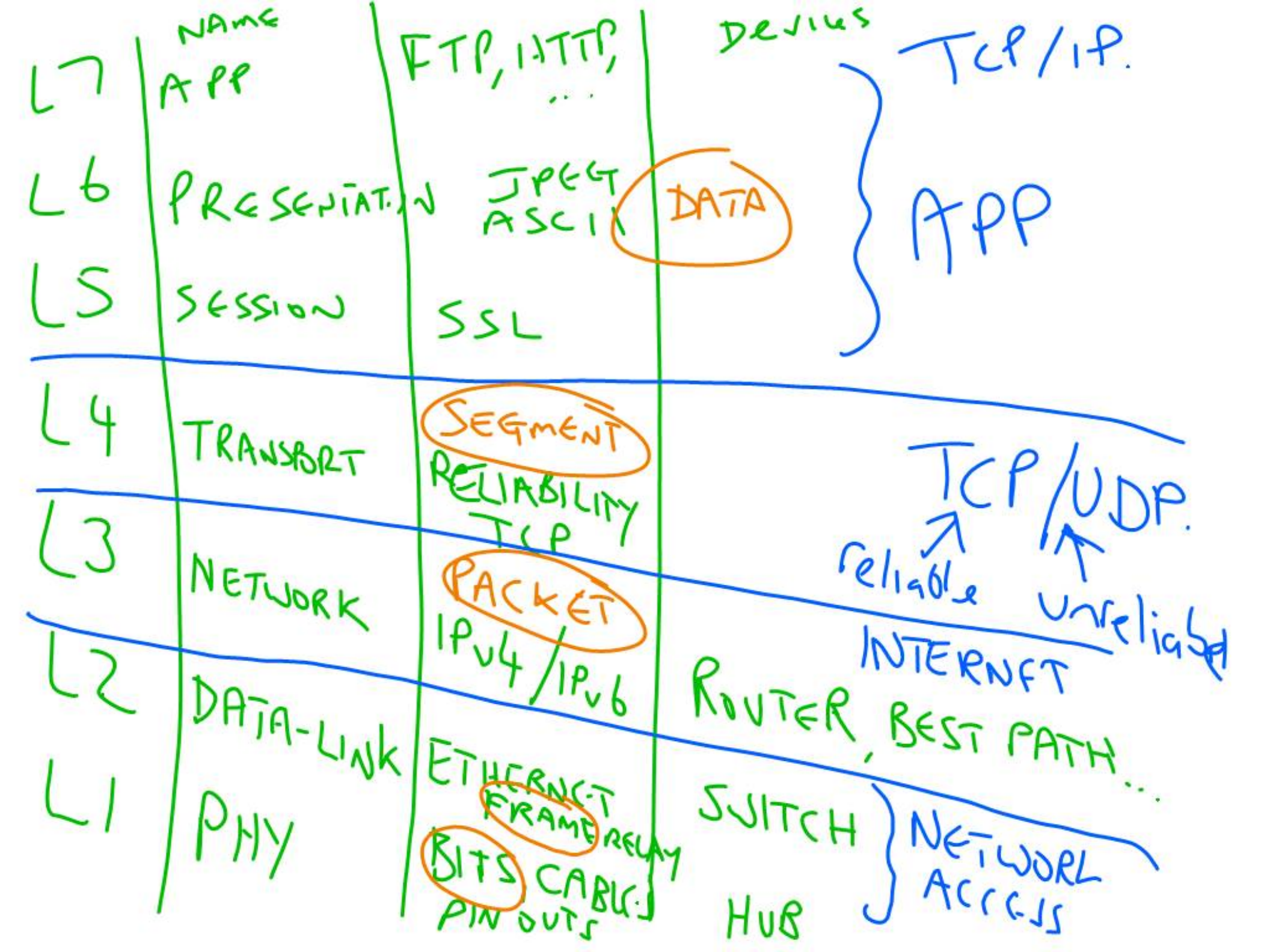

Switch
3 COLLISION DOMAINS

ipconfig /all

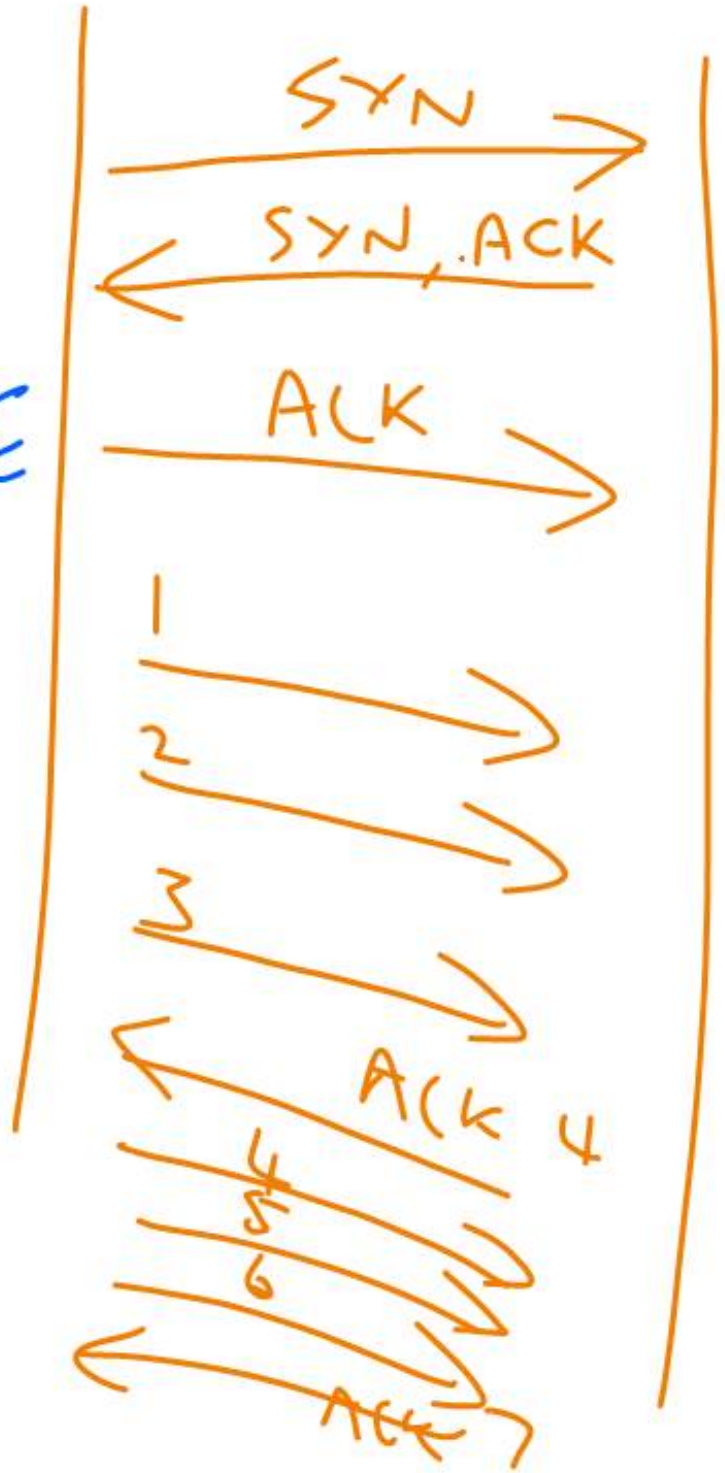
Hex 0-9, A B C ... F

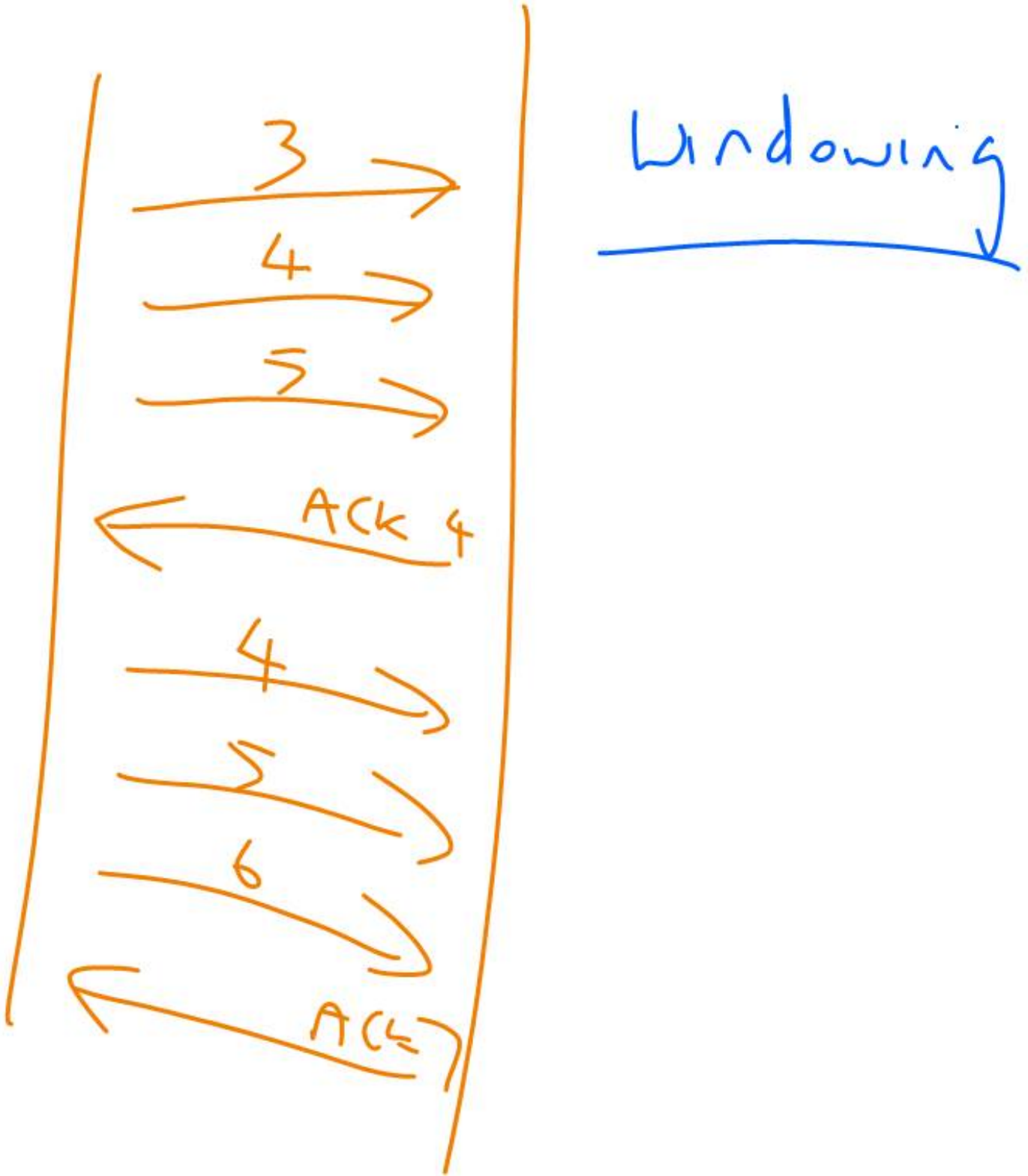
10 11 12 15

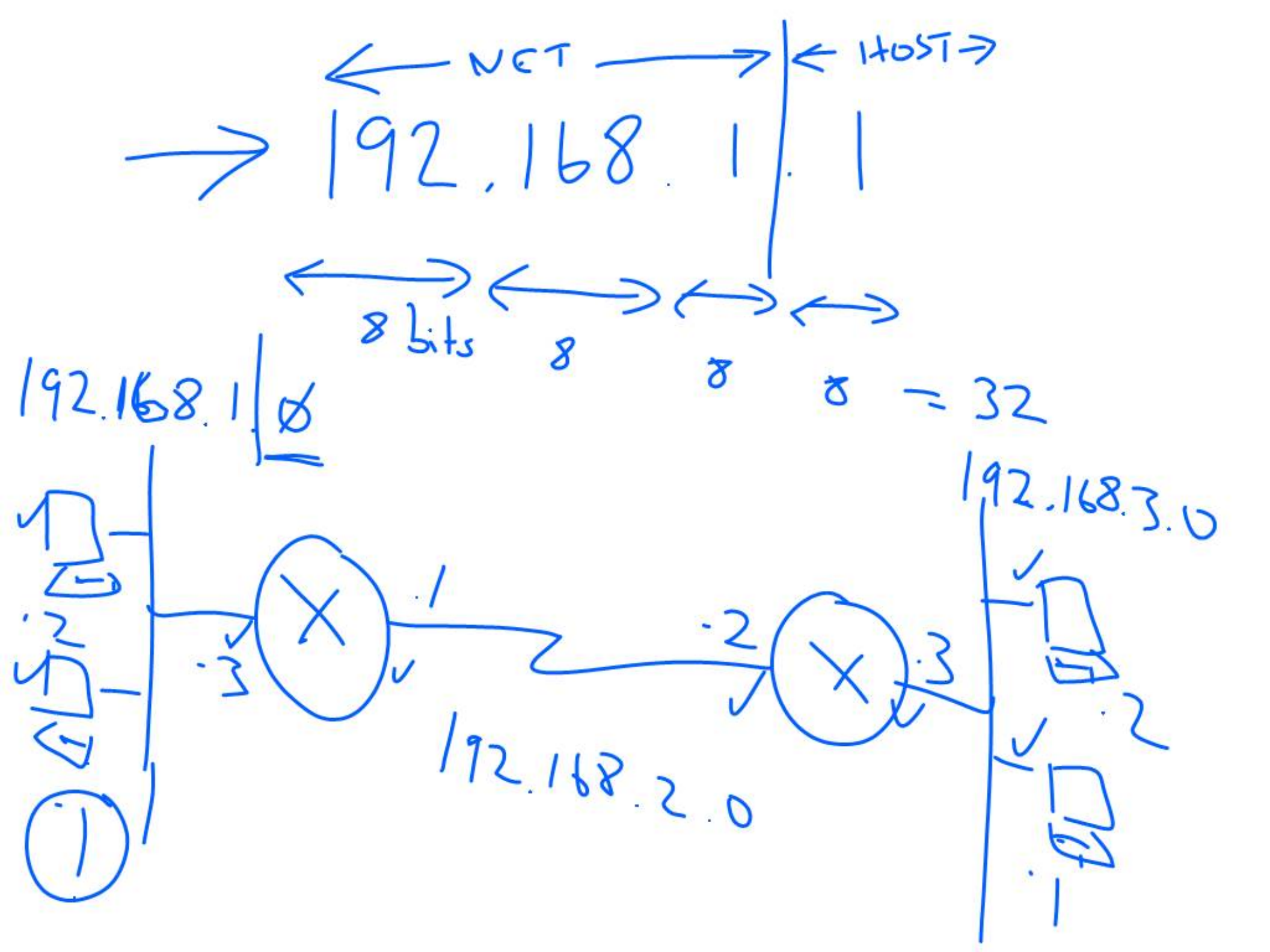

Frame Relay
Data Link Connection ID
DLC1
HQ
SP
Branch1
VC
VC
VC
DLC1=100
200
300
2
3
64
.
.
.
30 MB


NAME
DEVICES
L7
APP
FTP, HTTP, ...
L6
PRESENTATION
JPEG
ASCII
DATA
L5
SESSION
SSL
TCP/IP.
APP
L4
TRANSPORT
SEGMENT
RELIABILITY
TCP
L3
NETWORK
PACKET
IPv4/IPv6
L2
DATA-LINK
ETHERNET
FRAME RELAY
L1
PHY
BITS
CABLES
PIN OUTS
TCP/UDP.
reliable
unreliable
INTERNET
ROUTER, BEST PATH...
SWITCH
HUB
NETWORK ACCESS

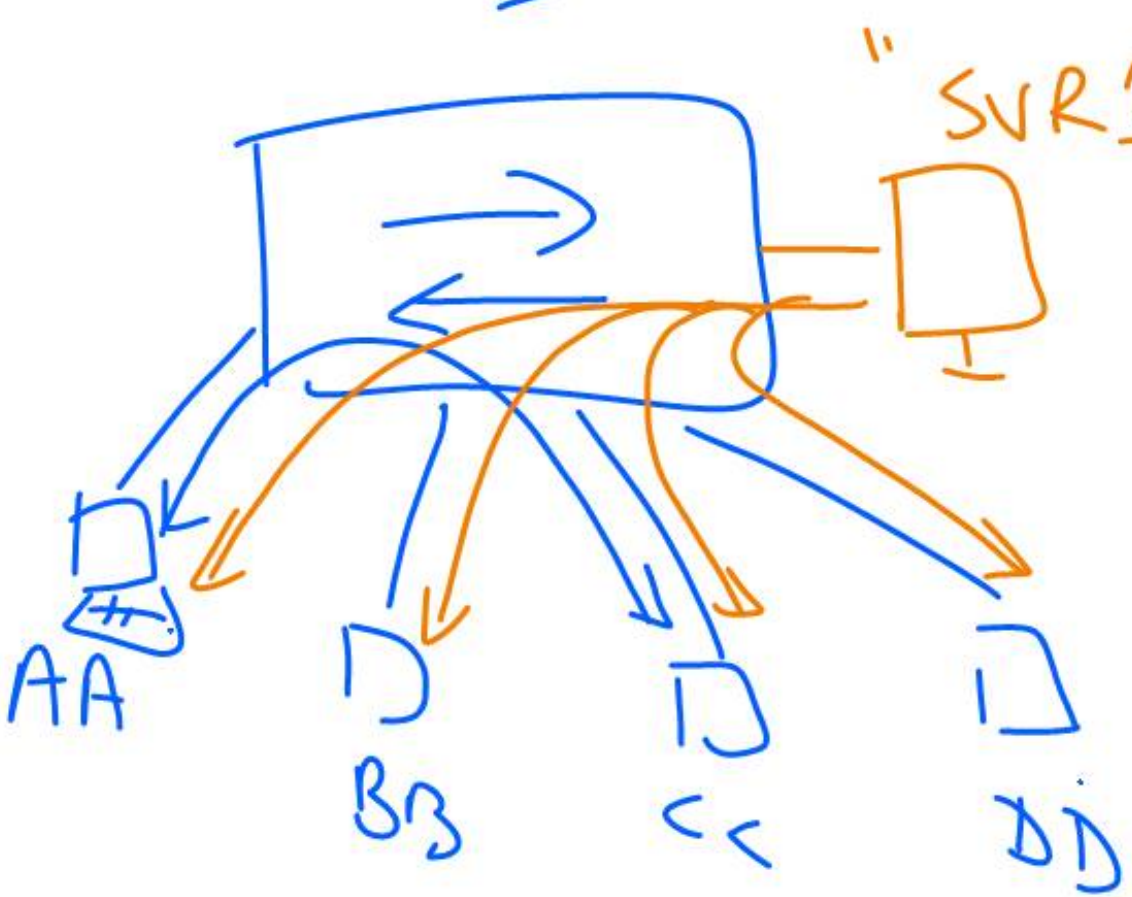
3-WAY HANDSHAKE




3
4
5
ACK 4
4
5
6
ACK 7
Windowing


NET
HOST
192.168.1.1
8 bits
8
8
8 = 32
192.168.1.0
192.168.2.0
192.168.3.0
.1
.2
.3
.3
.2
.1
.2
.1

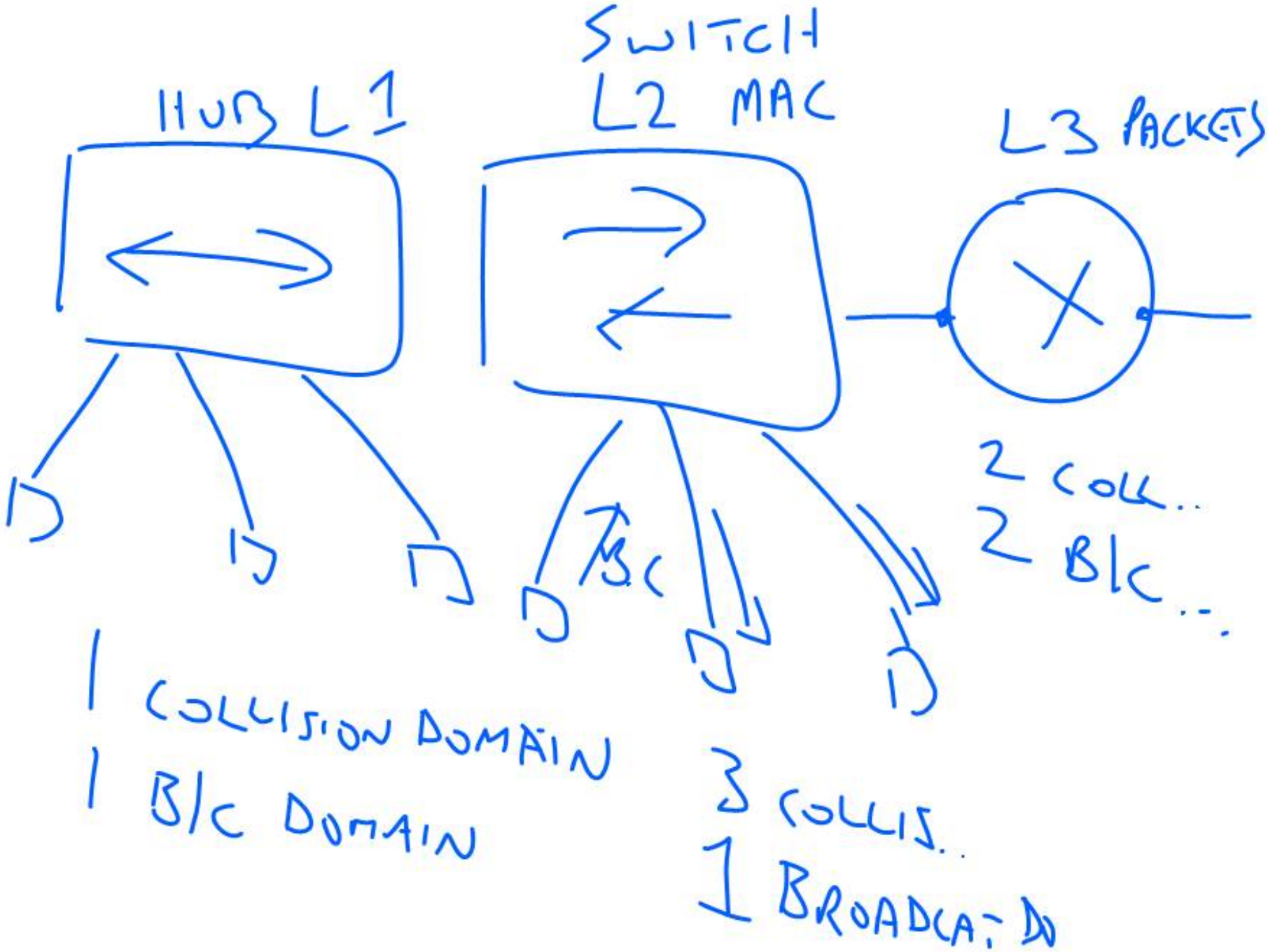
BROADCAST

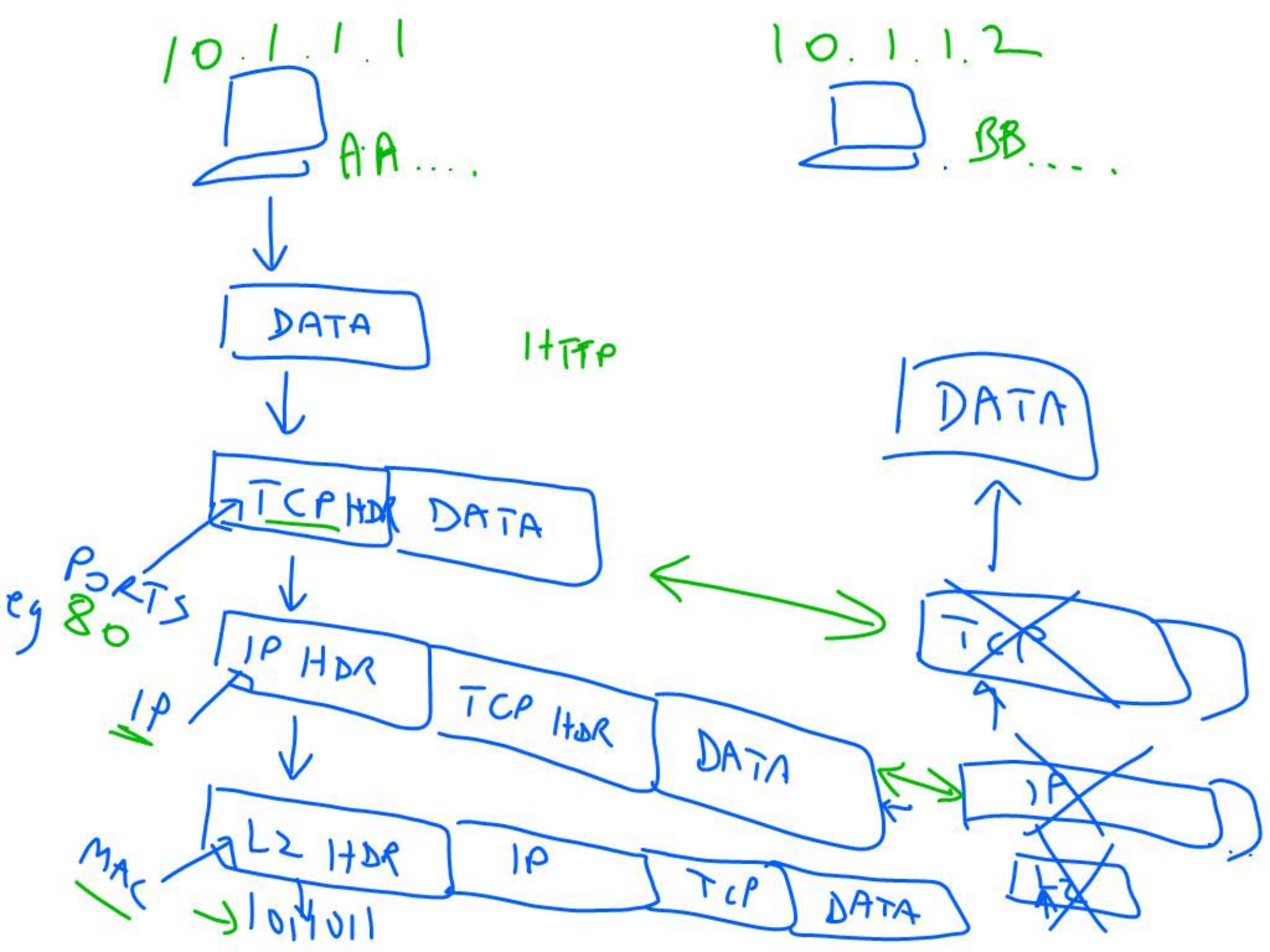


EG Server announcing its presence.

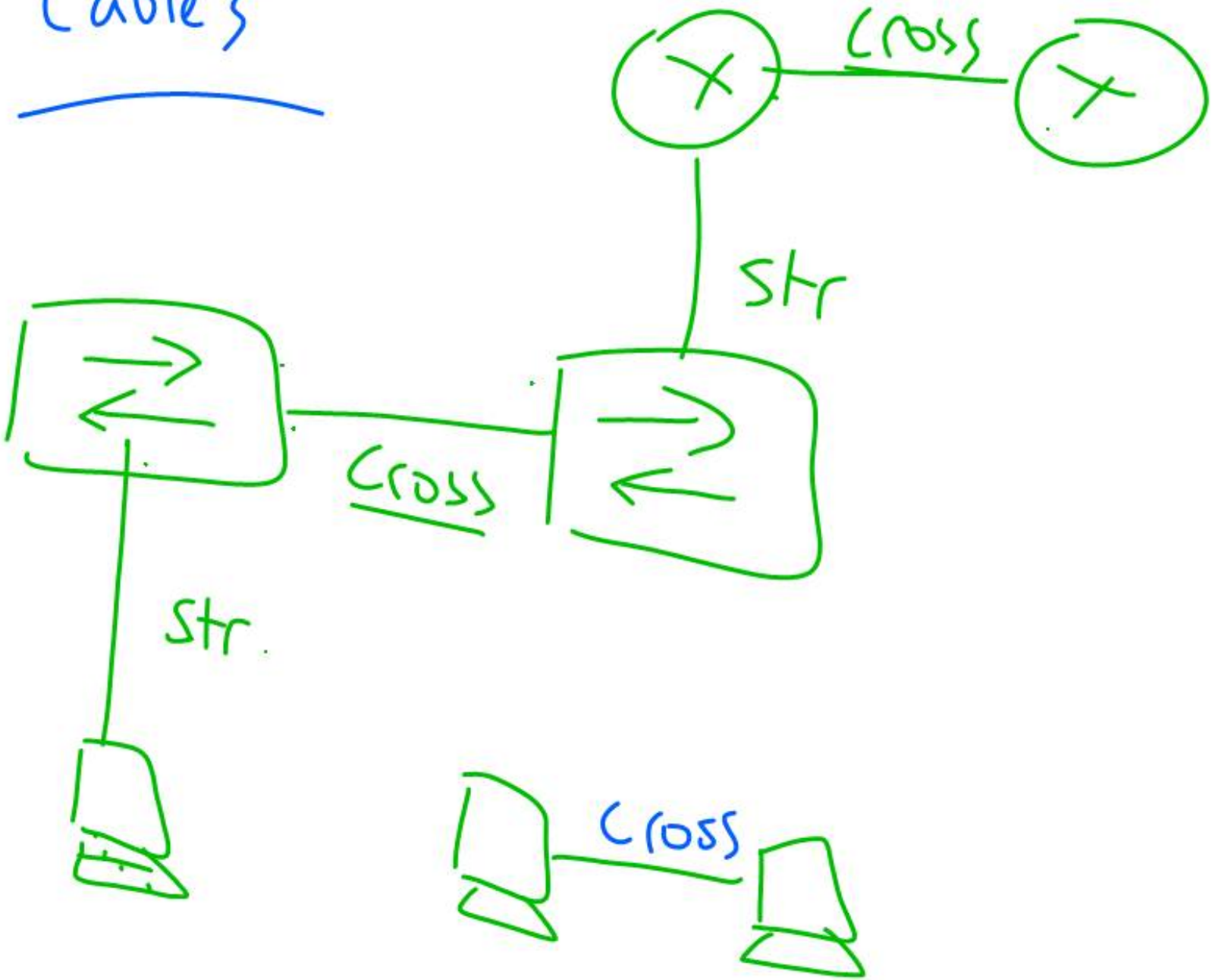
UNICAST 1 TO 1

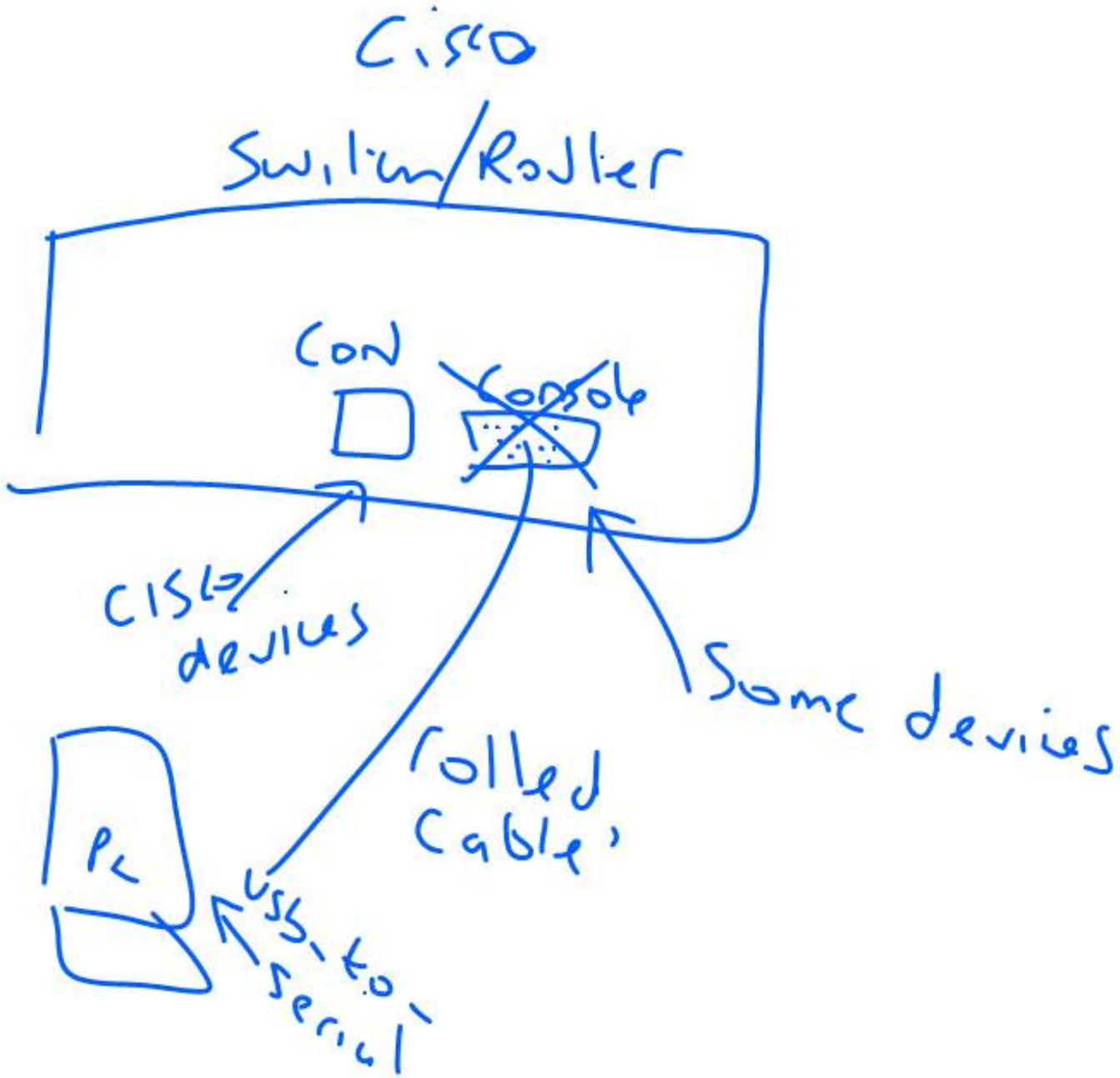
BCAST 1 TO ALL


HUB L1
SWITCH
L2 MAC
L3 PACKETS
2 COLL..
2 B/C..
1 COLLISION DOMAIN
1 B/C DOMAIN
3 COLLIS..
1 BROADCA:D


10.1.1.1
AA....
10.1.1.2
BB....
DATA
HTTP
DATA
TCP HDR
DATA
PORTS
eg 80
IP HDR
TCP HDR
DATA
IP
L2 HDR
IP
TCP
DATA
MAC
10.1.1.1

Cables




Cisco
Switch/Router
CON
Console
Cisco devices
Some devices
Rolled Cable
PC
USB-to-Serial

Decimal	128	64	32	16	8	4	2	1
~~0~~ =	0	0	0	0	0	0	0	0
1 =	0	0	0	0	0	0	0	1
2 =	0	0	0	0	0	0	1	0
3 =	0	0	0	0	0	0	1	1
4 =	0	0	0	0	0	1	0	0

128	64	32	16	8	4	2	1
1	0	1	0	1	1	0	0

$172 = 10101100$

$$\begin{array}{r} 172 \\ -\,128 \\ \hline 44 \end{array} \qquad \begin{array}{r} 44 \\ -\,32 \\ \hline 12 \end{array} \qquad \begin{array}{r} 128 \\ +\,32 \\ +\,8 \\ +\,4 \\ \hline 172 \end{array}$$

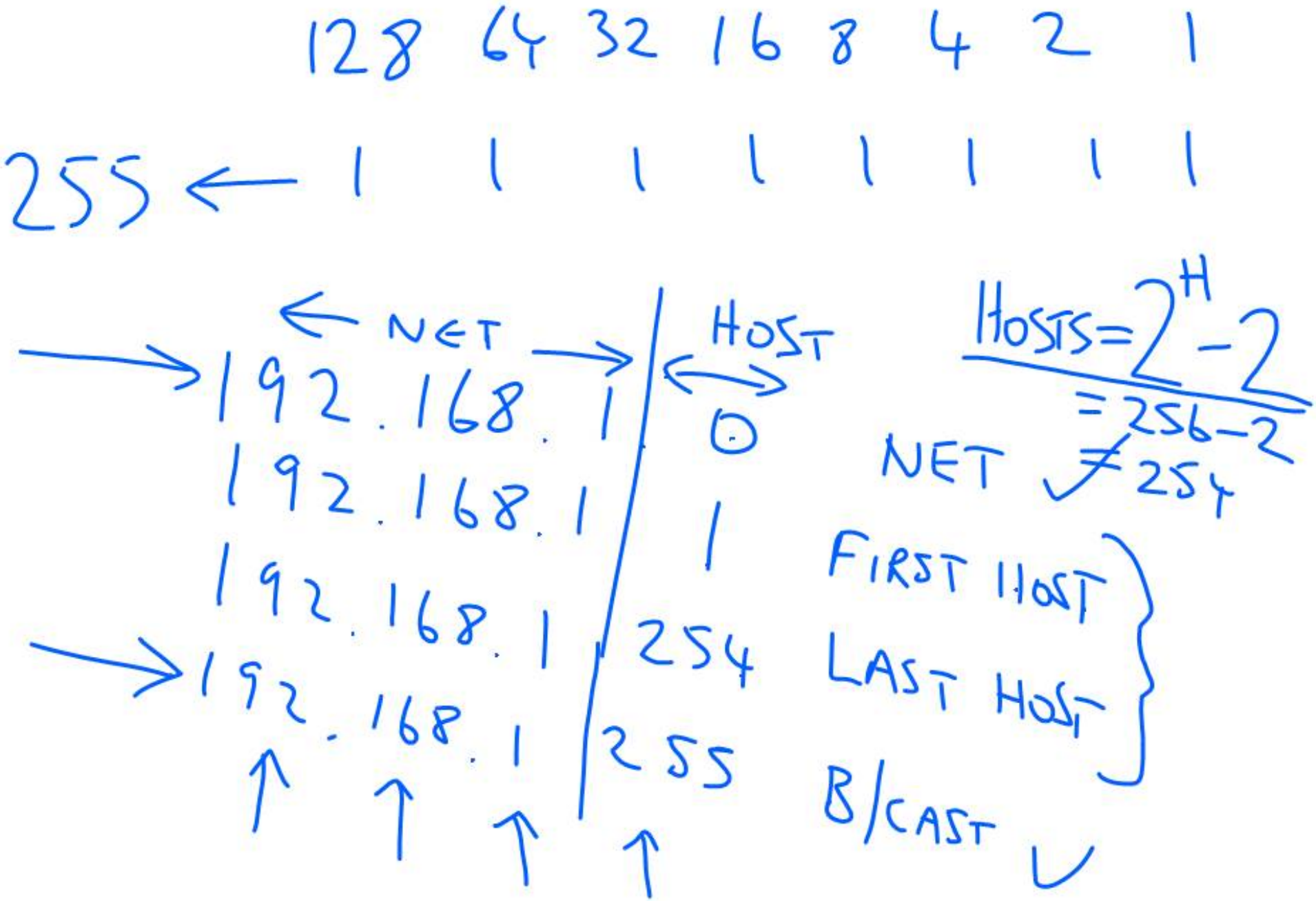
128 64 32 16 8 4 2 1

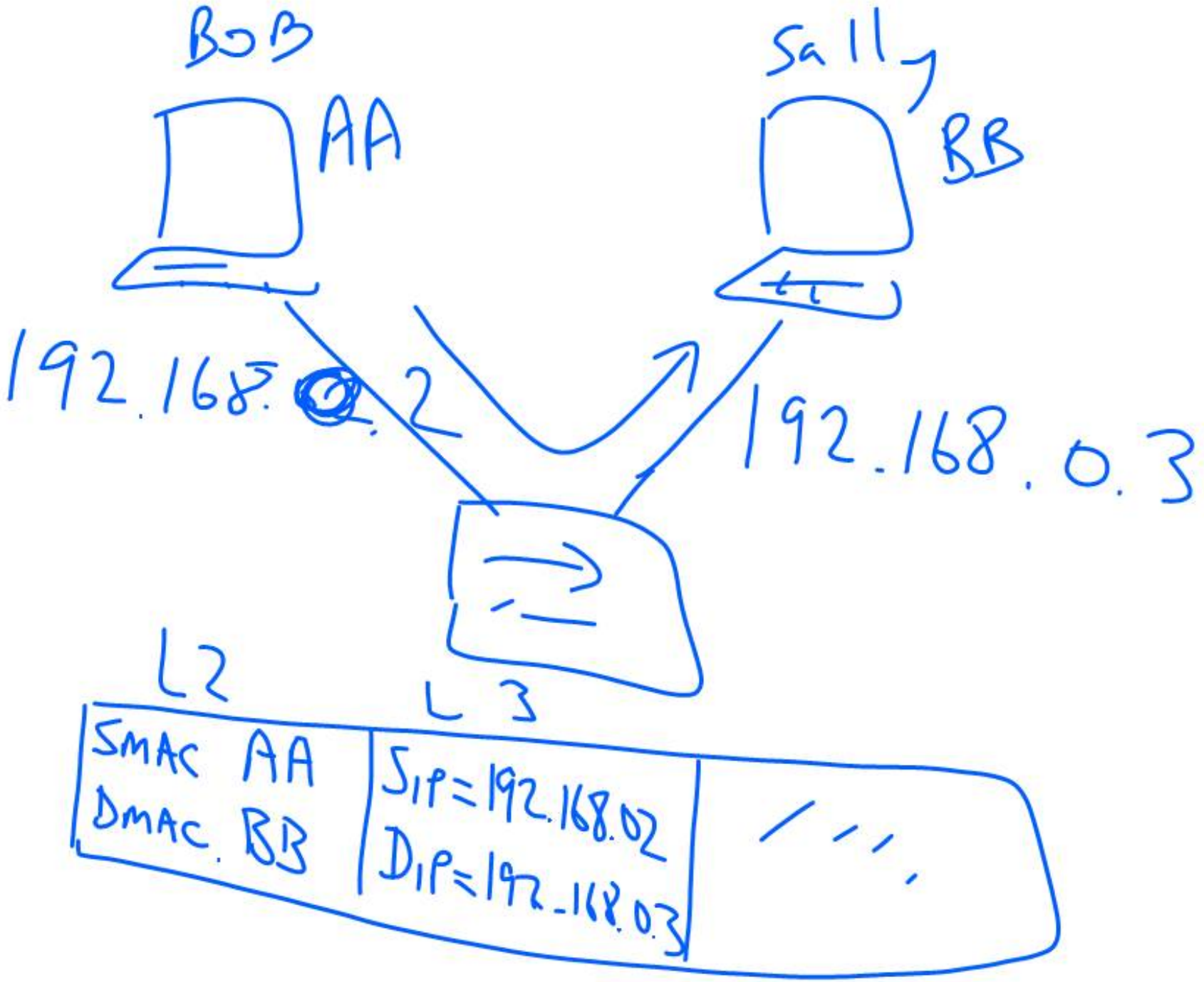
193 = 1 1 0 0 0 0 0 1

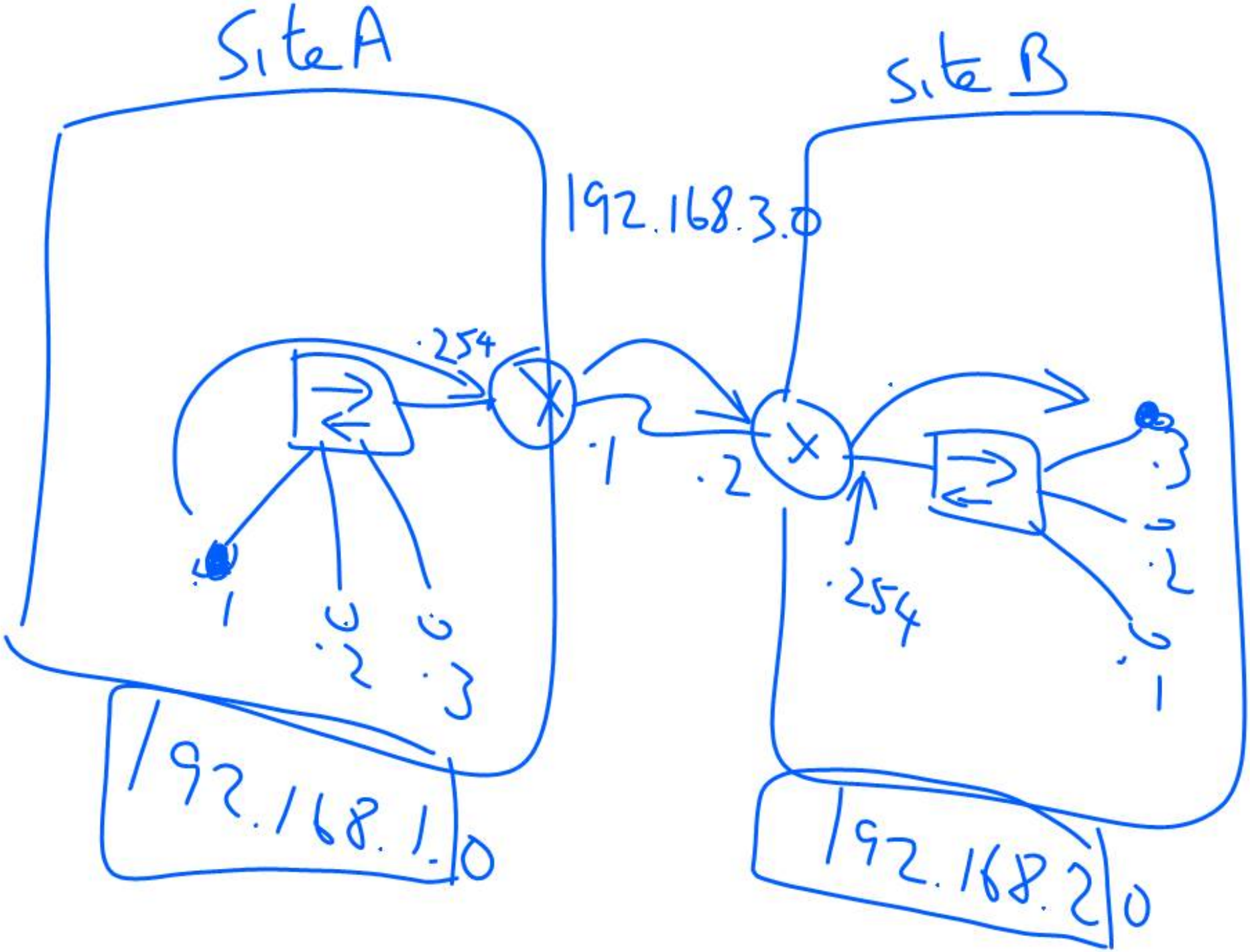
193

−128

65


128 64 32 16 8 4 2 1
255 ← 1 1 1 1 1 1 1 1
← NET →
HOST
192.168.1.0
192.168.1.1
192.168.1.254
192.168.1.255
Hosts = 2^H - 2
= 256 - 2
NET ✓ ≠ 254
FIRST HOST
LAST HOST
B/CAST


BOB
AA
Sally
BB
192.168.0.2
192.168.0.3
L2
L3
SMAC AA
DMAC BB
SIP=192.168.02
DIP=192.168.03


Site A
Site B
192.168.3.0
.254
.1
.2
.254
1
.2
.3
.2
.1
192.168.1.0
192.168.2.0

arp -d deletes arp cache

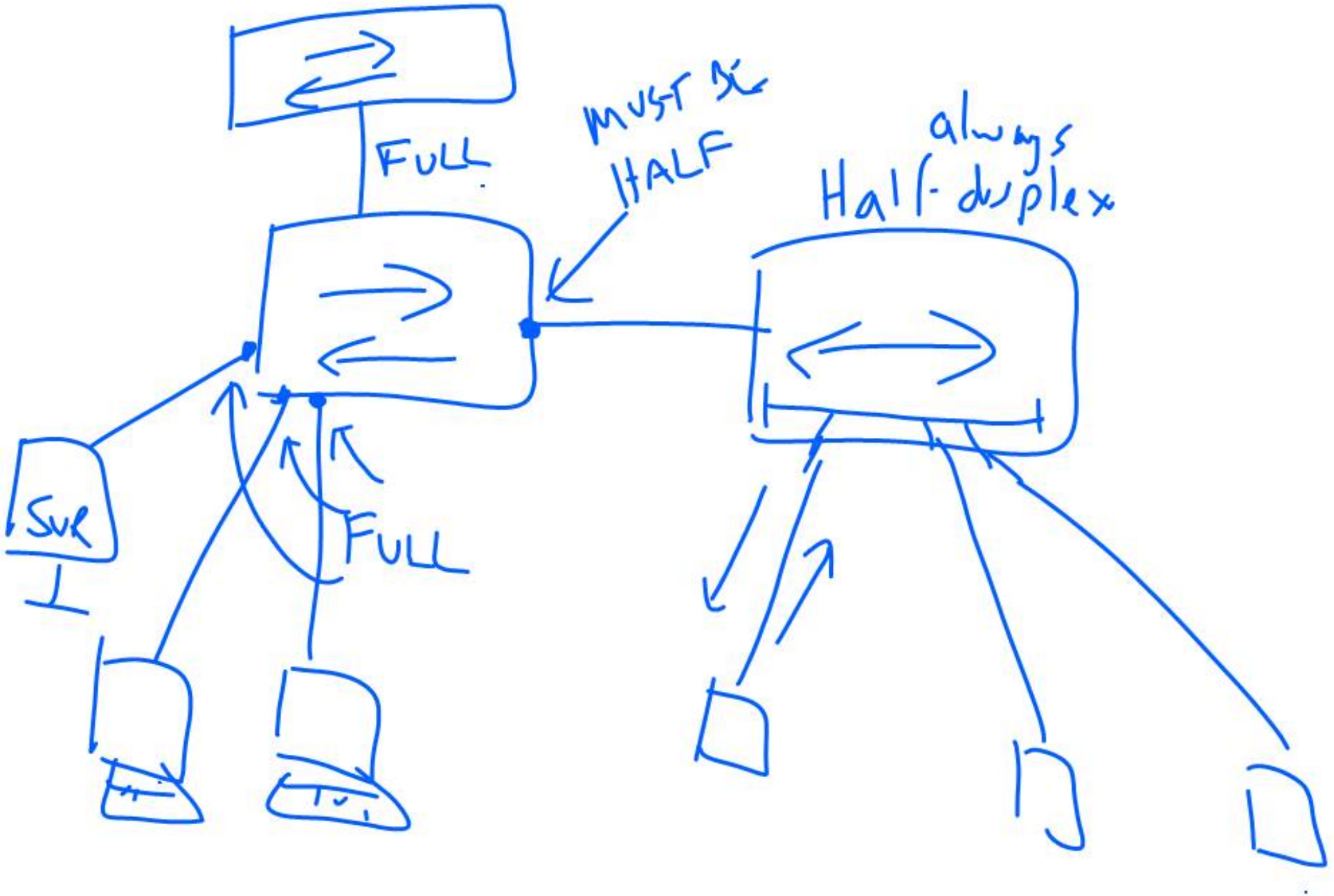
arp -a display .. ..

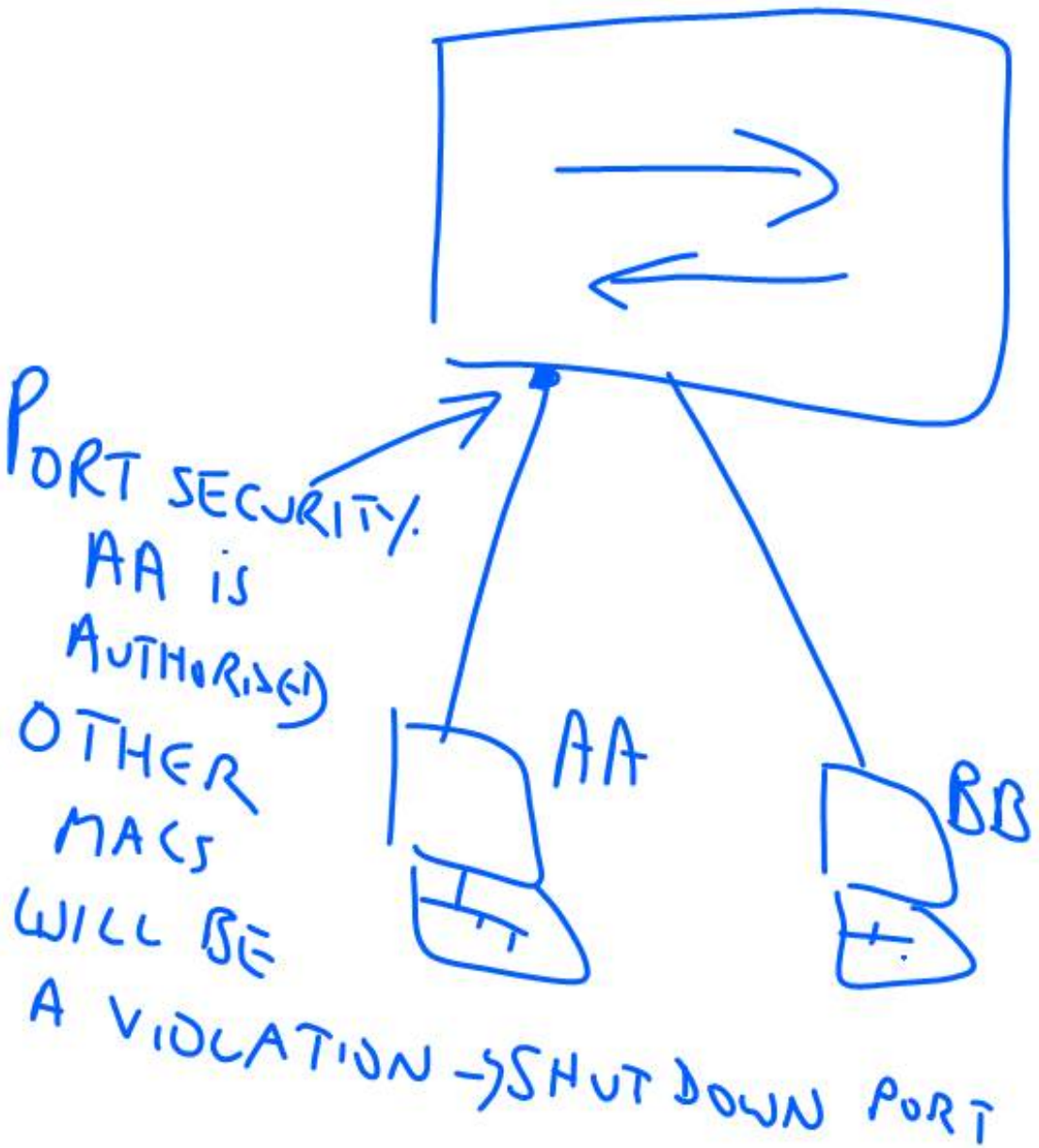
ping <web site>

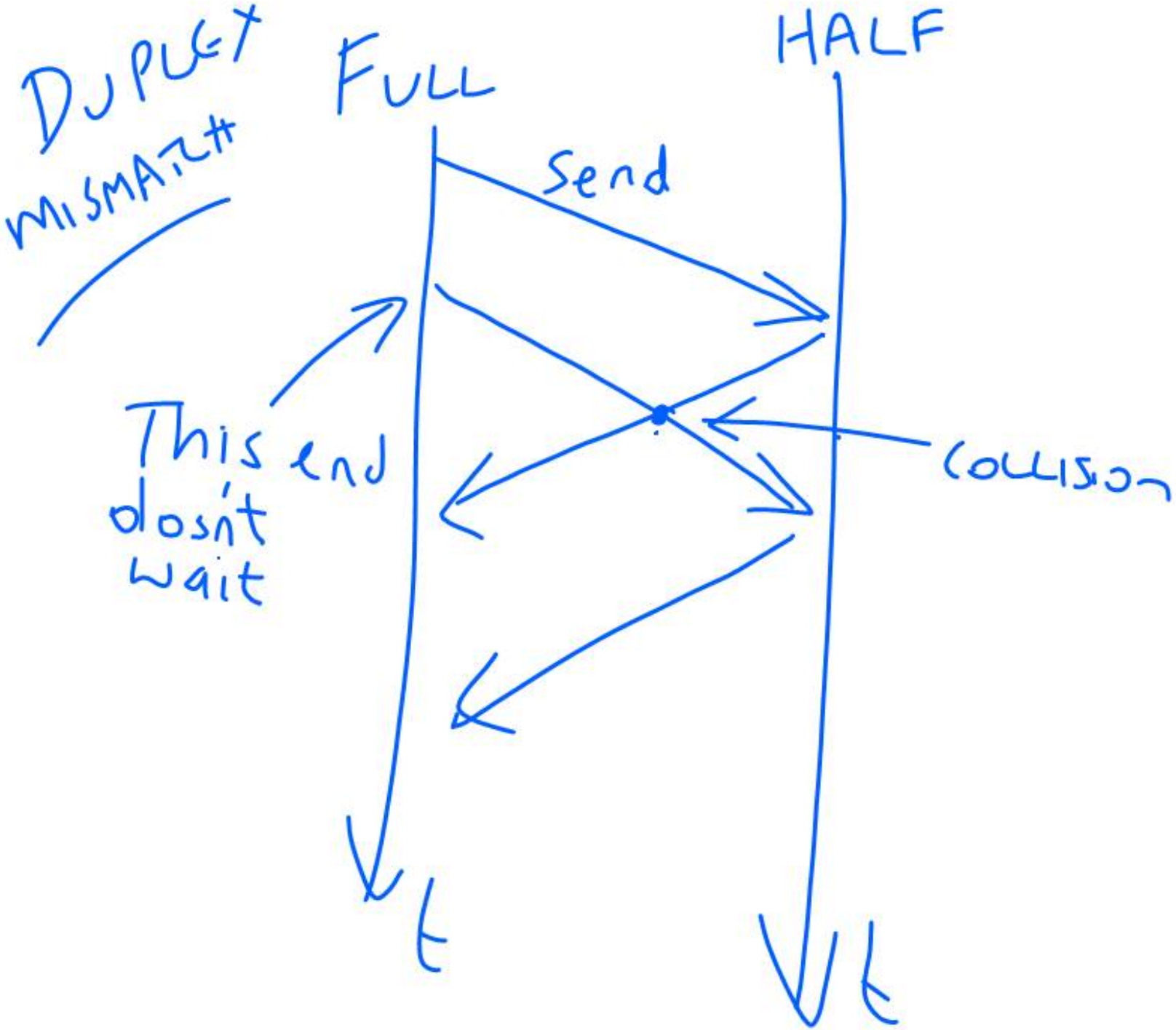
→ ping someone else in class

→ arp -a

If dosnt work - switch off windows firewall


FULL
must be
HALF
always
Half-duplex
Svr
FULL

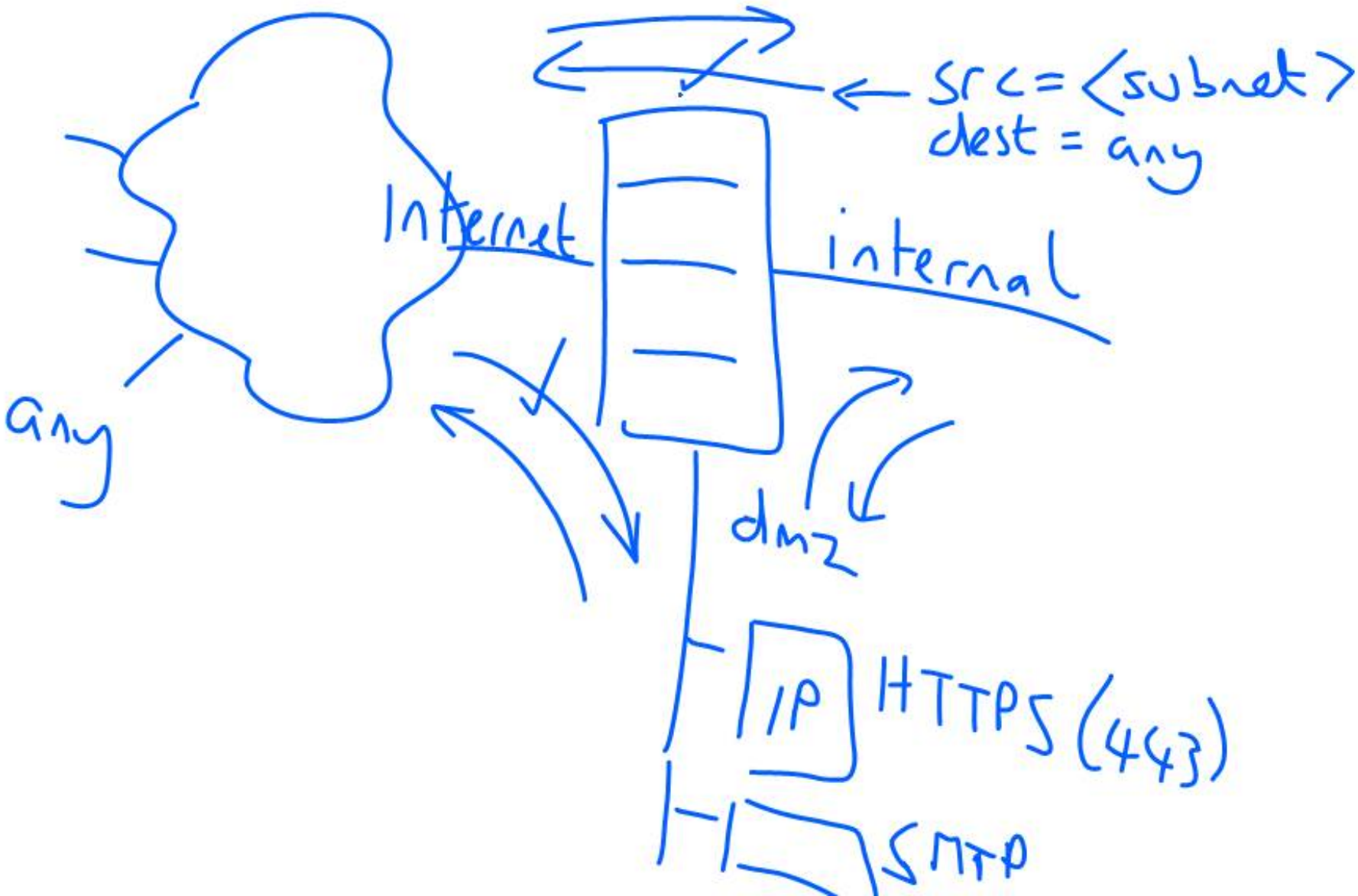

PORT SECURITY:
AA IS
AUTHORIZED
OTHER
MACS
WILL BE
A VIOLATION -> SHUT DOWN PORT
AA
BB

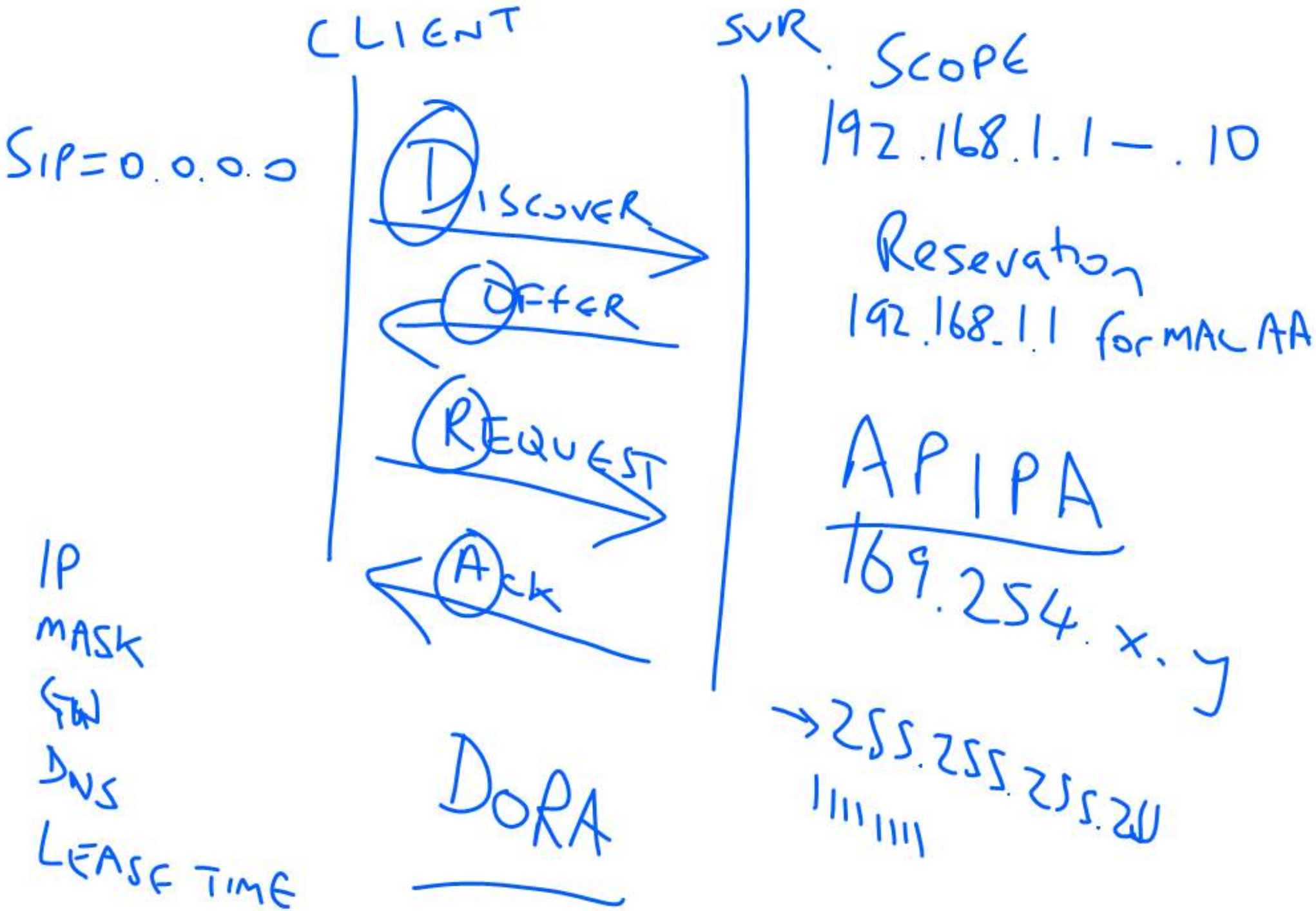

DUPLEX MISMATCH
FULL
HALF
Send
This end dosn't wait
COLLISION
t
t

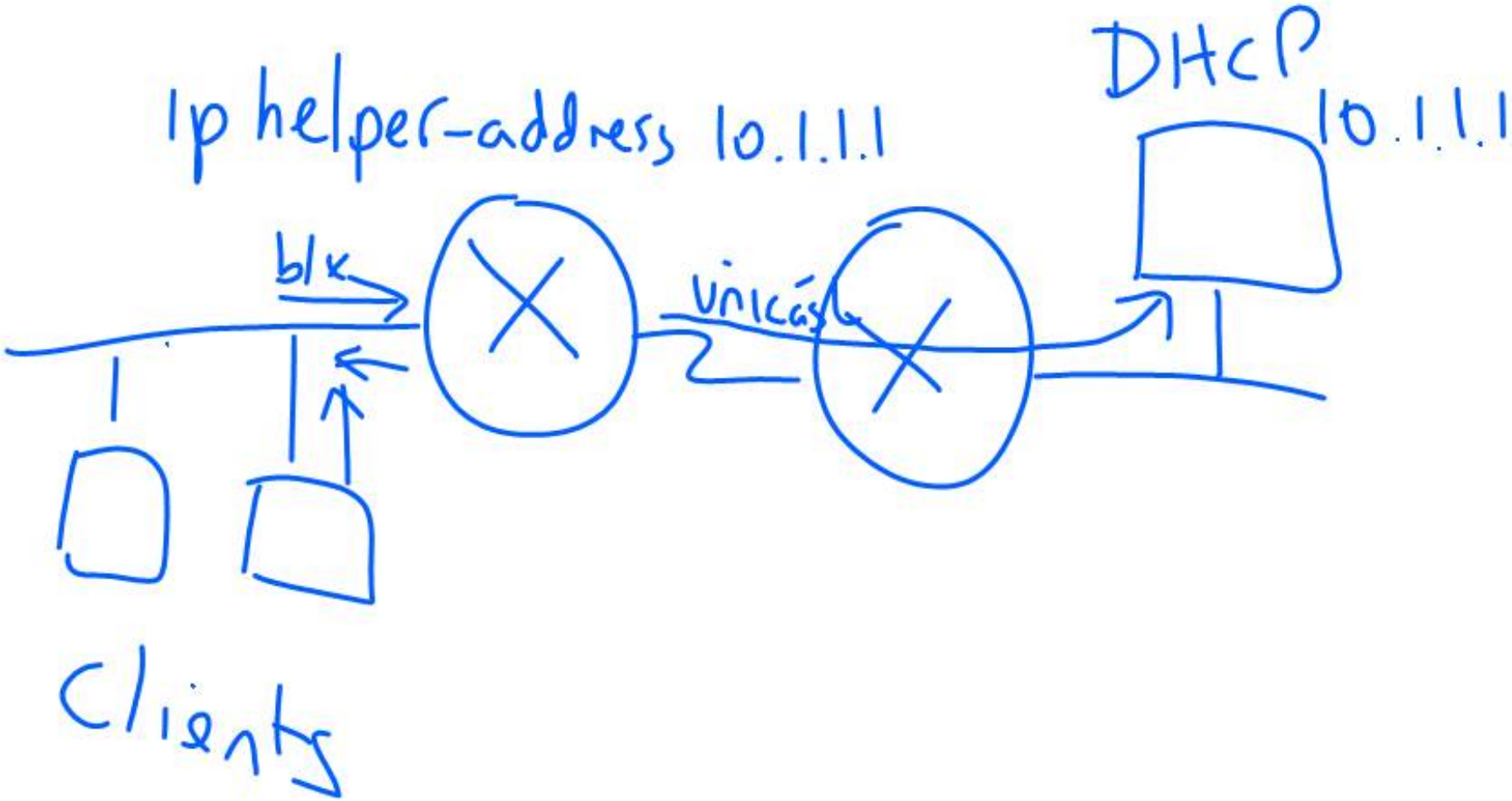
100BaseT

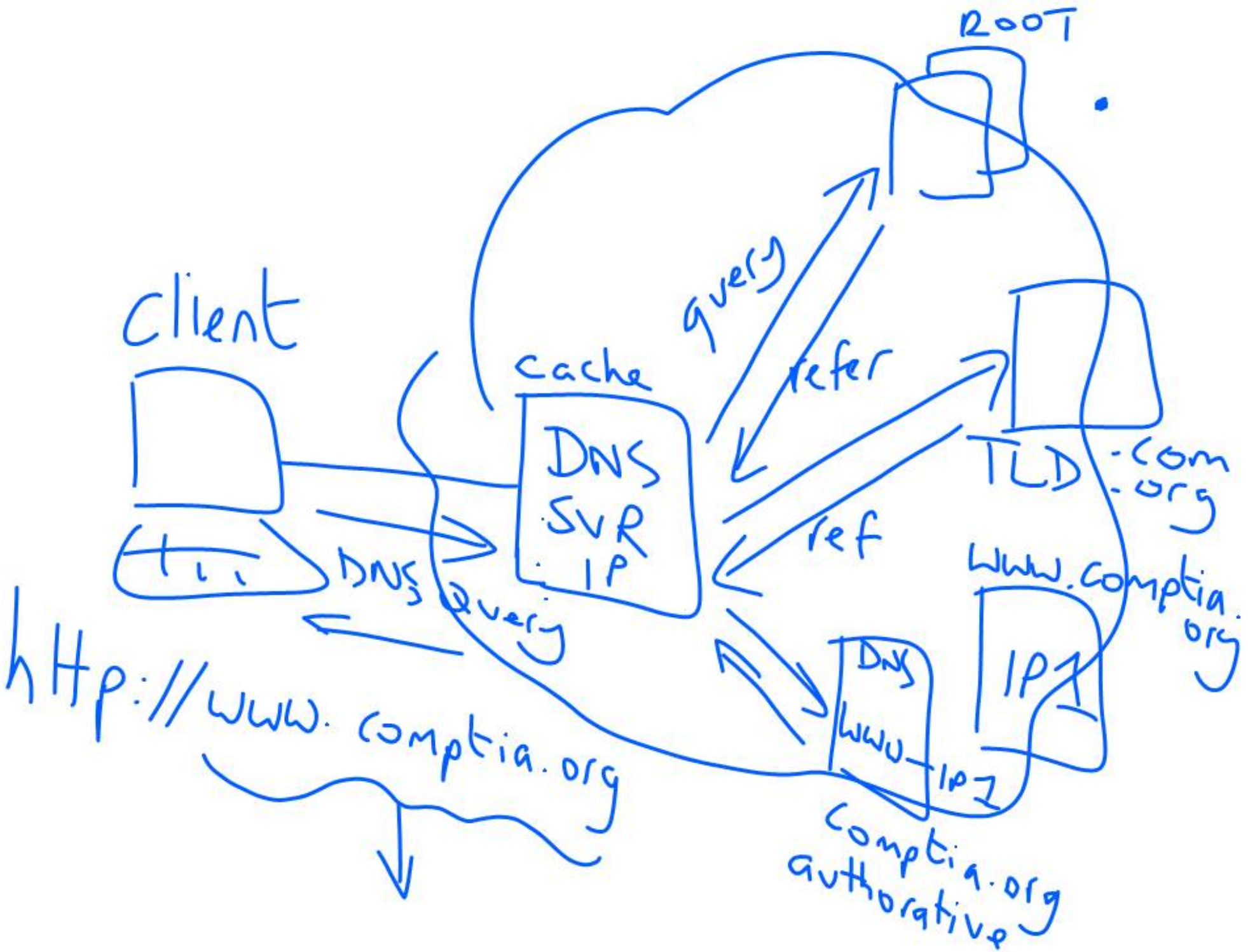
- 100BaseTX 4 wires cat 5
- 100BaseT4 8 wires 3, 4, 5
- " FX MMF

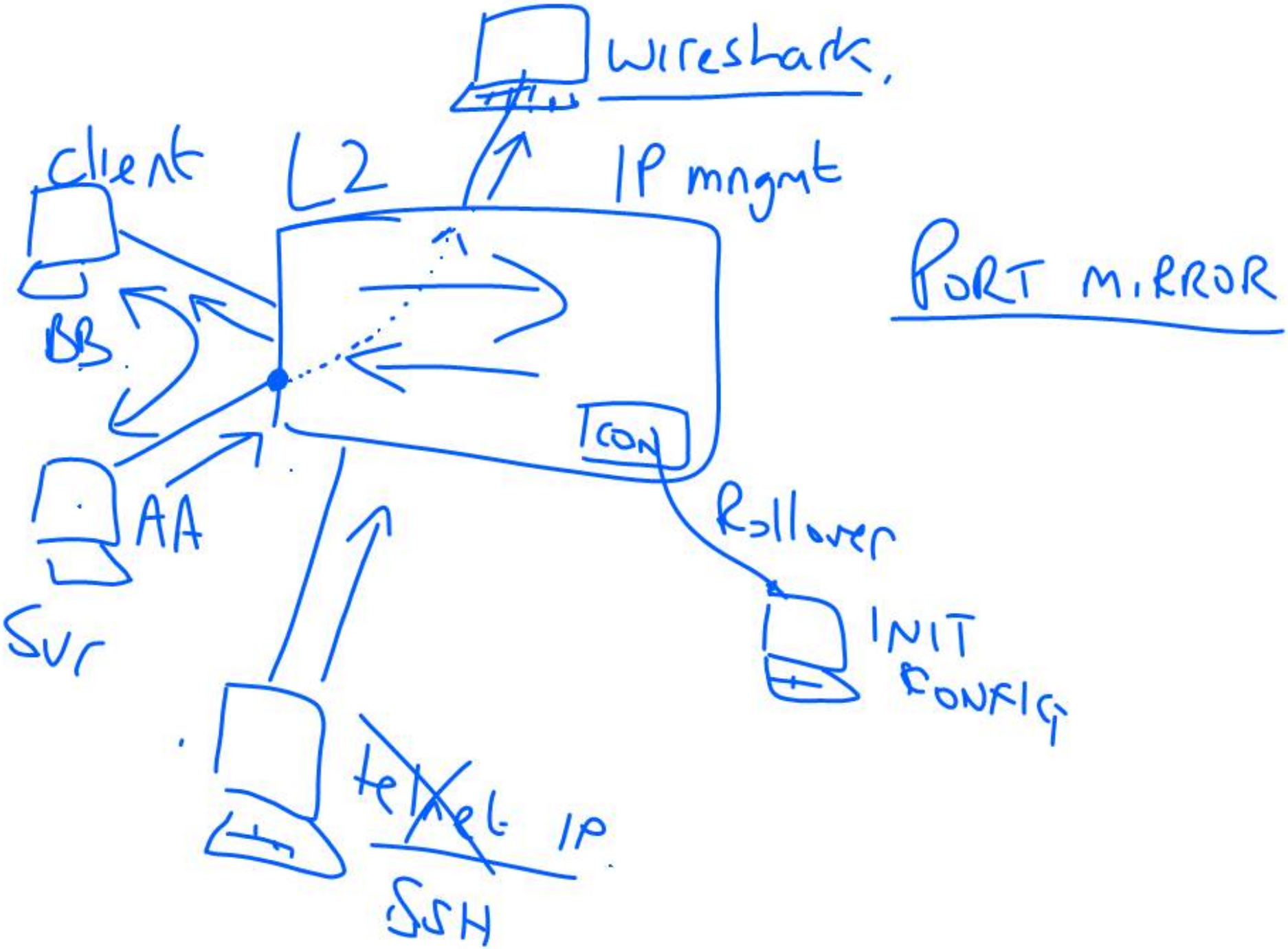

STATELESS — ACL
SOURCE IP
DEST IP
L3
SOURCE PORT
DEST PORT
L4
PROTOCOL ID
L3
STATEFULL
CONNECTION TABLE

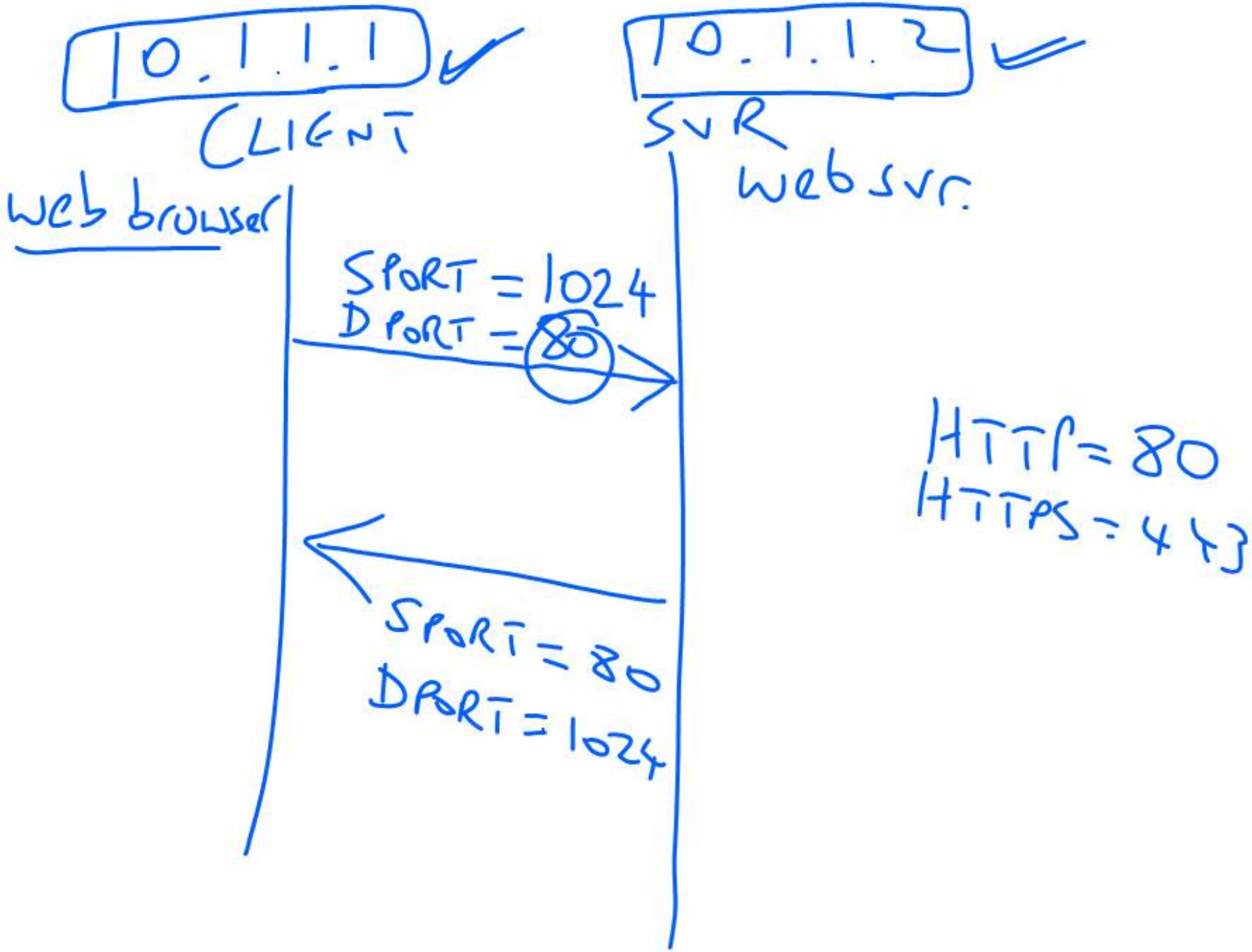

src = <subnet>
dest = any
Internet
internal
any
dmz
IP
HTTPS (443)
SMTP


CLIENT
SVR.
SCOPE
192.168.1.1 – .10
SIP=0.0.0.0
DISCOVER
OFFER
Reservation
192.168.1.1 for MAC AA
REQUEST
APIPA
169.254.x.y
ACK
IP
MASK
GW
DNS
LEASE TIME
DORA
→255.255.255.240
1111 1111


ip helper-address 10.1.1.1
DHCP
10.1.1.1
b/c
unicast
Clients


ROOT
client
cache
DNS SVR IP
query
refer
TLD .com .org
ref
DNS query
www.comptia.org
IP
DNS www IP
comptia.org authorative
hHp://www.comptia.org


Wireshark.
client
L2
IP mngmt
PORT MIRROR
BB
AA
SVR
CON
Rollover
INIT
CONFIG
telnet IP
SSH


10.1.1.1
CLIENT
10.1.1.2
SVR
web browser
web svr.
SPORT = 1024
DPORT = 80
HTTP = 80
HTTPS = 443
SPORT = 80
DPORT = 1024

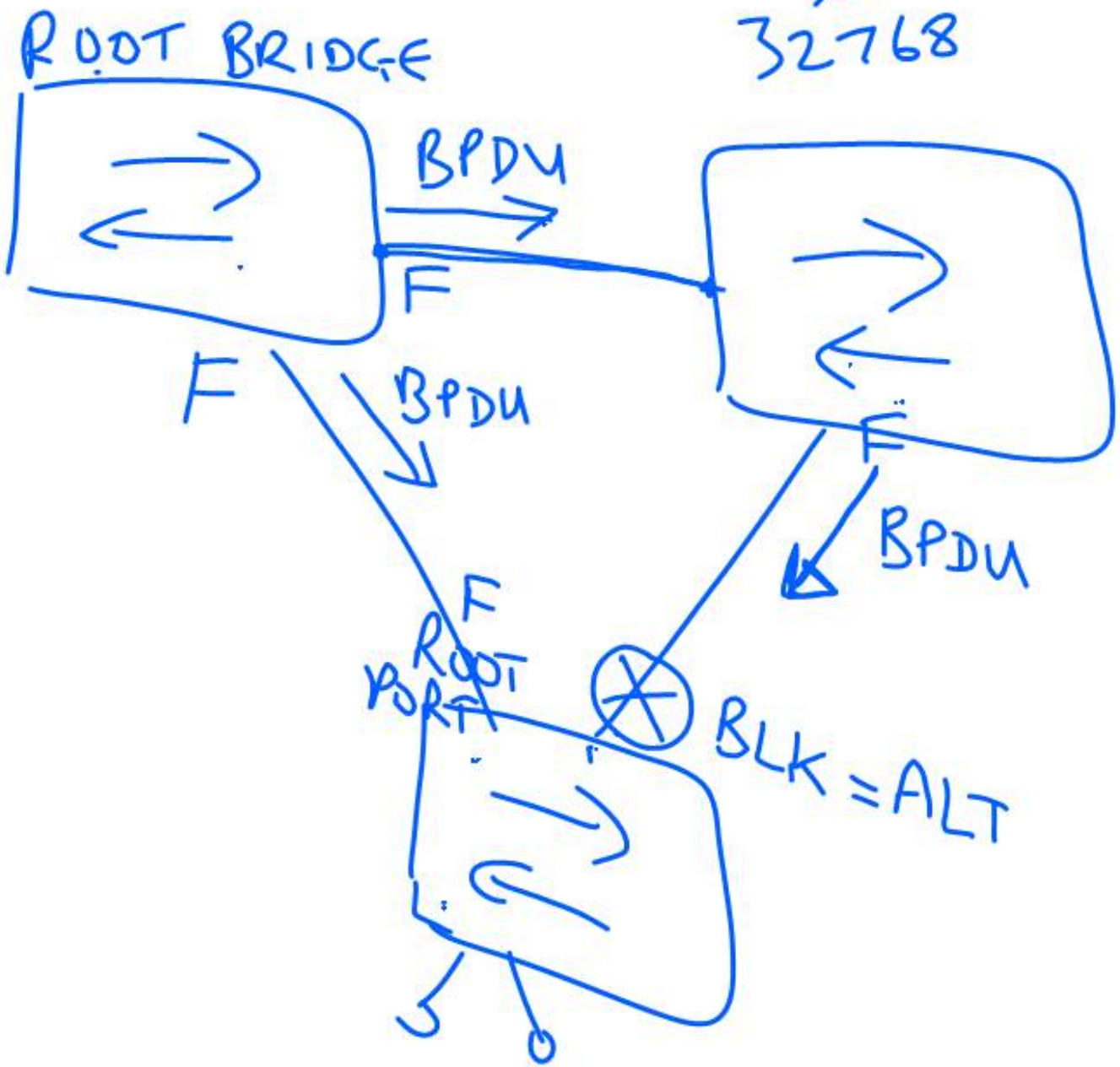
BPDU

STP

└ BRIDGE ID = PRIORITY. MAC

Ø

32768



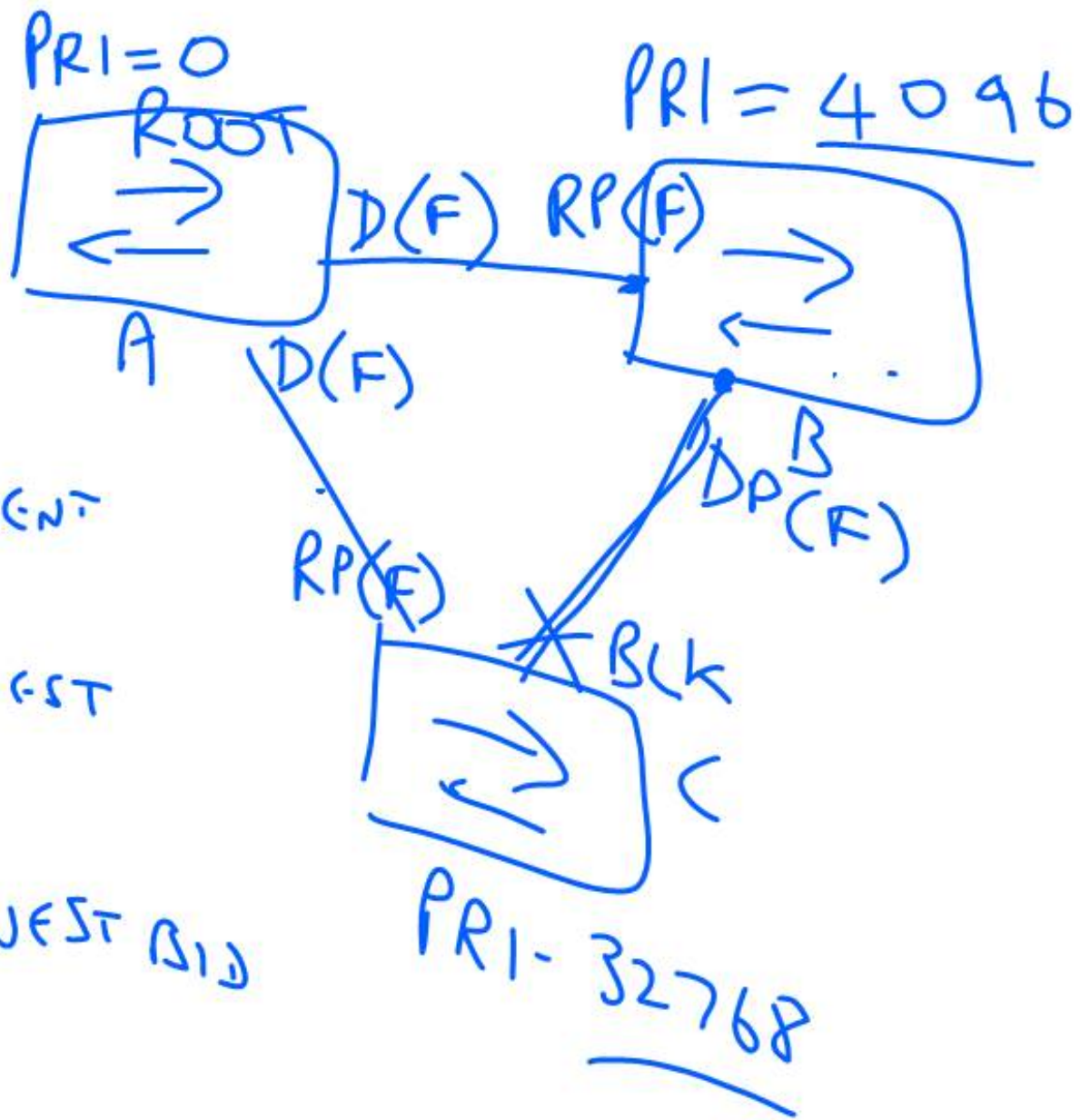
802.1d → RSTP

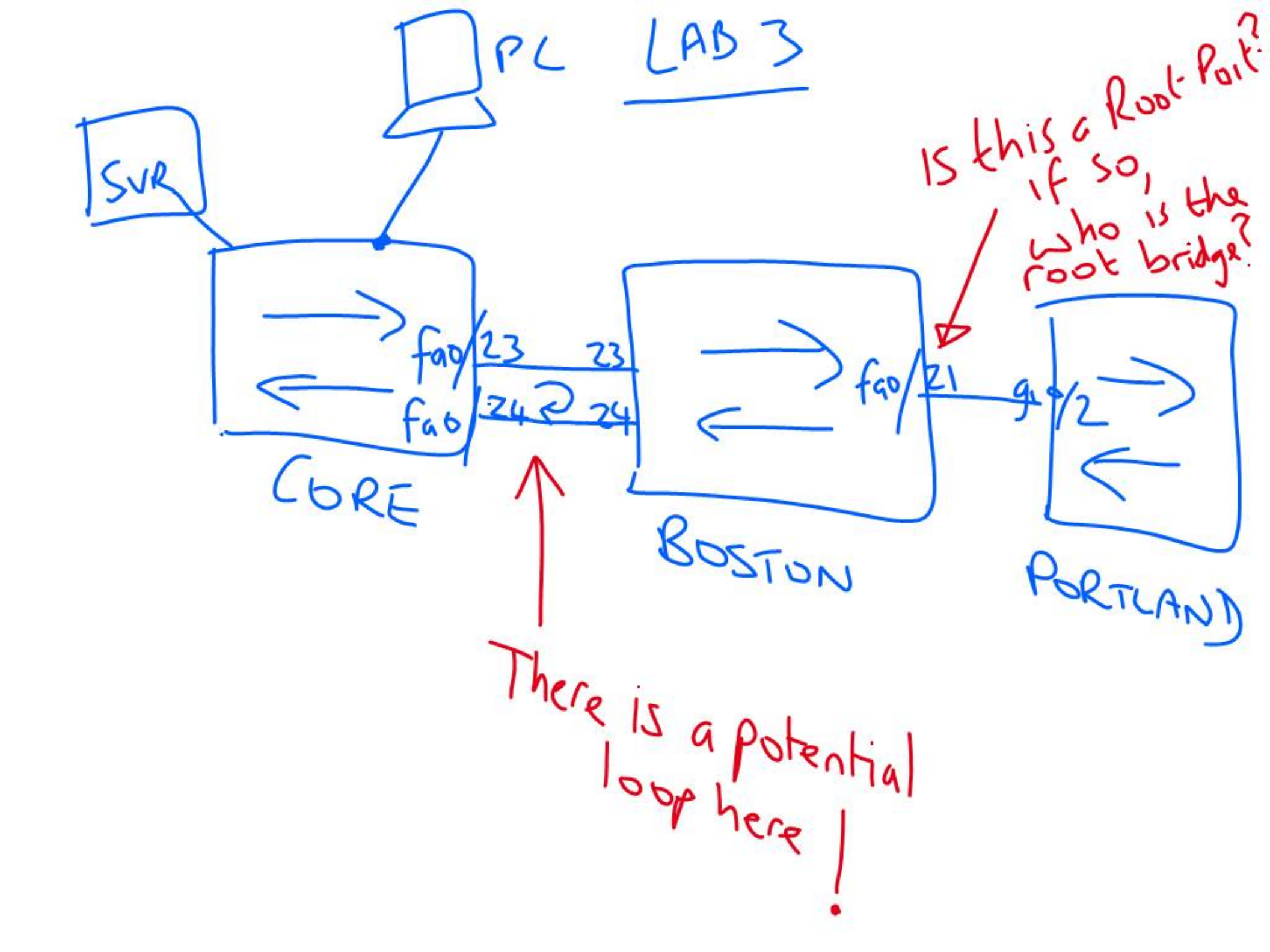
1) ELECT R.B.
LOWEST BID
ALL PORTS DES(F)

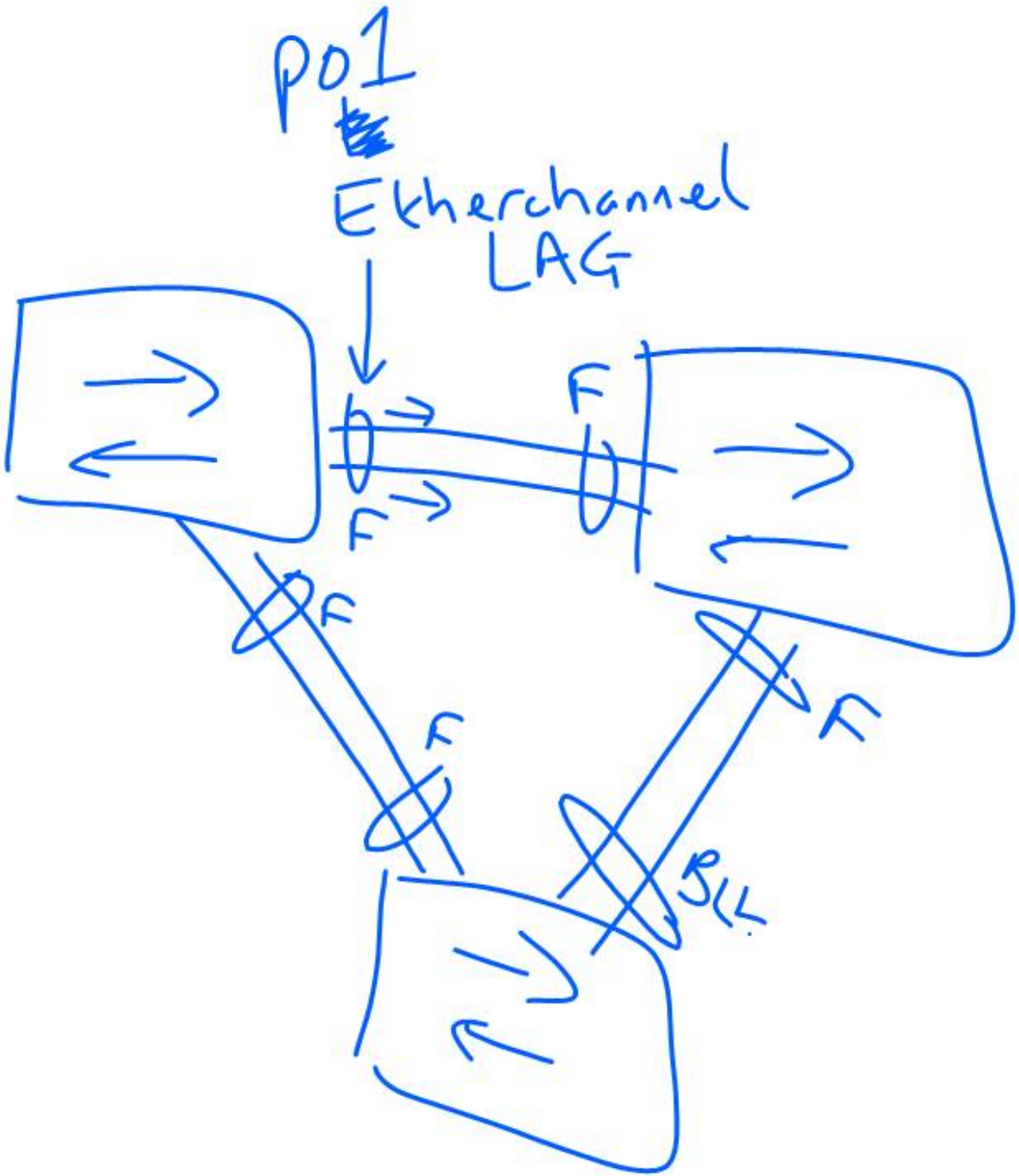
2) 1 RP(F) ON EACH
NON-ROOT BRIDGE
CLOSTEST TO RB

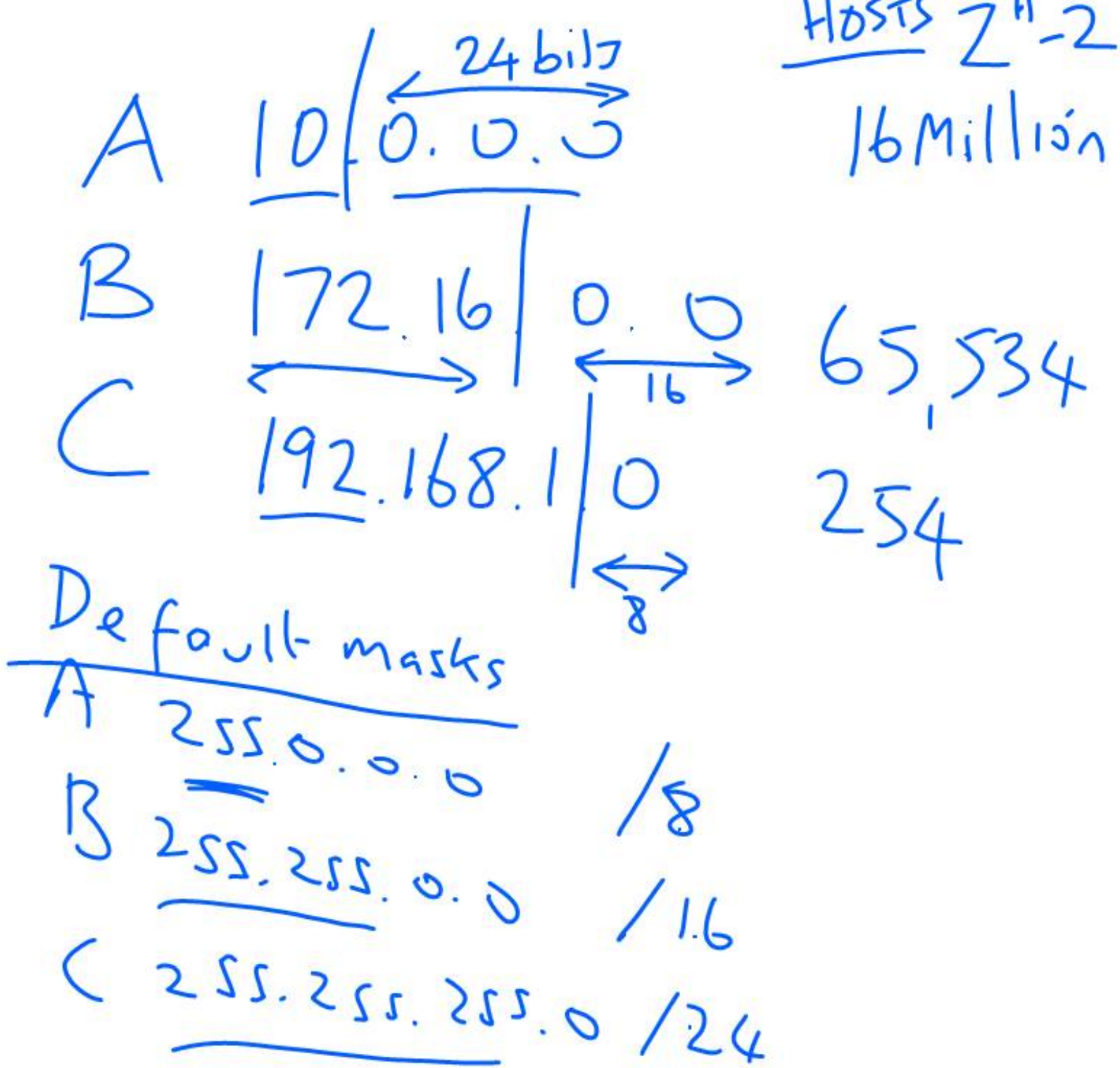
3) ON EACH SEGMENT
1 DP(F)
ON SWITCH CLOSEST
TO ROOT

TIE BREAK. LOWEST BID



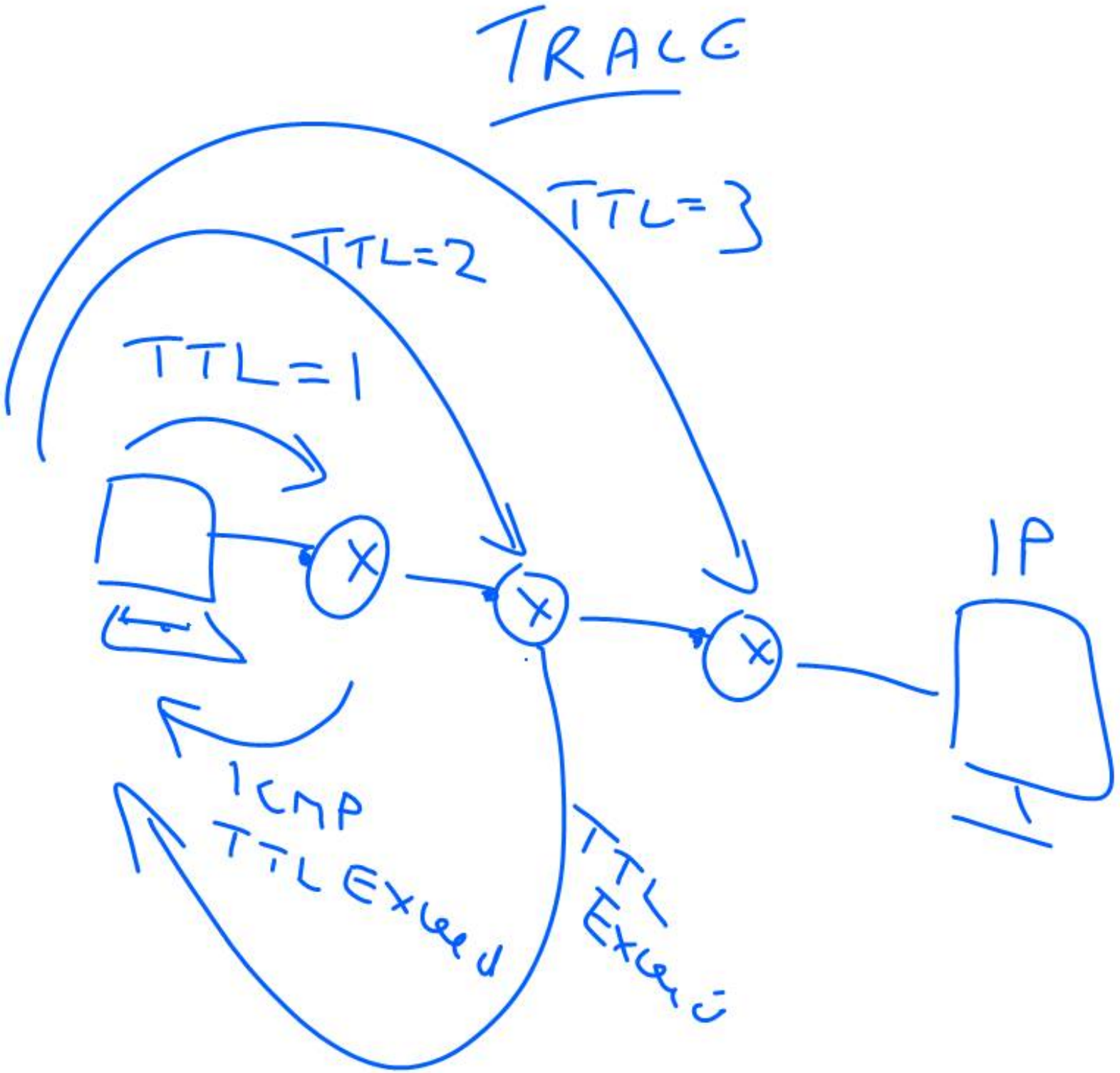

PC
LAB 3
SVR
Is this a Root Port?
If so,
who is the
root bridge?
fa0/23
23
fa0/24
24
fa0/21
gi0/2
CORE
BOSTON
PORTLAND
There is a potential
loop here!


Po1
Etherchannel
LAG
F
F
F
F
F
BLK


HOSTS $2^{H}-2$
24 bits
A 10 | 0.0.0
16 Million
B 172.16 | 0.0
16
65,534
C 192.168.1 | 0
254
8
Default masks
A 255.0.0.0 /8
B 255.255.0.0 /16
C 255.255.255.0 /24

CLASSES

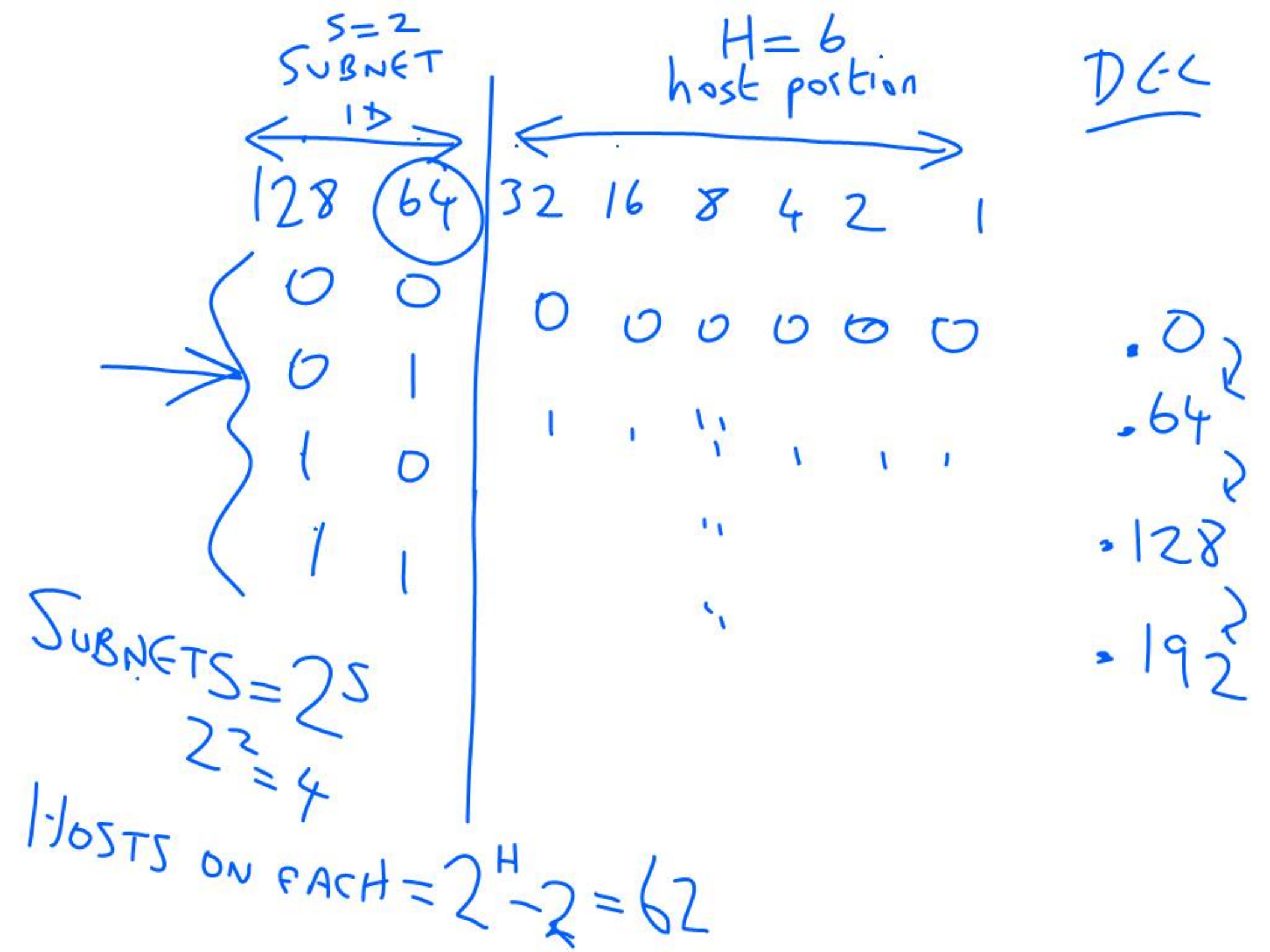
	FIRST OCTET
A	1 – 126
B	128 – 191
C	192 – 223
D	224 – 239 MULTICAST
E	240 – 255 RES

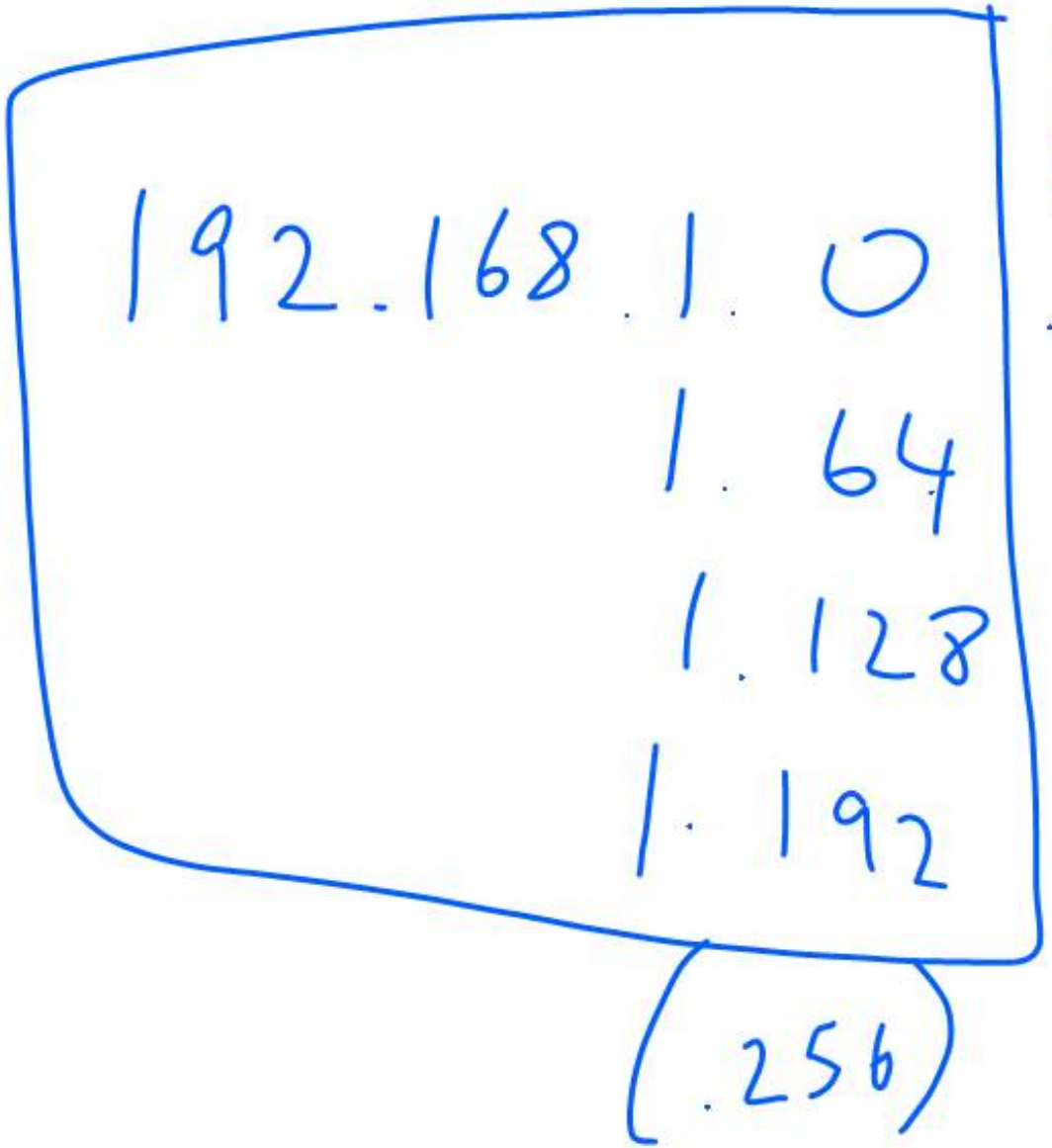

TRACE
TTL=3
TTL=2
TTL=1
IP
ICMP
TTL Exceed
TTL
Exceed

WHY SUBNET

192.168.1.0 /24 255.255.255.0

- Too many Broadcast
- Security
- Subnetworks - Manage
- Vlans.


S=2
SUBNET
ID
H=6
host portion
DEC
128 64 32 16 8 4 2 1
0 0 0 0 0 0 0 0
0 1 1 1 1 1 1 1
1 0
1 1
.0
.64
.128
.192
SUBNETS = 2^S
2^2 = 4
HOSTS ON EACH = 2^H - 2 = 62



	FIRST HOST	LAST HOST	B/C
.0	.1	.62	.63
.64	.65	.126	.127
.128	.129	.190	.191
.192	.193	.254	.255

255.255.255.0

11111111.11111111.11111111.11000000

↓

192

192.168.1.0/24 xxx|xxxxx

Require 8 subnets, 30 hosts on each

1) Bits to borrow? 3

subnets = 2^5

$8 = 2^?$

hosts = $2^5 - 2 = 30$

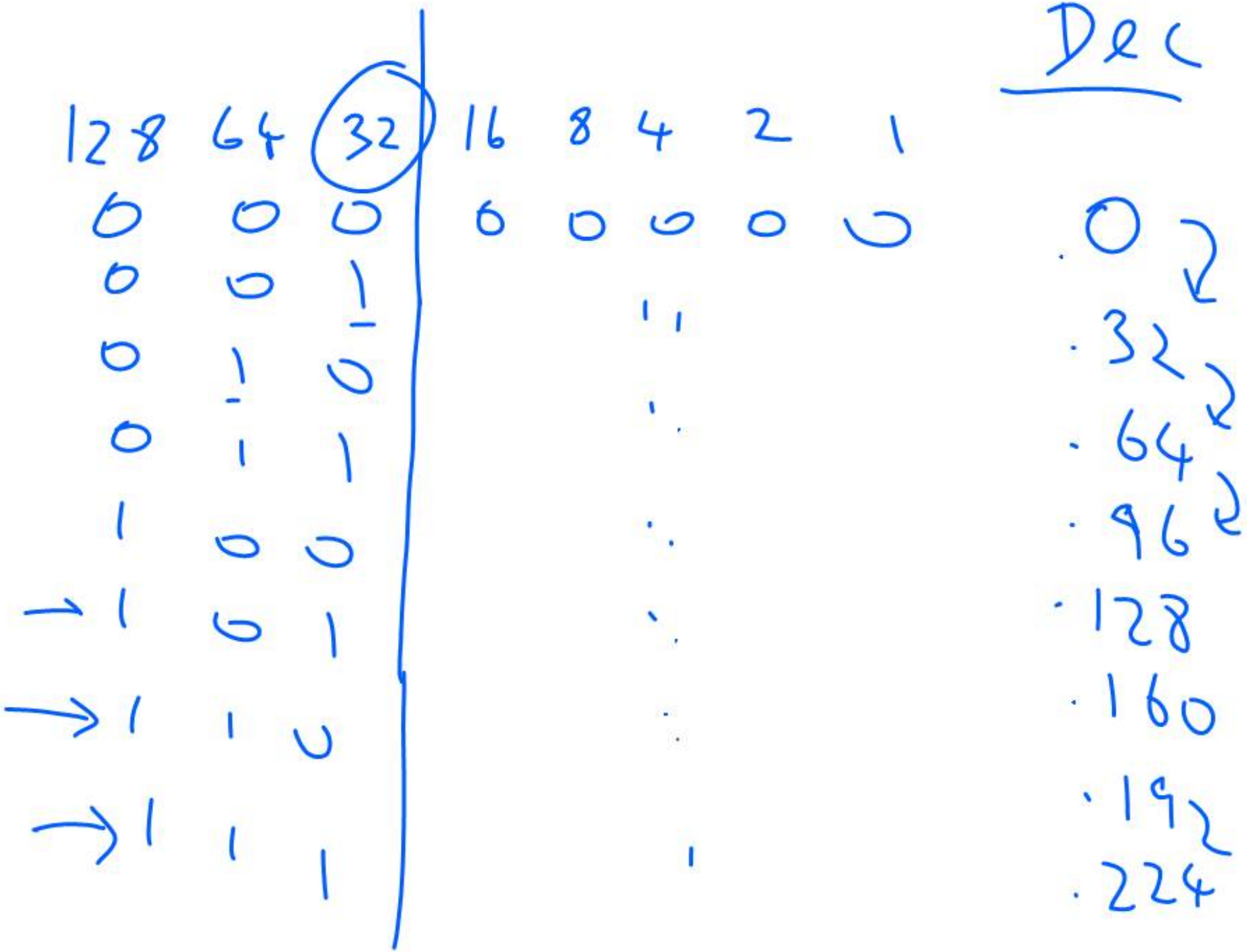
2) Mask?

255.255.255.111 00000

224

/27

3) Subnet addresses, host ranges, b/c


Dec
128 64 32 16 8 4 2 1
0 0 0 0 0 0 0 0
0 0 1 1
0 1 0
0 1 1
1 0 0
1 0 1
1 1 0
1 1 1
0
32
64
96
128
160
192
224

Subnets	Hosts	B/C
.0	.1 - .30	.31
.32	.33 - .62	.63
.64		
.96		
⋮		
⋮		

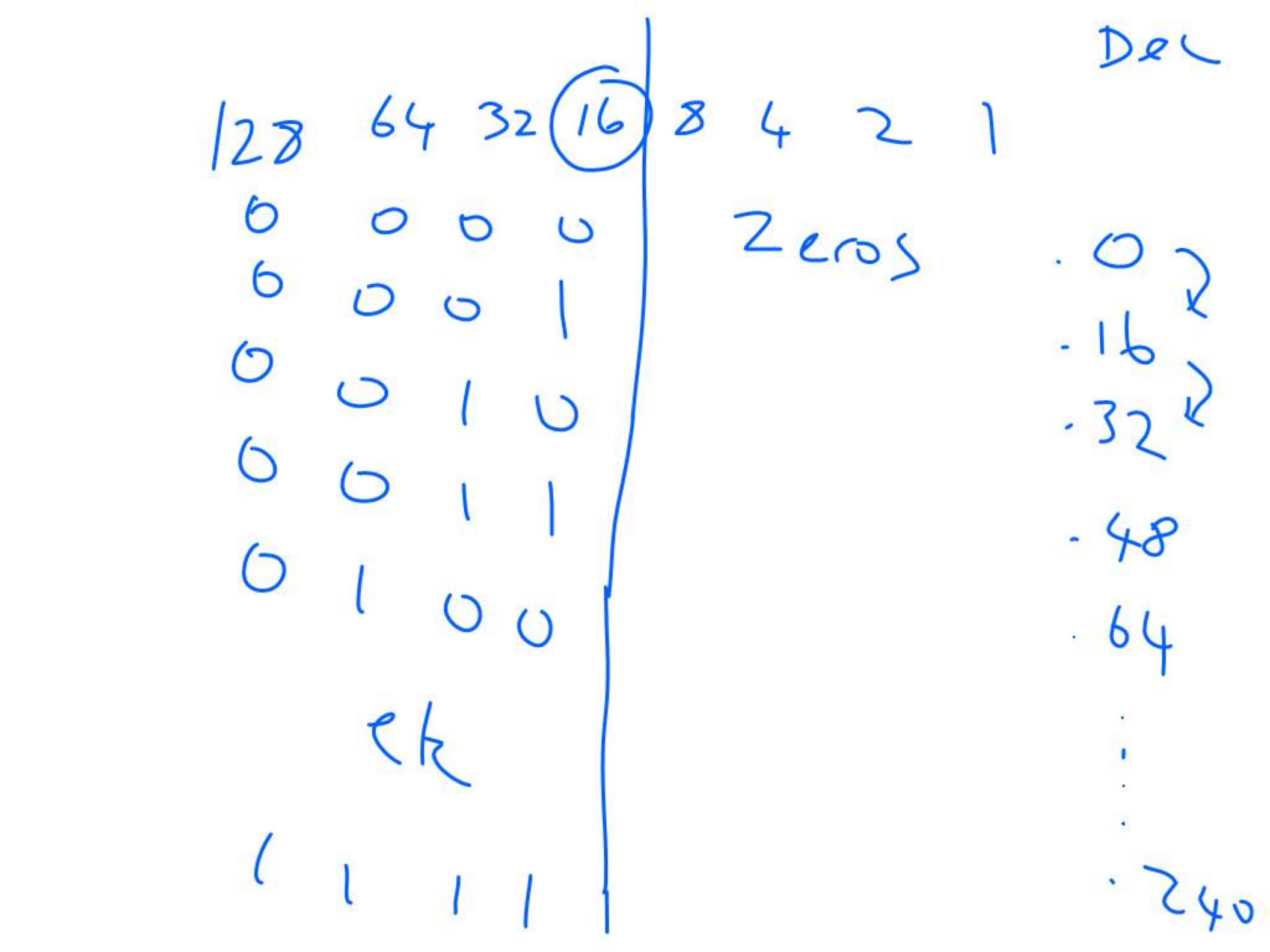
192.168.1.0

Require 16 subnets, 14 hosts on each.

1) Bits to borrow 4 bits Subnets = 2^5

2) mask? 11110000 .240 /28 $16 = 2^{(4)}$

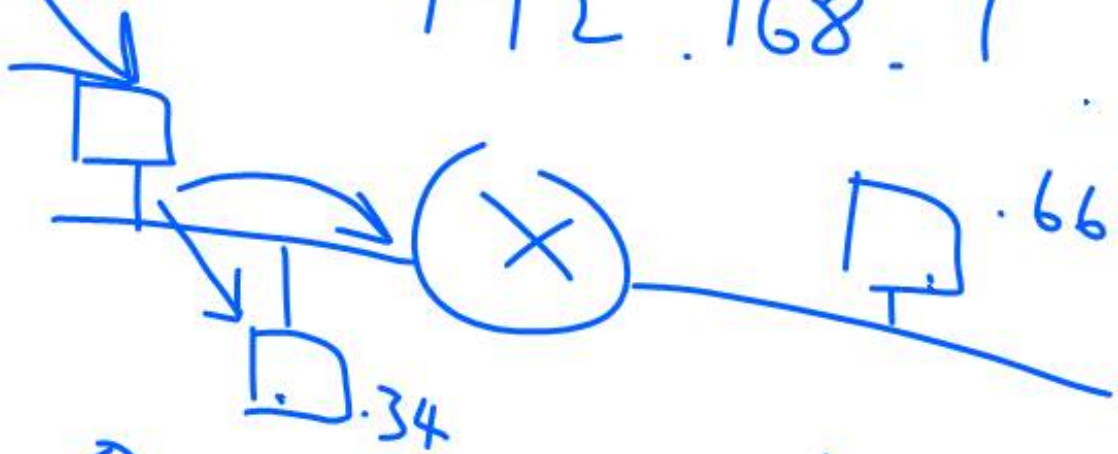
3) Subnet address & host ranges


Dec
128 64 32 16 8 4 2 1
0 0 0 0 Zeros .0
0 0 0 1 .16
0 0 1 0 .32
0 0 1 1 .48
0 1 0 0 .64
etc
1 1 1 1 .240

192.168.1.33

AND 255.255.255.240

192.168.1.32



0 AND 0 = 0

0 AND 1 = 0

1 AND 1 = 1

192 = 1100 0000

255 = 1111 1111

192 ← 1100 0000.

X | X | x x x x x x x

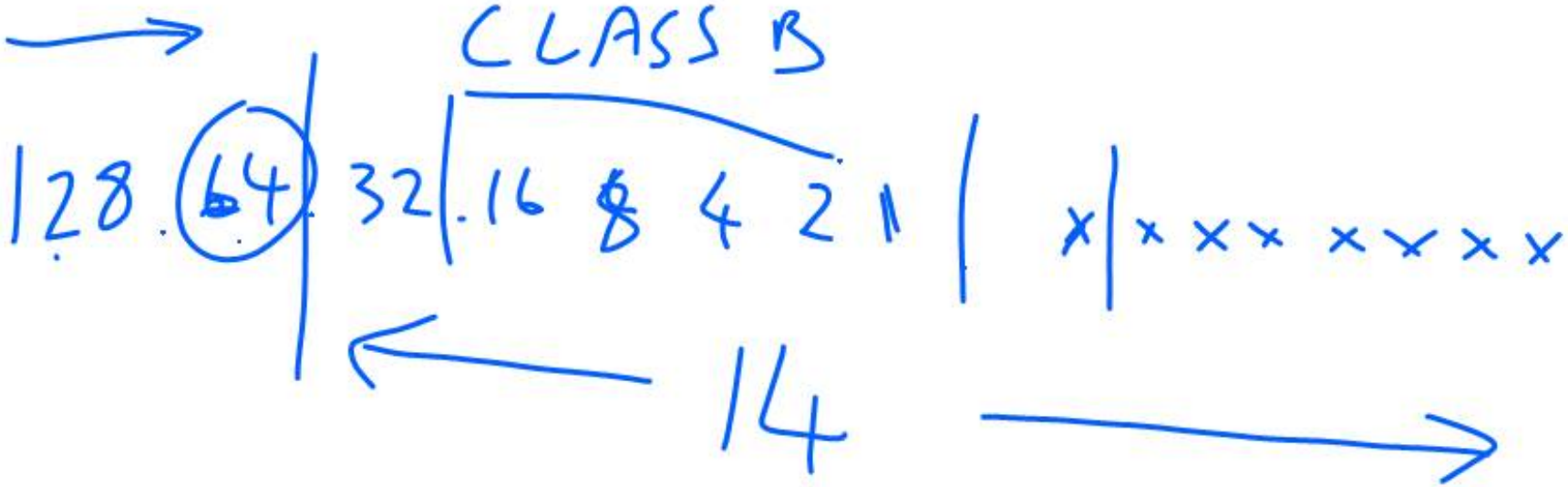
CLASS C

	S	SUBNETS 2^S	H	HOSTS $= 2^H - 2$
/25	1	2	7	126
/26	2	4	6	62
/27	3	8	5	30
/28	4	16	4	14
/29	5	32	3	6
/30	6	64	2	2

CLASS B

172.16.0.0/16

Require 4 subnets



HOSTS = $2^{14} - 2 = ?$

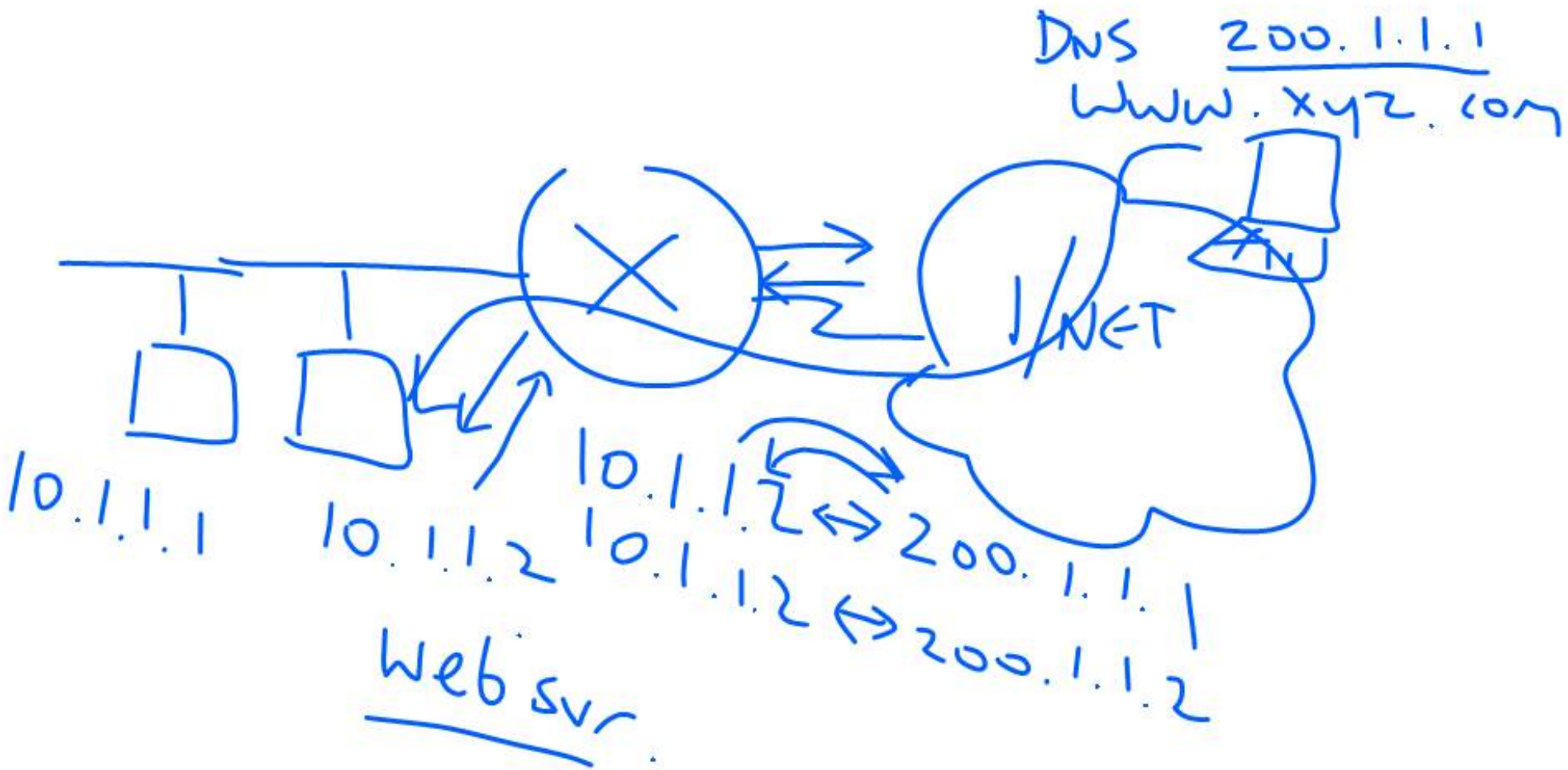
172.16.0.0 /18

64.0

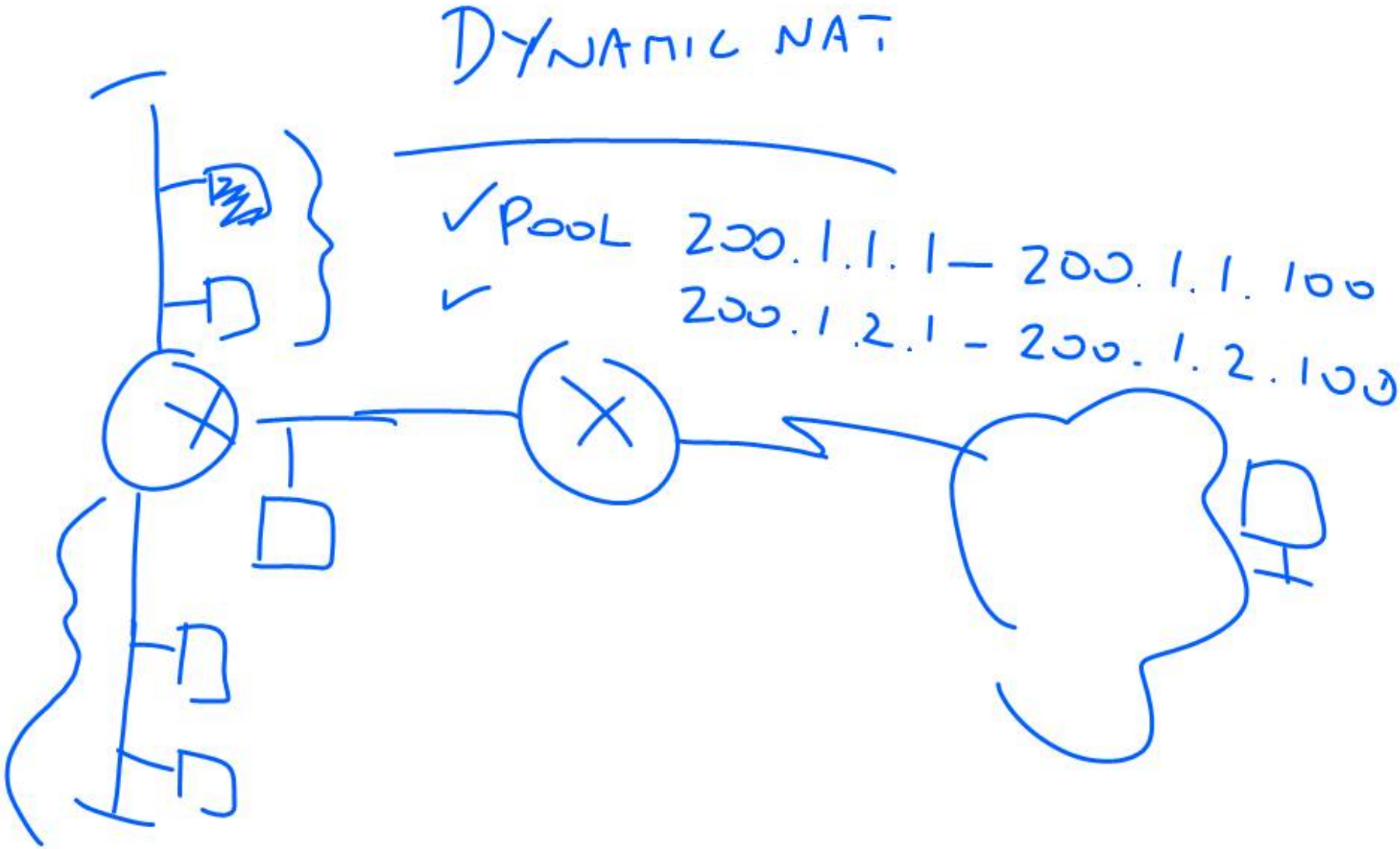
128.0

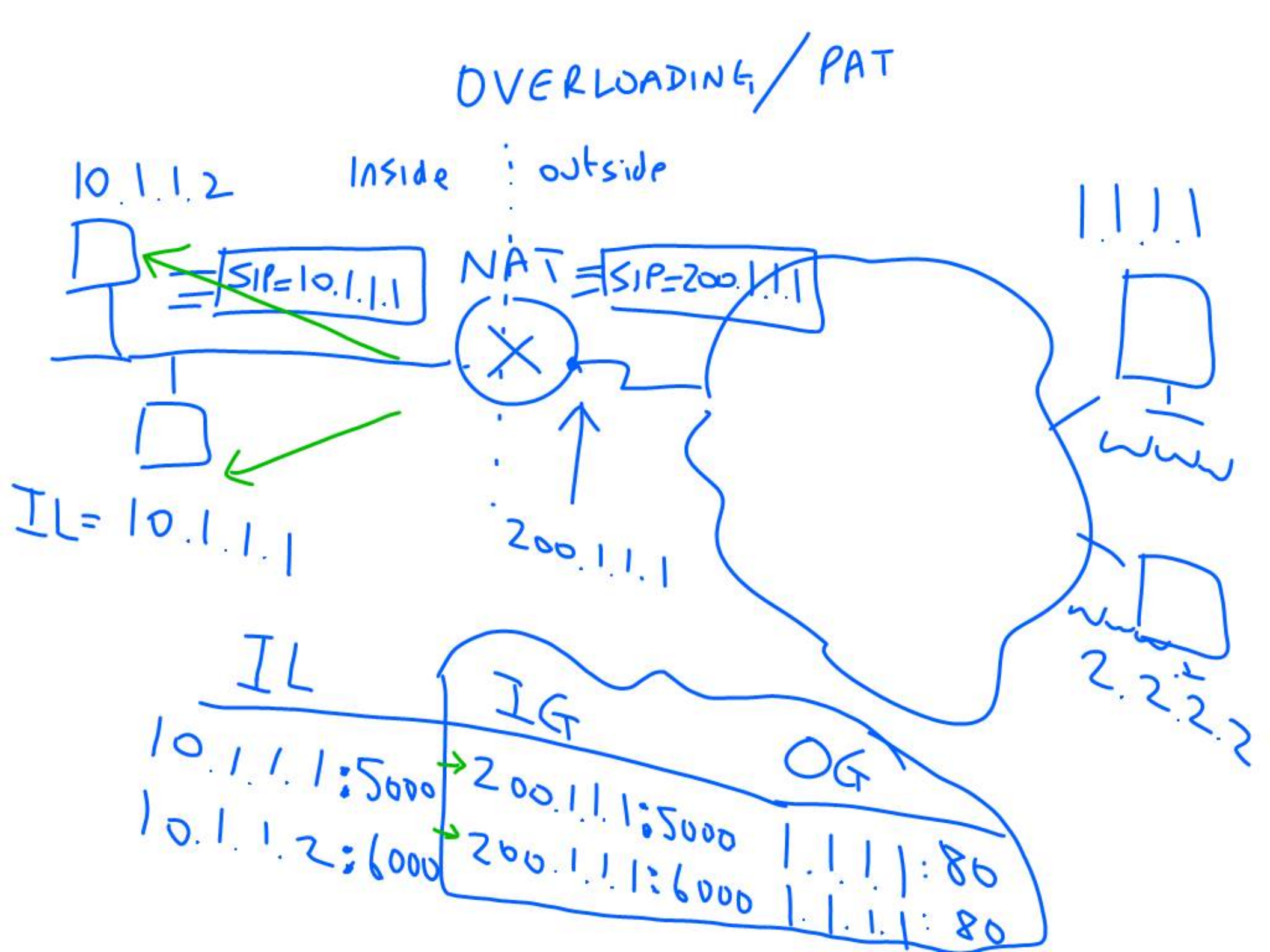
⋮

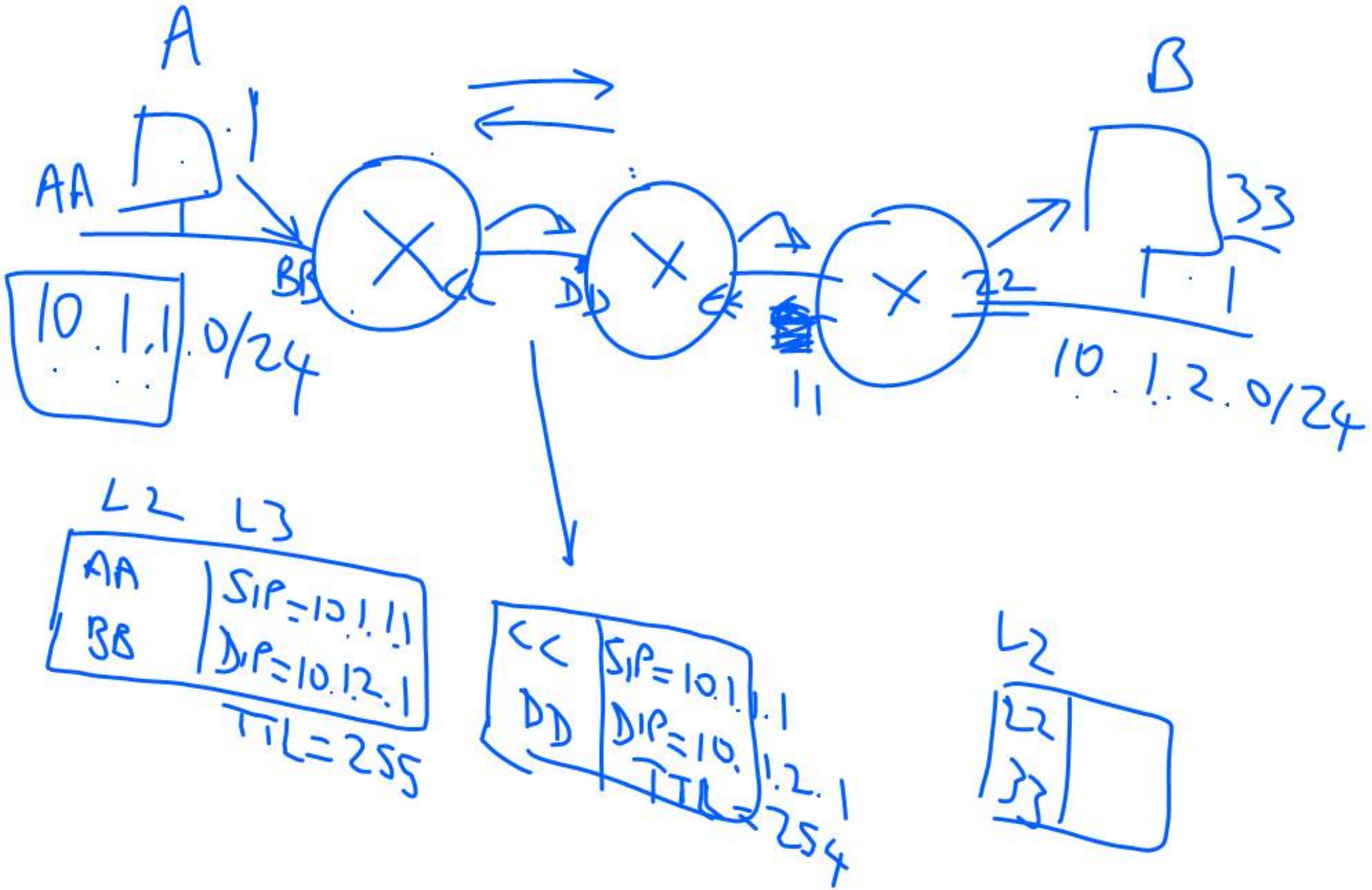
STATIC NAT


DNS 200.1.1.1
www.xyz.com
INET
10.1.1.1
10.1.1.2
10.1.1.2
200.1.1.1
10.1.1.2
200.1.1.2
Web svr.

DYNAMIC NAT

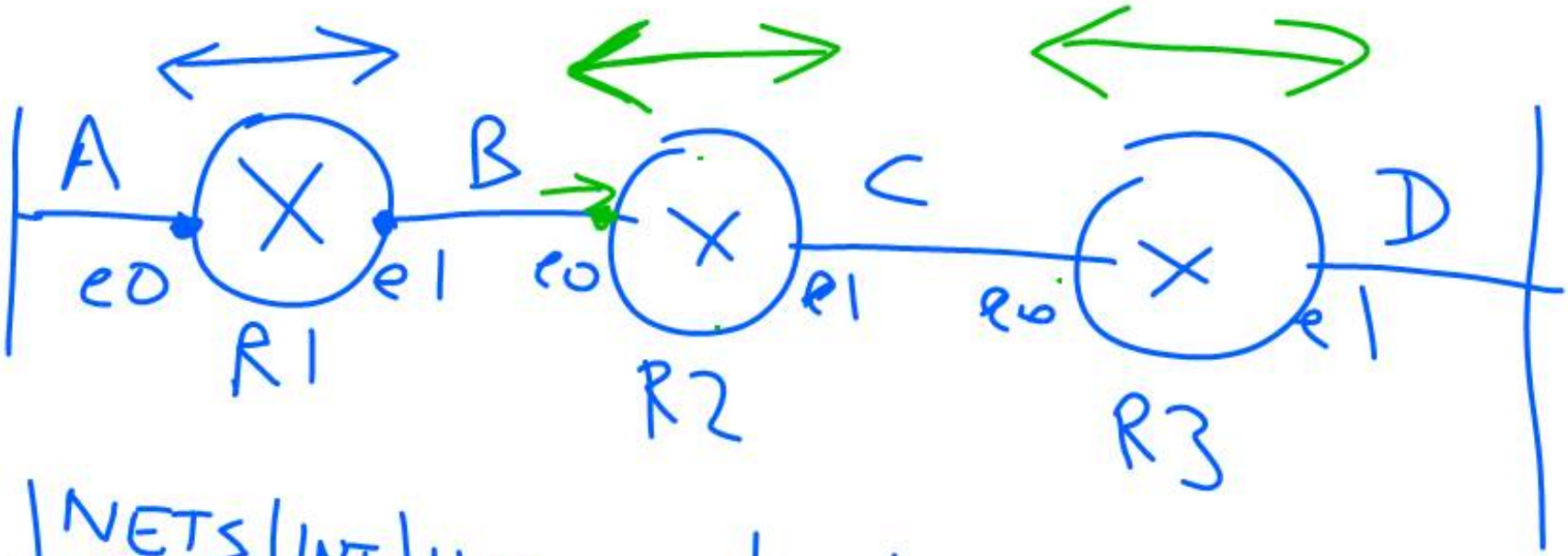



OVERLOADING / PAT
10.1.1.2
Inside
outside
SIP=10.1.1.1
NAT
SIP=200.1.1.1
1.1.1.1
IL=10.1.1.1
200.1.1.1
2.2.2.2
IL
IG
OG
10.1.1.1:5000
10.1.1.2:6000
200.1.1.1:5000
200.1.1.1:6000
1.1.1.1:80
1.1.1.1:80


A
AA
.1
BB
10.1.1.0/24
DD
11
.2
B
33
.1
10.1.2.0/24
L2 L3
AA
BB
SIP=10.1.1.1
DIP=10.12.1
TTL=255
CC
DD
SIP=10.1.
.1
DIP=10.
1.2.1
TTL=254
L2
L2
33

DV (RIP)

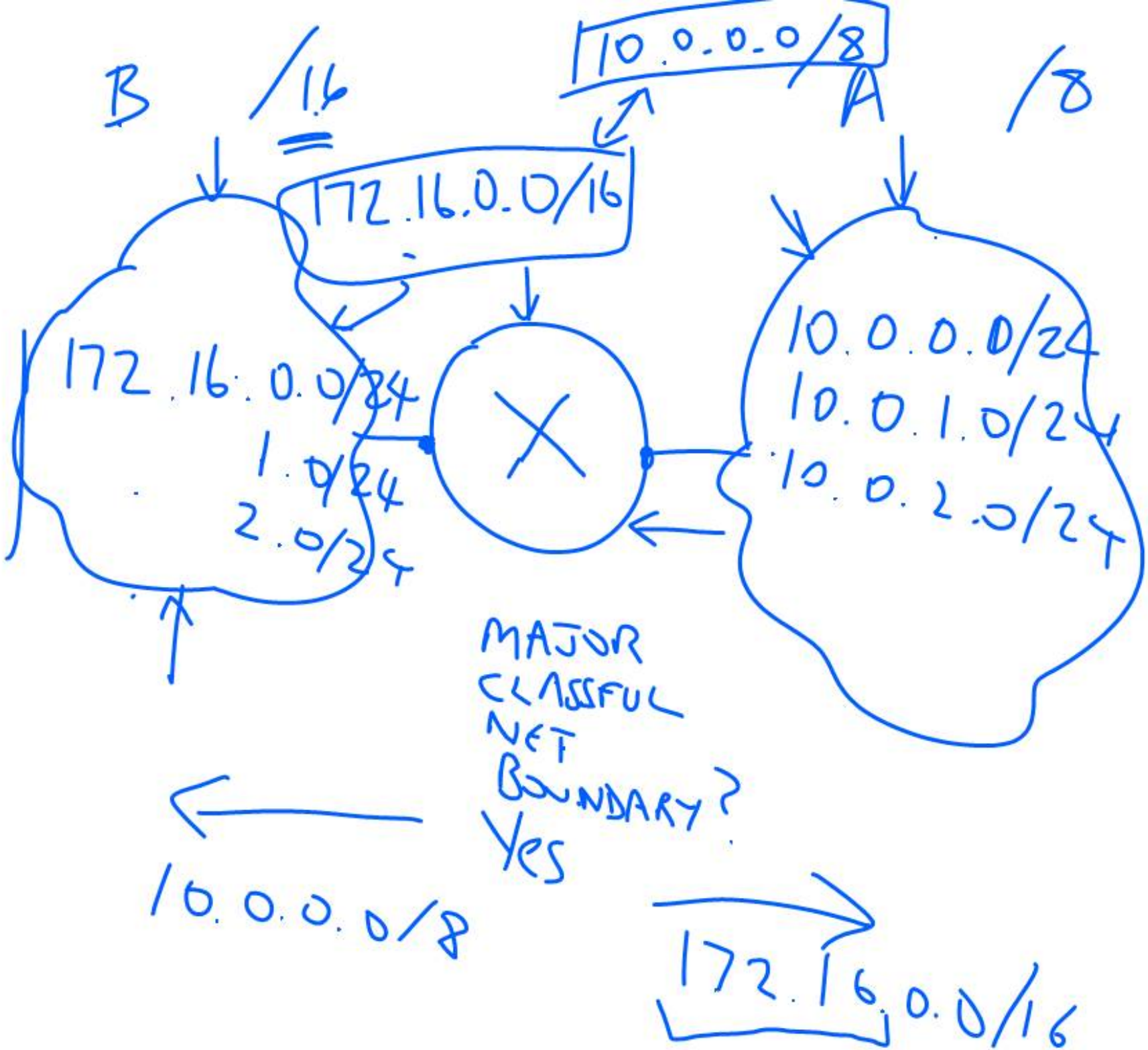
RIP v1 B/C
v2 224.0.0.9



	NETS	INT	HOP
C	A	e0	0
C	B	e1	0
	C	e1	1
	D	e1	2

B	e0	0
C	e1	0
A	e0	1
D	e1	1

C	e0	0
D	e1	0
A	e0	2
B	e0	1

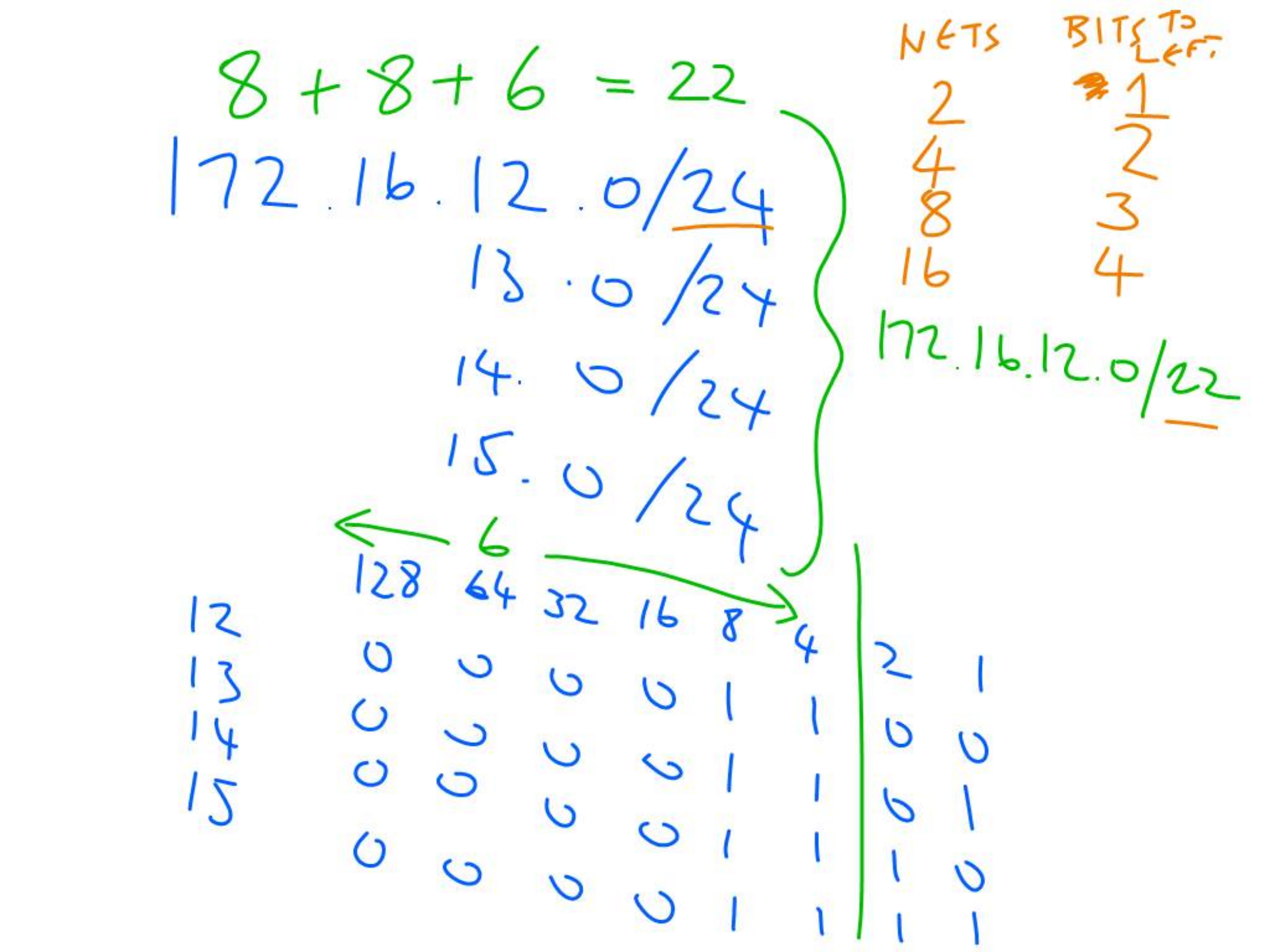

B
/16
10.0.0.0/8
A
/8
172.16.0.0/16
172.16.0.0/24
1.0/24
2.0/24
10.0.0.0/24
10.0.1.0/24
10.0.2.0/24
MAJOR
CLASSFUL
NET
BOUNDARY?
YES
10.0.0.0/8
172.16.0.0/16

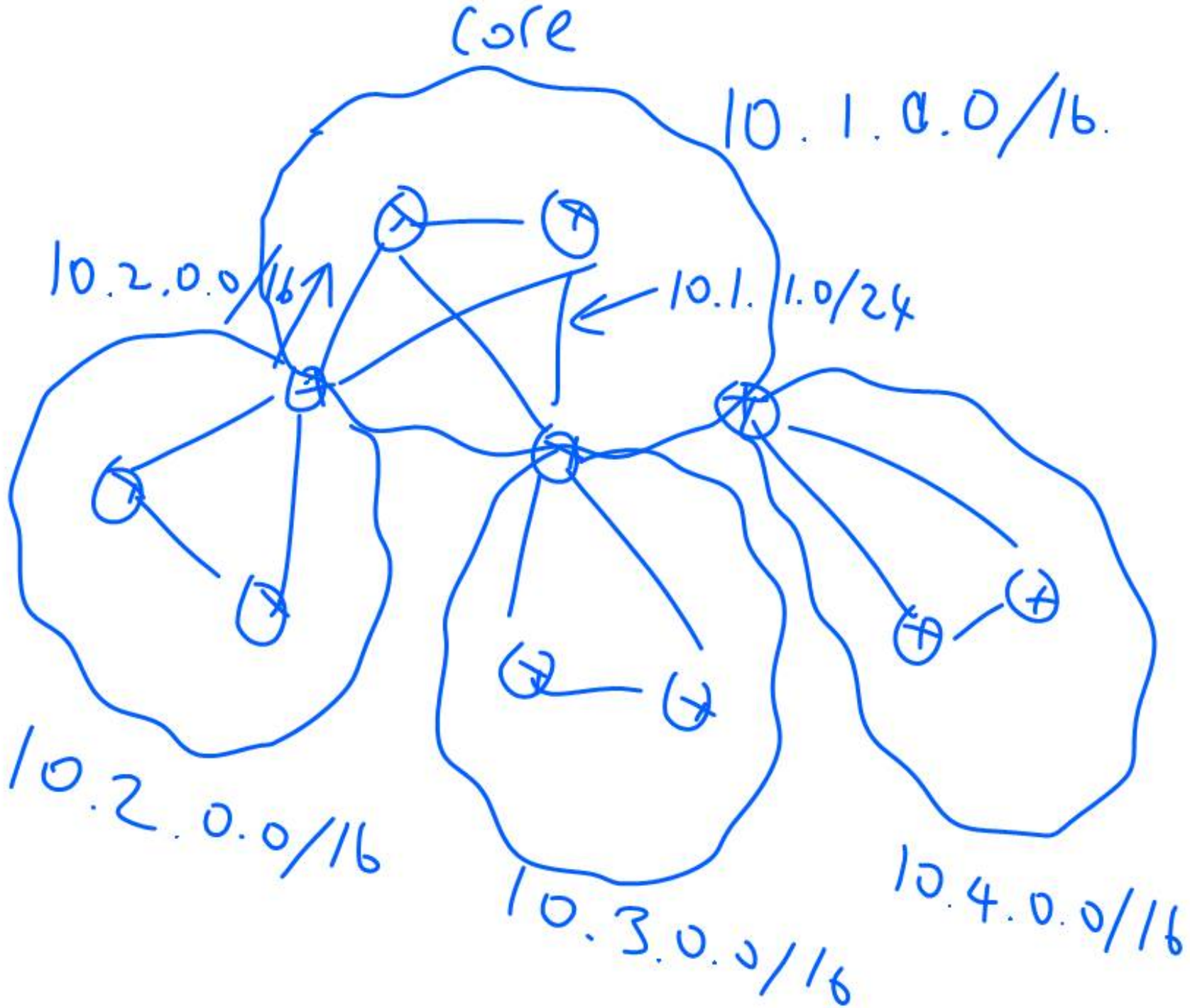
8 + 8 + 6 = 22

ROUTE SUMMARIZ.. 172.16.④.0

6 common bits →

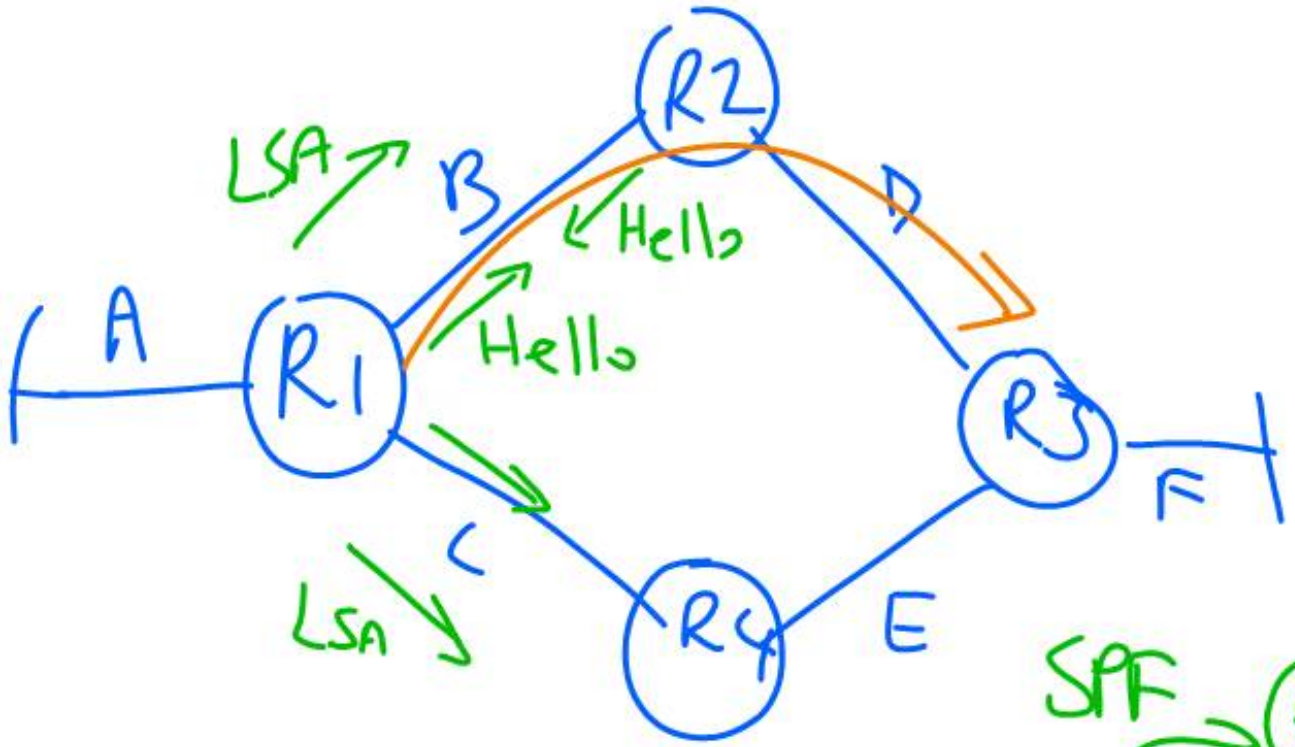
128	64	32	16	8	4	2	1
4 = 0	0	0	0	0	1	0	0
5 = 0	0	0	0	0	1	0	1
6 = 0	0	0	0	0	1	1	0
7 = 0	0	0	0	0	1	1	1


8 + 8 + 6 = 22
172.16.12.0/24
13.0/24
14.0/24
15.0/24
6
128 64 32 16 8 4
12 0 0 0 0 1 1
13 0 0 0 0 1 1
14 0 0 0 0 1 1
15 0 0 0 0 1 1
2 1
0 0
0 1
1 0
1 1
NETS
2
4
8
16
BITS TO LEFT
1
2
3
4
172.16.12.0/22


core
10.1.0.0/16
10.2.0.0/16
10.1.1.0/24
10.2.0.0/16
10.3.0.0/16
10.4.0.0/16

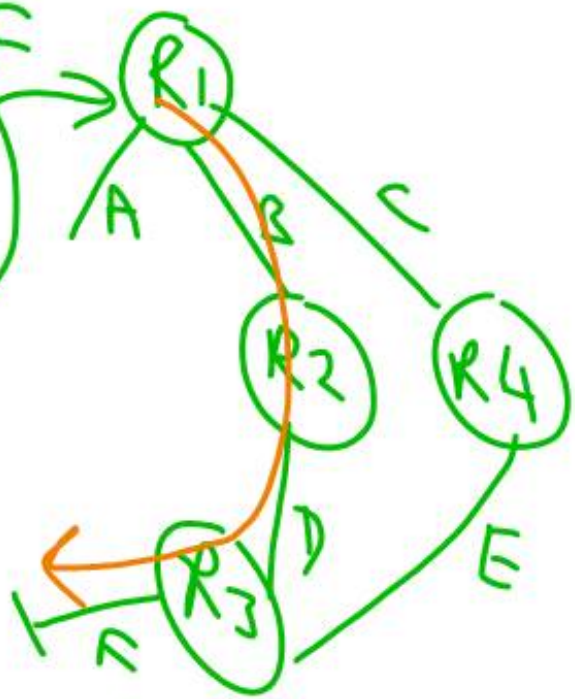
OSPF

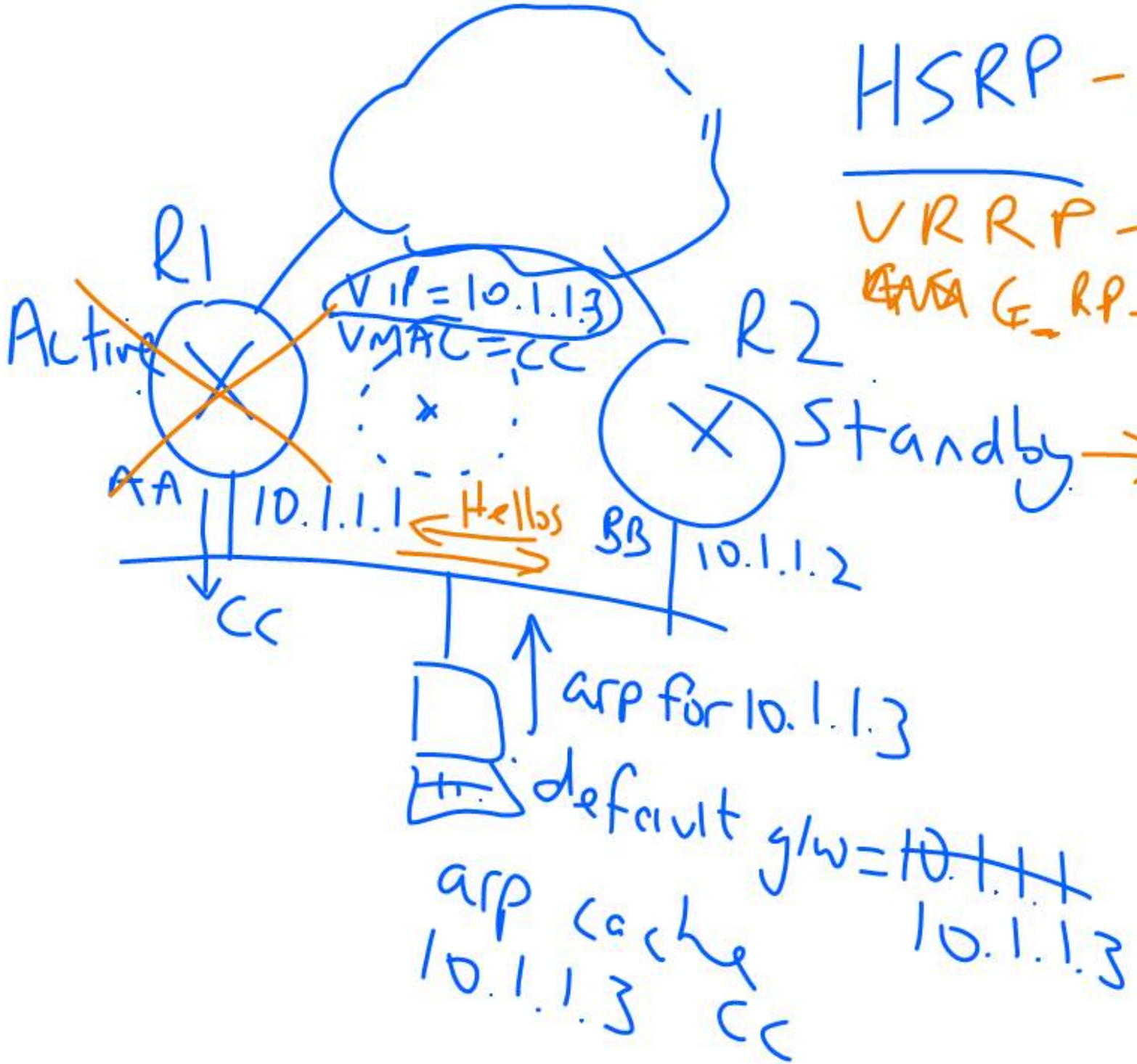
COST = f(Bandwidth)



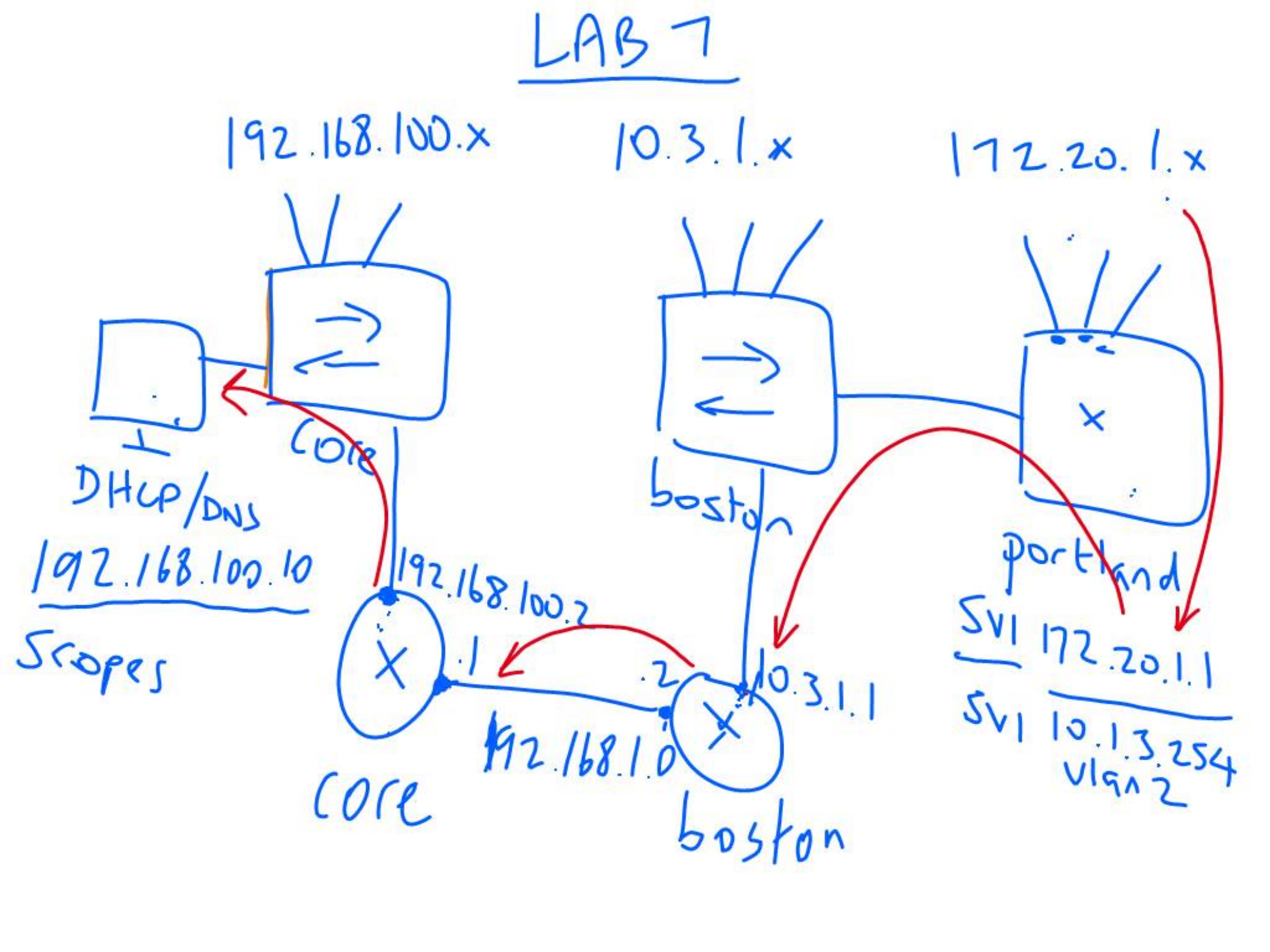
Hello
- Neigh Table
  - Exchange LSAs
    - LSDB
      - SPF
        - R.T.

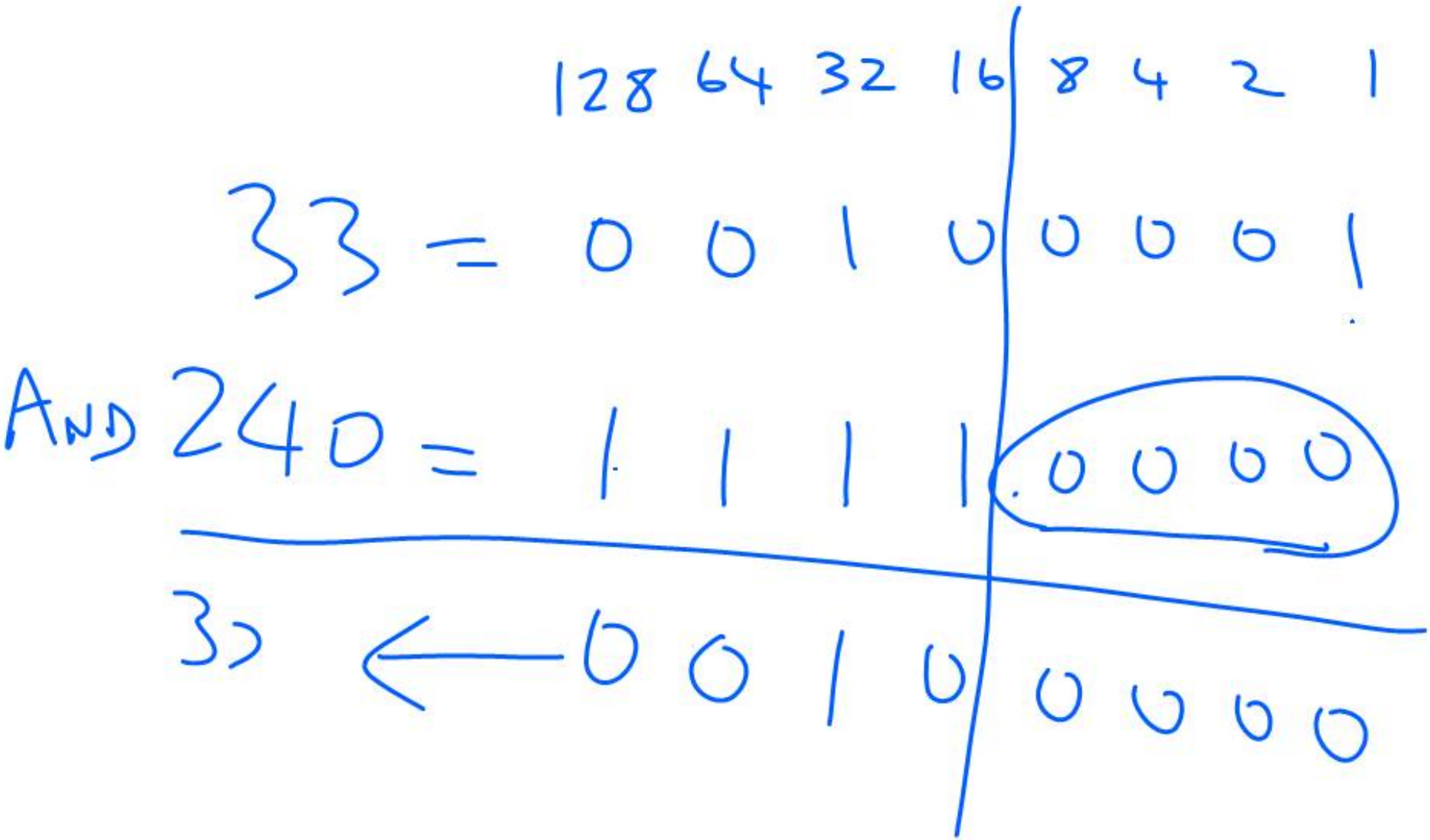
SPF




HSRP - Cisco
VRRP - open
GLBP - Cisco.
R1
Active
VIP = 10.1.1.3
VMAC = CC
R2
Standby → Active
AA
10.1.1.1
Hellos
BB
10.1.1.2
CC
arp for 10.1.1.3
default g/w = 10.1.1.3
arp cache
10.1.1.3 CC

LAB 7

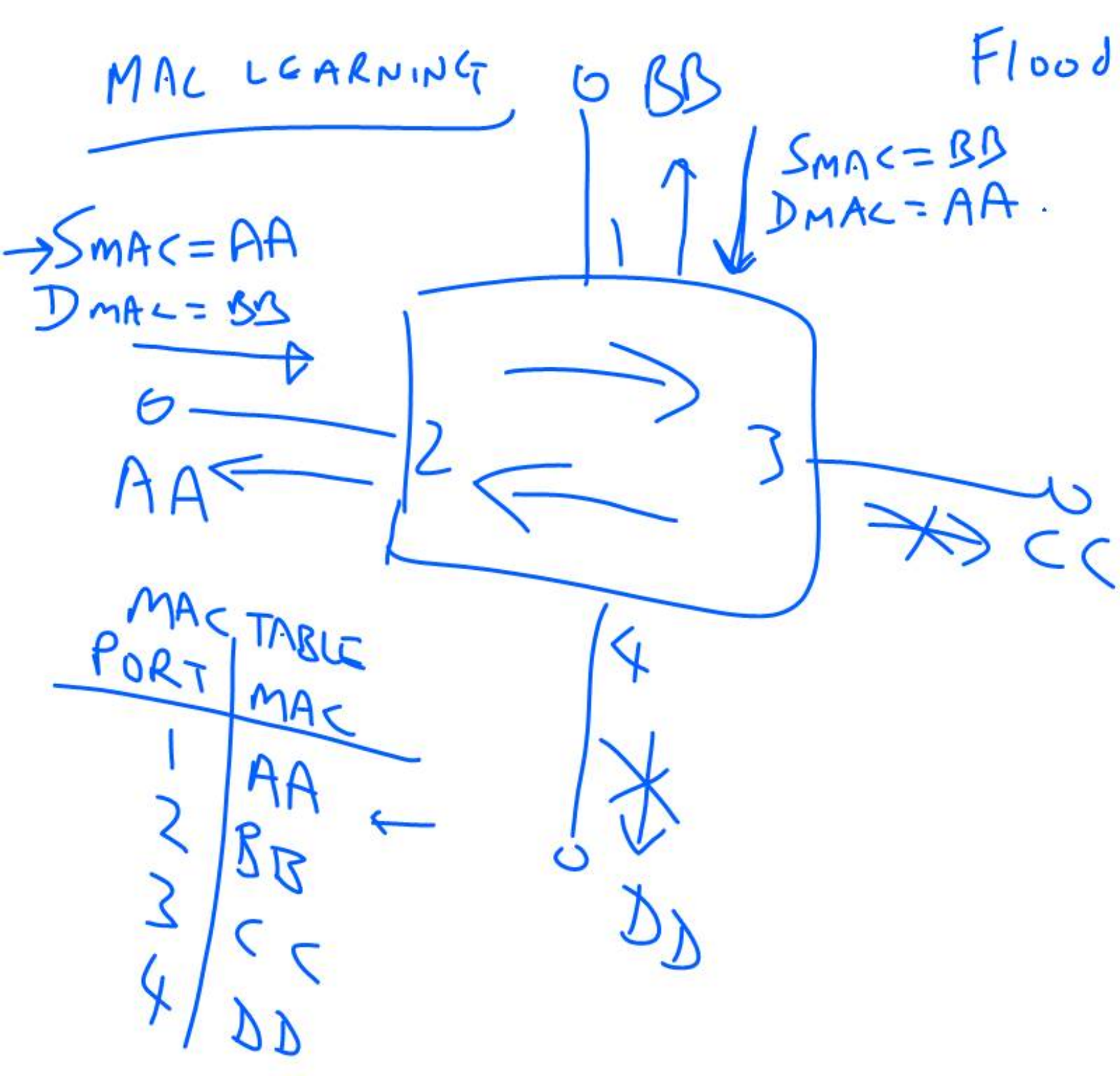

192.168.100.x
10.3.1.x
172.20.1.x
DHCP/DNS
192.168.100.10
Scopes
Core
192.168.100.2
.1
.2
192.168.1.0
Core
boston
10.3.1.1
boston
portland
SVI 172.20.1.1
SVI 10.1.3.254
vlan 2

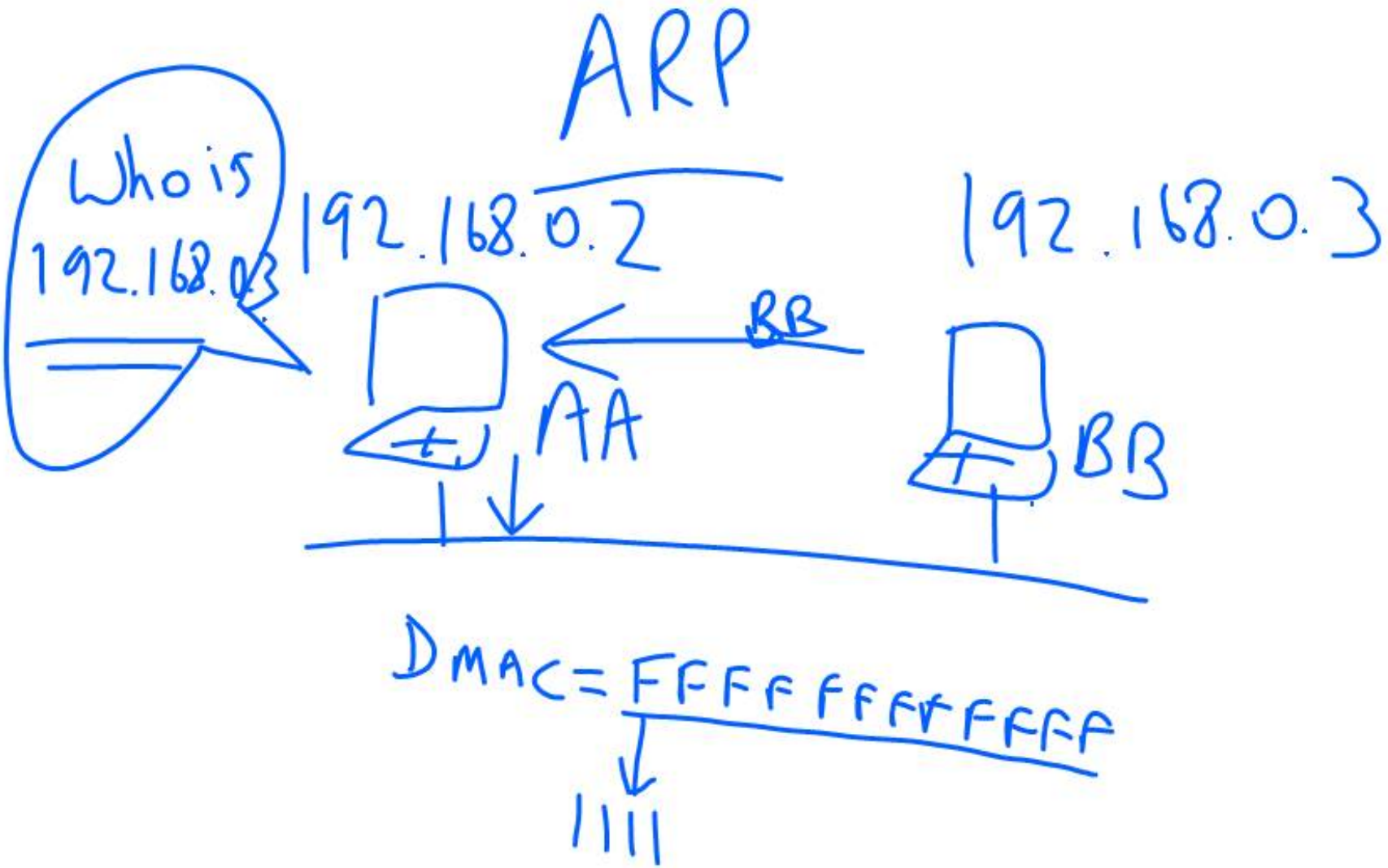

128 64 32 16 8 4 2 1
33 = 0 0 1 0 0 0 0 1
AND 240 = 1 1 1 1 0 0 0 0
32 ← 0 0 1 0 0 0 0 0

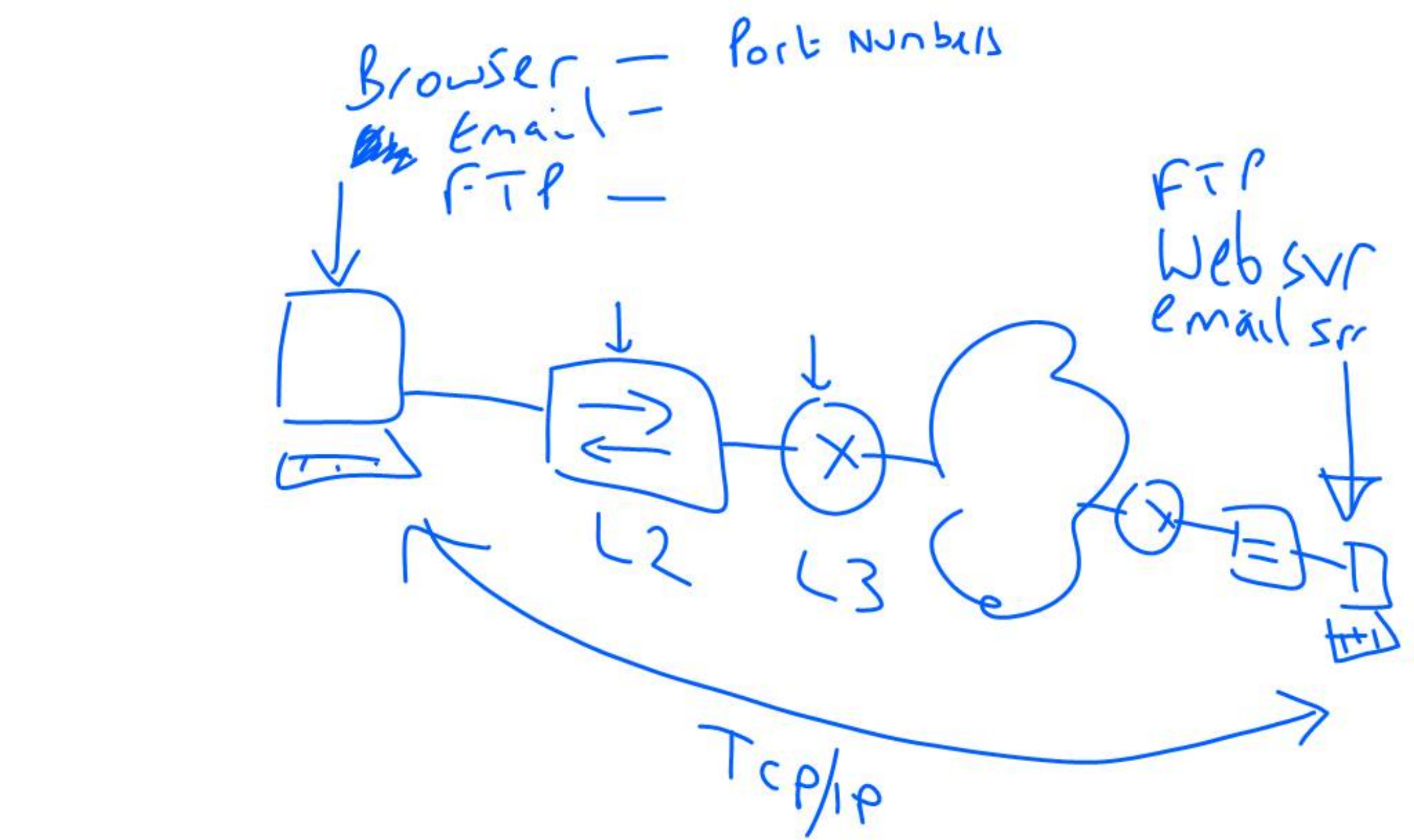
		4	2	1
∅	=	0	0	0
1	=	0	0	1
2	=	0	1	0
3	=	0	1	1
4	=	1	0	0
5	=	1	0	1
6	=	1	1	0
7	=	1	1	[illegible]

MASKS

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

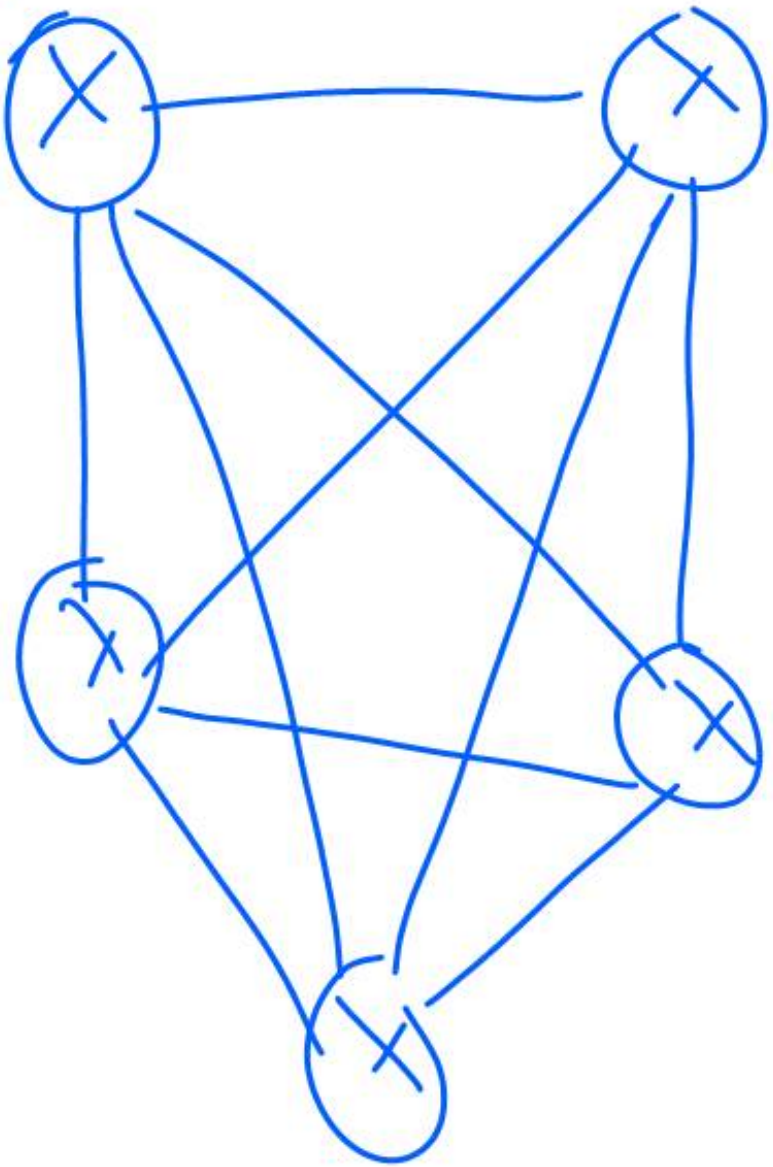

MAC LEARNING
Flood
BB
SMAC = BB
DMAC = AA
SMAC = AA
DMAC = BB
1
2
3
4
AA
CC
DD
MAC TABLE
PORT
MAC
1
AA
2
BB
3
CC
4
DD


ARP
Who is
192.168.0.3
192.168.0.2
192.168.0.3
BB
AA
BB
DMAC=FFFFFFFFFFFF
1111

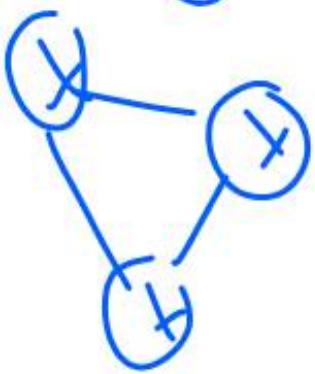

Browser —
Email —
FTP —
Port Numbers
FTP
Web svr
email svr
L2
L3
Tcp/ip

FULL MESH HQ

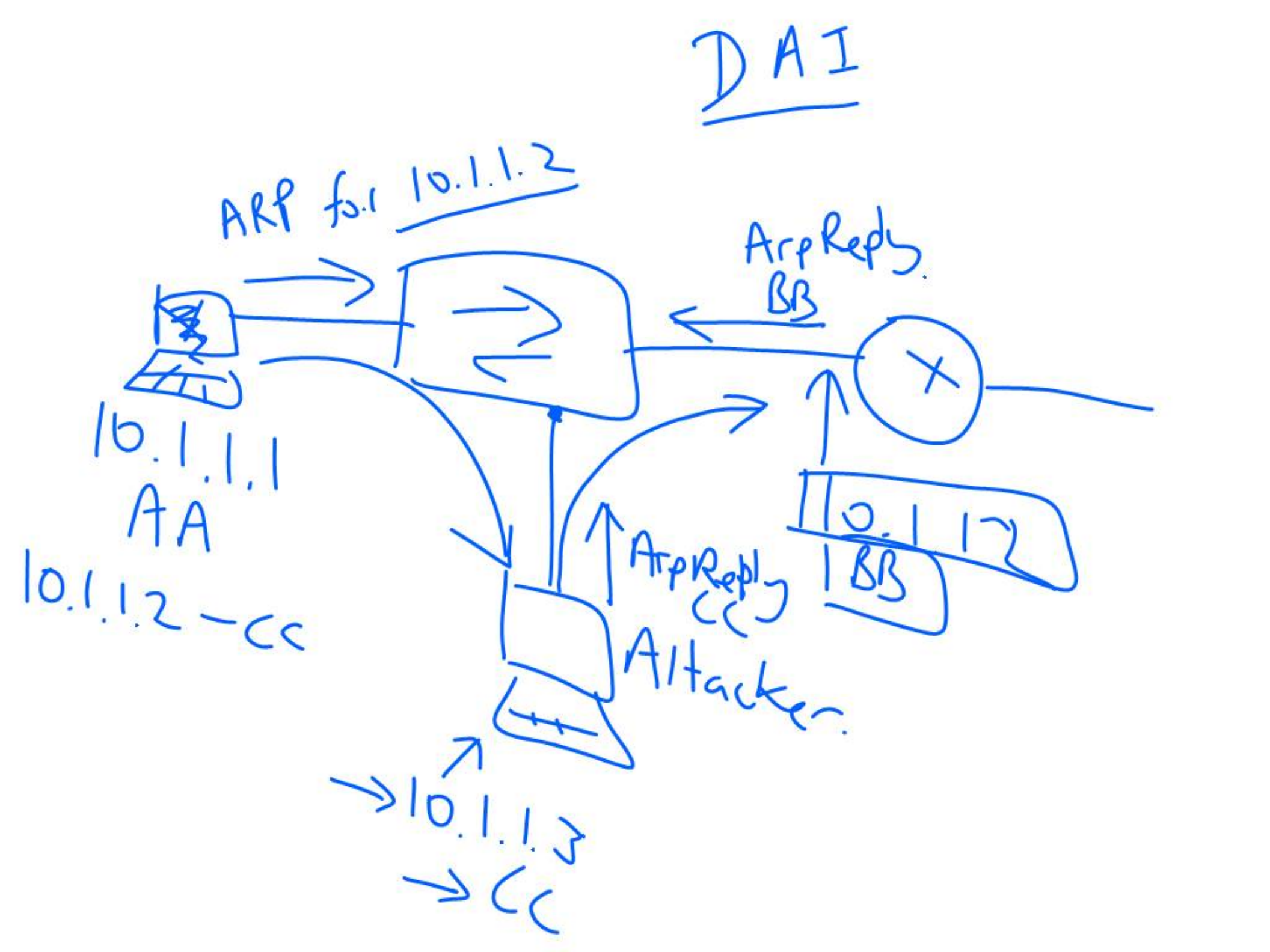
$$VCs = \frac{(N \times N-1)}{2}$$

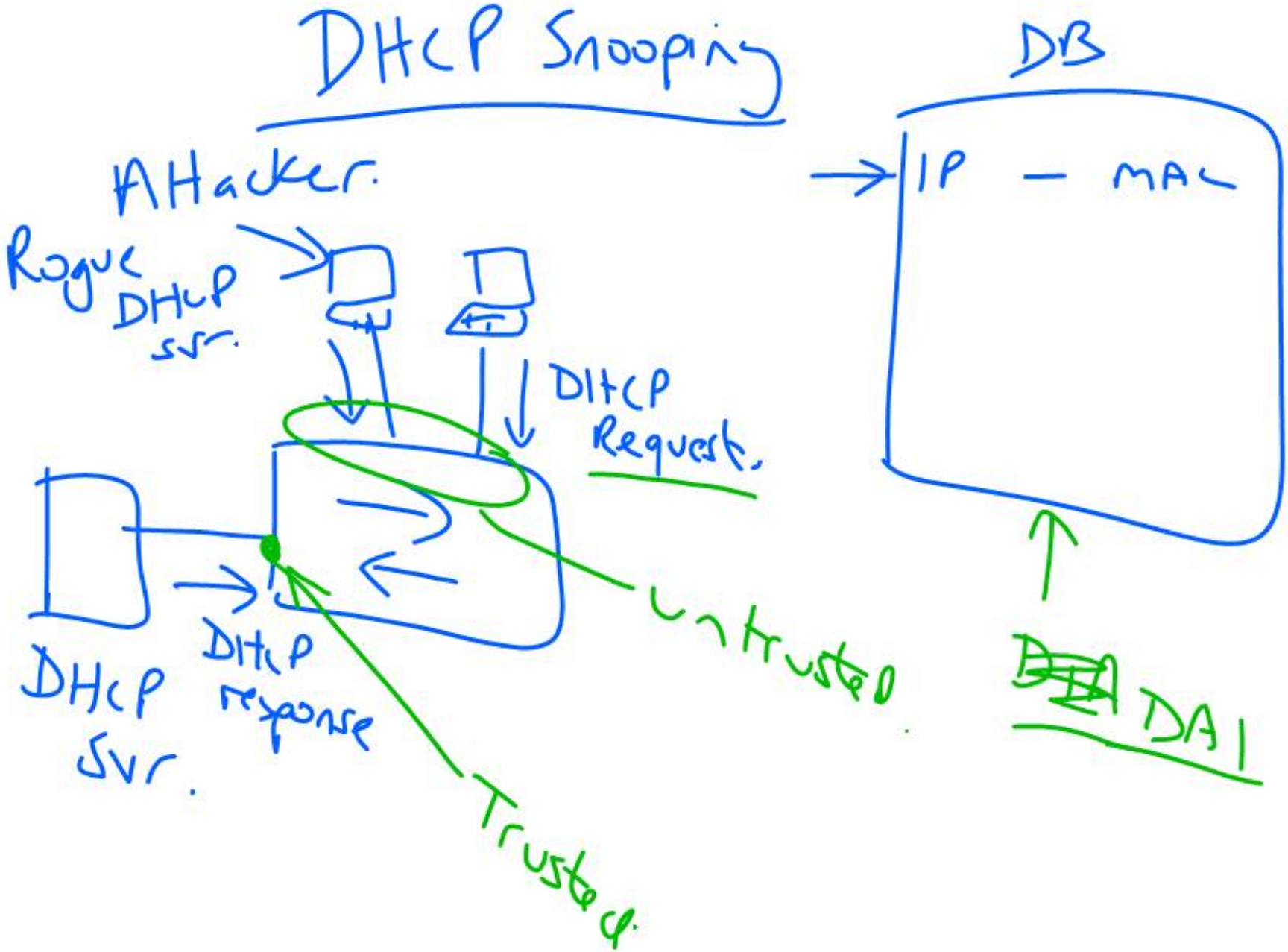


Nodes	VC's
2	1
3	3
4	6
5	10
6	15

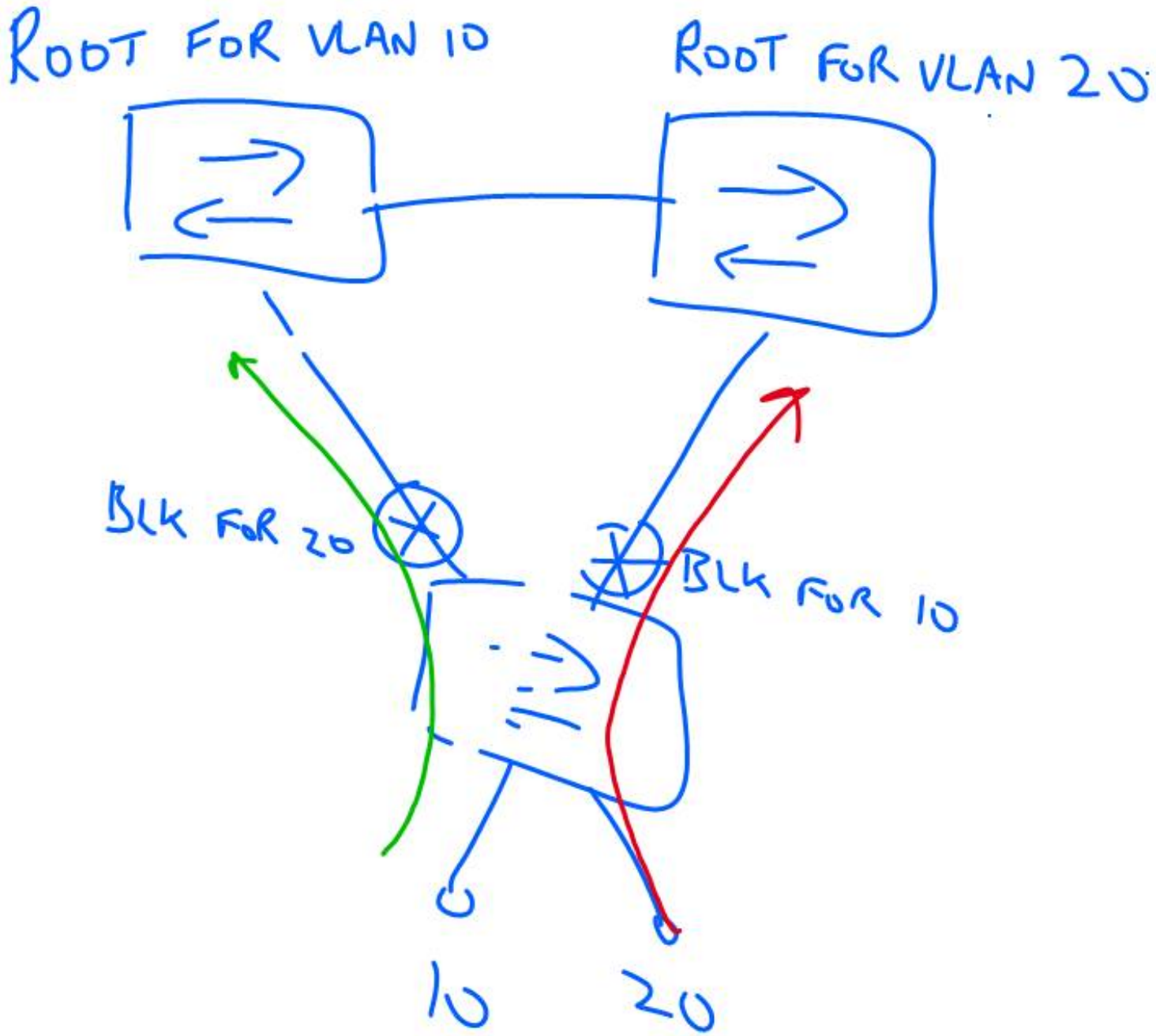


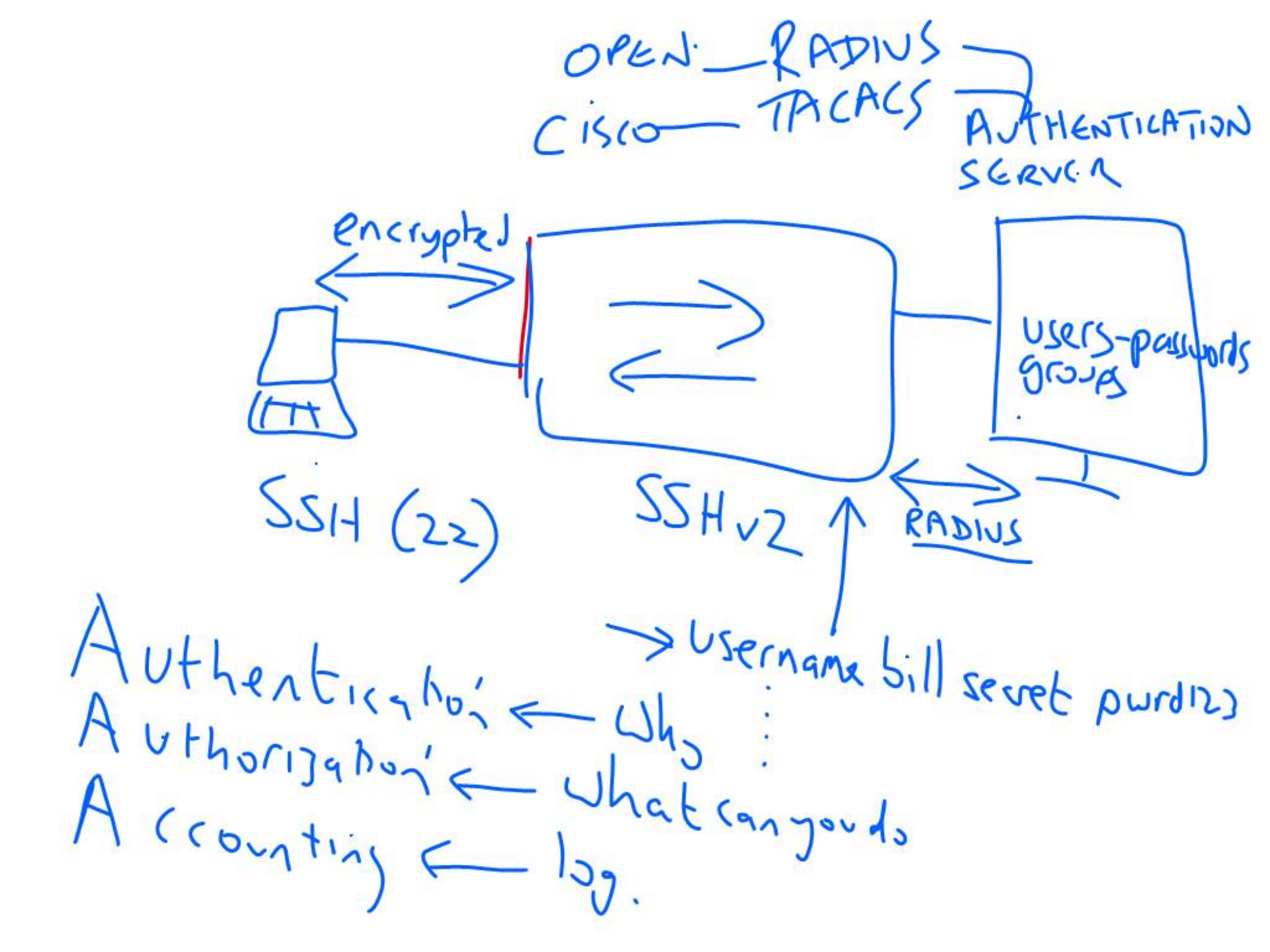
DAI

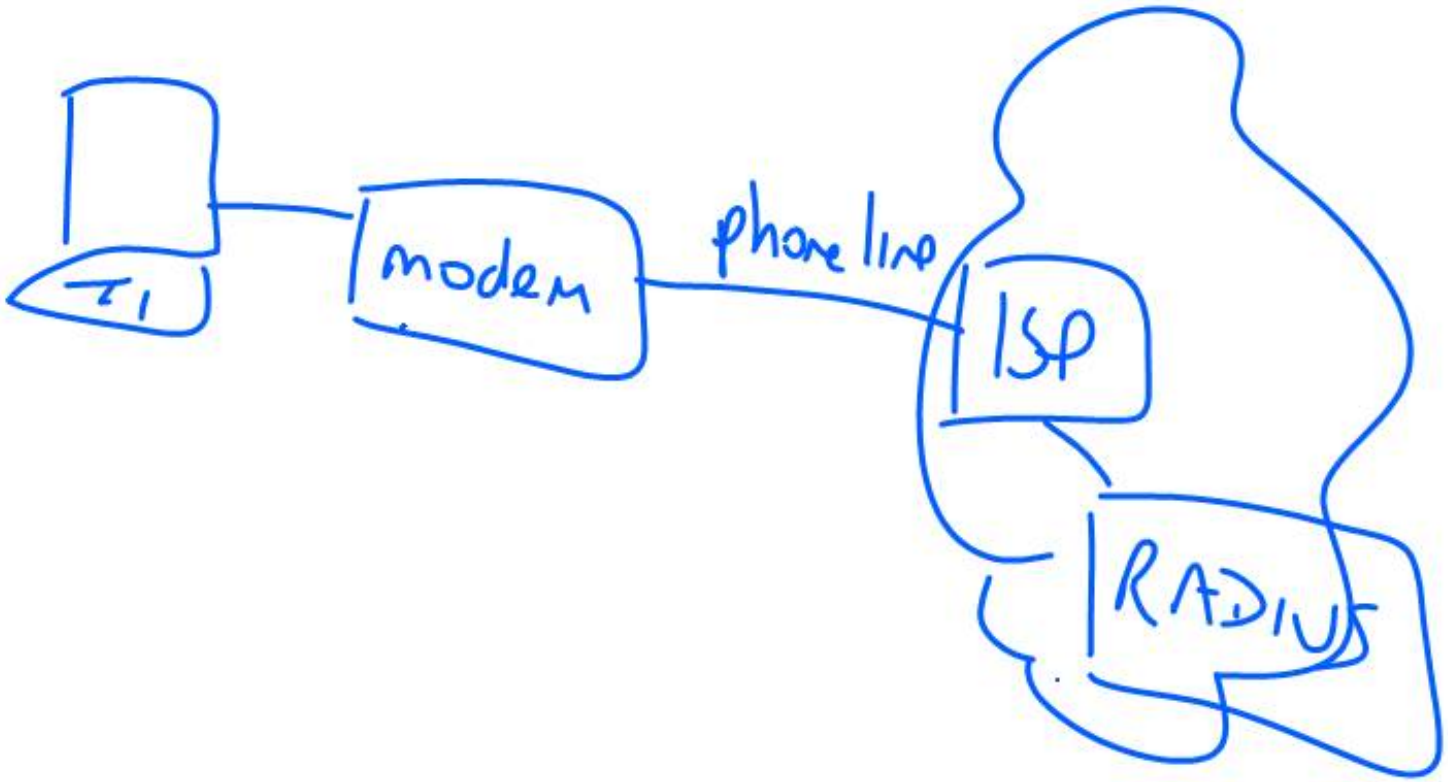

ARP for 10.1.1.2
ArpReply
BB
10.1.1.1
AA
10.1.1.2 - CC
ArpReply
CC
Attacker
10.1.1.2
BB
10.1.1.3
CC

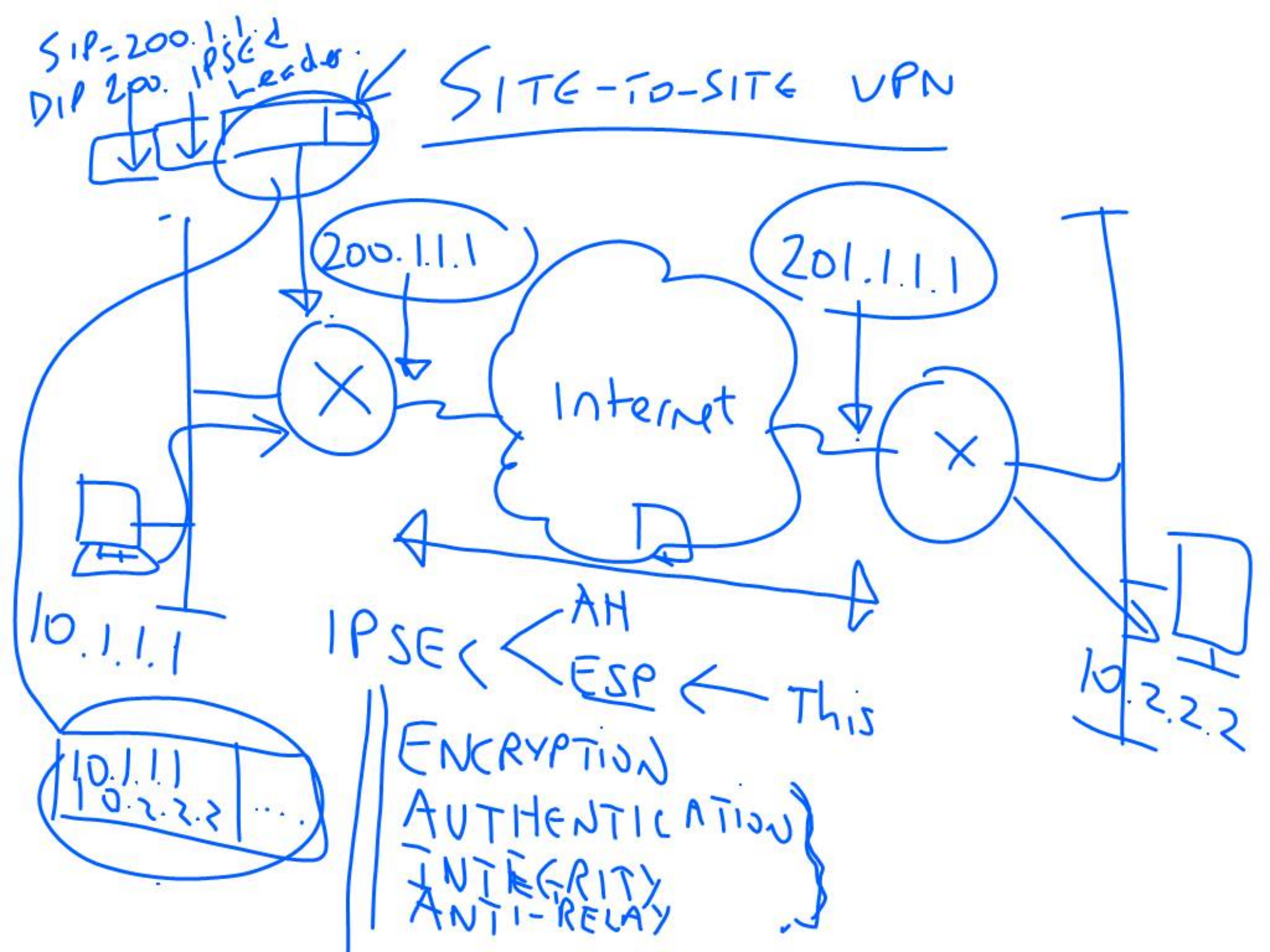

DHCP Snooping
DB
IP - MAC
AHacker.
Rogue DHCP svr.
DHCP Request.
DHCP response
DHCP svr.
Untrusted
DAI
Trusted

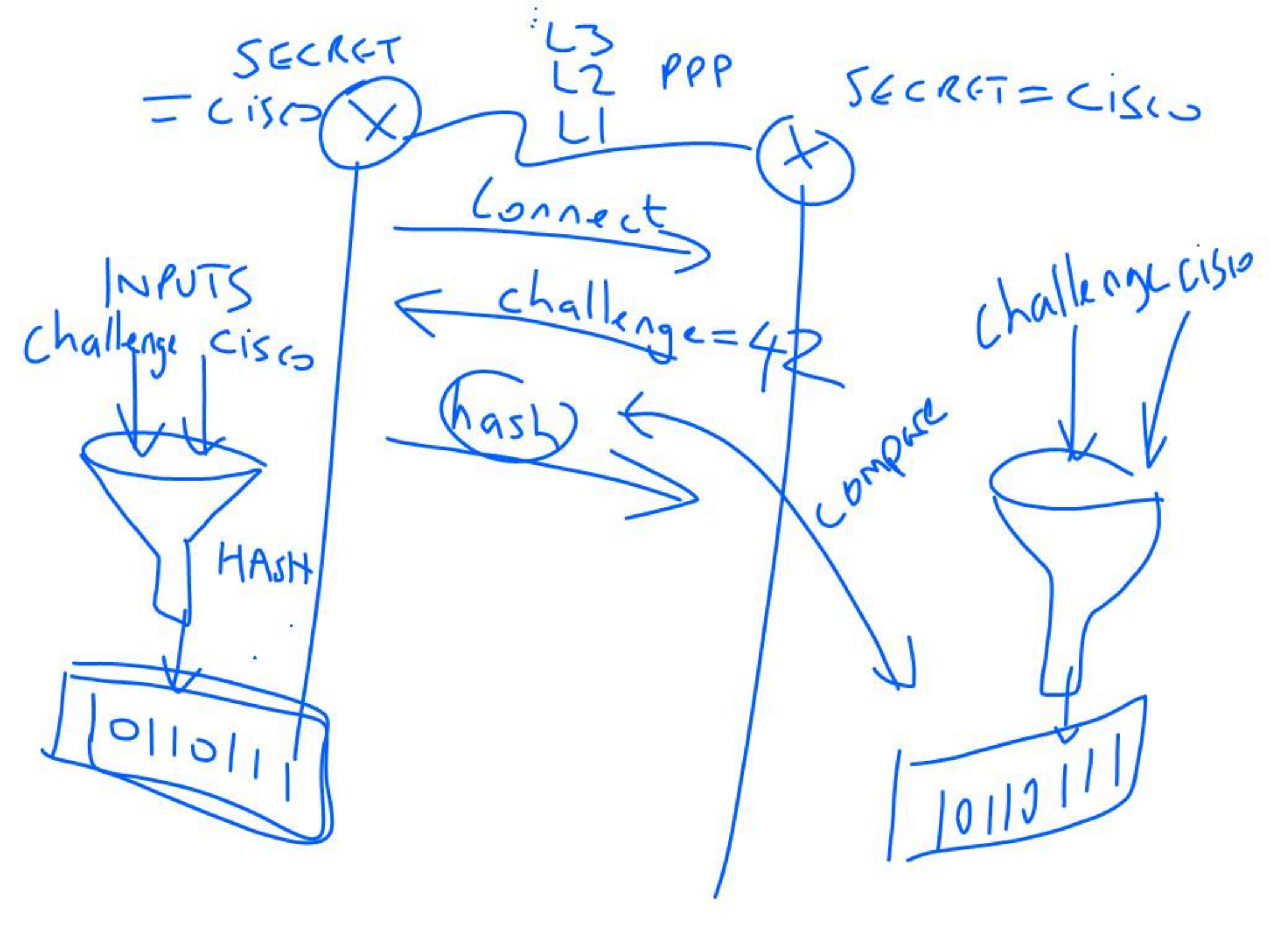
PVST



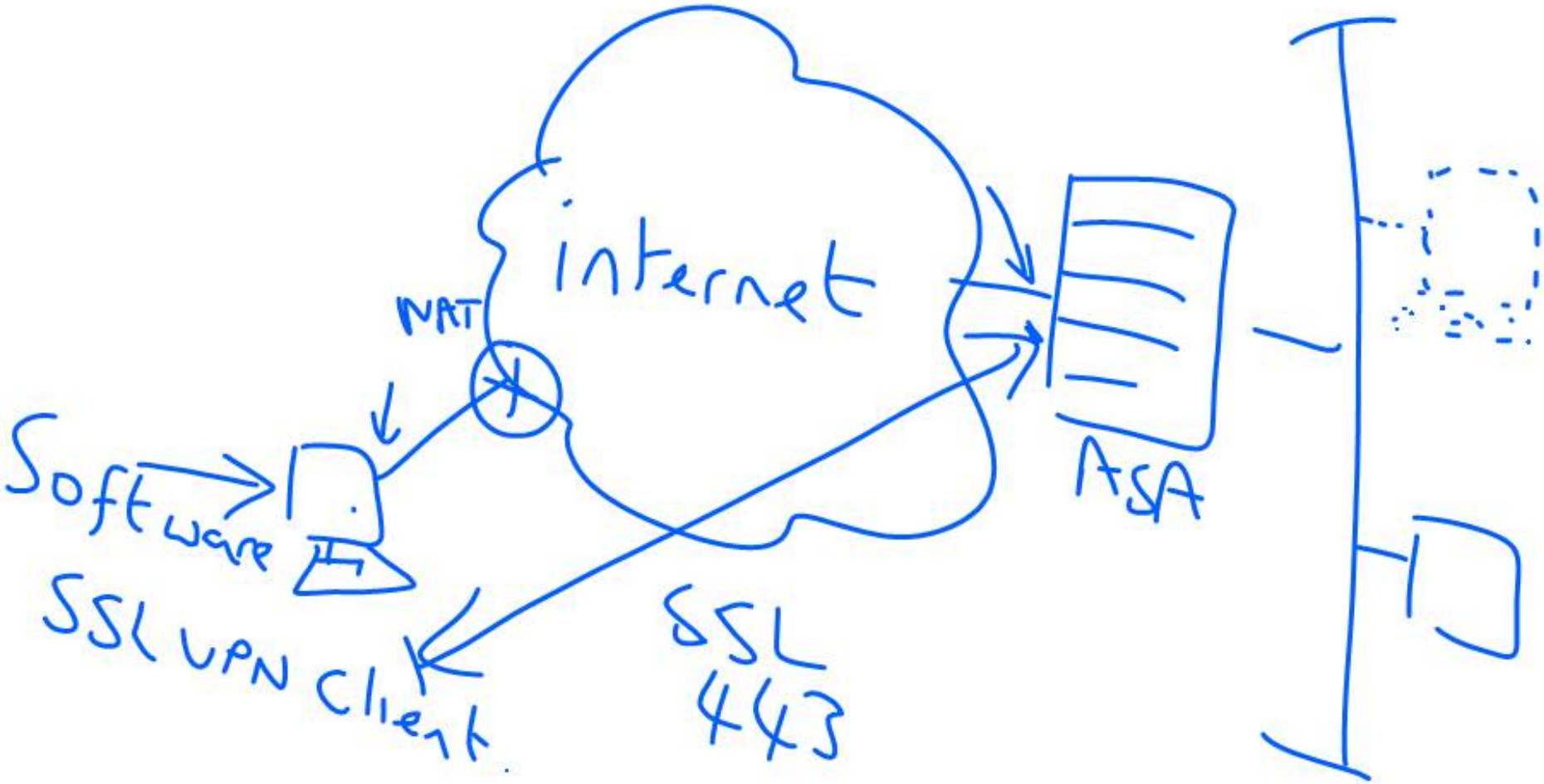

OPEN — RADIUS
CISCO — TACACS
AUTHENTICATION SERVER
encrypted
users-passwords groups
SSH (22)
SSHv2
RADIUS
→ username bill secret pwd123
Authentication ← who
Authorization ← what can you do
Accounting ← log.


T1
modem
phone line
ISP
RADIUS

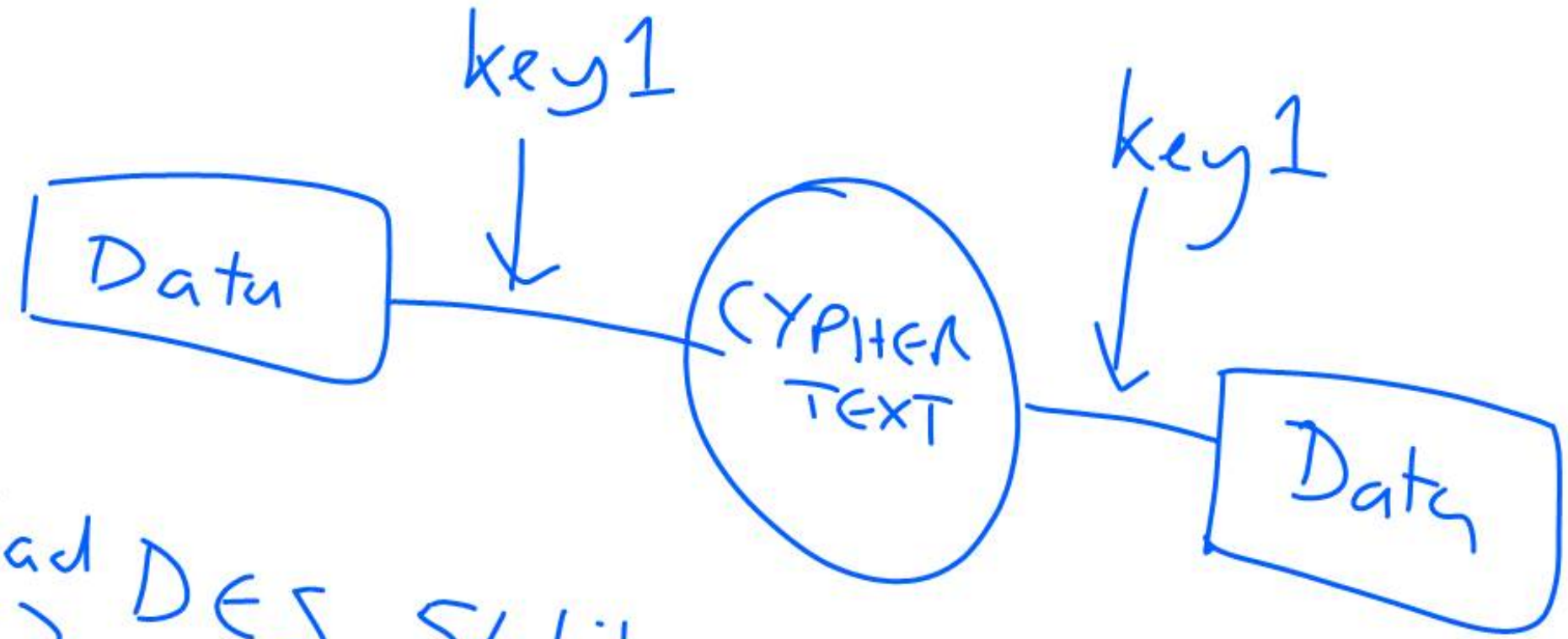

SIP=200.1.1.1
DIP 200.1.1.1
IPSEC Leader
SITE-TO-SITE VPN
200.1.1.1
201.1.1.1
Internet
10.1.1.1
10.2.2.2
IPSEC
AH
ESP
This
10.1.1.1
10.2.2.2
ENCRYPTION
AUTHENTICATION
INTEGRITY
ANTI-REPLAY


SECRET
= CISCO
L3
L2
L1
PPP
SECRET = CISCO
Connect
challenge=42
hash
INPUTS
Challenge CISCO
HASH
COMPARE
Challenge CISCO
0110111
0110111

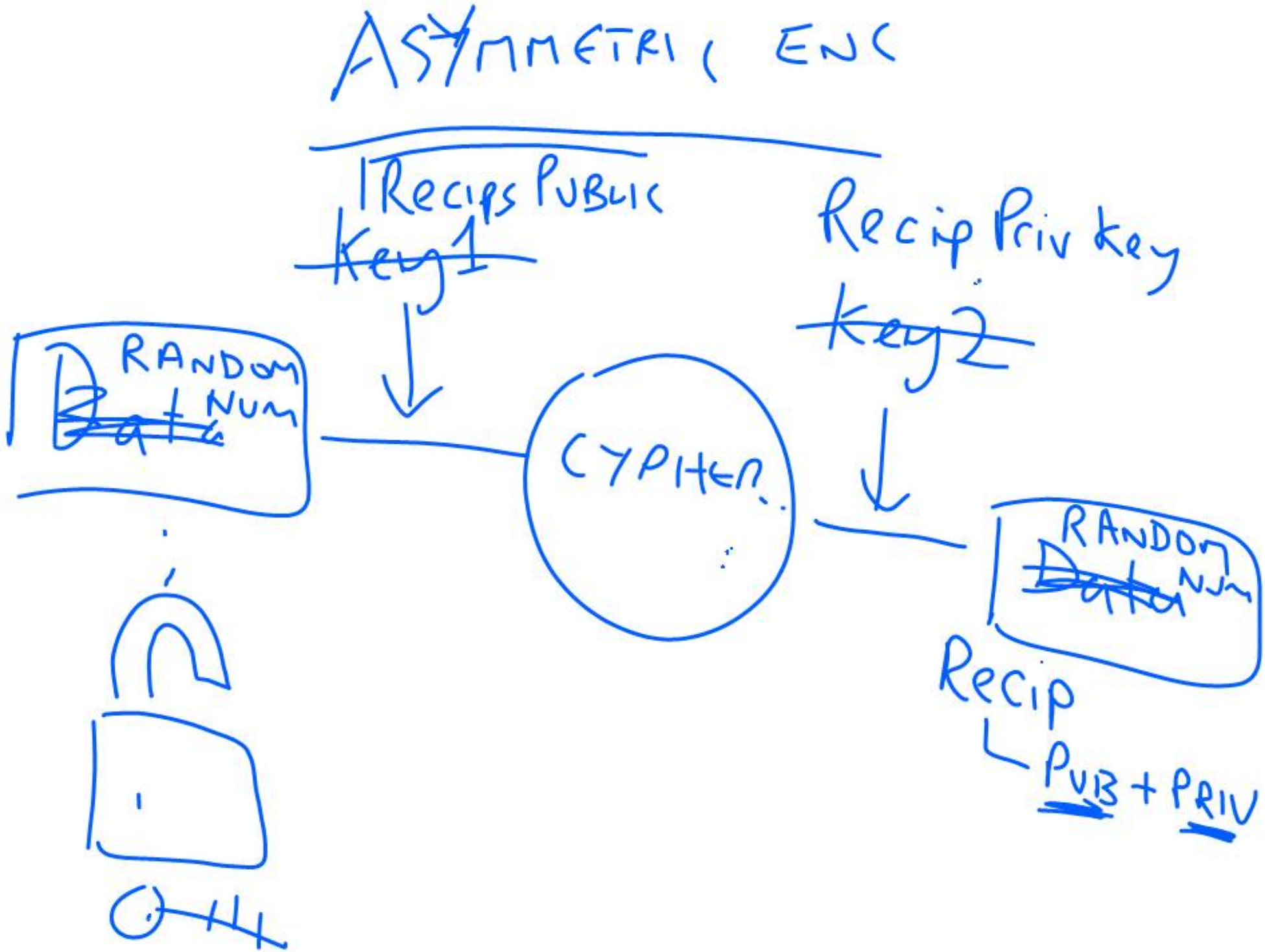
REMOTE-ACCESS VPN

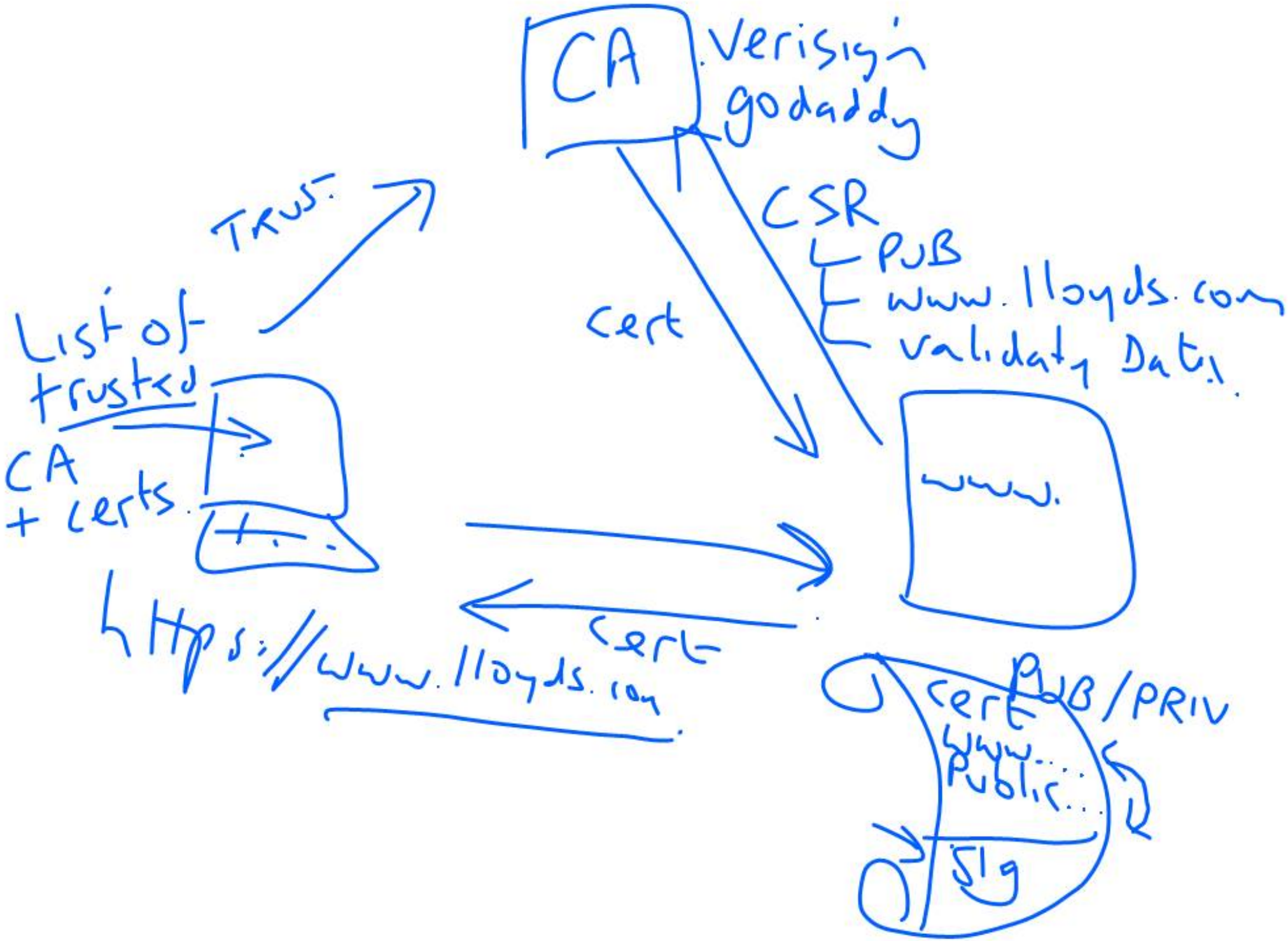


SYMMETRIC ENC



Bad DES 56 bit
3-DES 3x56 bit
✓ AES 128, 256...


ASYMMETRIC ENC
Recips PUBLIC
Key1
Recip Priv key
Key2
RANDOM
NUM
CYPHER
RANDOM
NUM
Recip
PUB + PRIV


CA
Verisign
godaddy
CSR
PUB
www.lloyds.com
validaty Data
cert
TRUST
List of
trusted
CA
+ certs
www.
https://www.lloyds.com
cert
PUB/PRIV
cert
www...
Public...
Sig