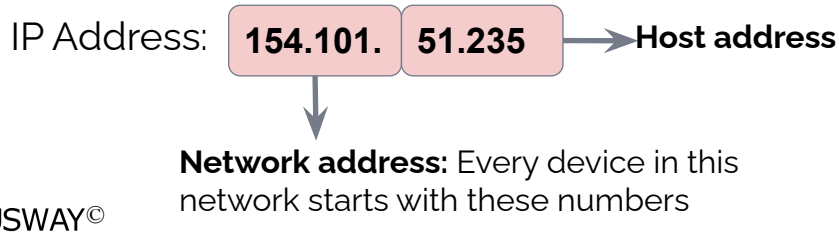
IP Terminology

- IP address consists of **32 bits** or **4 bytes** or **4 octets**
- Represented as:
  - 54.164.151.235 or
  - 00110110.10100100.10010111.11101011

The Hierarchical IP Addressing Scheme

- The **network address** (or **network number**) uniquely identifies each network
- Every machine on the same network shares that network address as part of its IP address
- For example:

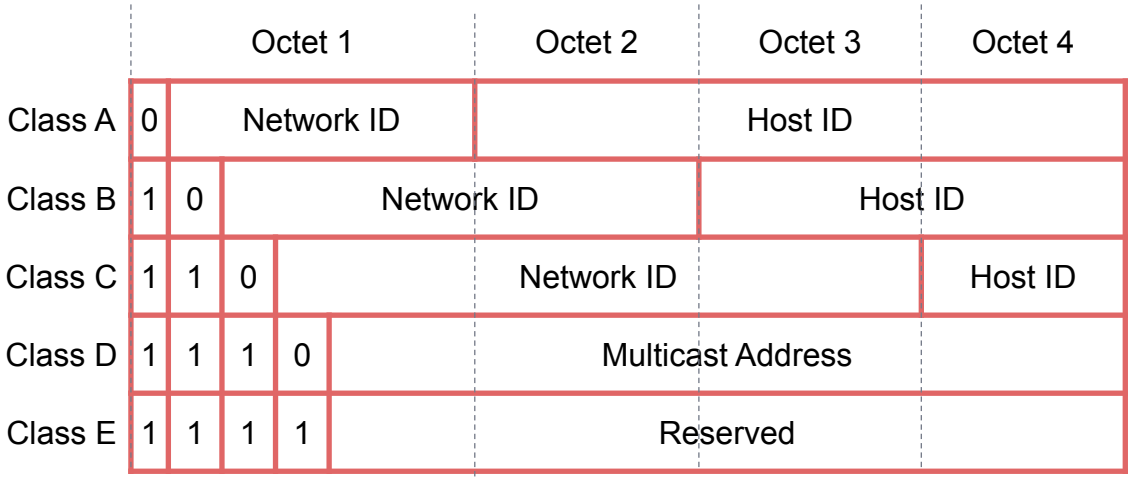


IP Terminology

- **Network Address** - The **network address** (or **network number**) uniquely identifies each network. This is the designation used in routing to send packets to a remote network.
- **Host Address** - A logical address used to define a single host
- **Broadcast Address** - Used by applications and hosts to send information to all hosts on a network. For example 255.255.255.255, which designates all networks and all hosts

The Hierarchical IP Addressing Scheme

Network addresses are divided into 5 classes:



The Hierarchical IP Addressing Scheme

IP Address Classes:

Address Class	1st Octet Range	1st Octet Bits	Network & Host Parts	# of Possible Networks # of Hosts per Network
A	**1-127**	**00000000 - 01111111**	**N.H.H.H**	128 nets (2^7) 16,777,214 hosts per net (2^{24})-2
B	**128-191**	**10000000 - 10111111**	**N.N.H.H**	16,384 nets (2^{14}) 65,534 hosts per net (2^{16})-2
C	**192-223**	**11000000 - 11011111**	**N.N.N.H**	2,097,150 nets (2^{21}) 254 hosts per net (2^8)-2

The Hierarchical IP Addressing Scheme

A Class=128 nets

16,777,214 hosts

B Class=16,384 nets

65,534 hosts

C Class=2,097,150 nets

254 hosts

Subnetting

- We need 3 networks and for each network we need 50 hosts.
- Which ip class we must select.

Subnetting

- We get the **192.168.123.0**
- In this case we have 1 subnet and 254 host.

```
11000000.10110000.01111011.00000000 (0)   = subnet id
11000000.10110000.01111011.00000001 (1)   = first host
11000000.10110000.01111011.11111110 (254)= last host
11000000.10110000.01111011.11111111 (255) = B.A.
```

Subnetting / Solution

- We get the **192.168.123.0**

- In this case we have 1 subnet and 254 host.

192.168.123.00000000 = 192.168.123.0 -> subnet address
192.168.123.00000001 = 192.168.123.1 -> first host
…
192.168.123.11111110 = 192.168.123.254 -> last host
192.168.123.11111111 = 192.168.123.255 -> broadcast address

Subnetting

- We get the **192.168.123.**0
- We have 1 subnet and 254 hosts. But we need 3 subnets.

192.168.123.00000000
11000000.10110000.01111011.00000000 (0)
11000000.10110000.01111011.01000000 (64)
11000000.10110000.01111011.10000000 (128)
11000000.10110000.01111011.11000000 (192)

Subnetting/Solution

- We get the **192.168.123.**0

11000000.10101000.01111011.00000000 = 192.168.123.0

11000000.10101000.01111011.01000000 = 192.168.123.64

11000000.10101000.01111011.10000000 = 192.168.123.128

11000000.10101000.01111011.11000000 = 192.168.123.192

Subnetting

Subnet addr. = **192.168.123.01**000000 = 192.168.123.64

First Host = **192.168.123.01000001 = 192.168.123.65**

Last Host = **192.168.123.01111110 = 192.168.123.126**

Broadcast Addr. = **192.168.123.01111111 = 192.168.123.127**

62 host
64 -2
1.si network adresi
sonuncusu B.A.

Subnetting/Solution

11000000.10101000.01111011.01000000 = 192.168.123.64

192.168.123.01000000 = 192.168.123.64 -> Subnet address

192.168.123.01000001 = 192.168.123.65 -> First Host

..

192.168.123.01111110 = 192.168.123.126 -> Last Host

192.168.123.01111111 = 192.168.123.127 -> Broadcast Address

The Subnet Mask

What is network of this ip?

Host ip = 192.168.123.194

192.168.123.11000010

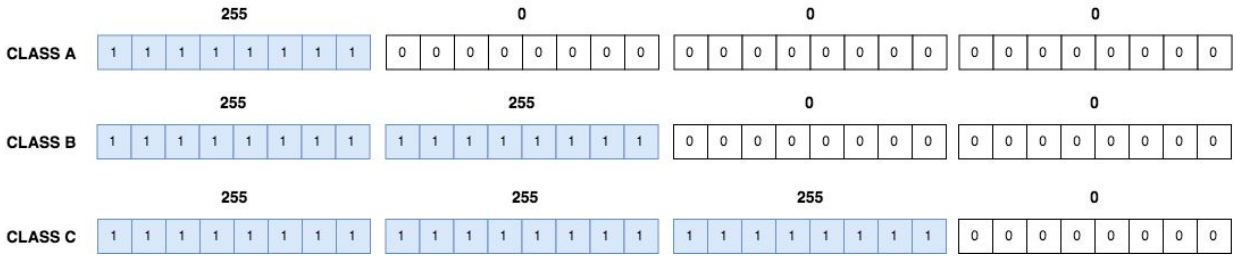
The Subnet Mask

A subnet mask is the representation of the network portion of an address. It is also made up of 32 bits with all the bits that represent the network portion being marked as 1s and the other parts marked as 0s.

For example, the default subnet masks of the IP address classes are:
Class A: 255.0.0.0
Class B: 255.255.0.0
Class C: 255.255.255.0

The Subnet Mask

For example, the default subnet masks of the IP address classes are:
Class A: 255.0.0.0
Class B: 255.255.0.0
Class C: 255.255.255.0



The Subnet Mask

What is network of this ip?

```
Host ip = 192.168.123.194
          192.168.123.11000010

Host ip     = 11000000.10101000.01111011.11000010 = 192.168.123.194
Subnet Msk = 11111111.11111111.11111111.11000000 = 255.255.255.192
Subnet Ad. = 11000000.10101000.01111011.11000000 = 192.168.123.192
```


Classless Inter-Domain Routing (CIDR)

Classless Inter-Domain Routing (CIDR)

- In order to reduce the wastage of IP addresses, a new concept of **CIDR** is introduced
- CIDR provides the flexibility of borrowing bits of Host part of the IP address
- By using subnetting, one single Class A address can be used to have smaller sub-networks which provides better network management capabilities

Classless Inter-Domain Routing (CIDR)

- **CIDR** notation examples:

IP address: 192.168.1.142
Subnet mask: 255.255.255.0 or
11111111.11111111.11111111.00000000

24 turned on bits (1s)

CIDR: 192.168.1.142 /24

IP address: 172.16.56.140
Subnet mask: 255.255.255.240 or
11111111.11111111.11111111.11110000

28 turned on bits (1s)

Classless Inter-Domain Routing (CIDR)

```
IP Address  = 11000000.10101000.01111011.11000010 = 192.168.123.194
Subnet Msk  = 11111111.11111111.11111111.11000000 = 255.255.255.192
Subnet      = 11000000.10101000.01111011.11000000 = 192.168.123.192
CIDR        = 192.168.123.194/26
```

CIDR/Solution

```
IP Address = 11000000.10101000.01111011.11000010 = 192.168.123.194
Subnet Msk = 11111111.11111111.11111111.11000000 = 255.255.255.192
Subnet     = 11000000.10101000.01111011.11000000 = 192.168.123.192
CIDR       = 192.168.123.194/26
```


Classless Inter-Domain Routing (CIDR)

```
IP Address = 11000000.10101000.00001010.00001001 = 192.168.10.9
Subnet Msk = 11111111.11111111.11111111.11100000 = 255.255.255.224
Subnet     = 11000000.10101000.00001010.00000000 = 192.168.10.0
CIDR       = 192.168.10.9/27
```

CIDR/Solution

```
IP Address = 11000000.10101000.00001010.00001001 = 192.168.10.9
Subnet Msk = 11111111.11111111.11111111.11100000 = 255.255.255.224
Subnet     = 11000000.10101000.00001010.00000000 = 192.168.10.0
CIDR       = 192.168.10.9/27
```


Subnetting Basics

- Source host : **172.16.0.55**
- Subnet mask : **255.255.128.0**
- Destination host : **172.16.123.109**

Source IP :
Subnet mask :
Network ID

Logical AND
( )

Destination IP :
Subnet mask :
Network ID

Logical AND
( )

Subnetting Basics

- Source host : 172.16.0.55
- Subnet mask : 255.255.128.0
- Destination host : 172.16.123.109

Source IP : 10101100.00010000.00000000.00110111
Subnet mask : 11111111.11111111.10000000.00000000
Logical AND
Network ID 10101100.00010000.00000000.00000000 (172.16.0.0)

Destination IP : 10101100.00010000.01111011.01101101
Subnet mask : 11111111.11111111.10000000.00000000
Logical AND
Network ID 10101100.00010000.00000000.00000000 (172.16.0.0)

Not Same result! Two hosts are on the different network.

Subnetting Basics

- Source host : 172.16.0.55
- Subnet mask : 255.255.128.0
- Destination host : 172.16.131.109

Source IP :
Subnet mask :
Logical AND
Network ID ( )

Destination IP :
Subnet mask :
Logical AND
Network ID ( )

Subnetting Basics

- Source host : 172.16.0.55
- Subnet mask : 255.255.128.0
- Destination host : 172.16.131.109

Source IP : 10101100.00010000.00000000.00110111
Subnet mask : 11111111.11111111.10000000.00000000
Network ID 10101100.00010000.00000000.00000000 (172.16.0.0)

Logical AND

Destination IP : 10101100.00010000.10000011.01101101
Subnet mask : 11111111.11111111.10000000.00000000
Network ID 10101100.00010000.10000000.00000000 (172.16.128.0)

Logical AND

Same result! Two hosts are on the same network.

Subnet Problem

```
Network Address    = 192.168.10.0
                     192.168.10.00000000
Subnet Msk         = 255.255.255.224
                     255.255.255.11100000
Cidr = 192.168.10.0/27
```

- How many subnets?

  $2^3 = 8$

- How many hosts?

  $2^5 = 32$ 32-2=30

- What are the valid subnets?
- What's the broadcast address for each subnet
- What are the valid hosts

Subnet Problem

```
Network Address    = 192.168.10.0
                     192.168.10.00000000
Subnet Msk         = 255.255.255.224
                     255.255.255.11100000
Cidr = 192.168.10.0/27
```

- What are the valid subnets?

192.168.10.00000000 **192.168.10.100**00000

192.168.10.00100000 **192.168.10.101**00000

192.168.10.01000000 **192.168.10.110**00000

192.168.10.01100000 **192.168.10.111**00000

- What's the broadcast address for each subnet
- What are the valid hosts

Subnet Problem

192.168.10.00000000 (0)

192.168.10.00100000 (32)

192.168.10.01000000 (64)

192.168.10.01100000 (96)

192.168.10.10000000 (128)

192.168.10.10100000 (160)

192.168.10.11000000 (192)

192.168.10.11100000 (224)

Subnet Problem

Network Address = 192.168.10.0
192.168.10.00000000
Subnet Msk = 255.255.255.224
255.255.255.11100000
Cidr = 192.168.10.0/27

- What are the valid subnets?

What's the broadcast address for each subnet

192.168.10.10100000

192.168.10.10111111 (191)

- What are the valid hosts

192.168.10.10100001 (161)

192.168.10.10111110 (190)

Subnet Solution

Network Address= 192.168.10.0 = 11000000.10101000.00001010.00000000
Subnet Msk = 255.255.255.224 = **11111111.11111111.11111111.11100000**

- How many subnets?

11000000.10101000.00001010.000**00000**
$2^3=8$

- How many hosts?

$2^5-2=32-2=30$

- What are the valid subnets?
- What's the broadcast address for each subnet
- What are the valid hosts

Subnet Solution

Network Address= 192.168.10.0 = 11000000.10101000.00001010.00000000
Subnet Msk = 255.255.255.224 = **11111111.11111111.11111111.11100000**

- How many subnets? 8
- How many hosts? 30
- What are the valid subnets?

11000000.10101000.00001010.000**00000**
000**00000** = 0
001**00000** = 32
010**00000** = 64
011**00000** = 96
100**00000** = 128
101**00000** = 160
110**00000** = 192
111**00000** = 224

Subnet Solution

Network Address= 192.168.10.0 = 11000000.10101000.00001010.00000000
Subnet Msk = 255.255.255.224 = **11111111.11111111.11111111.11100000**

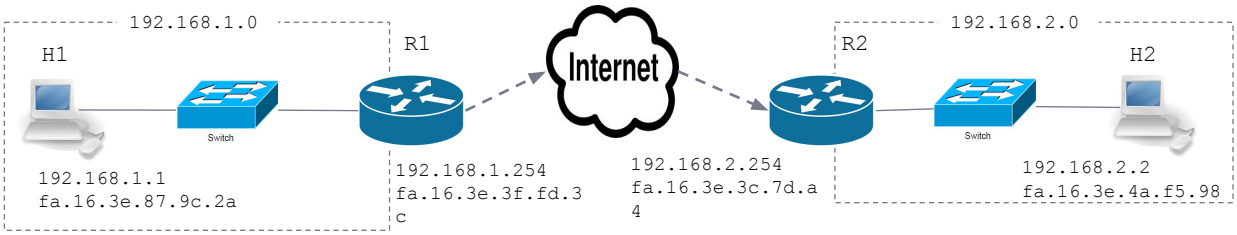
- How many subnets? 8
- How many hosts? 30
- What are the valid subnets?
- What's the broadcast address for each subnet

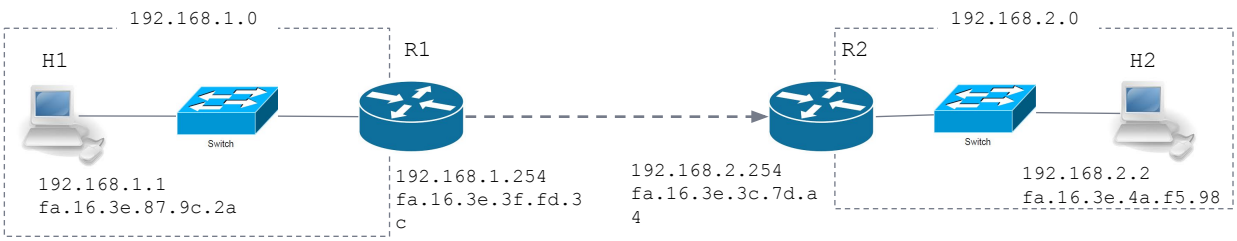
11000000.10101000.00001010.011**00000** = 192.168.10.96
11000000.10101000.00001010.011**11111** = 192.168.10.127

- What are the valid hosts

11000000.10101000.00001010.011**00001** = 192.168.10.97
11000000.10101000.00001010.011**11110** = 192.168.10.126

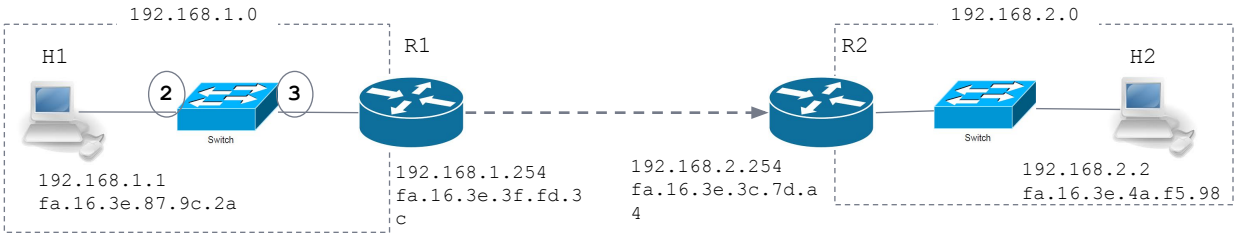
IP Routing


192.168.1.0
H1
Switch
192.168.1.1
fa.16.3e.87.9c.2a
R1
192.168.1.254
fa.16.3e.3f.fd.3
c
Internet
192.168.2.254
fa.16.3e.3c.7d.a
4
R2
192.168.2.0
Switch
H2
192.168.2.2
fa.16.3e.4a.f5.98


192.168.1.0
H1
Switch
192.168.1.1
fa.16.3e.87.9c.2a
R1
192.168.1.254
fa.16.3e.3f.fd.3
c
192.168.2.254
fa.16.3e.3c.7d.a
4
R2
192.168.2.0
Switch
H2
192.168.2.2
fa.16.3e.4a.f5.98

MAC Address Table

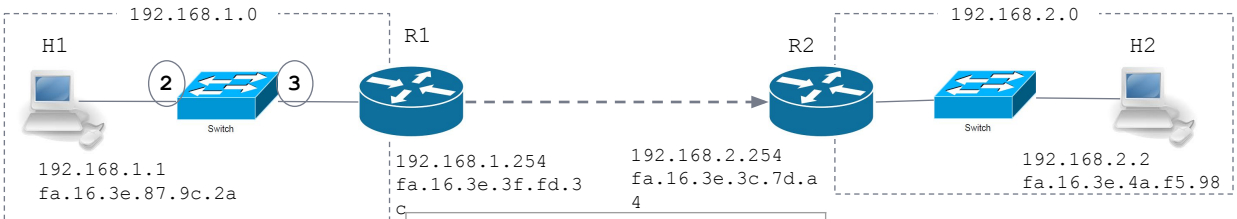
The MAC address table is where the **switch** stores information about the other Ethernet interfaces to which it is connected on a network.



Port	Mac Address
2	fa.16.3e.87.9c.2a
3	fa.16.3e.3f.fd.3c

ARP Table

Address Resolution Protocol (ARP) is the method for finding a host's Link Layer (MAC) address when only its IP address is known.
The ARP table is **used to maintain a correlation between each MAC address and its corresponding IP address.**



R1 Arp Table	
Ip Address	Mac Address
192.168.1.1	fa.16.3e.87.9c.2a
192.168.2.254	fa.16.3e.3c.7d.a4

Routing Table

A **routing table** is a table or database that stores the location of routers based on their IP addresses.

The routing table consists of at least three information fields:

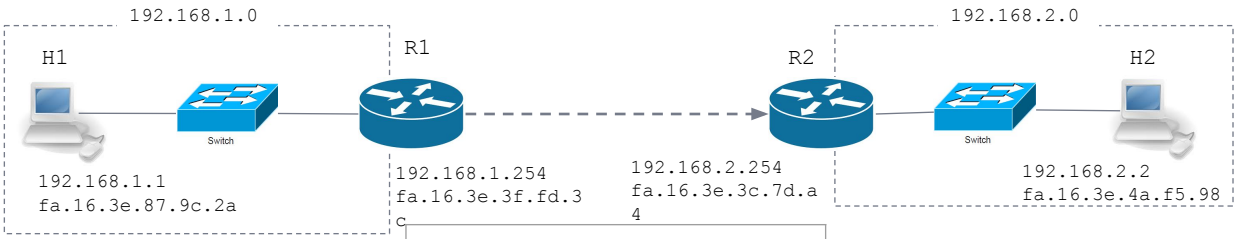
- **network identifier:** The destination subnet and netmask
- **metric:** The routing metric of the path through which the packet is to be sent. The route will go in the direction of the gateway with the lowest metric.
- **next hop:** The next hop, or gateway, is the address of the next station to which the packet is to be sent on the way to its final destination

Routing Table

Example routing table contents

Network destination	Netmask	Gateway	Interface	Metric
0.0.0.0	0.0.0.0	192.168.0.1	192.168.0.100	10
127.0.0.0	255.0.0.0	127.0.0.1	127.0.0.1	1
192.168.0.0	255.255.255.0	192.168.0.100	192.168.0.100	10
192.168.0.100	255.255.255.255	127.0.0.1	127.0.0.1	10
192.168.0.1	255.255.255.255	192.168.0.100	192.168.0.100	10

Routing Table



R1 Routing Table

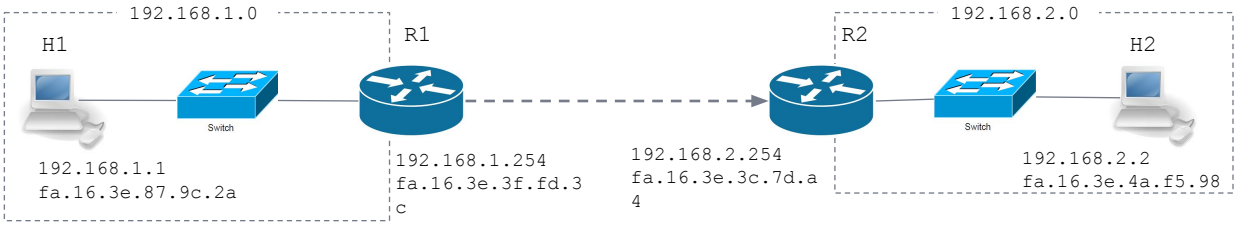
Destination	Target
192.168.1.0	D.C.
192.168.2.0	192.168.2.254

ARP Table

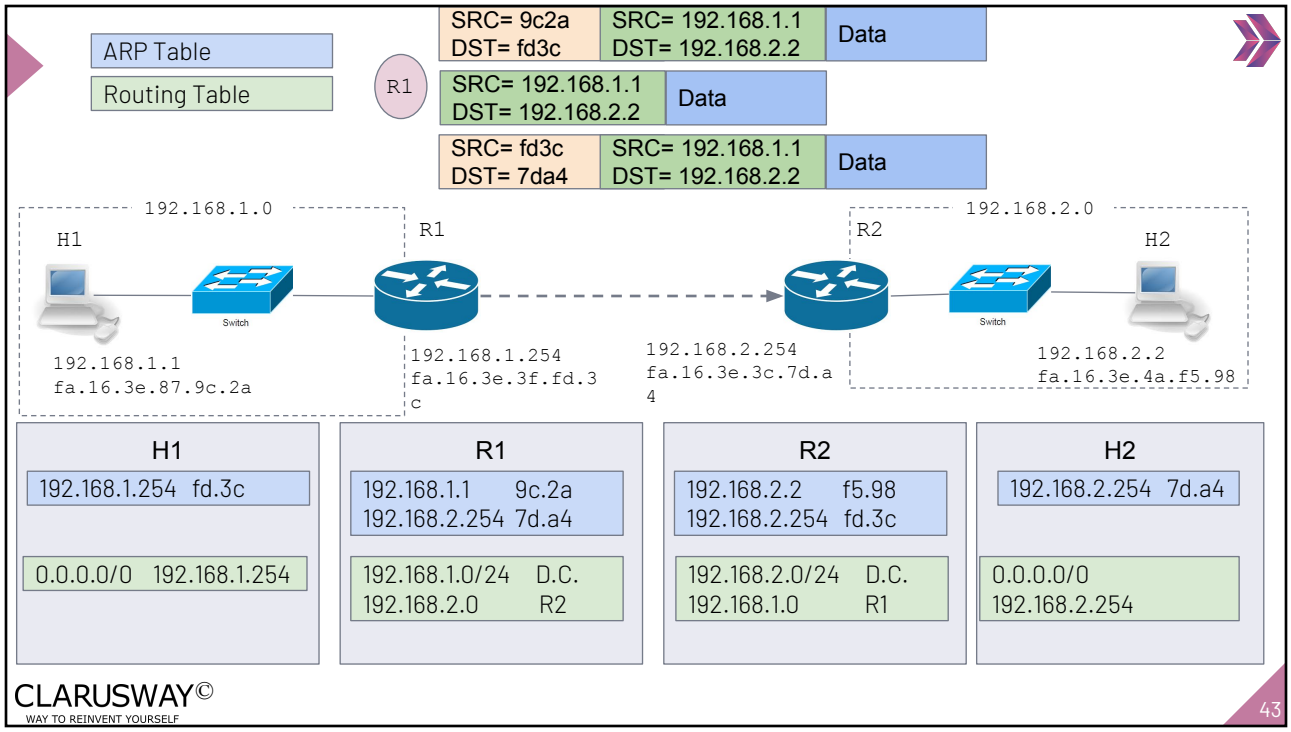
Routing Table

H1

L2 Header	L3 Header	Data
SRC= 9c2a DST= fd3c	SRC= 192.168.1.1 DST= 192.168.2.2	Data



H1	R1	R2	H2
192.168.1.254 fd.3c	192.168.1.1 9c.2a 192.168.2.254 7d.a4	192.168.2.2 f5.98 192.168.1.254 fd.3c	192.168.2.254 7d.a4
0.0.0.0/0 192.168.1.254	192.168.1.0/24 D.C. 192.168.2.0 R2	192.168.2.0/24 D.C. 192.168.1.0 R1	0.0.0.0/0 192.168.2.254


ARP Table
Routing Table
R1
SRC= 9c2a
DST= fd3c
SRC= 192.168.1.1
DST= 192.168.2.2
Data
SRC= 192.168.1.1
DST= 192.168.2.2
Data
SRC= fd3c
DST= 7da4
SRC= 192.168.1.1
DST= 192.168.2.2
Data
192.168.1.0
H1
R1
R2
192.168.2.0
H2
Switch
Switch
192.168.1.1
fa.16.3e.87.9c.2a
192.168.1.254
fa.16.3e.3f.fd.3
c
192.168.2.254
fa.16.3e.3c.7d.a
4
192.168.2.2
fa.16.3e.4a.f5.98
H1
192.168.1.254 fd.3c
0.0.0.0/0 192.168.1.254
R1
192.168.1.1 9c.2a
192.168.2.254 7d.a4
192.168.1.0/24 D.C.
192.168.2.0 R2
R2
192.168.2.2 f5.98
192.168.2.254 fd.3c
192.168.2.0/24 D.C.
192.168.1.0 R1
H2
192.168.2.254 7d.a4
0.0.0.0/0
192.168.2.254
CLARUSWAY©
WAY TO REINVENT YOURSELF
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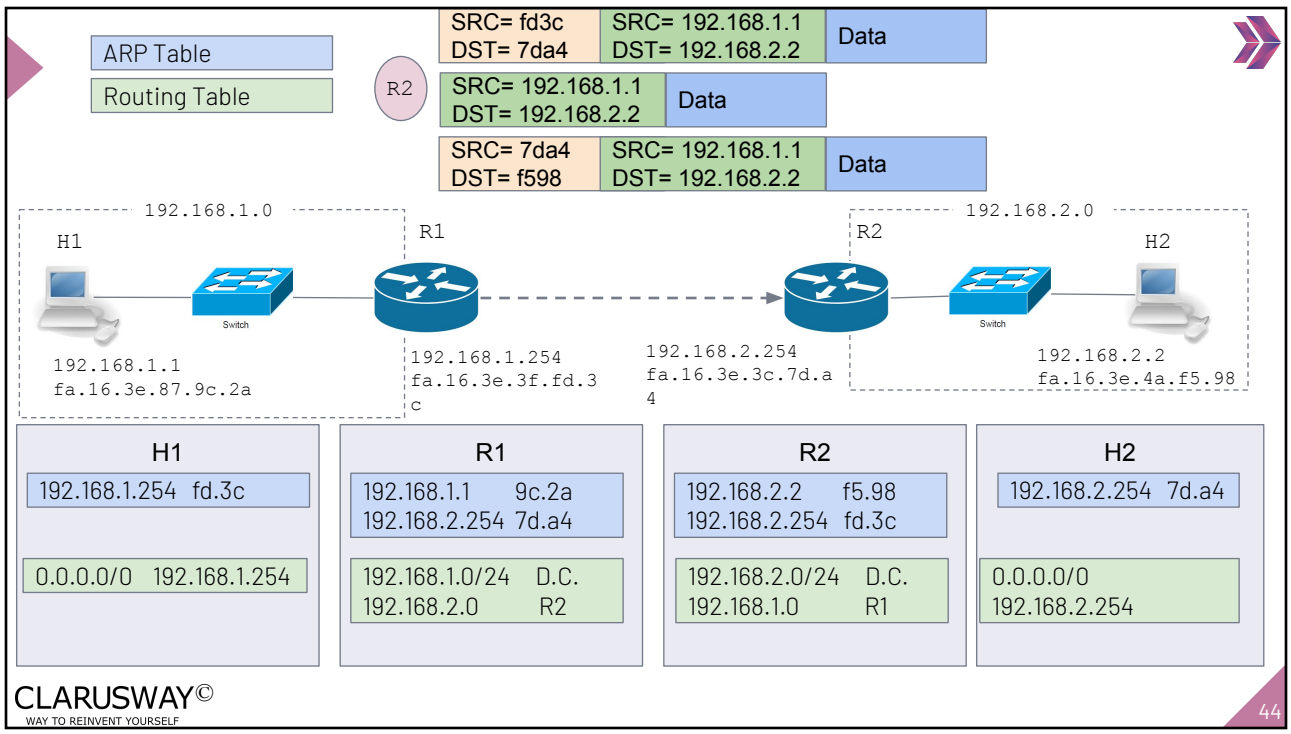
ARP Table
Routing Table
R2
SRC= fd3c
DST= 7da4
SRC= 192.168.1.1
DST= 192.168.2.2
Data
SRC= 192.168.1.1
DST= 192.168.2.2
Data
SRC= 7da4
DST= f598
SRC= 192.168.1.1
DST= 192.168.2.2
Data
192.168.1.0
H1
R1
R2
192.168.2.0
H2
Switch
Switch
192.168.1.1
fa.16.3e.87.9c.2a
192.168.1.254
fa.16.3e.3f.fd.3
c
192.168.2.254
fa.16.3e.3c.7d.a
4
192.168.2.2
fa.16.3e.4a.f5.98
H1
192.168.1.254 fd.3c
0.0.0.0/0 192.168.1.254
R1
192.168.1.1 9c.2a
192.168.2.254 7d.a4
192.168.1.0/24 D.C.
192.168.2.0 R2
R2
192.168.2.2 f5.98
192.168.2.254 fd.3c
192.168.2.0/24 D.C.
192.168.1.0 R1
H2
192.168.2.254 7d.a4
0.0.0.0/0
192.168.2.254
CLARUSWAY©
WAY TO REINVENT YOURSELF
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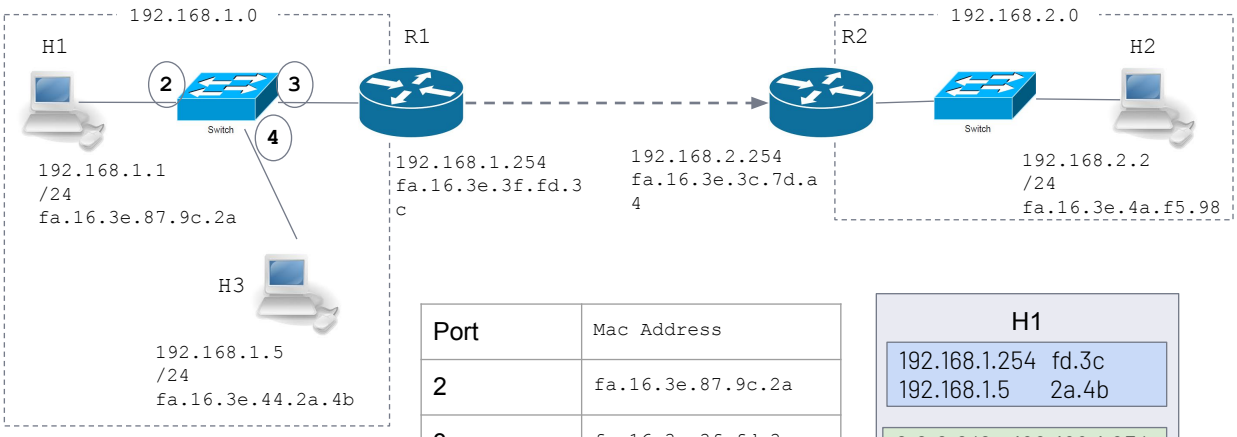
ARP Table

Routing Table

L2 Header	L3 Header	Data
SRC= 9c2a DST= 2a4b	SRC= 192.168.1.1 DST= 192.168.1.5	Data



Port	Mac Address
2	fa.16.3e.87.9c.2a
3	fa.16.3e.3f.fd.3c
4	fa.16.3e.44.2a.4b

H1

192.168.1.254	fd.3c
192.168.1.5	2a.4b

0.0.0.0/0	192.168.1.254

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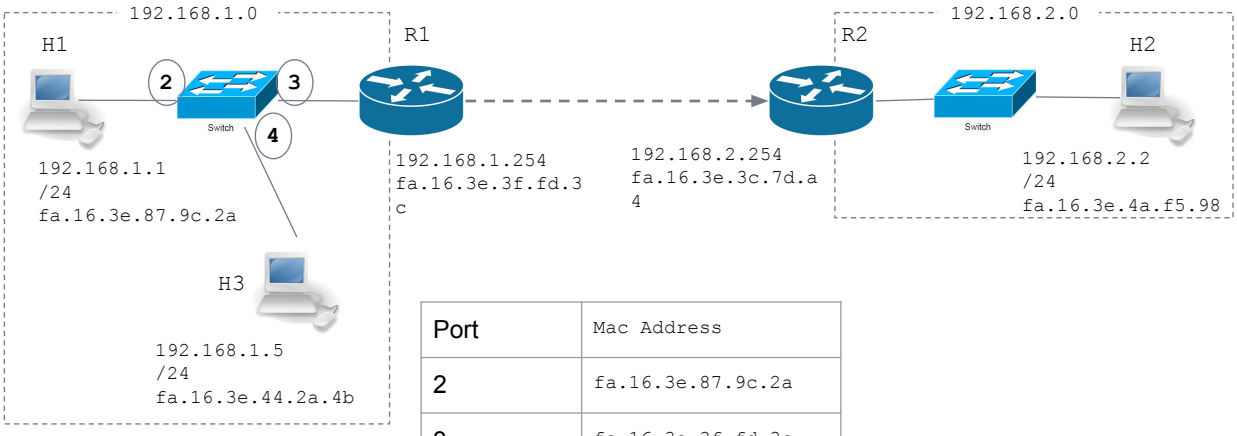
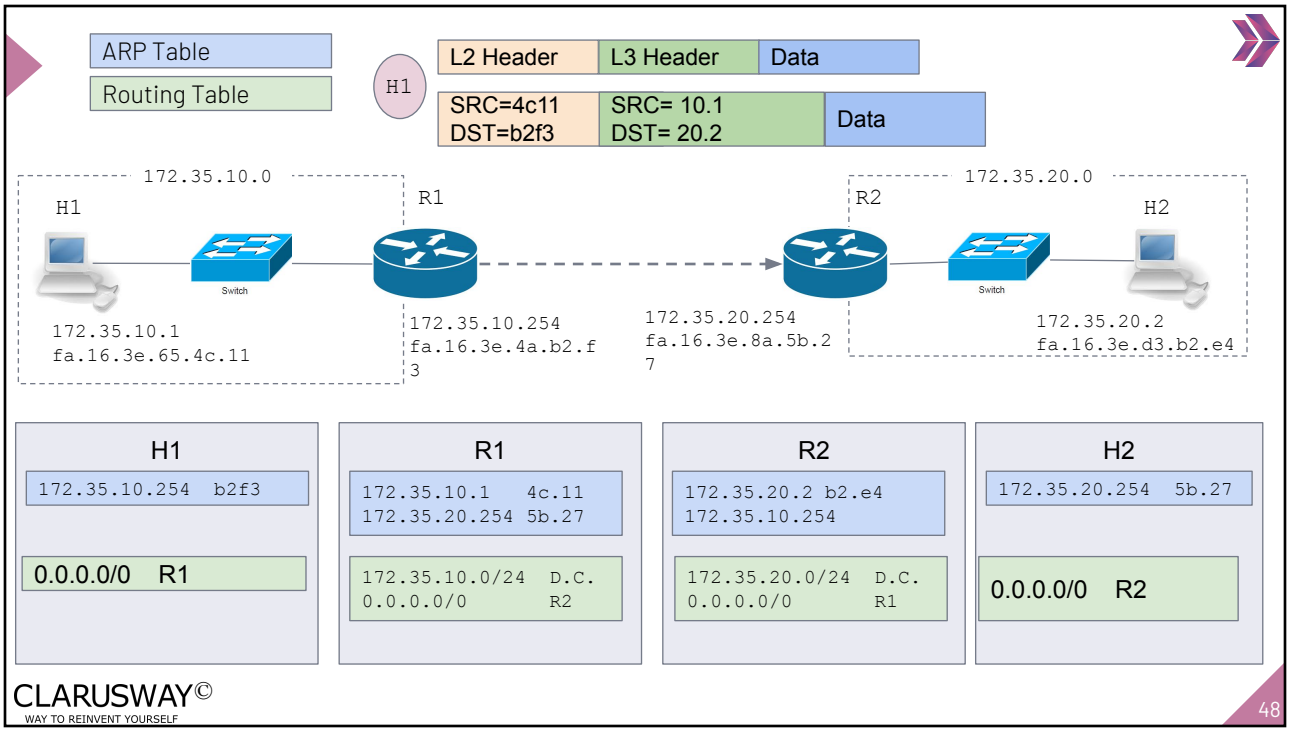
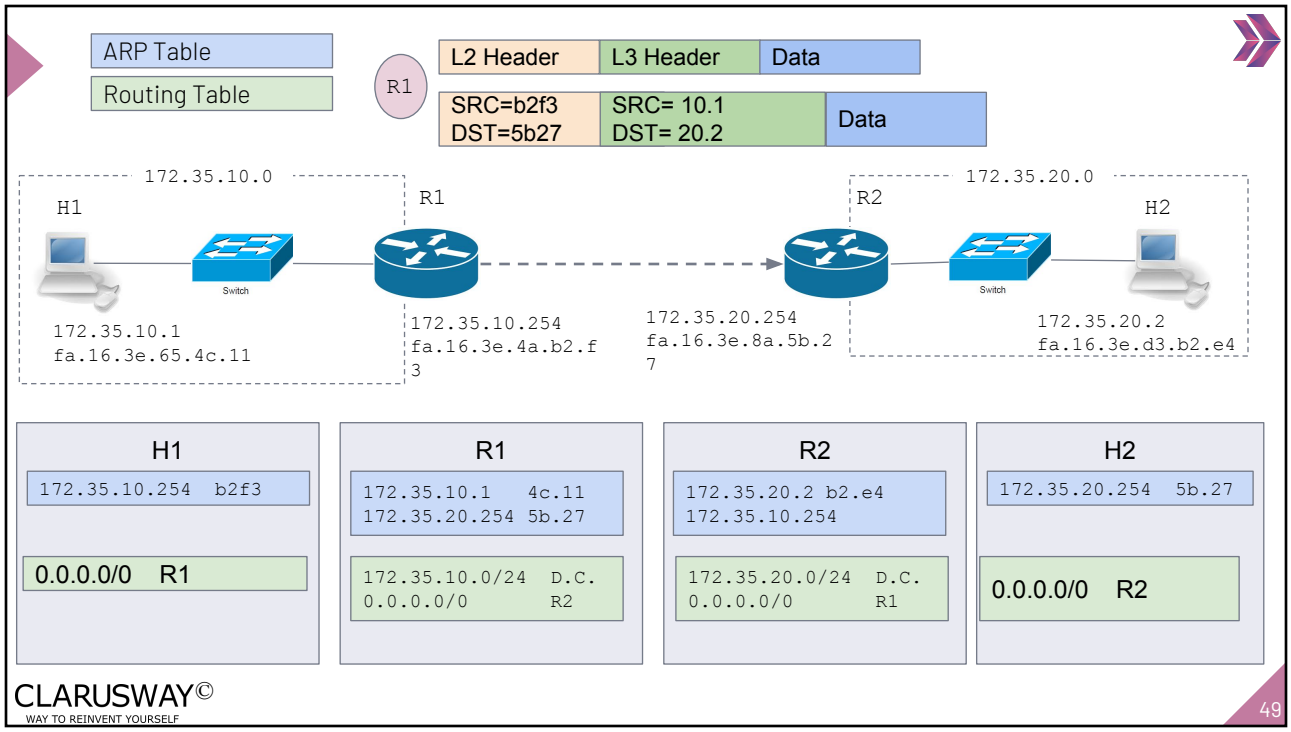


Port	Mac Address
2	fa.16.3e.87.9c.2a
3	fa.16.3e.3f.fd.3c
4	fa.16.3e.44.2a.4b

CLARUSWAY©
WAY TO REINVENT YOURSELF


ARP Table
Routing Table
H1
L2 Header
L3 Header
Data
SRC=4c11
DST=b2f3
SRC= 10.1
DST= 20.2
Data
172.35.10.0
H1
R1
R2
172.35.20.0
H2
Switch
Switch
172.35.10.1
fa.16.3e.65.4c.11
172.35.10.254
fa.16.3e.4a.b2.f3
172.35.20.254
fa.16.3e.8a.5b.27
172.35.20.2
fa.16.3e.d3.b2.e4
H1
172.35.10.254 b2f3
0.0.0.0/0 R1
R1
172.35.10.1 4c.11
172.35.20.254 5b.27
172.35.10.0/24 D.C.
0.0.0.0/0 R2
R2
172.35.20.2 b2.e4
172.35.10.254
172.35.20.0/24 D.C.
0.0.0.0/0 R1
H2
172.35.20.254 5b.27
0.0.0.0/0 R2



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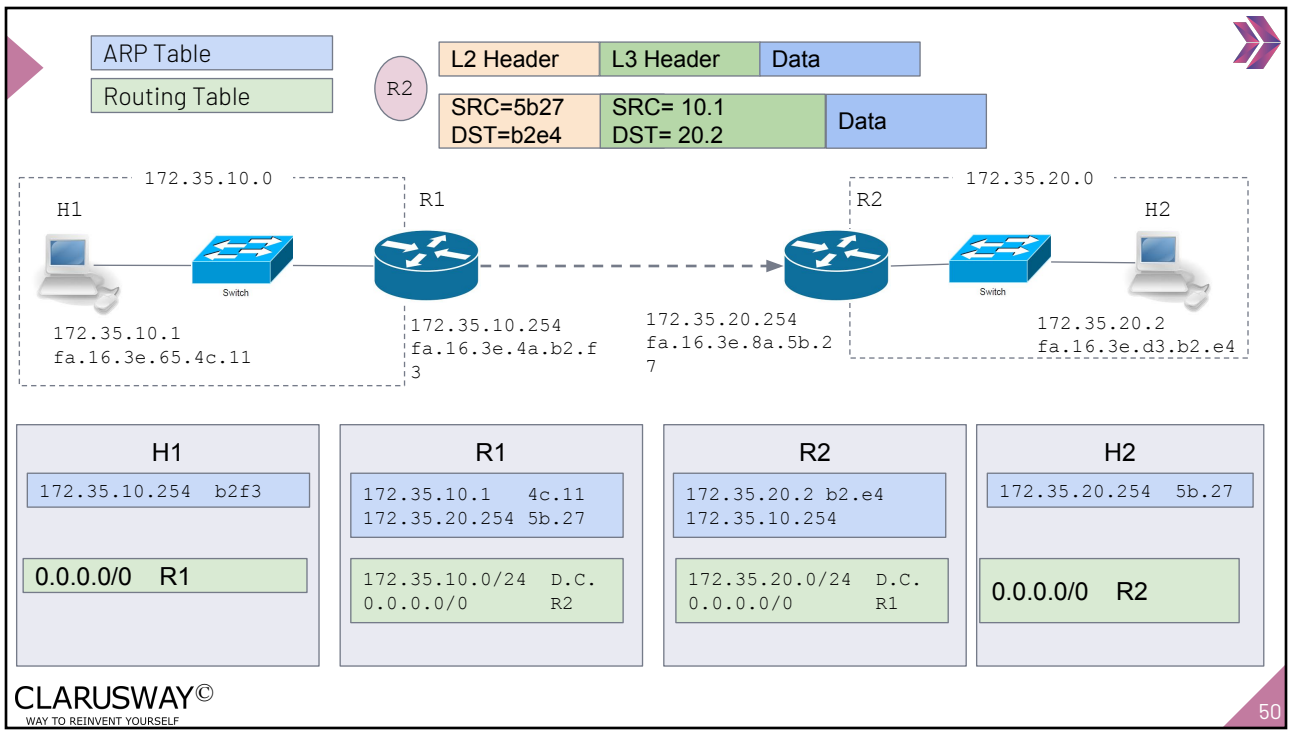

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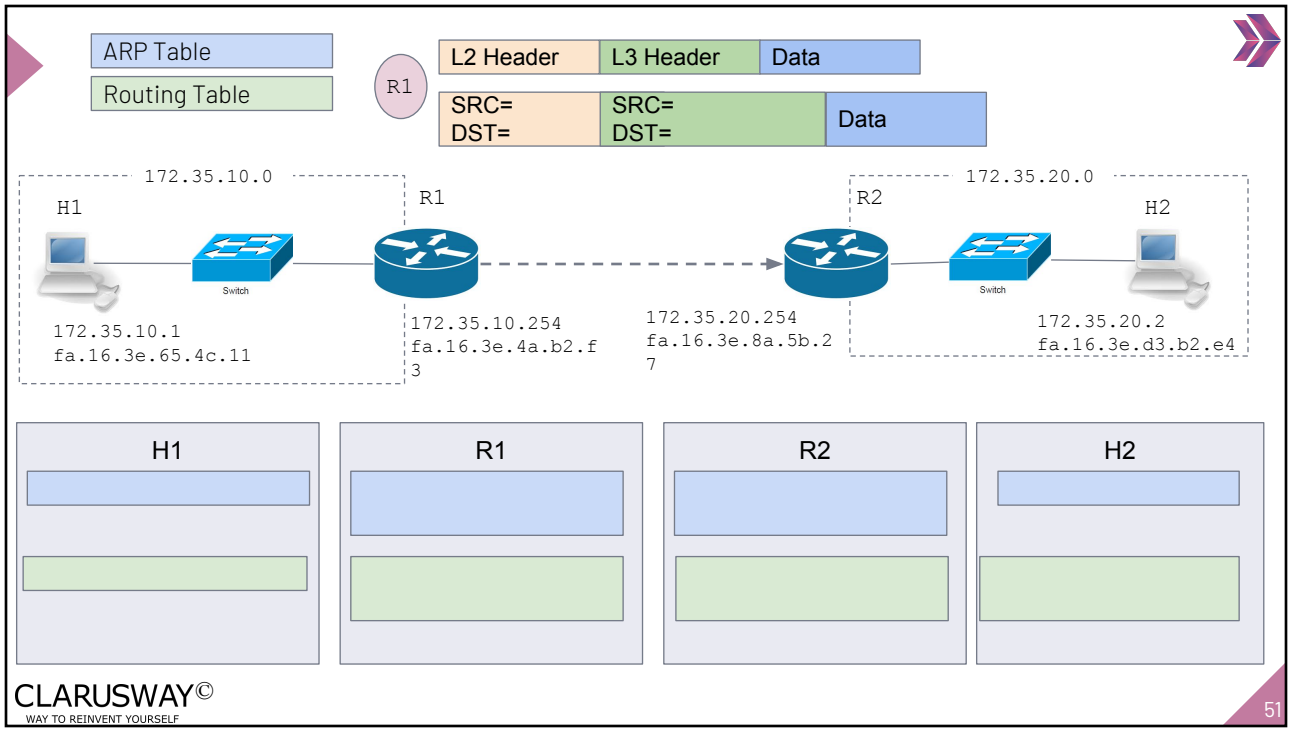
ARP Table
Routing Table
R1
L2 Header
L3 Header
Data
SRC=
DST=
SRC=
DST=
Data
172.35.10.0
H1
R1
R2
172.35.20.0
H2
Switch
Switch
172.35.10.1
fa.16.3e.65.4c.11
172.35.10.254
fa.16.3e.4a.b2.f
3
172.35.20.254
fa.16.3e.8a.5b.2
7
172.35.20.2
fa.16.3e.d3.b2.e4
H1
R1
R2
H2
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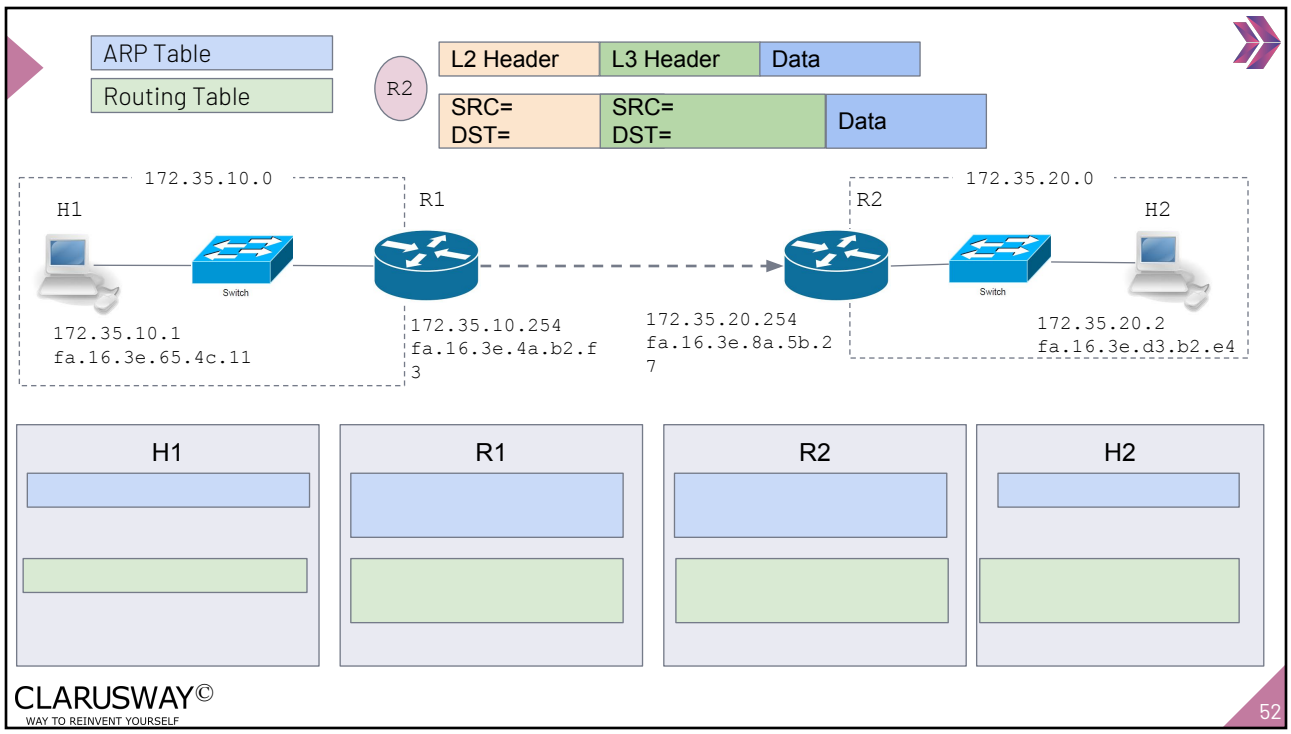
ARP Table
Routing Table
R2
L2 Header
L3 Header
Data
SRC=
DST=
SRC=
DST=
Data
172.35.10.0
H1
R1
R2
172.35.20.0
H2
Switch
Switch
172.35.10.1
fa.16.3e.65.4c.11
172.35.10.254
fa.16.3e.4a.b2.f
3
172.35.20.254
fa.16.3e.8a.5b.2
7
172.35.20.2
fa.16.3e.d3.b2.e4
H1
R1
R2
H2
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