NETWORK DESIGN

A1

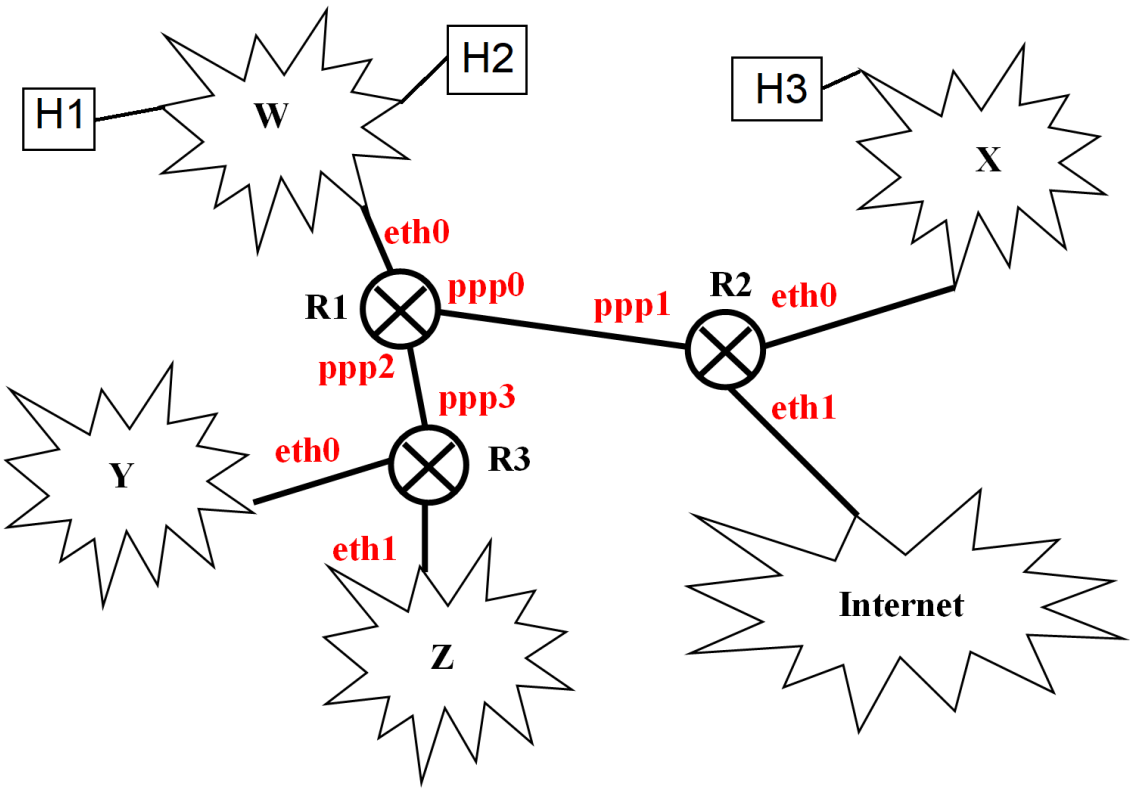
- IP address: 41.104.123.31/21
- Mask: 255.255.248.0

The network address is the AND operation between the IP address and the mask: 41.104.120.0, in binary:

IP address	00101001.01101000.01111011.00011111
Mask	11111111.11111111.11111000.00000000
AND	00101001.01101000.01111000.00000000 → 41.104.120.0

And the broadcast address is the OR operation between the IP address and the mask inverted: 41.104.127.255, in binary:

IP address	00101001.01101000.01111011.00011111
Mask inverted	00000000.00000000.00000111.11111111
OR	00101001.01101000.01111111.11111111 → 41.104.127.255



A2

Network address: 41.104.120.0 → 00101001.01101000.01111000.00000000
Mask: 21 bits 11

So this network can provide up to 2^{11}-2 = 2046 hosts.

If the subnetwork Z has a mask /24, it has 32-24=8 "free" bits that correspond to the host ids, so this network has 2^8-2=254 hosts.

Subnetwork Z /24

00101001.01101000.01111**000**.00000000 (41.104.120.0)

Subnetwork W /26

00101001.01101000.01111**001.00**000000 (41.104.121.0)

Subnetwork X /26

00101001.01101000.01111**001.01**000000 (41.104.121.64)

For the next subnet, half of the hosts are needed (at least 10), so since X and W have mask 26, this one will have mask 27.

Subnetwork Y /27

00101001.01101000.01111**001.100**00000 (41.104.121.128)

Subnetwork R1-R3 /30

00101001.01101000.01111**001.1010000**0 (41.104.121.160)

Subnetwork R1-R2 /30

00101001.01101000.01111**001.1010010**0 (41.104.121.164)

The range of IP addresses without assignation is from 41.104.121.168 to 41.104.127.255 (including network and broadcast addresses).

To summarize:

41.104.120.0 41.104.120.255	254 hosts /24	Network Z
41.104.121.0 41.104.121.63	62 hosts /26	Network W
41.104.121.64 41.104.121.127	62 hosts /26	Network X
41.104.121.128 41.104.121.159	30 hosts /27	Network Y
41.104.121.160 41.104.121.163	2 hosts /30	R1-R3
41.104.121.164 41.104.121.167	2 hosts /30	R1-R2
41.104.121.168 41.104.127.255		Free

A3

- Subnet Z: 41.104.120.0/24

  First host ID: 41.104.120.1
  Last host ID: 41.104.120.254
  (Range of possible IP addresses)

  Broadcast address: 41.104.120.255

- Subnet W: 41.104.121.0/26

  First host ID: 41.104.121.1
  Last host ID: 41.104.121.62
  (Range of possible IP addresses)

  Broadcast address: 41.104.121.63

- Subnet X: 41.104.121.64/26

  First host ID: 41.104.121.65
  Last host ID: 41.104.124.126
  (Range of possible IP addresses)

  Broadcast address: 41.104.121.127

- Subnet Y: 41.104.121.128/27

  First host ID: 41.104.121.129
  Last host ID: 41.104.121.158
  (Range of possible IP addresses)

  Broadcast address: 41.104.121.159

- Subnet R1-R3: 41.104.121.160/30

  First host ID: 41.104.121.161
  Last host ID: 41.104.121.162
  (Range of possible IP addresses)

  Broadcast address: 41.104.121.163

- Subnet R1-R2: 41.104.121.164/30

  First host ID: 41.104.121.165
  Last host ID: 41.104.121.166
  (Range of possible IP addresses)

  Broadcast address: 41.104.121.167

A4

Router	Interface	Network	IP
R1	eth0	W	41.104.121.1
R1	ppp0	R1-R2	41.104.121.165
R1	ppp2	R1-R3	41.104.121.161
R2	eth0	X	41.104.121.65
R2	ppp1	R1-R2	41.104.121.166
R2	eth1	Internet	?
R3	ppp3	R1-R3	41.104.121.162
R3	eth0	Y	41.104.121.129
R3	eth1	Z	41.104.120.1

A5

R1:

Destination	Mask	Next hop	Interface
41.104.121.160	/30	-	ppp2
41.104.121.165	/30	-	ppp0
41.104.121.128	/27	41.104.121.162	ppp2
41.104.121.64	/26	41.104.121.166	ppp0
41.104.121.0	/26	-	eth0
41.104.120.0	/24	41.104.121.166	ppp2
0.0.0.0	-	41.104.121.166	ppp0

Simplified:

Destination	Mask	Next hop	Interface
41.104.121.160	/30	-	ppp2
41.104.121.165	/30	-	ppp0
41.104.121.128	/27	41.104.121.162	ppp2
41.104.121.0	/26	-	eth0
41.104.120.0	/24	41.104.121.166	ppp2
0.0.0.0	-	41.104.121.166	ppp0

R2:

Destination	Mask	Next hop	Interface
41.104.121.160	/30	41.104.121.165	ppp1
41.104.121.165	/30	-	ppp1
41.104.121.128	/27	41.104.121.165	ppp1
41.104.121.64	/26	-	eth0
41.104.121.0	/26	41.104.121.165	ppp1
41.104.120.0	/24	41.104.121.165	ppp1
0.0.0.0	-	-	eth1

R3:

Destination	Mask	Next hop	Interface
41.104.121.160	/30	-	ppp3
41.104.121.165	/30	41.104.121.161	ppp3
41.104.121.128	/27	-	eth0
41.104.121.64	/26	41.104.121.161	ppp3
41.104.121.0	/26	41.104.121.161	ppp3
41.104.120.0	/24	-	eth1
0.0.0.0	-	41.104.121.161	ppp3

Simplified:

Destination	Mask	Next hop	Interface
41.104.121.160	/30	-	ppp3
41.104.121.128	/27	-	eth0
41.104.120.0	/24	-	eth1
0.0.0.0	-	41.104.121.161	ppp3

NETWORK TRAFFIC ANALYSIS

Between Host 1 and Host 2

Src: Host 1 → IP: 41.104.121.2, MAC: 00:00:5e:00:53:af

Destination: Host 2 → IP: 41.104.121.3, MAC: ff:ff:ff:ff:ff:ff

The ARP traffic got sent because we know the IP address of the destination but not its MAC address.

Now we have it: Destination: Host 2 → IP: 41.104.121.3, MAC: 00:1b:44:11:3a:b7

Once we have all the information, the ping is sent (ICMP traffic).

From	To	Protocol
Host 1	R1	ARP
R1 (41.104.121.1)	Host 2	ARP
Host 2	R1	ARP
R1	Host 1	ARP
Host 1	R1	ICMP
R1	Host 2	ICMP
Host 2	R1	ICMP
R1	Host 1	ICMP

Between Host 2 and Host 3

Src: Host 2 → IP: 41.104.121.3, MAC: 00:1b:44:11:3a:b7

Destination: Host 3 → IP: 41.104.121.66, MAC: ff:ff:ff:ff:ff:ff

The ARP traffic got sent because we know the IP address of the destination but not its MAC address. And once the ARP has been sent, only the host who has the IP that is requested, responds with its MAC address.

Now we have it: Destination: Host 3 → IP: 41.104.121.66, MAC: 00:00:0a:bb:28:fc

Once we have all the information, the ping is sent (ICMP traffic).

From	To	Protocol
Host 2	R1	ARP
Host 2	Host 1	ARP
R1 (41.104.121.1)	Host 2	ARP
Host 2	R1	ICMP
R1	R2	ARP
R2 (41.104.121.166)	R1	ARP
R1	R2	ICMP
R2	Host 3	ARP
R2	Internet	ARP
Host 3	R2	ARP
R2	Host 3	ICMP
Host 3	R2	ICMP
R2	R1	ICMP
R1	Host 2	ICMP