IP Networks

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AARHUS UNIVERSITY SCHOOL OF ENGINEERING

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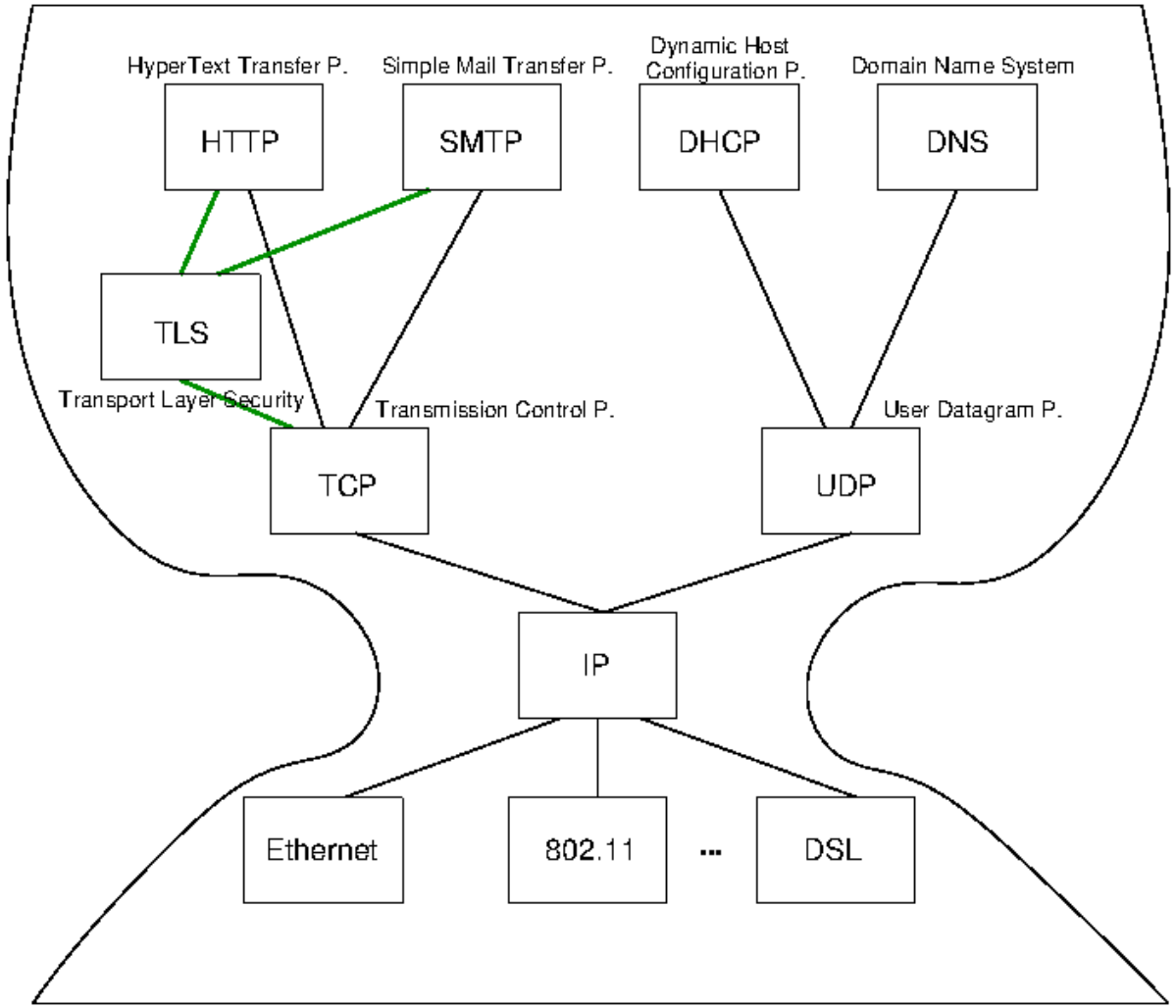
“Hourglass design” of the internet



Internet Architecture with narrow waist

IP is focal point
“Narrow waist”

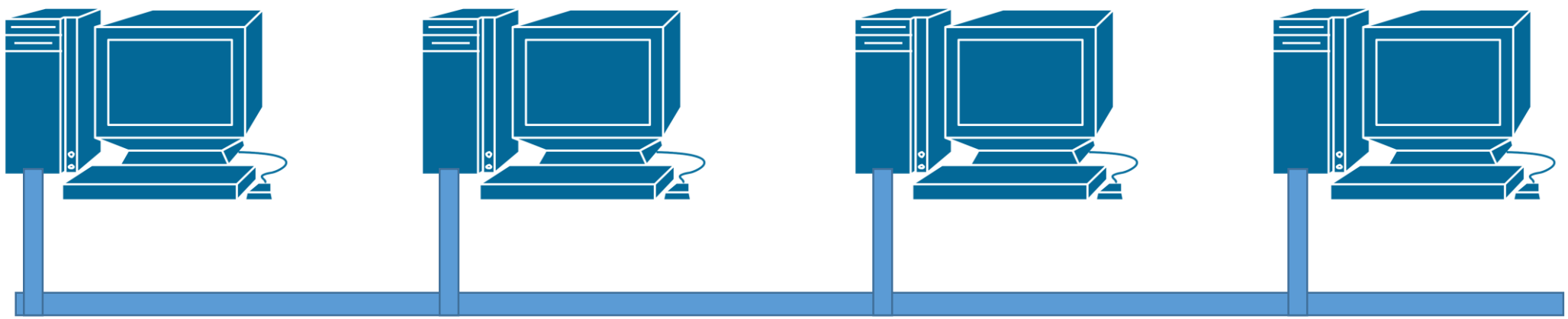
Application independent!
Everything over IP

Network independent!
IP over everything

Source: https://oer.gitlab.io/DS/DS02-Internet.html#/slide-internet-architecture

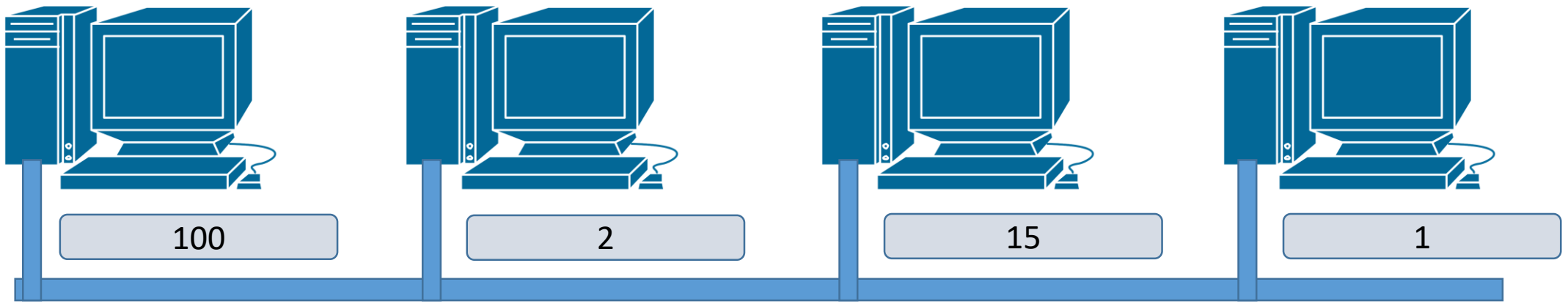
IP Addresses on a network

We want to communicate from one computer to another.



We want to communicate from one computer to another.

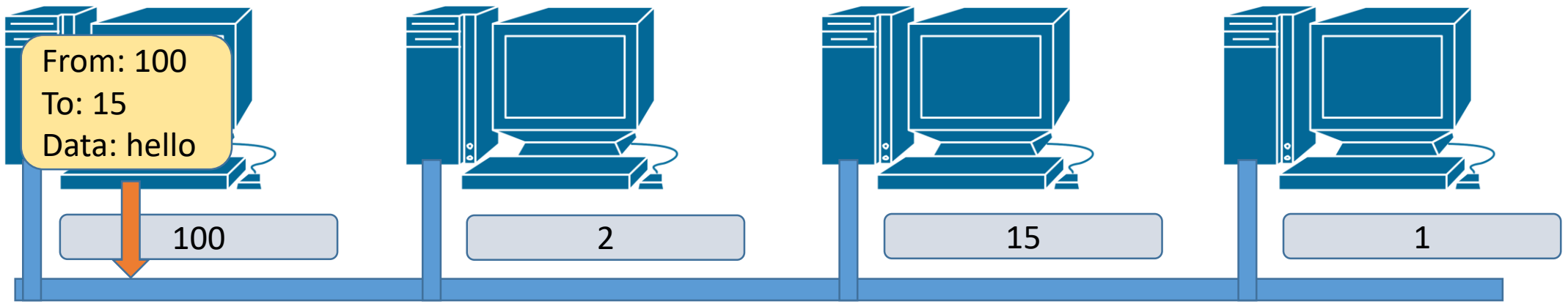
So we connect them to a network. Each computer can send data to the network and see data from other computers on the network.

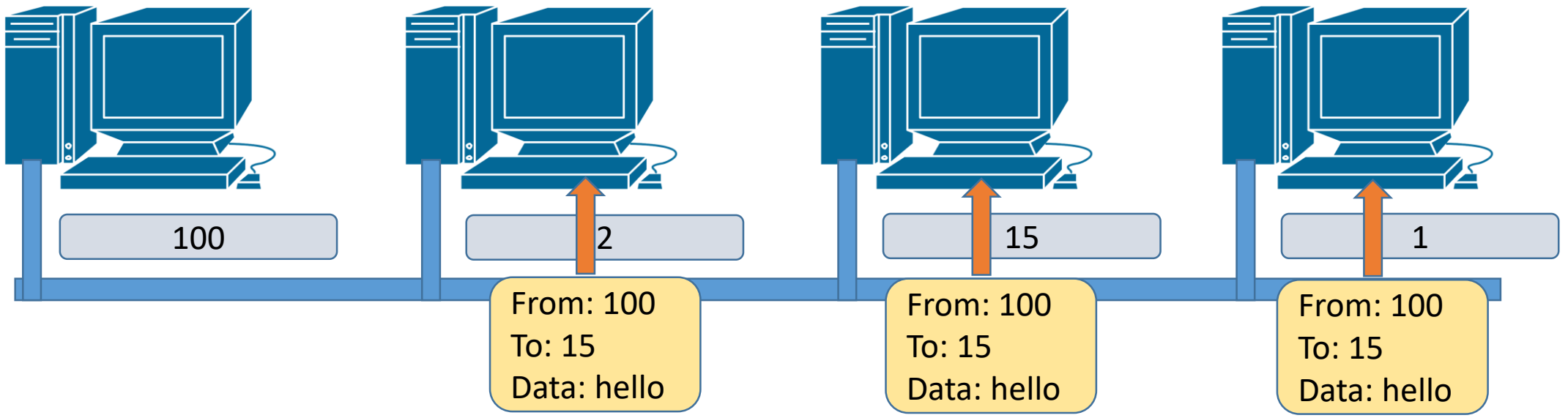


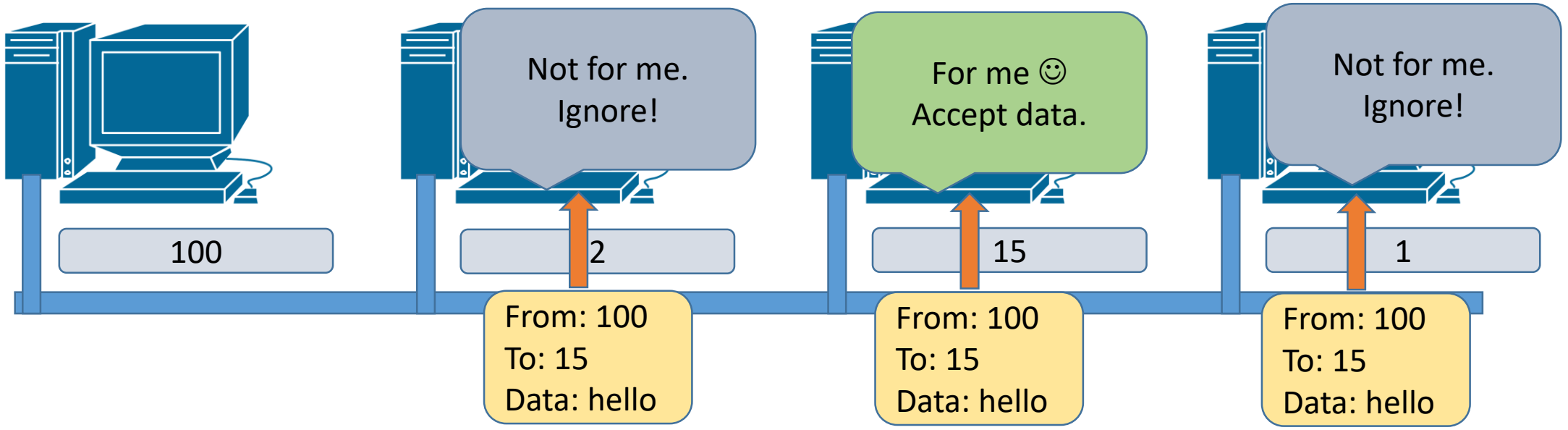
We want to communicate from one computer to another.

So we connect them to a network. Each computer can send data to the network and see data from other computers on the network.

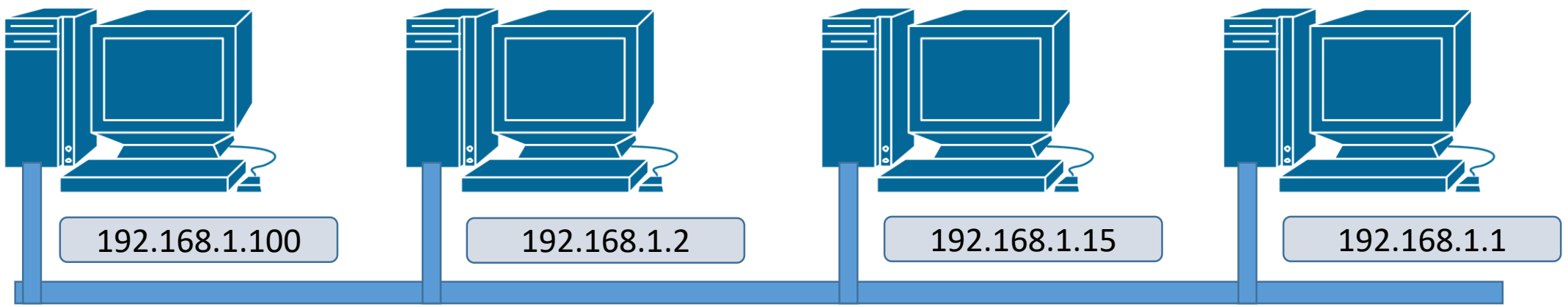
The computers are each given a number. The number is used to see, who sends data and who should receive it.


From: 100
To: 15
Data: hello
100
2
15
1


100
2
15
1
From: 100
To: 15
Data: hello
From: 100
To: 15
Data: hello
From: 100
To: 15
Data: hello


Not for me.
Ignore!
For me ☺
Accept data.
Not for me.
Ignore!
100
2
15
1
From: 100
To: 15
Data: hello
From: 100
To: 15
Data: hello
From: 100
To: 15
Data: hello

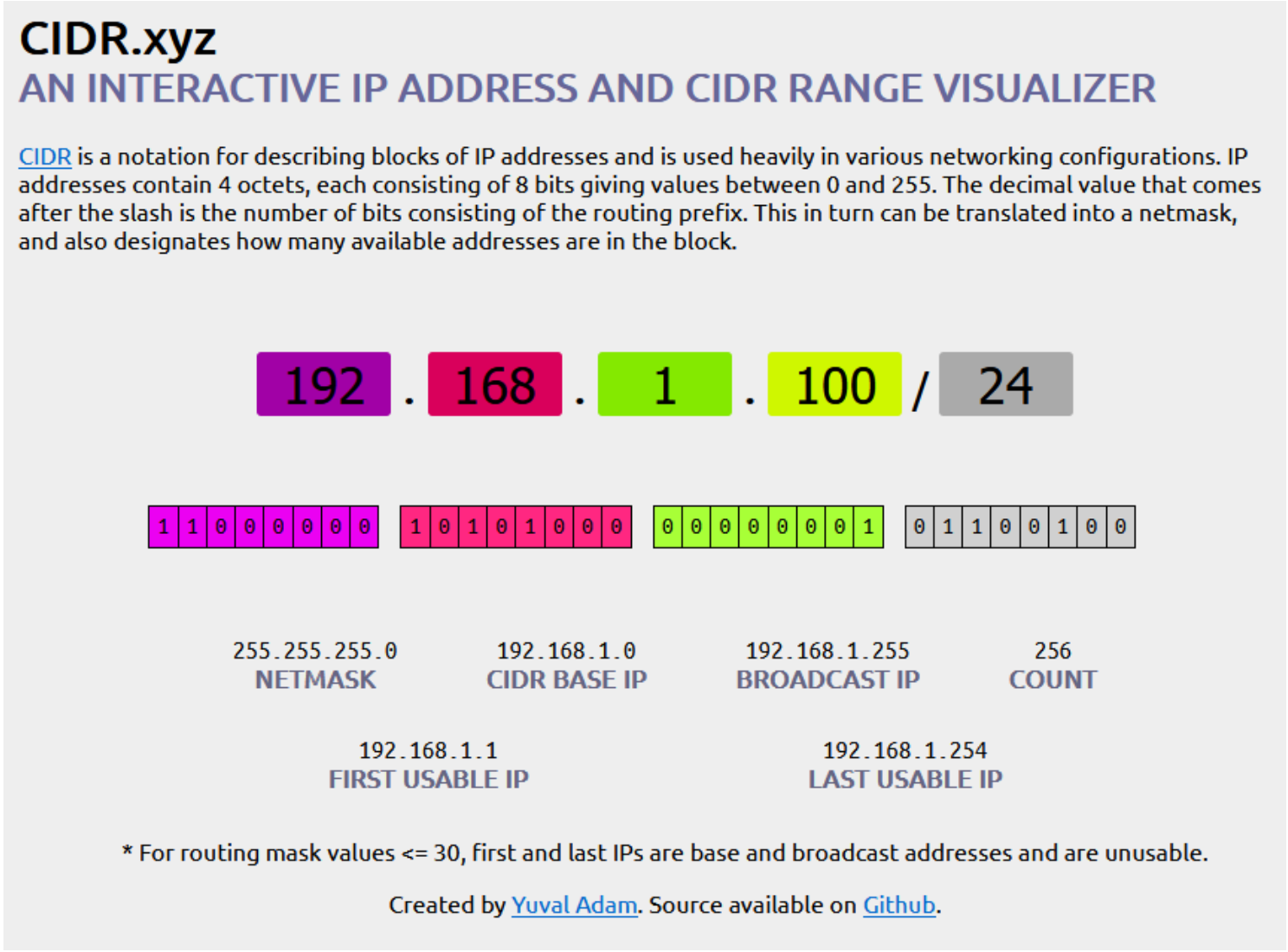
IPv4 addresses



IPv4 addresses are 32 bits long. They are written as 4 bytes.

E.g. 192.168.1.100

IP Address format



Networks can be split in to subnets. A subnet has an IP address range, which are the addresses usable in that network.

Data is routed inside a subnet.

The 32 bit IP addresses used in the subnet is split in NETWORK and HOST parts.

The 32 bits set to 1 in the NETMASK specifies the NETWORK part. The bits set to 0 defines the HOST parts.

The NETWORK part of an address can also be specified in CIDR format (Classless Inter-Domain Routing).

The IP address ending with .0 or .255 can not be used by a HOST.

https://cidr.xyz/

Local IP Networks

Portions of the IPv4 space are reserved for specific uses.

Loopback

127.0.0.0 to 127.255.255.255

Typically 127.0.0.1 is “loopback” or “localhost”

Private networks

10.0.0.0 to 10.255.255.255

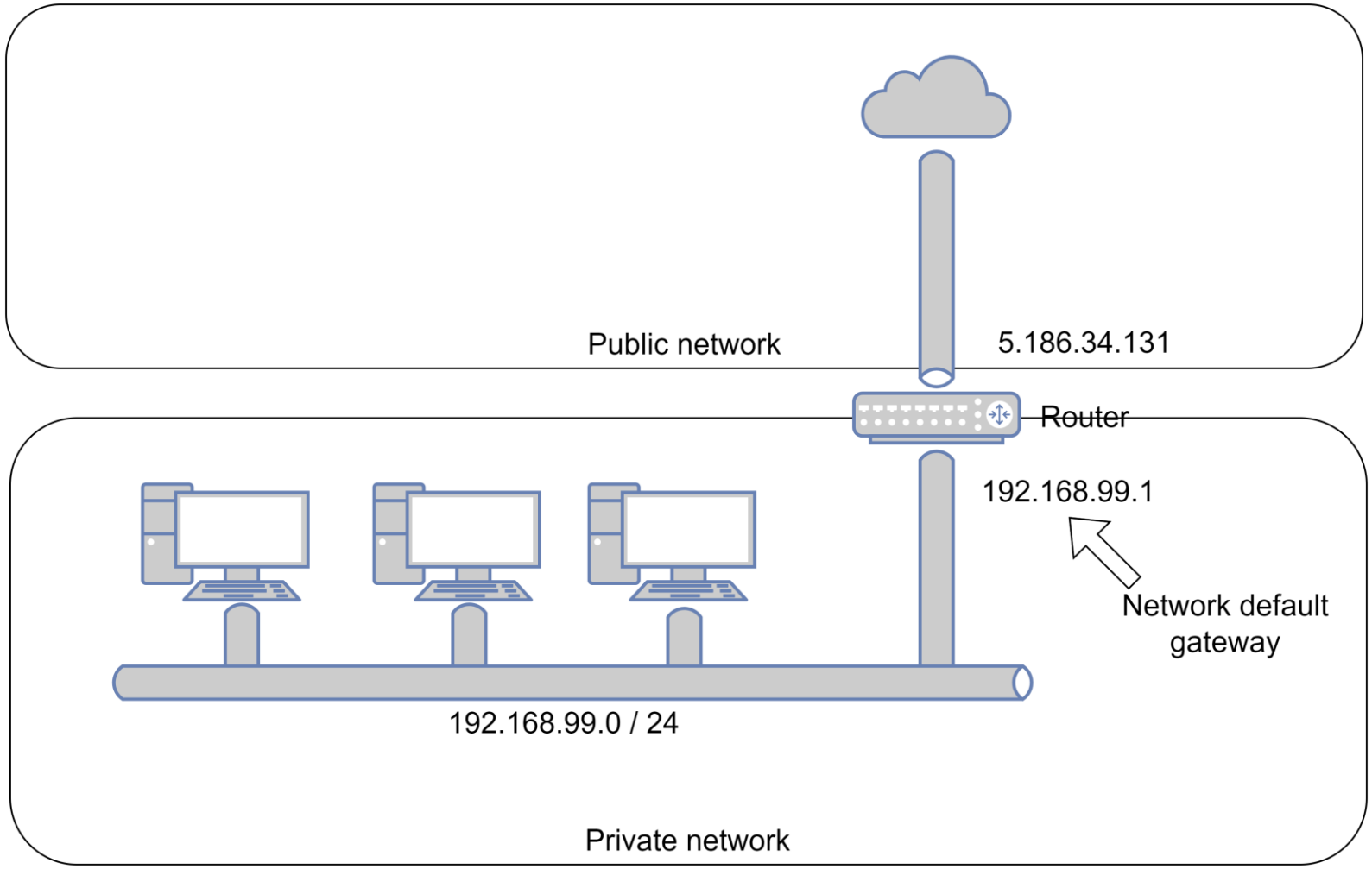
172.16.0.0 to 172.31.255.255

192.168.0.0 to 192.168.255.255

Any computer that is not hooked up to the internet directly (any computer that goes through a router or other NAT system) can use these addresses at will.

Source: https://www.digitalocean.com/community/tutorials/understanding-ip-addresses-subnets-and-cidr-notation-for-networking

Public address vs. Local network address



Michael's network.

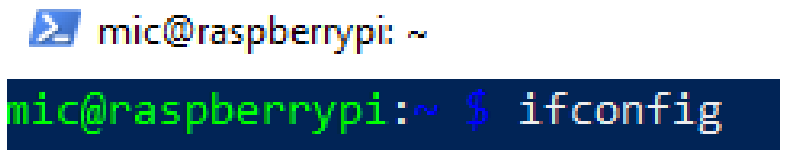
192.168.99.0/24 is local addresses. They are managed by Michael.

5.186.34.131 is the public address. It is managed by Fibia (the internet provider).

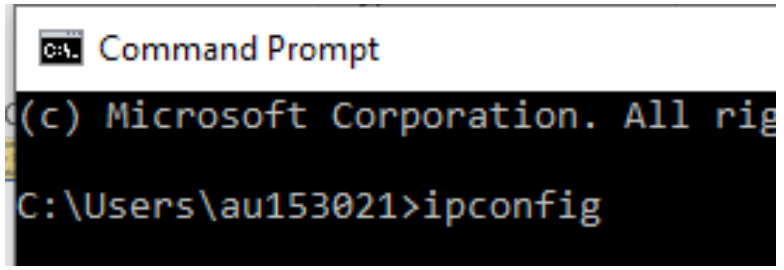
Exercise

- Exercise:
  - Find your LAN IP address and exchange address with another student.
  - What subnet are you on?
  - Ping each others machines
    - Ping is probably blocked in your windows firewall.
    - Try to ping 8.8.8.8 (google DNS) or Michaels Raspberry Pi if he remembered to bring it.
  - Find your external (WAN) IP Address using https://www.whatsmyip.org/

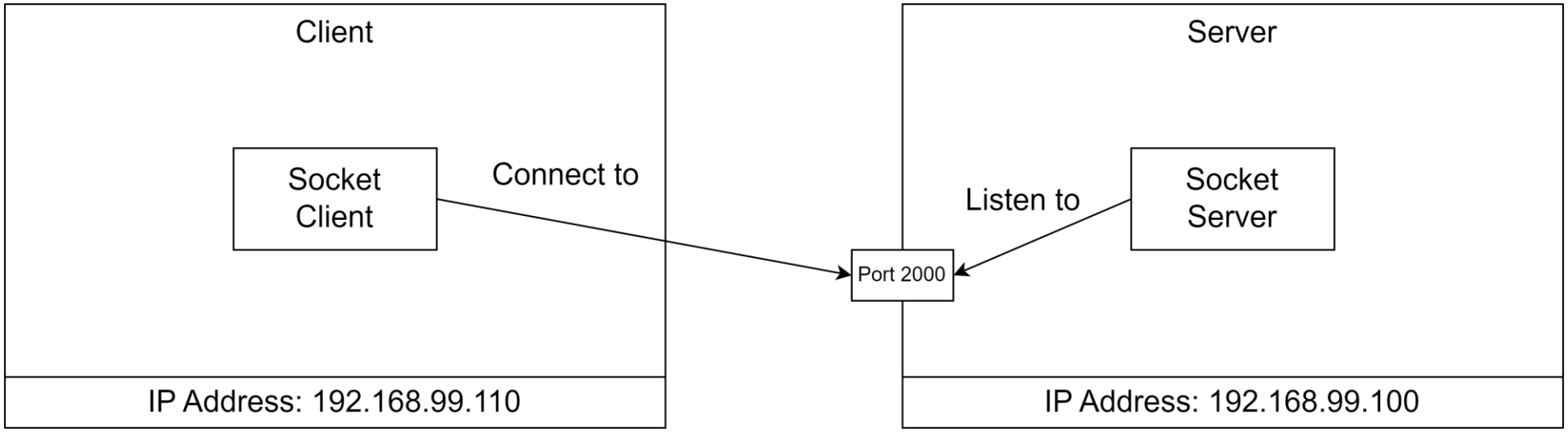
Linux / Mac:



Windows:



Ports



A machine has an IP address and 65535 Ports.

A program on a machine can listen to a specific port.

A program on another machine will specify the IP address and port it wants to communicate with.

Reserved ports

Ports from 0 to 1023 are reserved.

Examples:

- 20 FTP — Data
- 21 FTP — Control
- 22 SSH Remote Login Protocol
- 23 Telnet
- 25 Simple Mail Transfer Protocol (SMTP)
- 37 Time
- 53 Domain Name System (DNS)
- 80 HTTP
- 110 POP3
- 119 Newsgroup (NNTP)
- 443 HTTPS
- 546 DHCP Client
- 547 DHCP Server

Wikipedia has a complete list of reserved ports:

https://en.wikipedia.org/wiki/List_of_TCP_and_UDP_port_numbers

TCP / IP

Transmission Control Protocol (TCP) is a transport protocol that is used on top of IP to ensure reliable transmission of packets.

It handles retransmission of lost packages, reception of out-of-order packages and congestion control.

UDP / IP

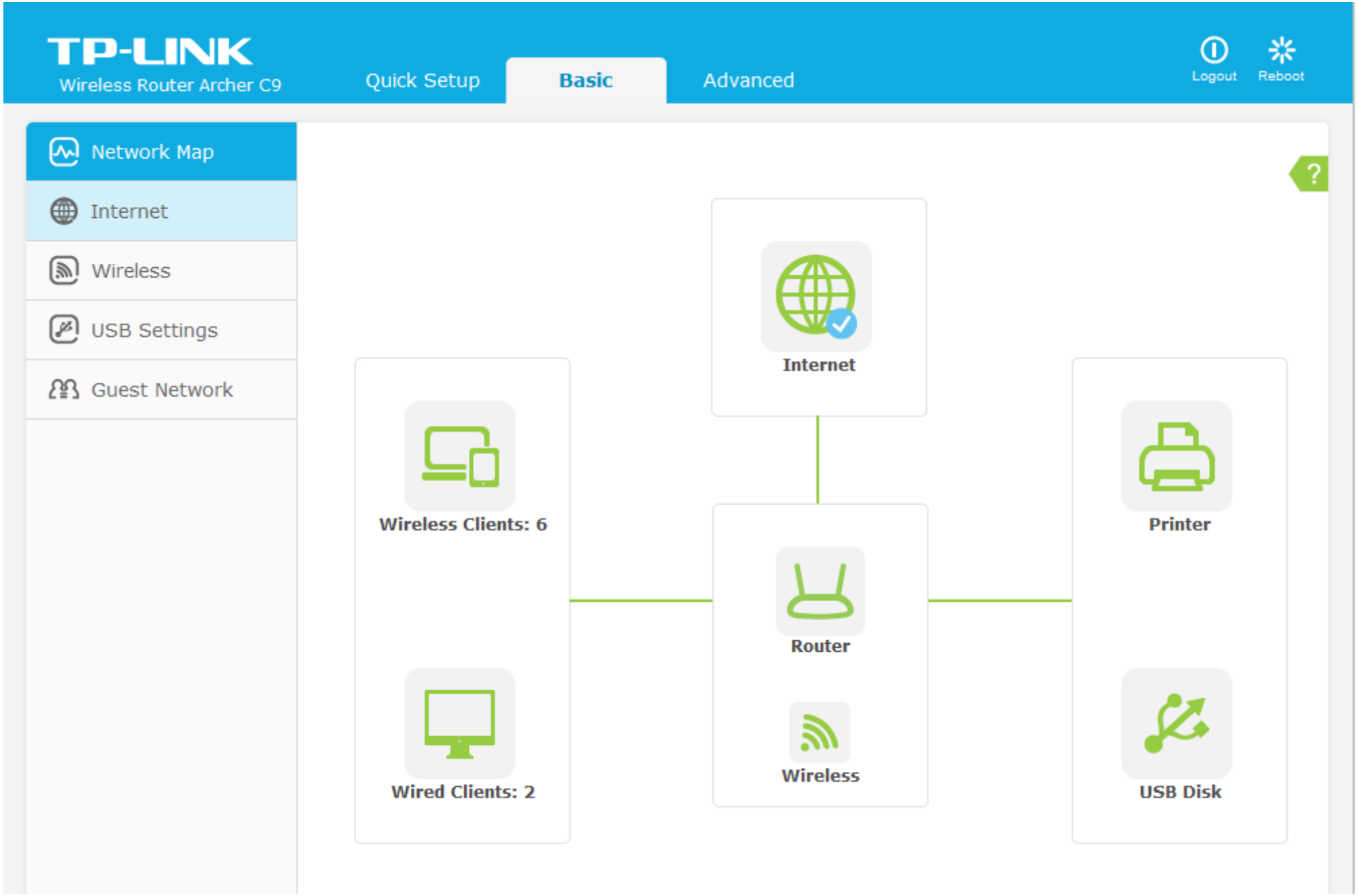
User Datagram Protocol (UDP) is a lightweight data transport protocol that works on top of IP.

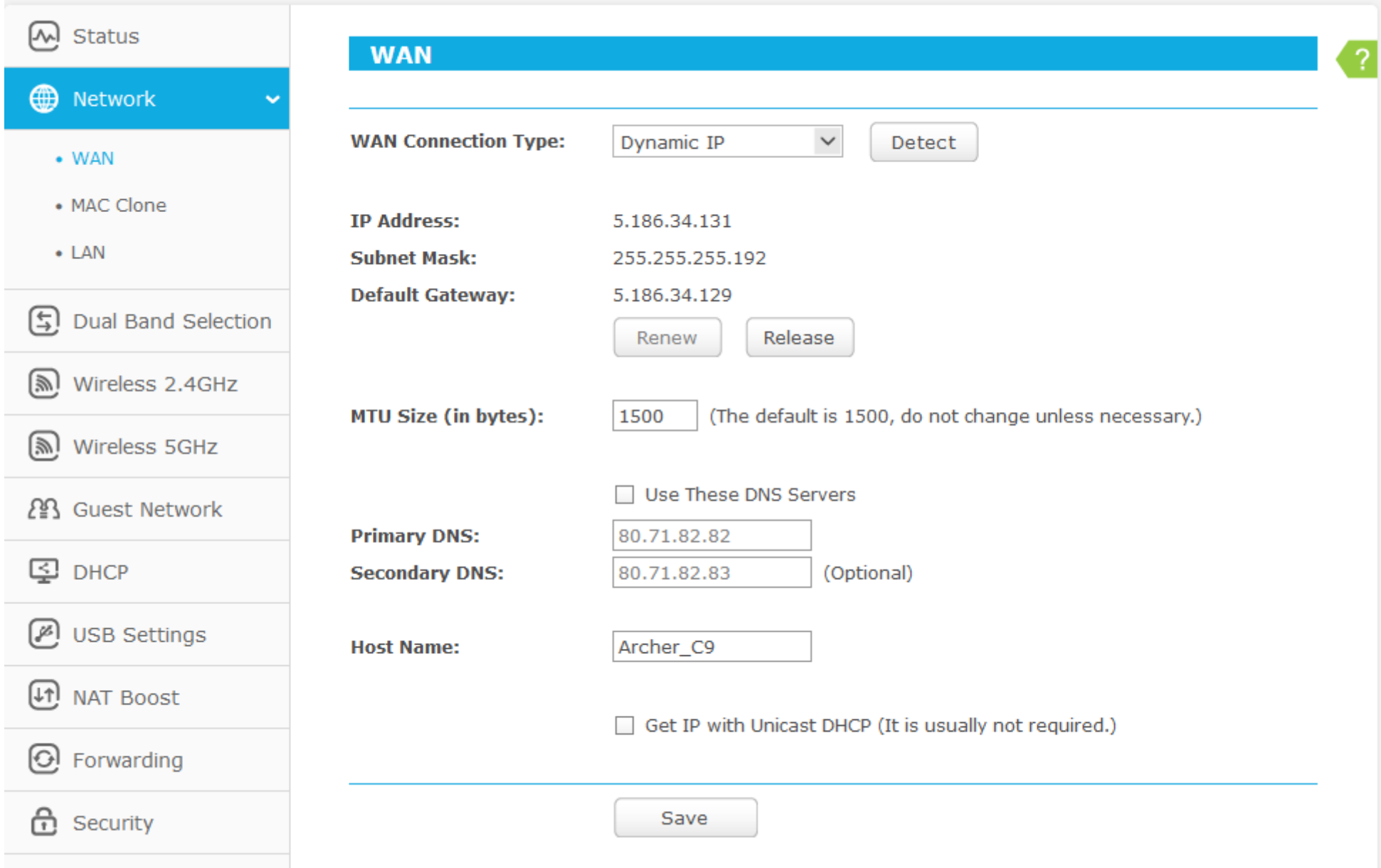
Detects and discards corrupt packages. Does not handle lost or out of order packages.

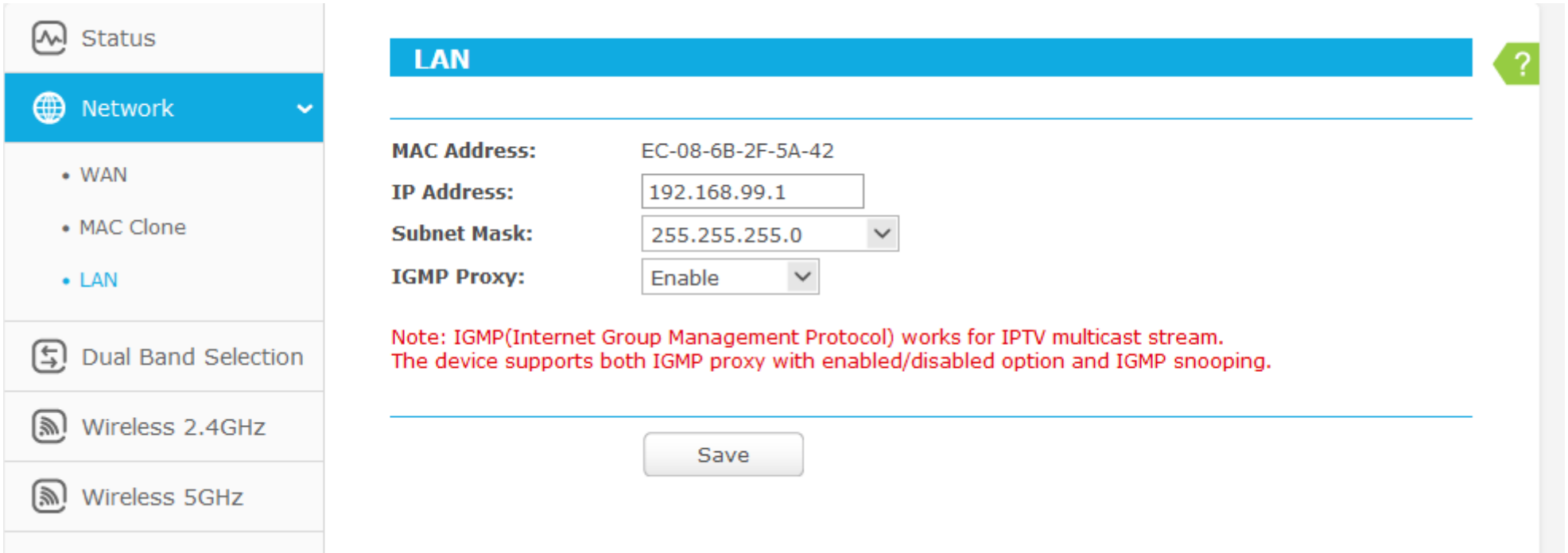
It's often used for time-sensitive applications (such as real-time video streaming) where speed is more important than accuracy.

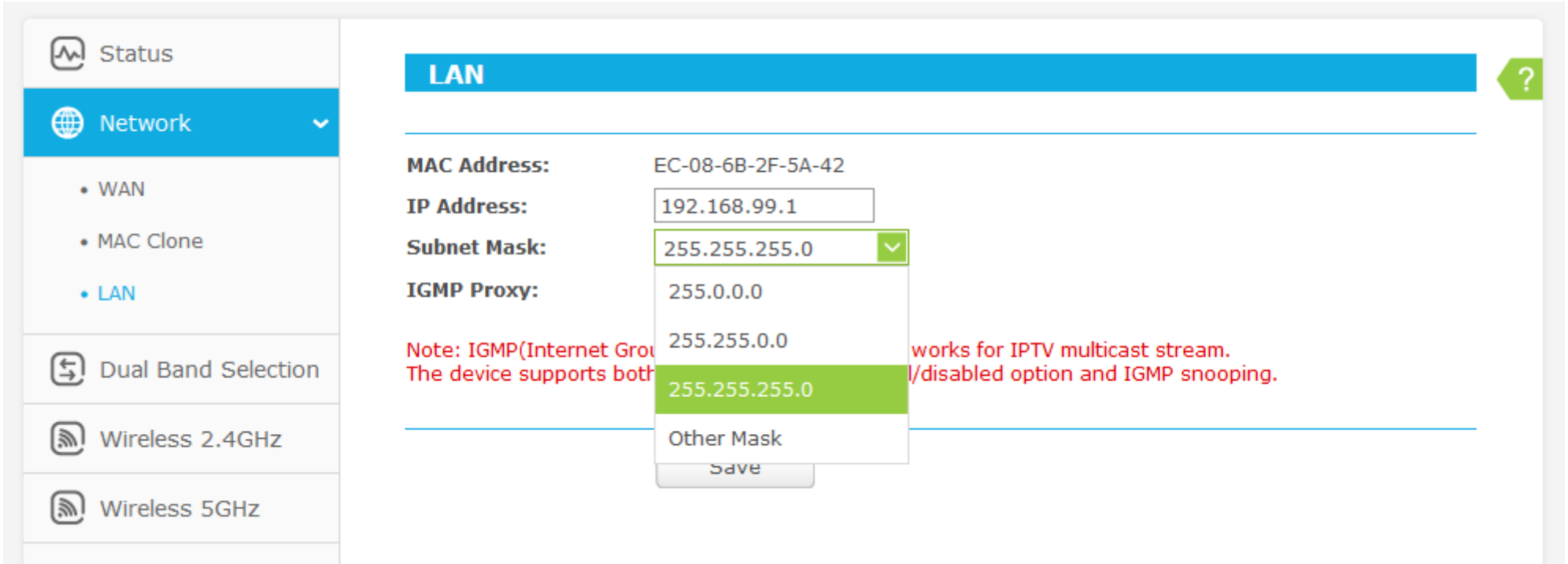
- Address assignment
  - DHCP
  - MAC address
- Naming
  - DNS lookup

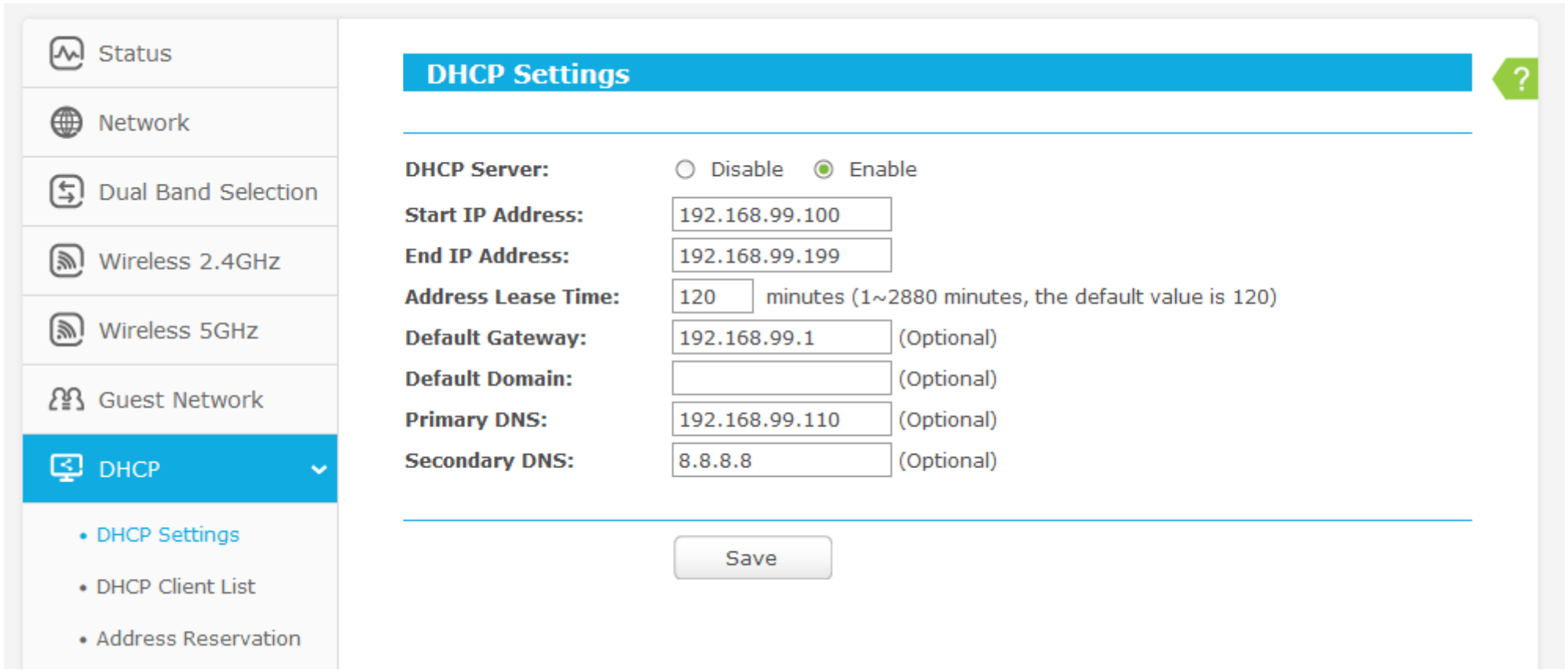
Example router setup

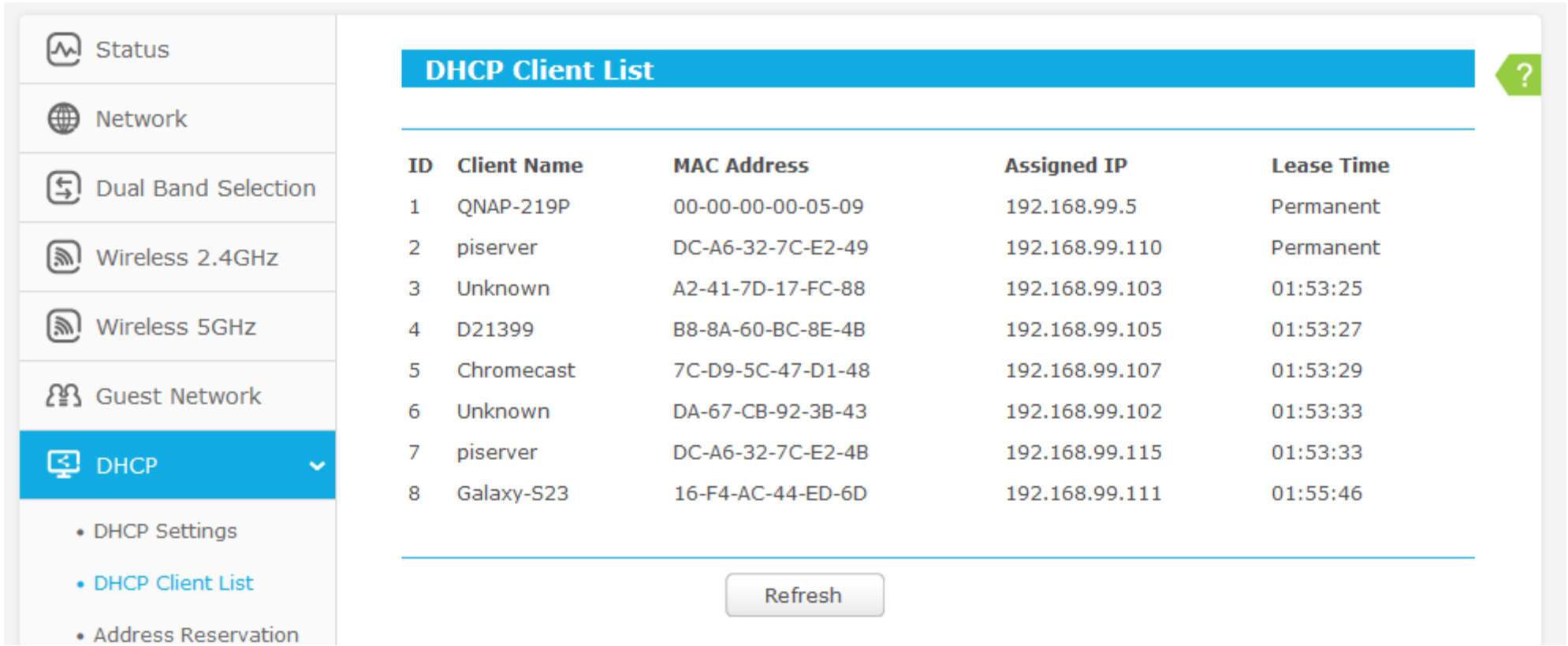

TP-LINK
Wireless Router Archer C9
Quick Setup
Basic
Advanced
Logout
Reboot
Network Map
Internet
Wireless
USB Settings
Guest Network
?
Internet
Wireless Clients: 6
Wired Clients: 2
Router
Wireless
Printer
USB Disk

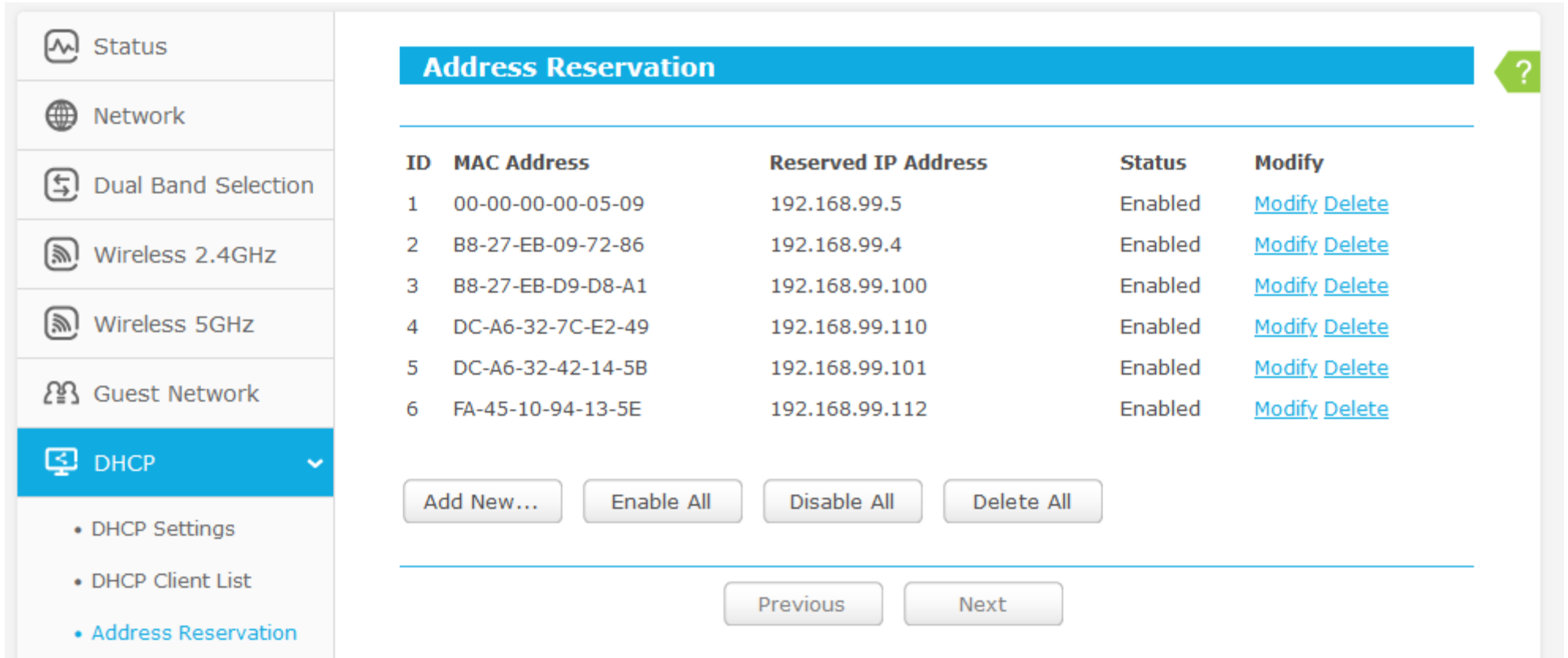

Status
Network
WAN
MAC Clone
LAN
Dual Band Selection
Wireless 2.4GHz
Wireless 5GHz
Guest Network
DHCP
USB Settings
NAT Boost
Forwarding
Security
WAN
WAN Connection Type:
Dynamic IP
Detect
IP Address:
5.186.34.131
Subnet Mask:
255.255.255.192
Default Gateway:
5.186.34.129
Renew
Release
MTU Size (in bytes):
1500
(The default is 1500, do not change unless necessary.)
Use These DNS Servers
Primary DNS:
80.71.82.82
Secondary DNS:
80.71.82.83
(Optional)
Host Name:
Archer_C9
Get IP with Unicast DHCP (It is usually not required.)
Save


Status
Network
WAN
MAC Clone
LAN
Dual Band Selection
Wireless 2.4GHz
Wireless 5GHz
LAN
?
MAC Address:
EC-08-6B-2F-5A-42
IP Address:
192.168.99.1
Subnet Mask:
255.255.255.0
IGMP Proxy:
Enable
Note: IGMP(Internet Group Management Protocol) works for IPTV multicast stream.
The device supports both IGMP proxy with enabled/disabled option and IGMP snooping.
Save


Status
Network
WAN
MAC Clone
LAN
Dual Band Selection
Wireless 2.4GHz
Wireless 5GHz
LAN
MAC Address:
EC-08-6B-2F-5A-42
IP Address:
192.168.99.1
Subnet Mask:
255.255.255.0
IGMP Proxy:
255.0.0.0
255.255.0.0
255.255.255.0
Other Mask
works for IPTV multicast stream.
/disabled option and IGMP snooping.
Save


Status
Network
Dual Band Selection
Wireless 2.4GHz
Wireless 5GHz
Guest Network
DHCP
DHCP Settings
DHCP Client List
Address Reservation
DHCP Settings
?
DHCP Server:
Disable
Enable
Start IP Address:
192.168.99.100
End IP Address:
192.168.99.199
Address Lease Time:
120
minutes (1~2880 minutes, the default value is 120)
Default Gateway:
192.168.99.1
(Optional)
Default Domain:
(Optional)
Primary DNS:
192.168.99.110
(Optional)
Secondary DNS:
8.8.8.8
(Optional)
Save


Status
Network
Dual Band Selection
Wireless 2.4GHz
Wireless 5GHz
Guest Network
DHCP
DHCP Settings
DHCP Client List
Address Reservation
DHCP Client List
ID Client Name MAC Address Assigned IP Lease Time
1 QNAP-219P 00-00-00-00-05-09 192.168.99.5 Permanent
2 piserver DC-A6-32-7C-E2-49 192.168.99.110 Permanent
3 Unknown A2-41-7D-17-FC-88 192.168.99.103 01:53:25
4 D21399 B8-8A-60-BC-8E-4B 192.168.99.105 01:53:27
5 Chromecast 7C-D9-5C-47-D1-48 192.168.99.107 01:53:29
6 Unknown DA-67-CB-92-3B-43 192.168.99.102 01:53:33
7 piserver DC-A6-32-7C-E2-4B 192.168.99.115 01:53:33
8 Galaxy-S23 16-F4-AC-44-ED-6D 192.168.99.111 01:55:46
Refresh


Status
Network
Dual Band Selection
Wireless 2.4GHz
Wireless 5GHz
Guest Network
DHCP
DHCP Settings
DHCP Client List
Address Reservation
Address Reservation
?
ID MAC Address Reserved IP Address Status Modify
1 00-00-00-00-05-09 192.168.99.5 Enabled Modify Delete
2 B8-27-EB-09-72-86 192.168.99.4 Enabled Modify Delete
3 B8-27-EB-D9-D8-A1 192.168.99.100 Enabled Modify Delete
4 DC-A6-32-7C-E2-49 192.168.99.110 Enabled Modify Delete
5 DC-A6-32-42-14-5B 192.168.99.101 Enabled Modify Delete
6 FA-45-10-94-13-5E 192.168.99.112 Enabled Modify Delete
Add New...
Enable All
Disable All
Delete All
Previous
Next

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References and image sources

https://www.digitalocean.com/community/tutorials/understanding-ip-addresses-subnets-and-cidr-notation-for-networking

https://fab.cba.mit.edu/classes/961.04/people/neil/ip.pdf

https://iximiuz.com/en/posts/computer-networking-101/

https://www.youtube.com/watch?v=PwWhJEJVGI4

https://www.youtube.com/watch?v=NyZWSvSj8ek

https://www.youtube.com/playlist?list=PL7zRJGi6nMRzg0LdsR7F3olyLGoBcIvvg