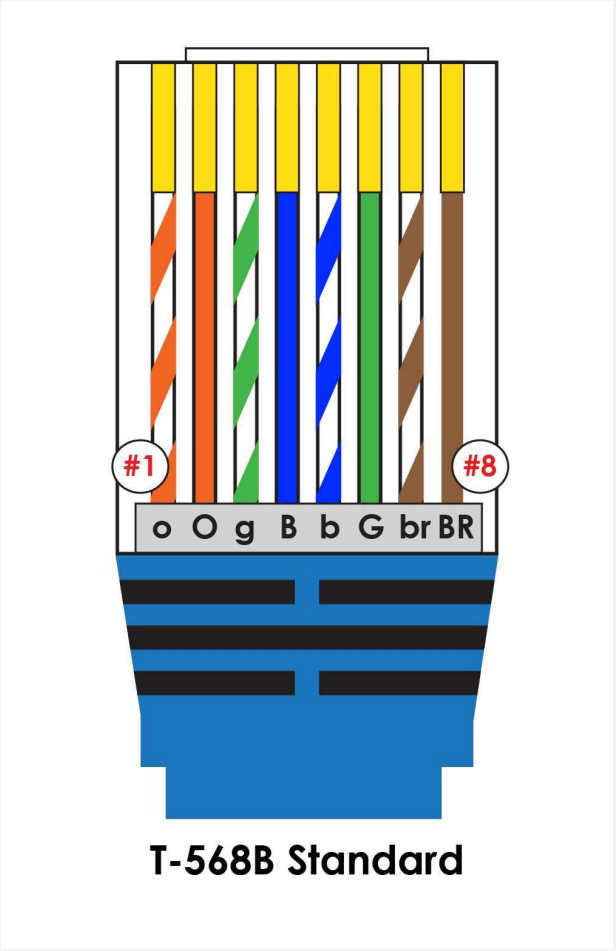
Science and Technology Facilities Council

Networking 101

From Computer to the Internet



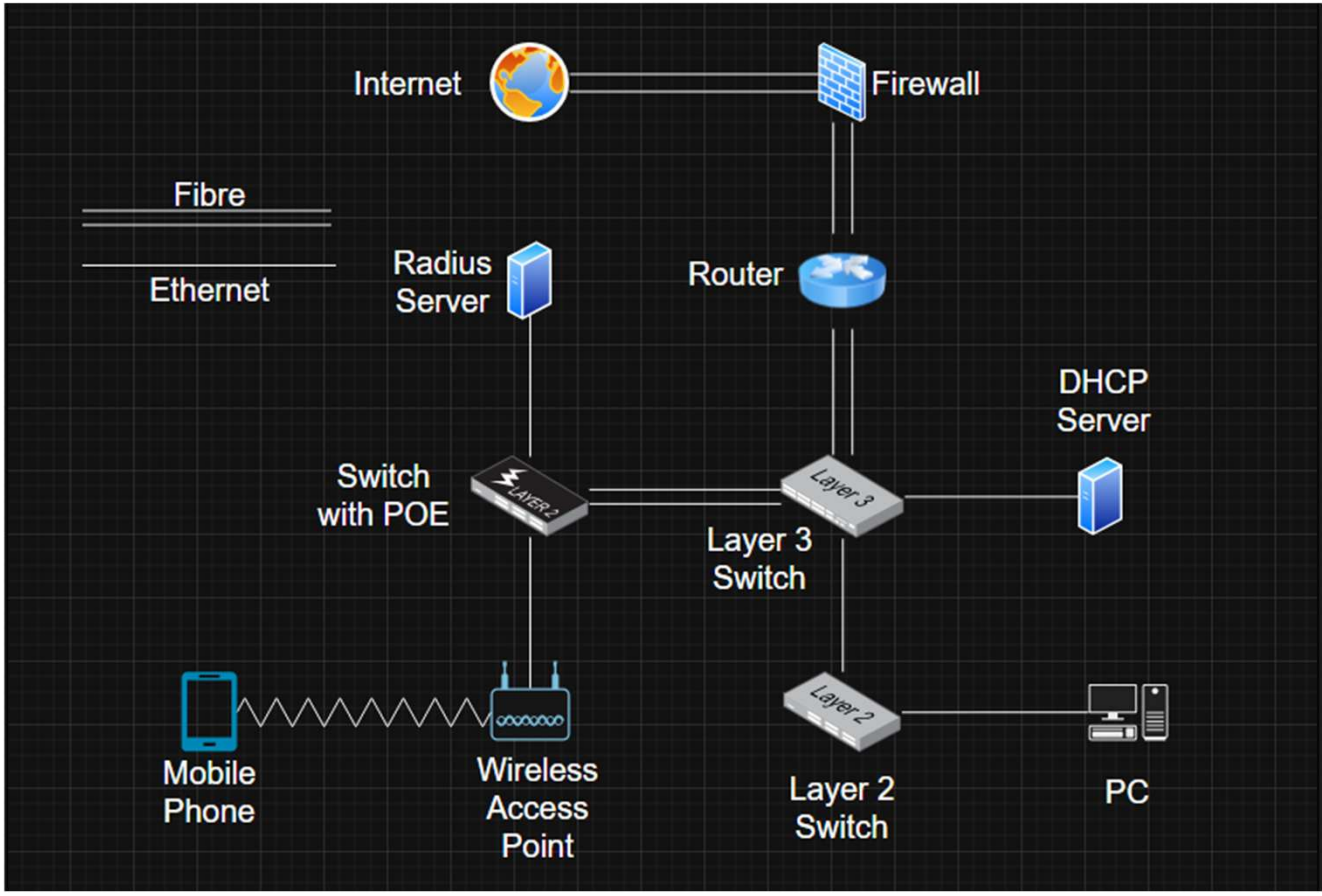
By James McManus

The Network

Today we will explore how your computer connects to the internet.

From getting an Ip to how your data reaches the internet.

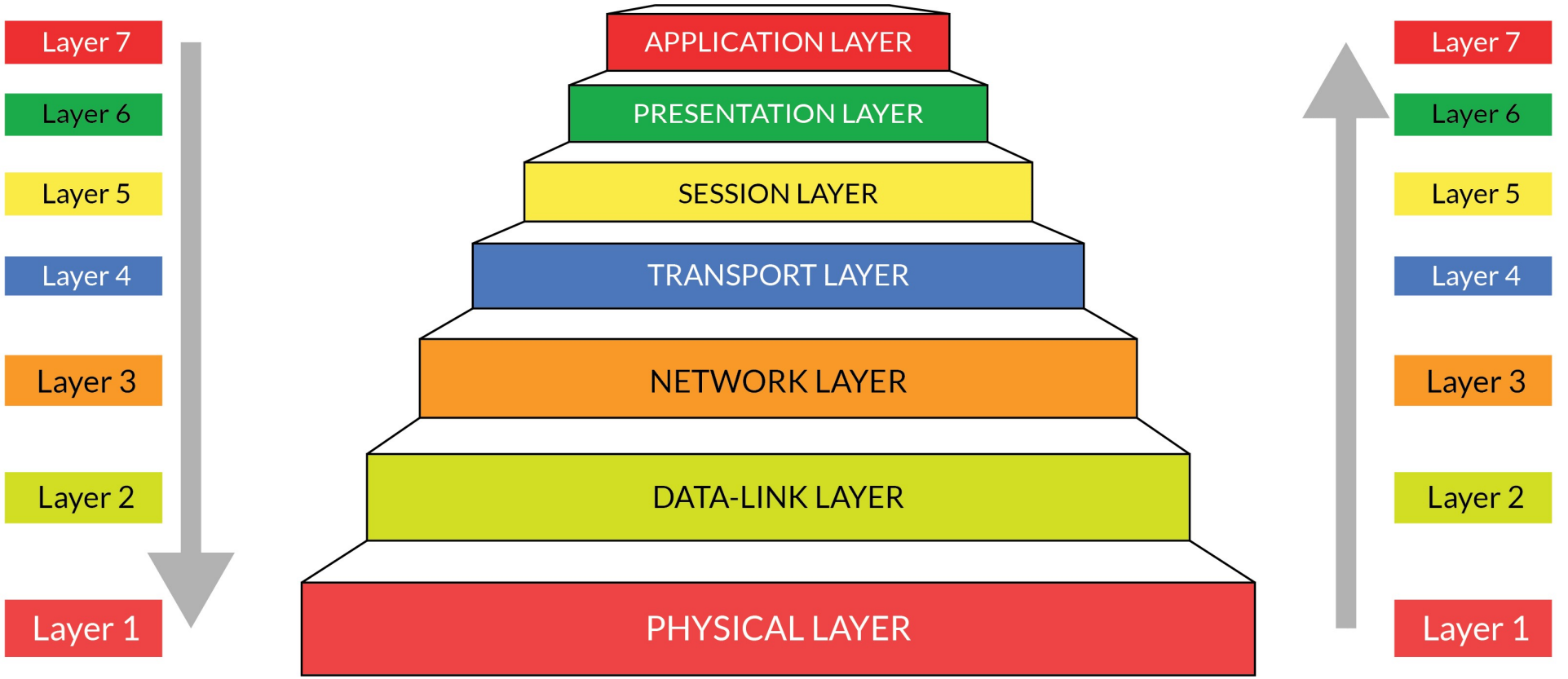
Commercial network example.



OSI MODEL

Client Side

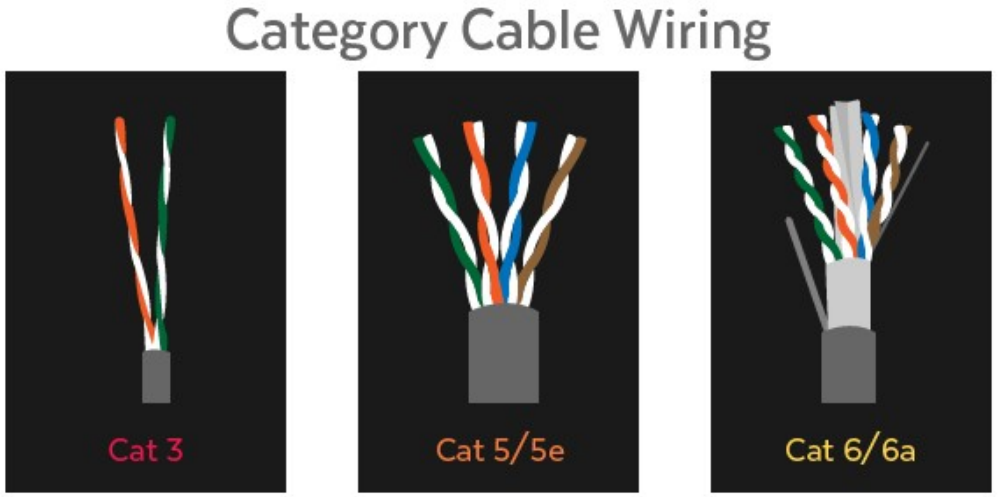
Server Side



How is data transfered?

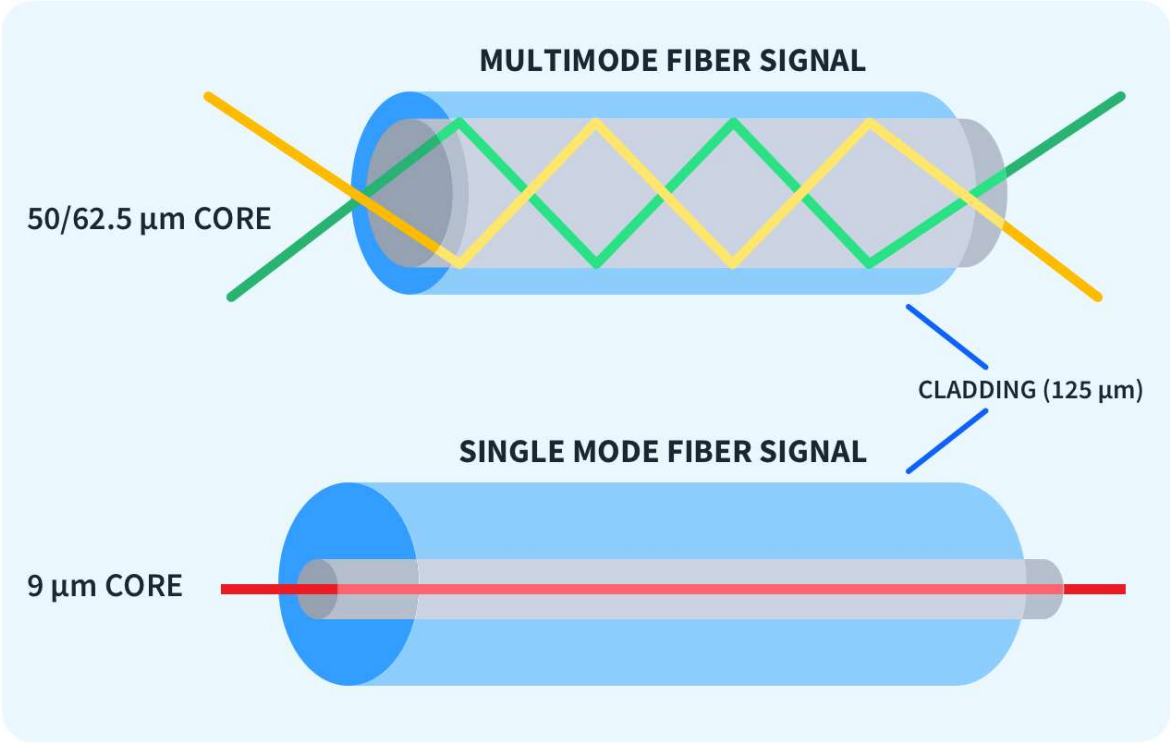
The Humble Ethernet

- Ethernet is the backbone of modern networking.
- Cat 5e is the most common in use for offices. Cat 6 is also widely adopted for data centres, but newer more cutting-edge data centres will use cat 7 or even cat 8.



Cable Type	Shielding	Maximum Frequency	Max Data Rate	Speed	Year Developed
Cat 3	No	16Mhz	10 Mbps	10Mbps	1991
Cat 5	No	100MHz	100 Mbps	100Mbps	1995
Cat 5e	No	100MHz	1,000 Mbps / 1 Gbps	1Gbps	2001
Cat 6	Sometimes	250Mhz	1,000 Mbps / 1 Gbps	1Gbps	2002
Cat 6a	Sometimes	500MHz	10,000 Mbps / 10 Gbps	10Gbps	2009
Cat 7	Yes	600Mhz	40,000 Mbps/ 40 Gbps	10Gbps	2010
Cat 8	Yes	2GHz	25 Gbps or 40 Gbps	40Gbps	2016

The Flashy Fibre



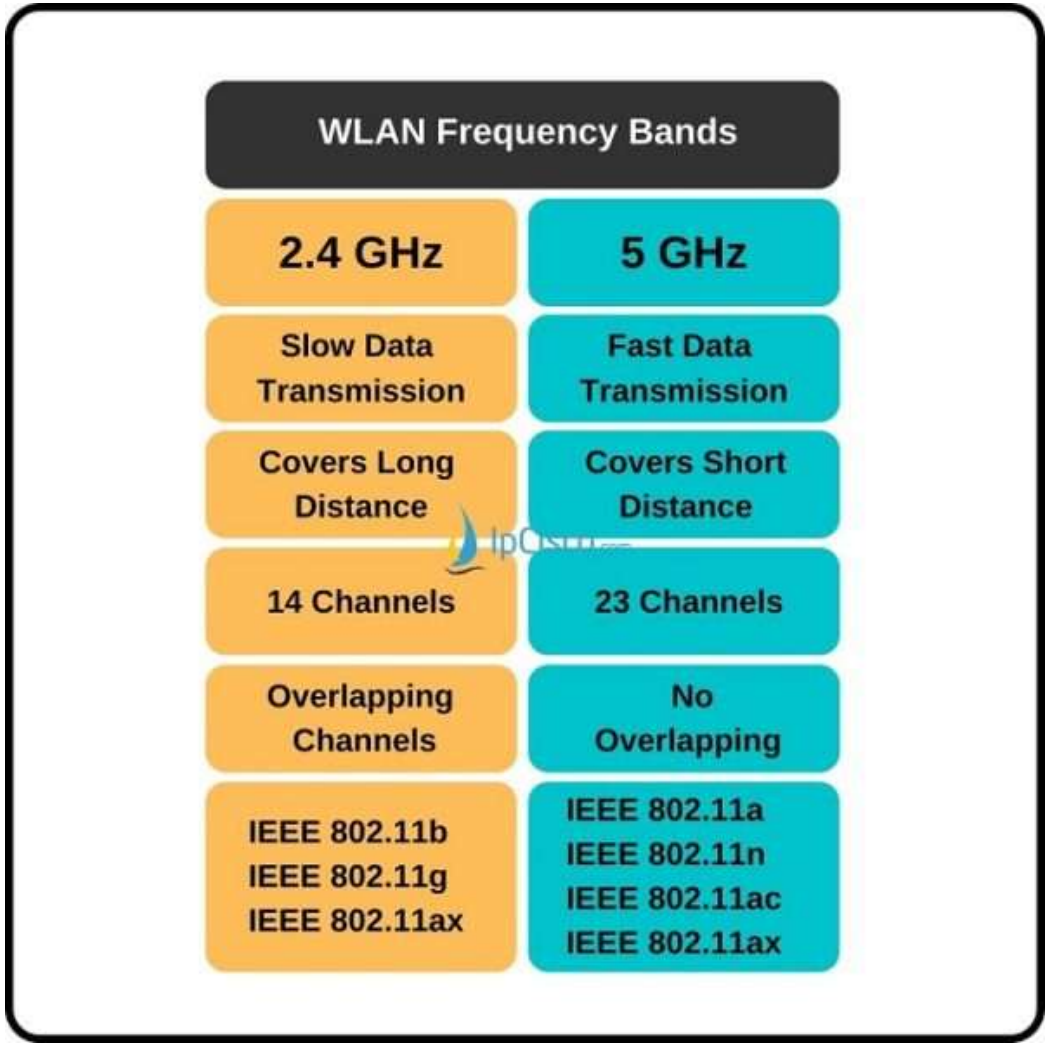
Two types of fibre cables:

- Single Mode Fibre
  - Single beam path
  - Long distance but less bandwidth
- Multi Mode Fibre
  - Multiple beam paths
  - Short distance but more bandwidth

Single Fibre is what's used by broadband providers.

Wi-Fi

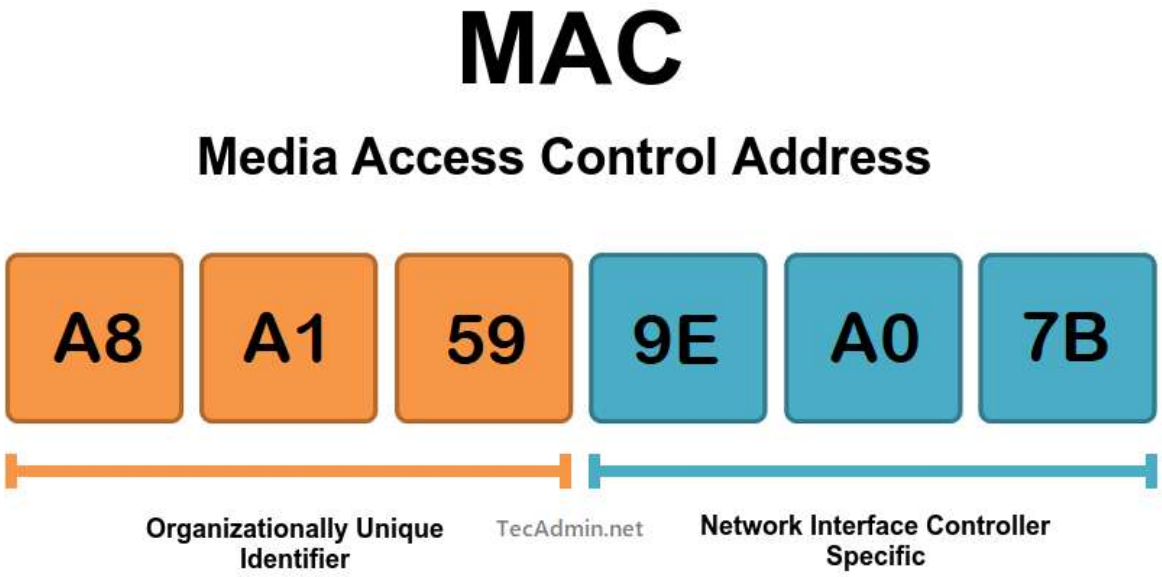
- Uses radio waves to transmit data wirelessly.
- It does this by using carrier frequencies which allow the signal to travel a workable distance.
- More on how devices communicate using Wi-Fi later



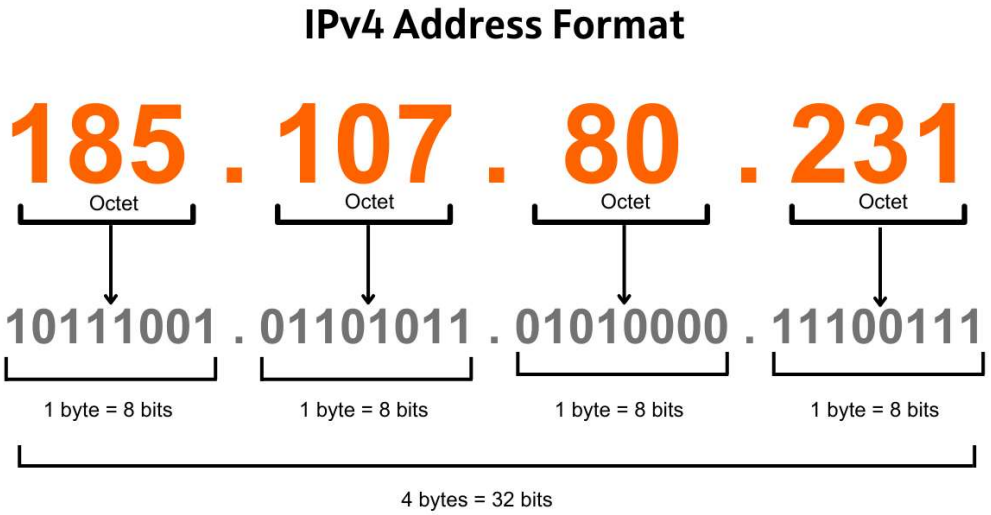
How are devices and networks identified?

Mac address

- All devices have one from the manufacturer
- 6-byte number represents the layer 2 address of devices
- 281,474,976,710,656 or 2^48
- They are “unique” per device. IEEE have a registration authority which assigns blocks of macs to manufacturers



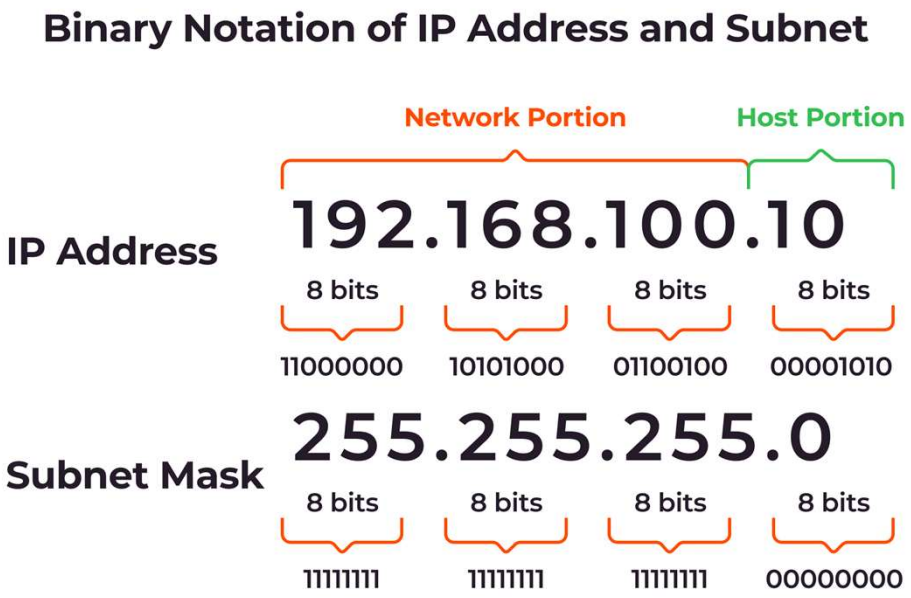
IP address



- Assigned when connecting a device
- Public and Private
  - Public should be unique globally
    - DL has 148.79.0.0/16
    - RAL has 130.246.0.0/16
  - Private is unique to a network
    - Eg.192.168.0.0/16
- Needs to be unique on the network

Subnets

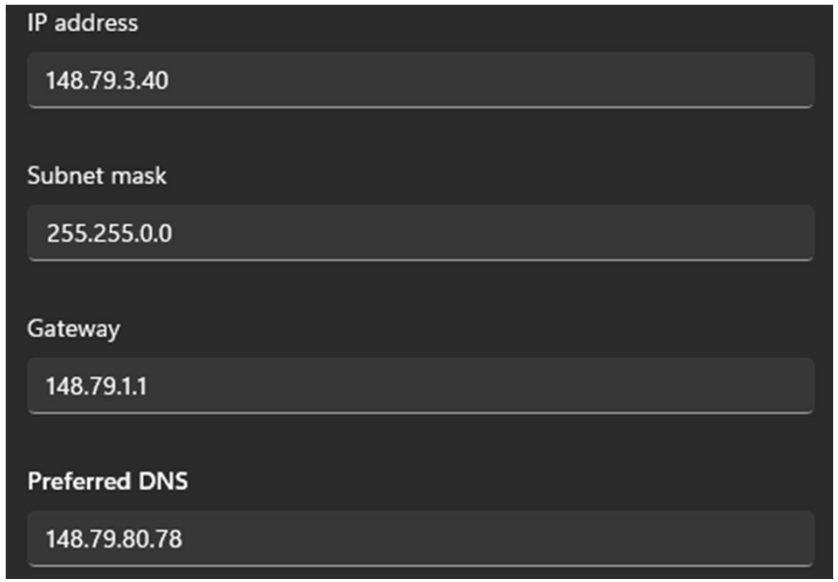
- A flexible division of a network based on IP
- Splits IP into a network section and host section.
- Notations:
  - Binary: 11111111-11111111-00000000-00000000
  - Simplified: 255.255.0.0
  - Slash: /16
  - Class: Class B Network
- First address is reserved for wild card
- Last address is reserved for the broadcast domain

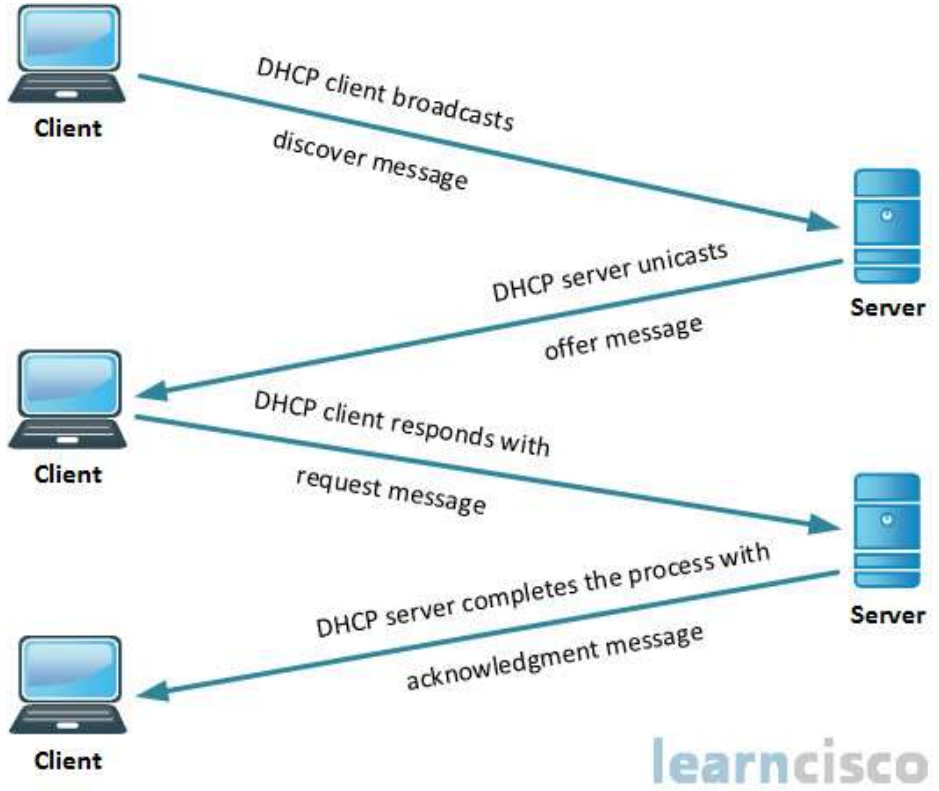


Static vs DHCP

A device needs an IP to be able to connect to a network. It can either be assigned statically on the device, or the device can use Dynamic Host Configuration Protocol (DHCP)to get the IP from a DHCP server.

Static assignment needs an IP, Subnet





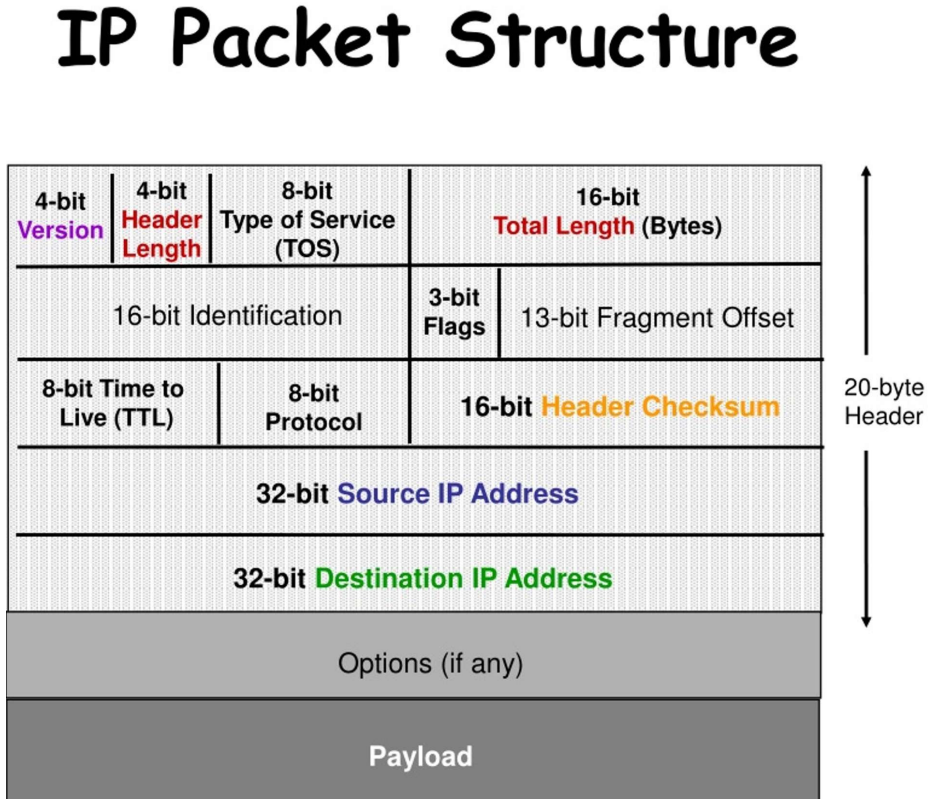
When a device uses DHCP, it alerts the DHCP server on a network and the server sends the Ip configuration back to the device.

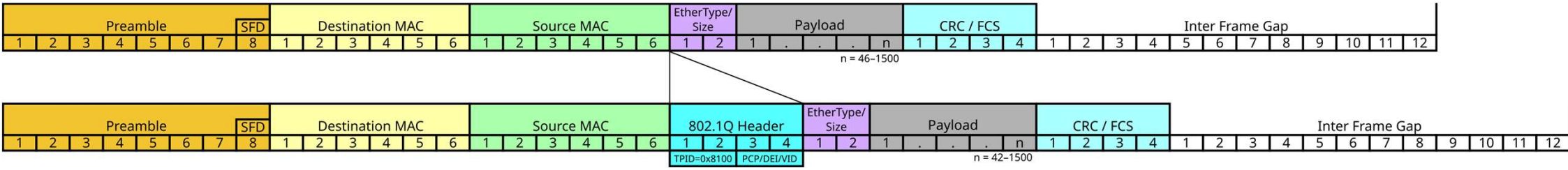
The device continues to communicate with the DHCP server periodically to check if the IP is still valid.

How does data travel around the network?

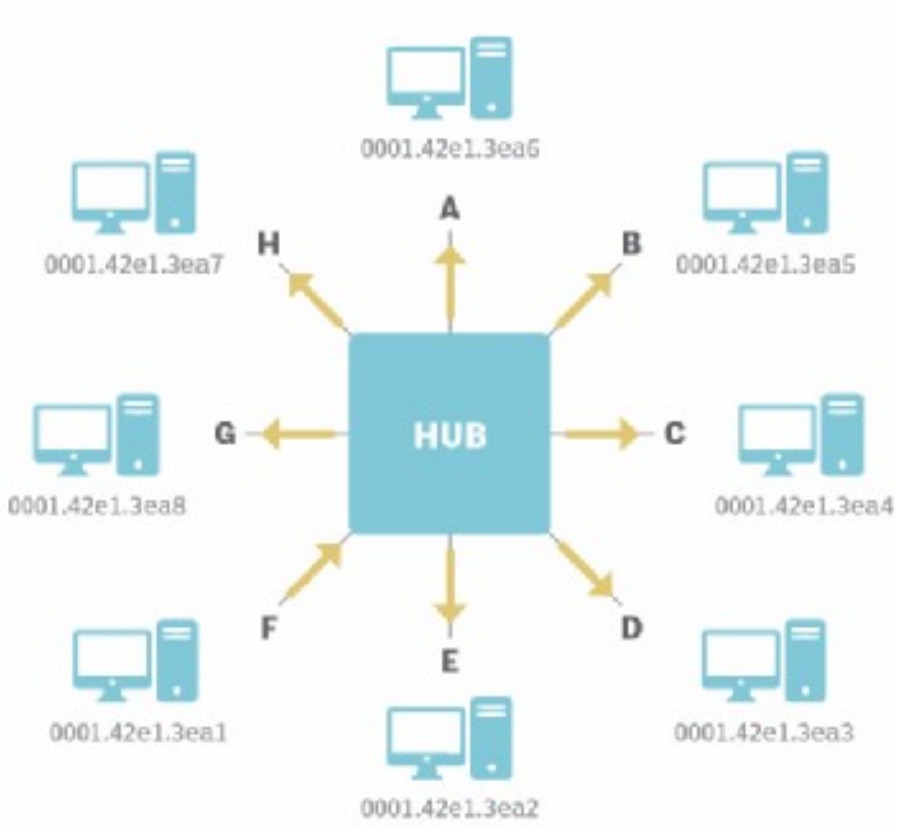
Packets

- All Data is wrapped in meta data which holds information such as where the packet originated, where the packet should end up, and error correction.
- These are different for the different points in a packets journey.
- It can depend on the medium such as Wi-Fi or ethernet, also whether it's internet traffic or internal traffic.





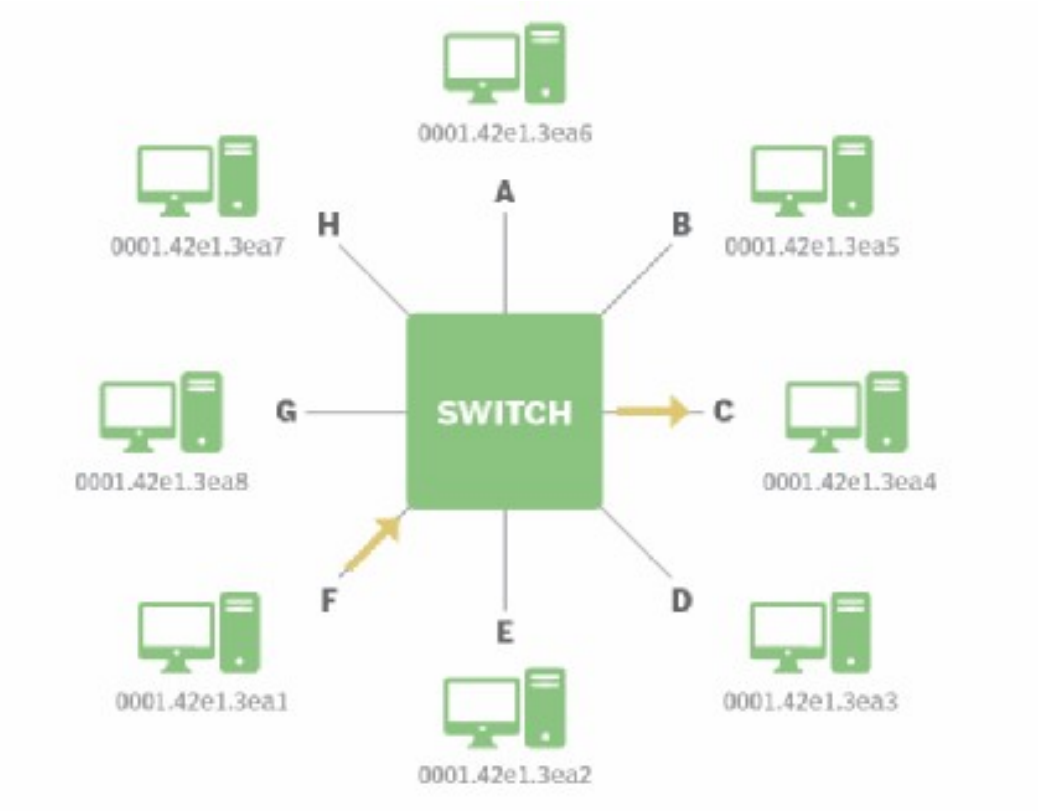
Network Hubs



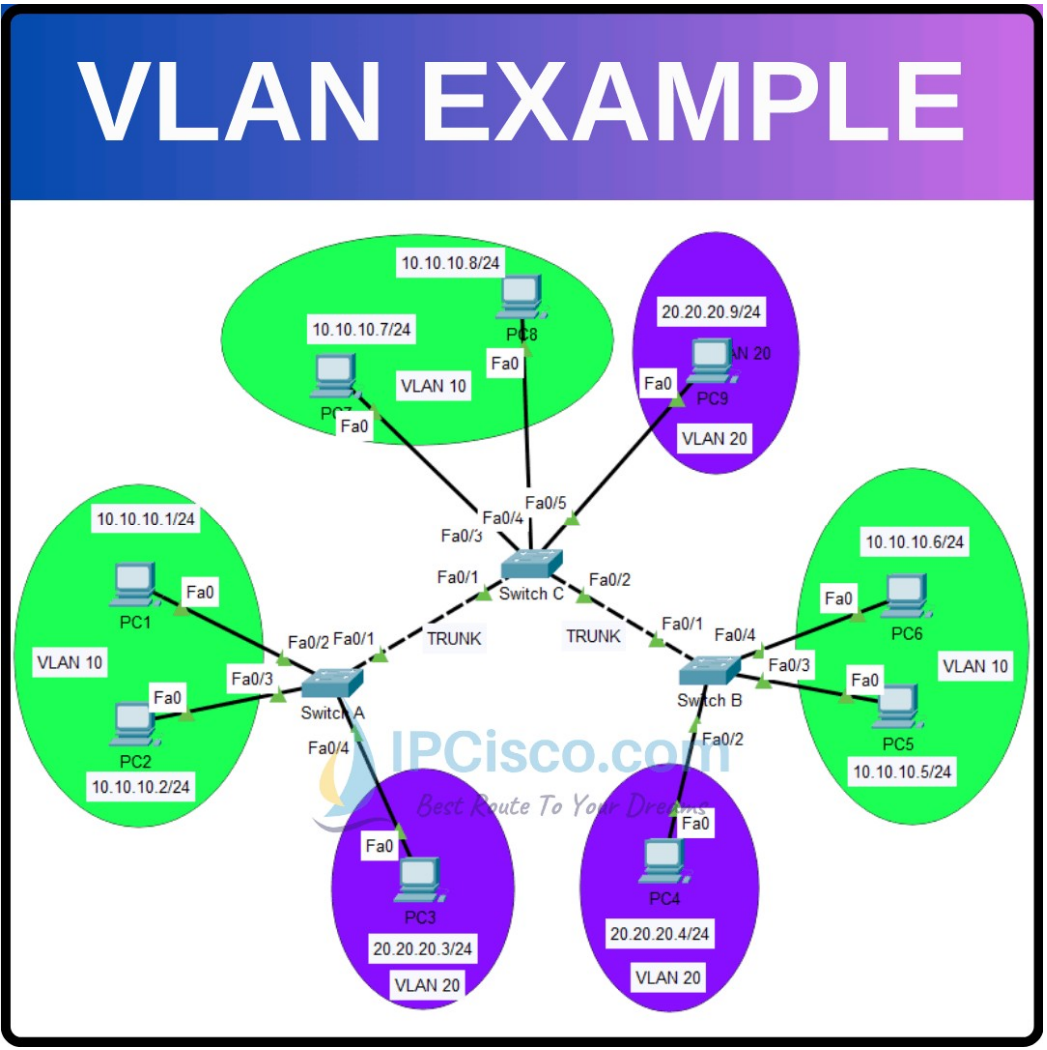
- Early method of connecting multiple computers together.
- Forwards all traffic to all devices connected.
- Since it’s so “dumb” it work on the physical layer

Network Switches

- Like the hub deals with layer 2 traffic.
- They use mac-addresses to forward traffic towards the intended device.
- Use mac-tables to learn which port connects to a mac-address.
- Modern switches are cable of hosting multiple networks through VLANS.



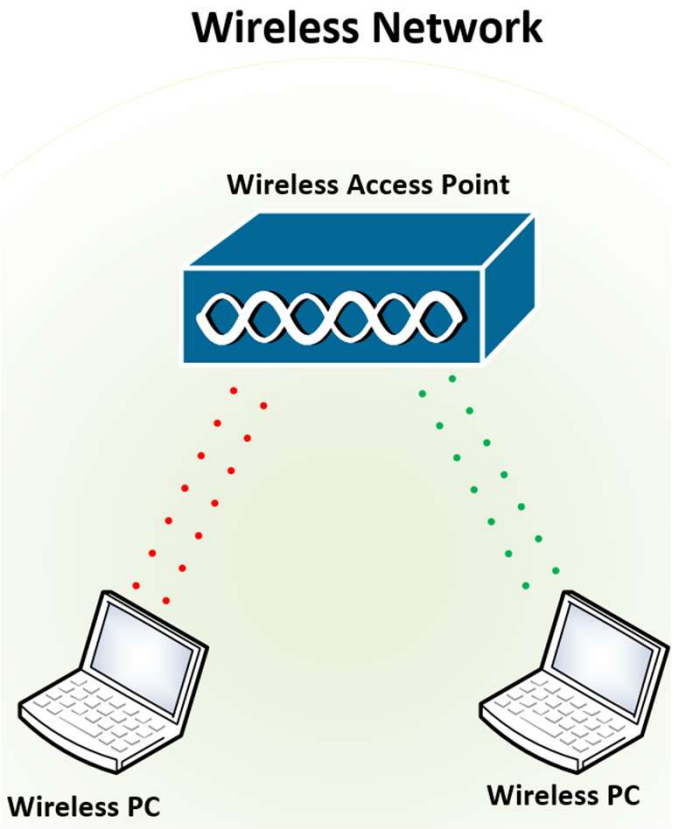
VLANs



- One principle of IT security is Segregation of Duties. This extends to devices as well as individuals.
- Achieving this by having different switches for different networks is inefficient particularly in larger networks.
- Virtual Local Area Networks (VLANs) work by assigning meta data to packets which determine what which ports the traffic can travel down.

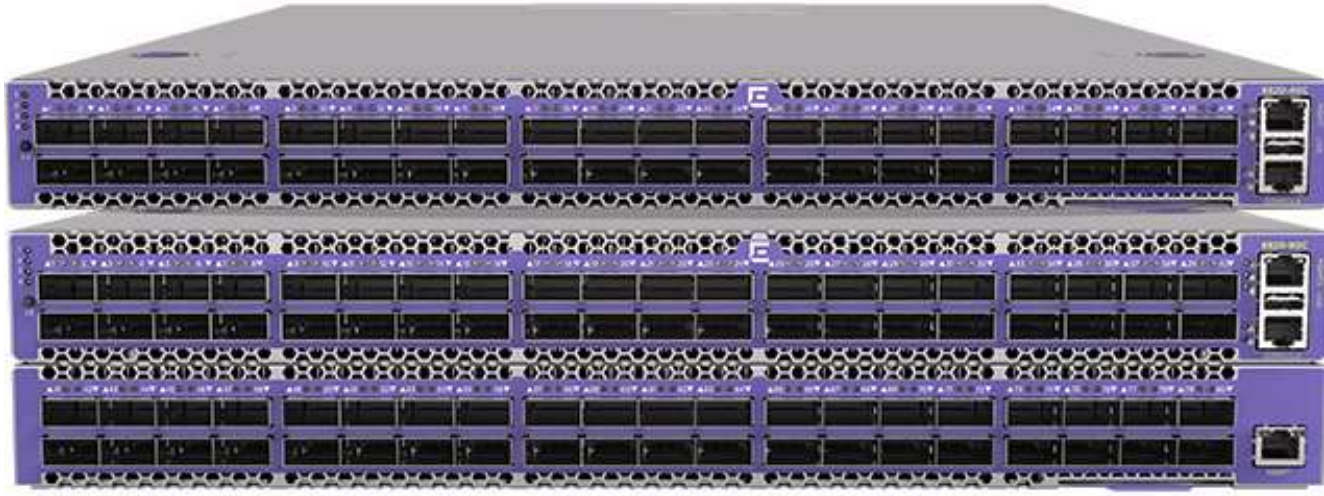
Wireless Access Points

- Devices connect to Wireless Access Points (Thanks, Cardi B for ruining that Acronym).
- These effectively work as switches for wireless traffic
- Devices will choose which AP to connect to based on signal strength.
- When a device connects, it's credentials are sent to a radius server. The server has 3 functions:
  - Authentication – Check credentials
  - Authorisation – Assign level of access (VLAN, Access, IP info)
  - Accounting – Log the session

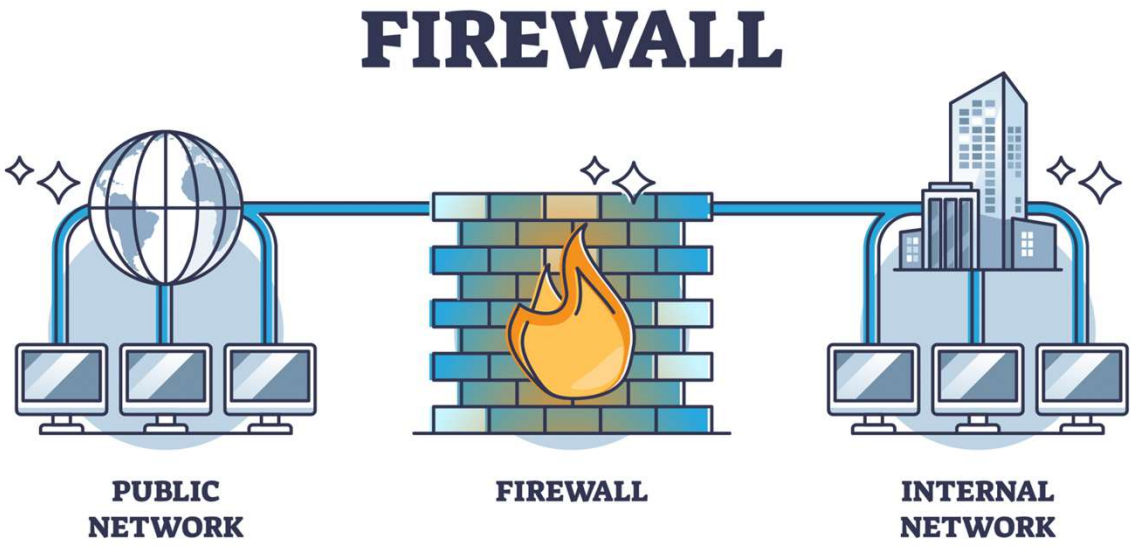


Routers

- Layer 3 device
- The Gateway for a network
- Uses routing protocols to forward packets to external networks
  - Can be static or usually dynamic
  - Examples of dynamic are: OSFP,BGP,RIP
  - Classic best path problem, OSFP uses shortest path first, BGP communicates with other routers using BGP to figure out the shortest path.

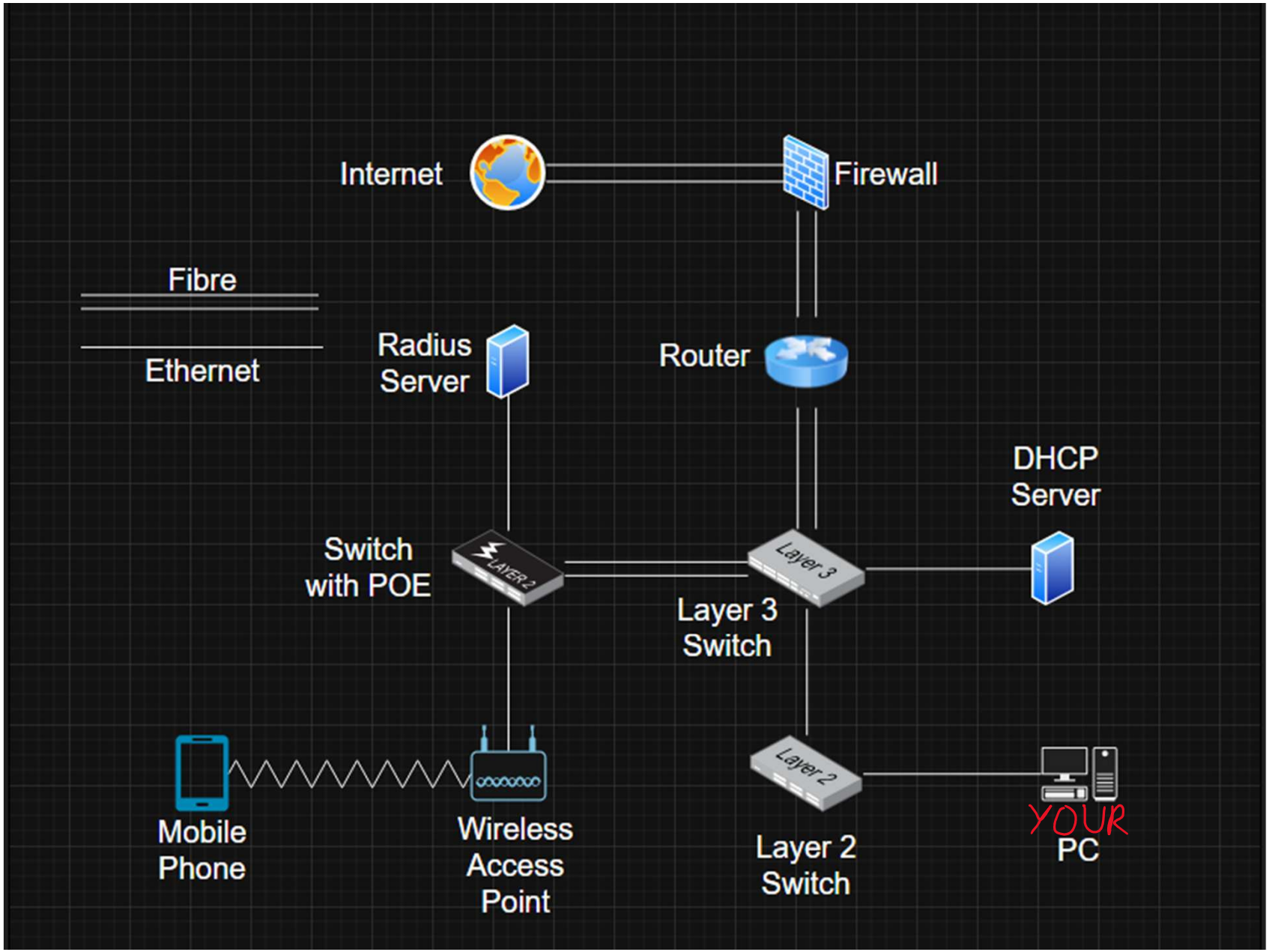


Firewalls

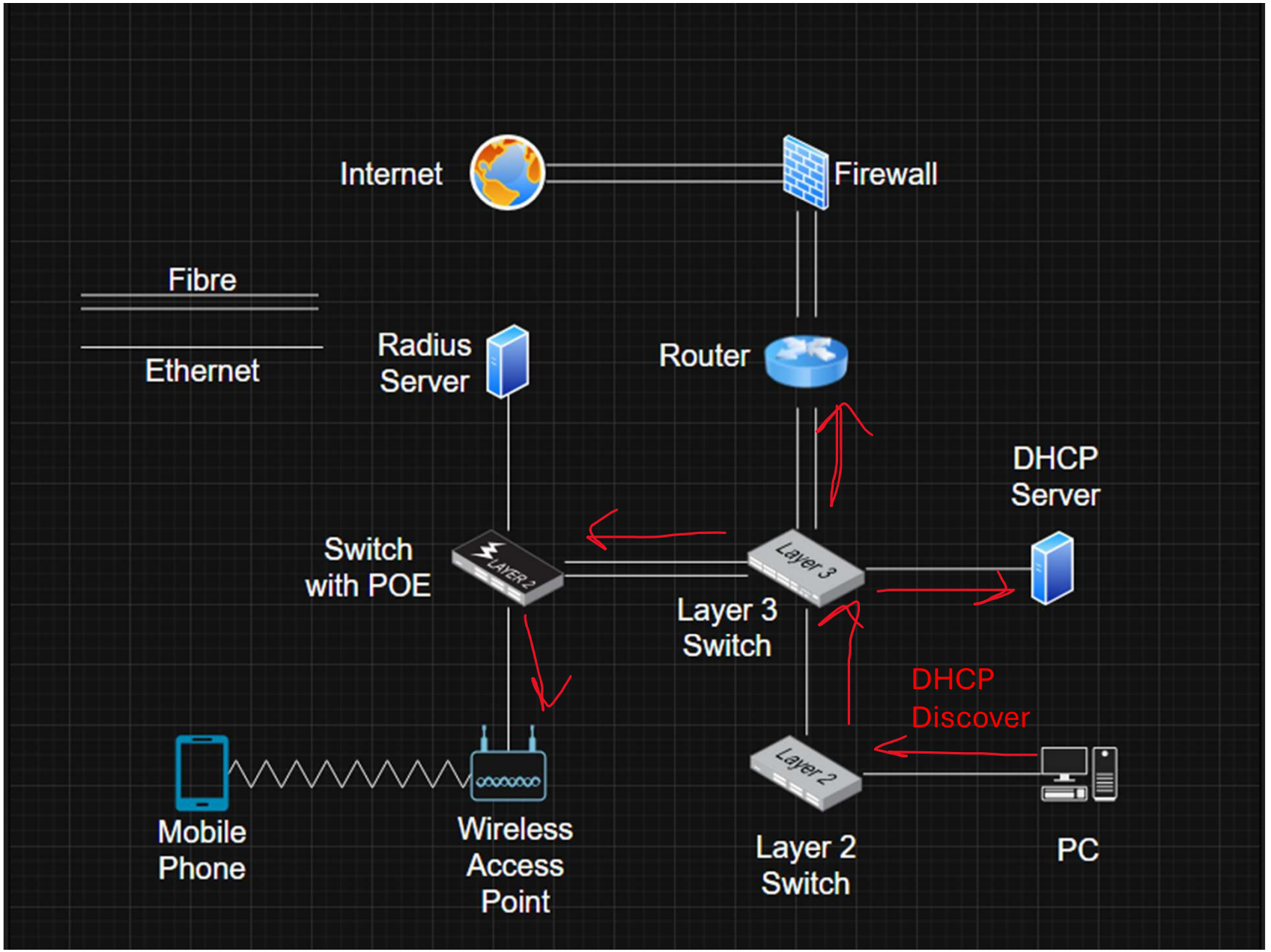


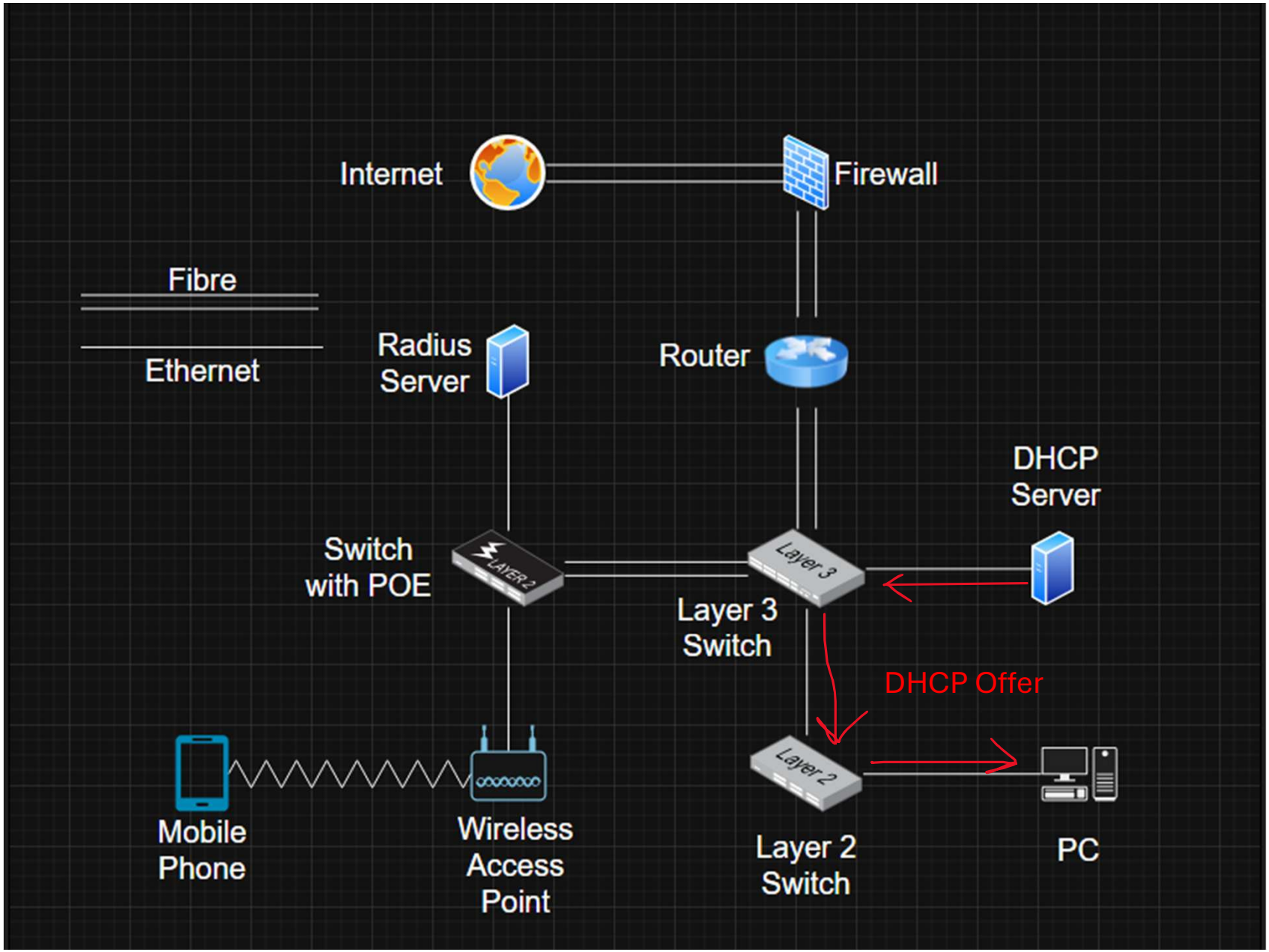
- The standard security device
- Tools the Firewall has:
  - Access Control List: Dennies or Allows communication based on source and destination IP.
  - Packet Scanning: scans the data in packets for known malicious data.
  - Application Control: Blocks or restricts access to applications

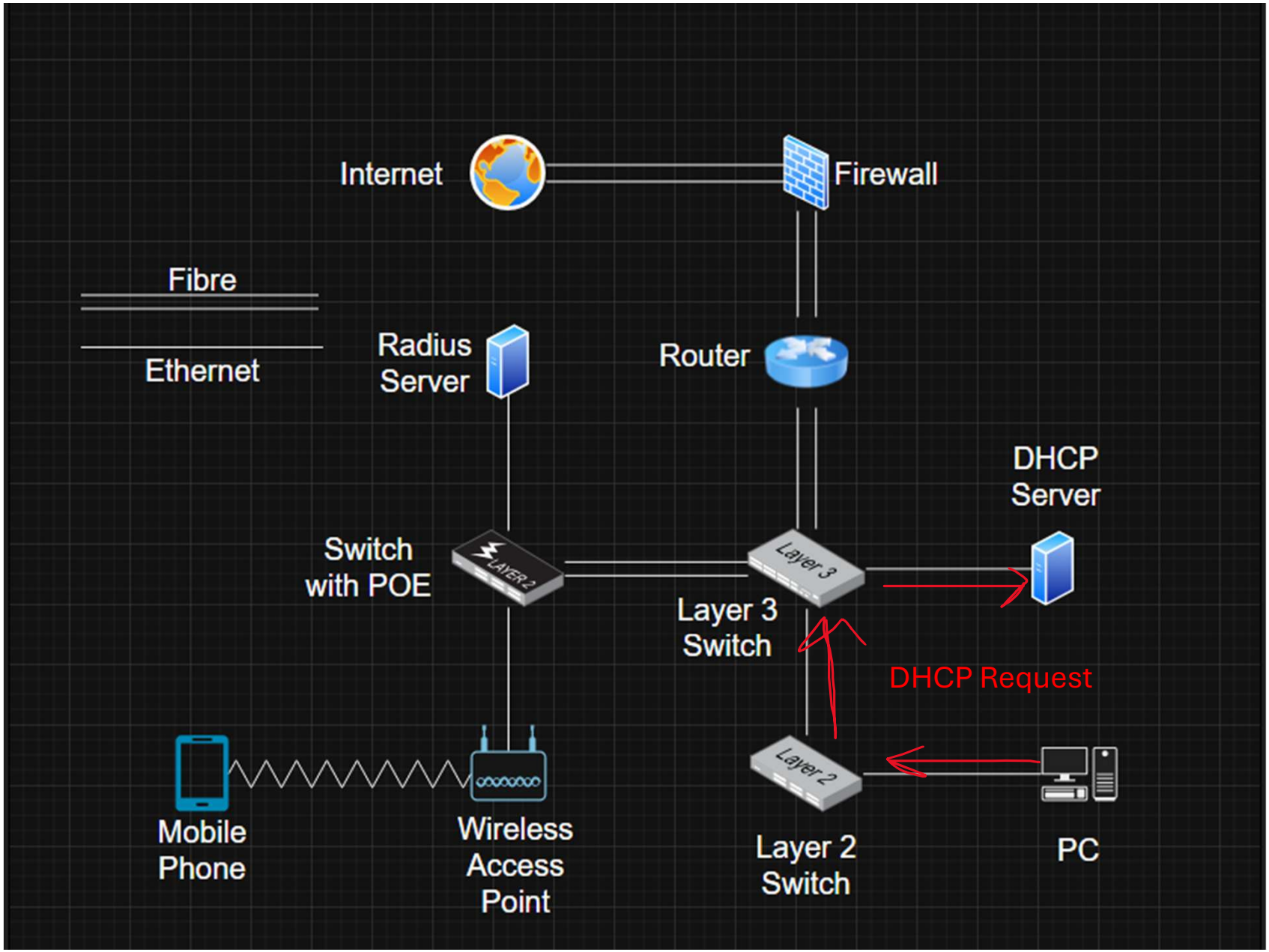
So… you want to connect to the Internet

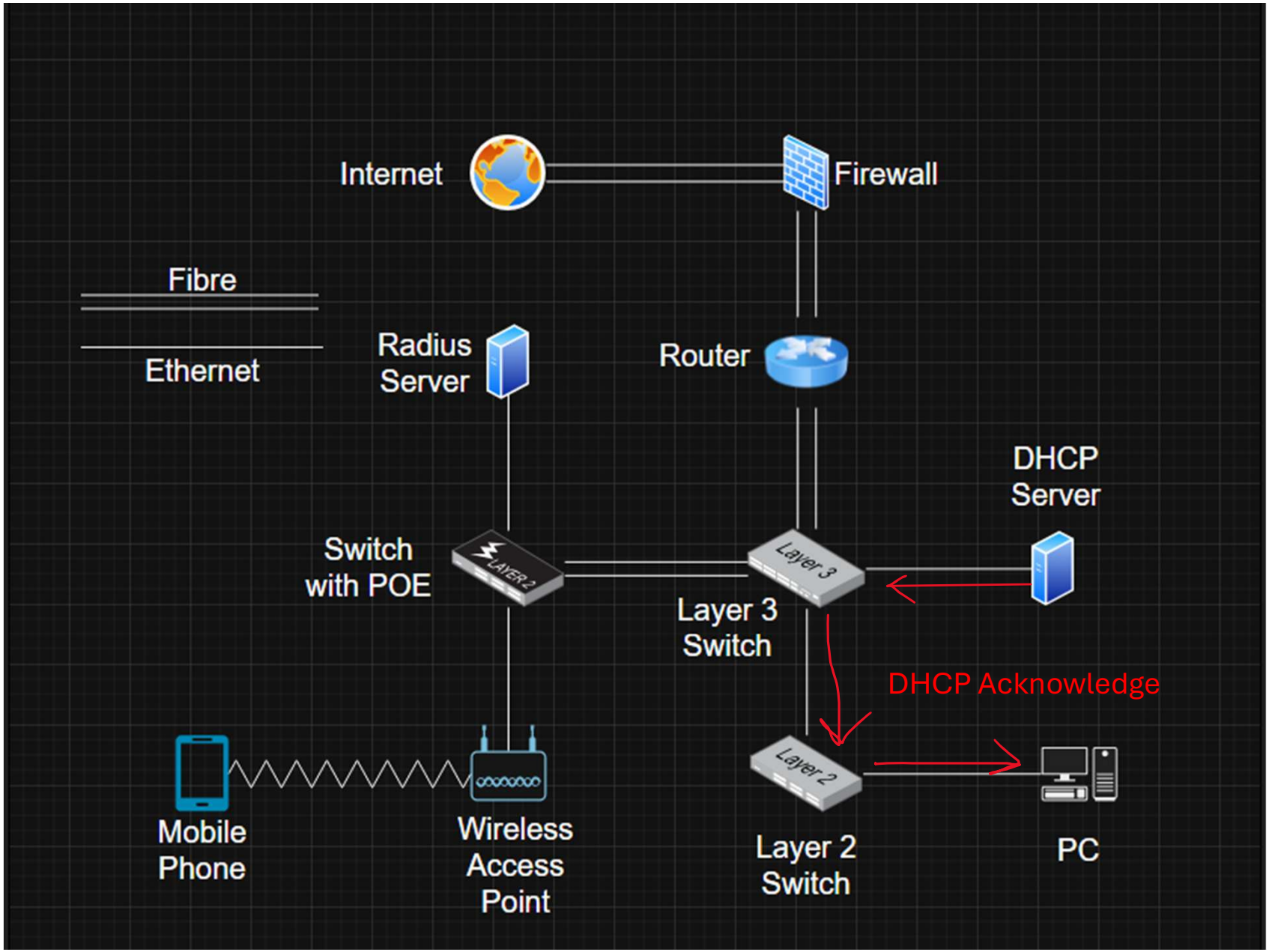

Internet
Firewall
Fibre
Ethernet
Radius Server
Router
DHCP Server
Switch with POE
LAYER 2
Layer 3
Layer 3 Switch
Mobile Phone
Wireless Access Point
Layer 2
Layer 2 Switch
YOUR
PC

Well, first we need an Ip address
Let's do DHCP

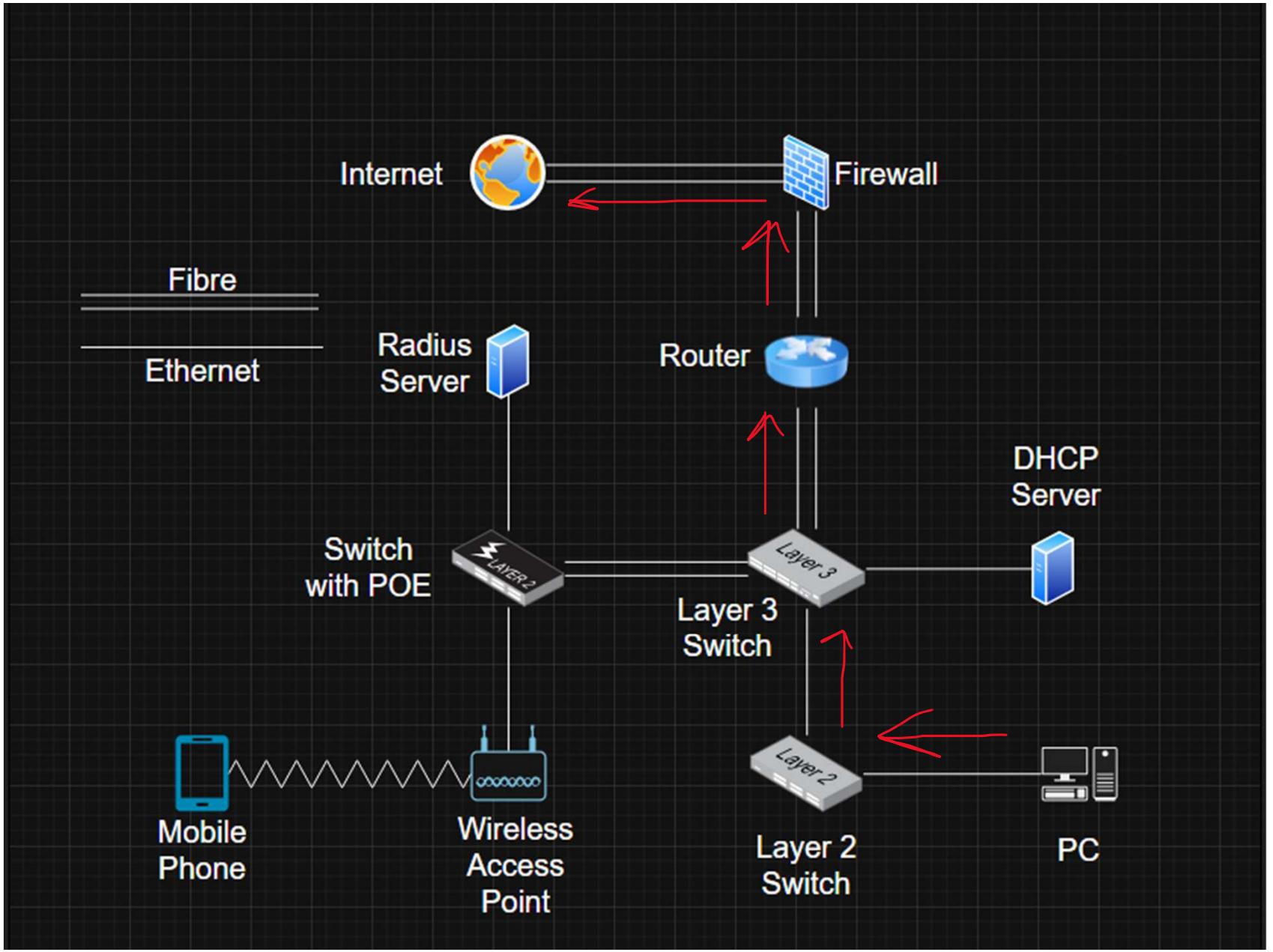

Internet
Firewall
Fibre
Ethernet
Radius Server
Router
DHCP Server
Switch with POE
LAYER 2
Layer 3
Layer 3 Switch
DHCP Discover
Mobile Phone
Wireless Access Point
Layer 2
Layer 2 Switch
PC

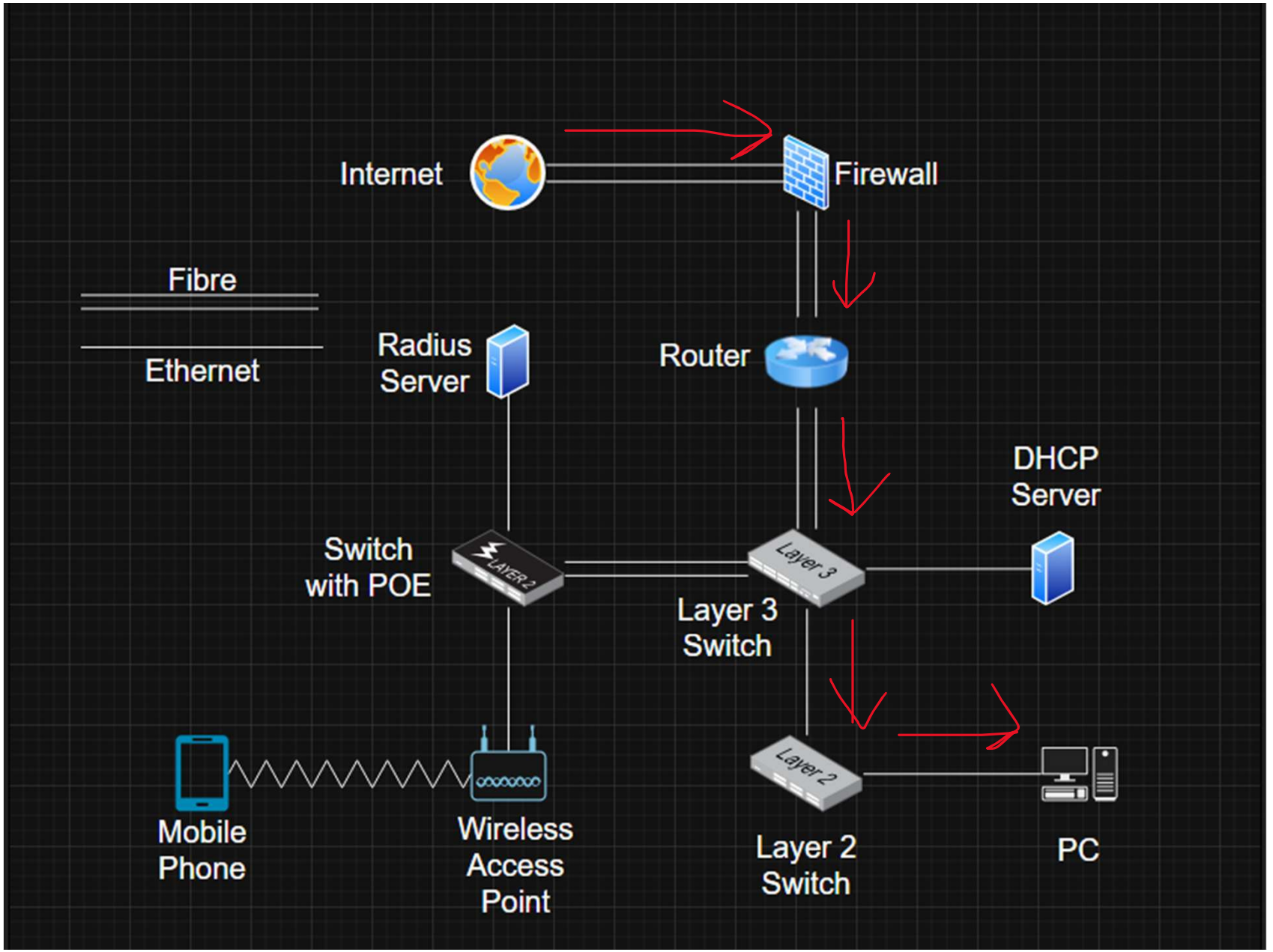

Internet
Firewall
Fibre
Ethernet
Radius Server
Router
DHCP Server
Switch with POE
LAYER 2
Layer 3
Layer 3 Switch
DHCP Offer
Layer 2
Mobile Phone
Wireless Access Point
Layer 2 Switch
PC


Internet
Firewall
Fibre
Ethernet
Radius Server
Router
DHCP Server
Switch with POE
Layer 3 Switch
DHCP Request
Mobile Phone
Wireless Access Point
Layer 2 Switch
PC

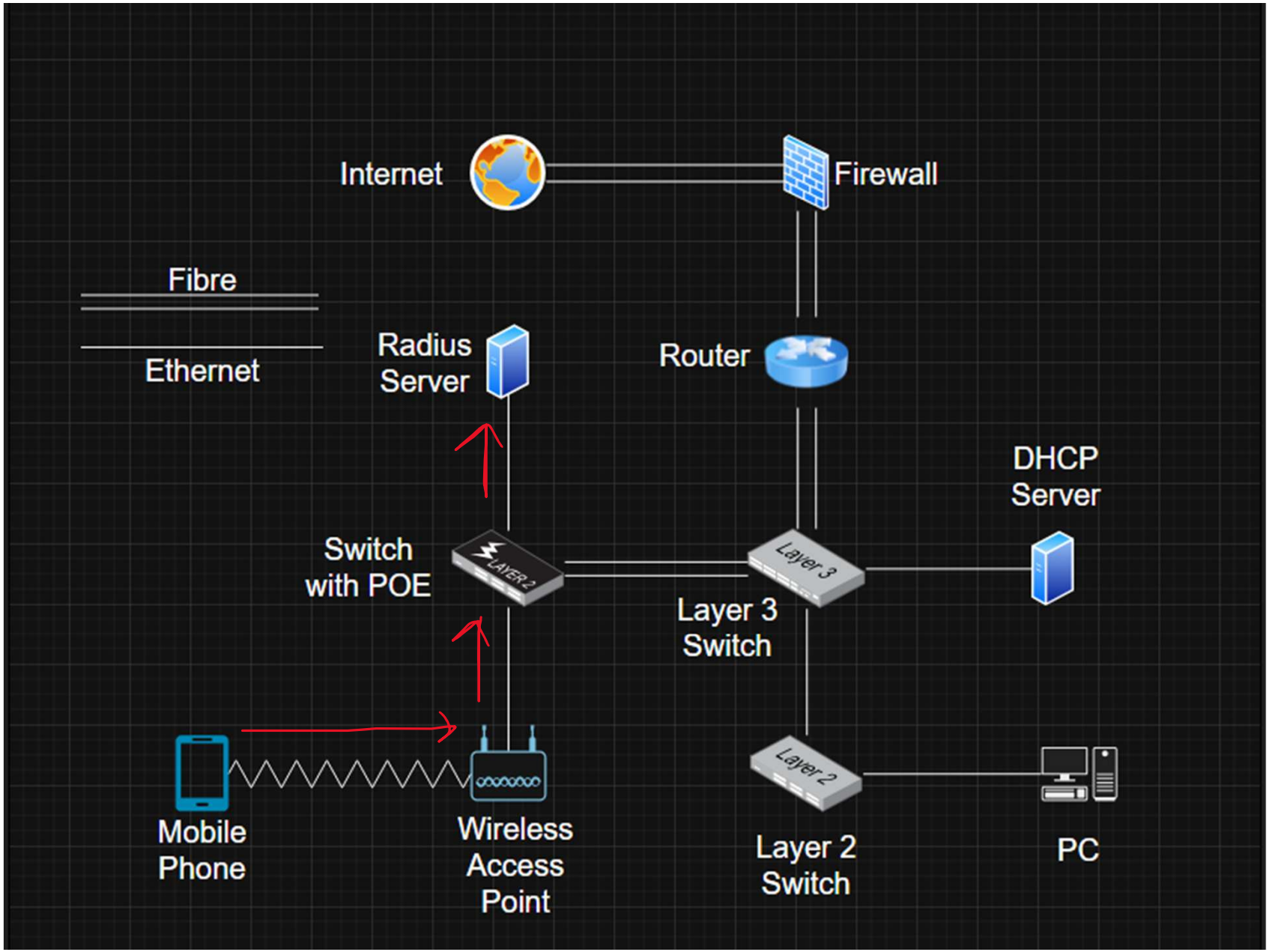

Internet
Firewall
Fibre
Ethernet
Radius Server
Router
DHCP Server
Switch with POE
LAYER 2
Layer 3
Layer 3 Switch
DHCP Acknowledge
Mobile Phone
Wireless Access Point
Layer 2
Layer 2 Switch
PC

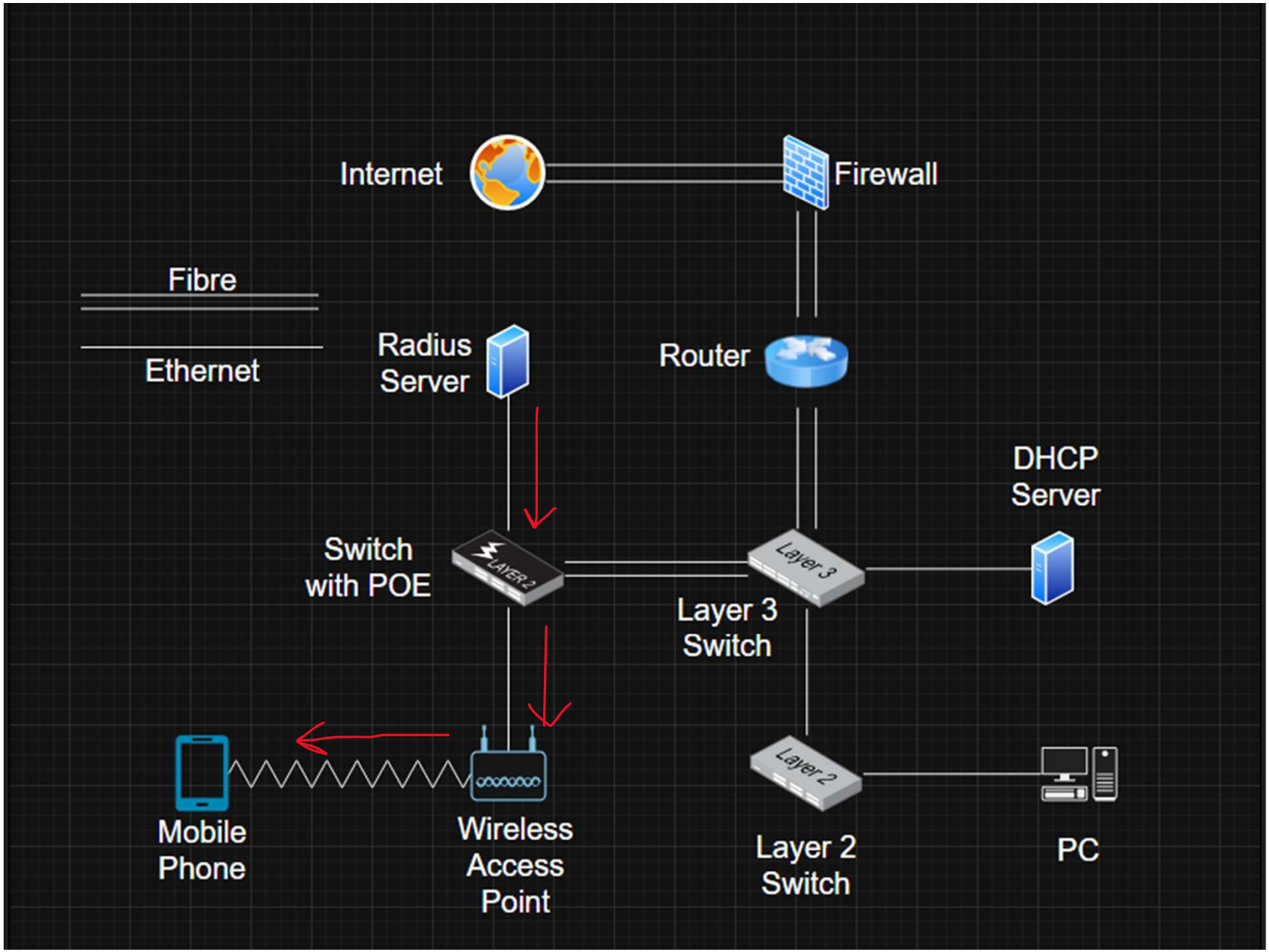
Great, we have an Ip lets try to reach Google


Internet
Firewall
Fibre
Ethernet
Radius Server
Router
DHCP Server
Switch with POE
LAYER 2
Layer 3
Layer 3 Switch
Mobile Phone
Wireless Access Point
Layer 2
Layer 2 Switch
PC

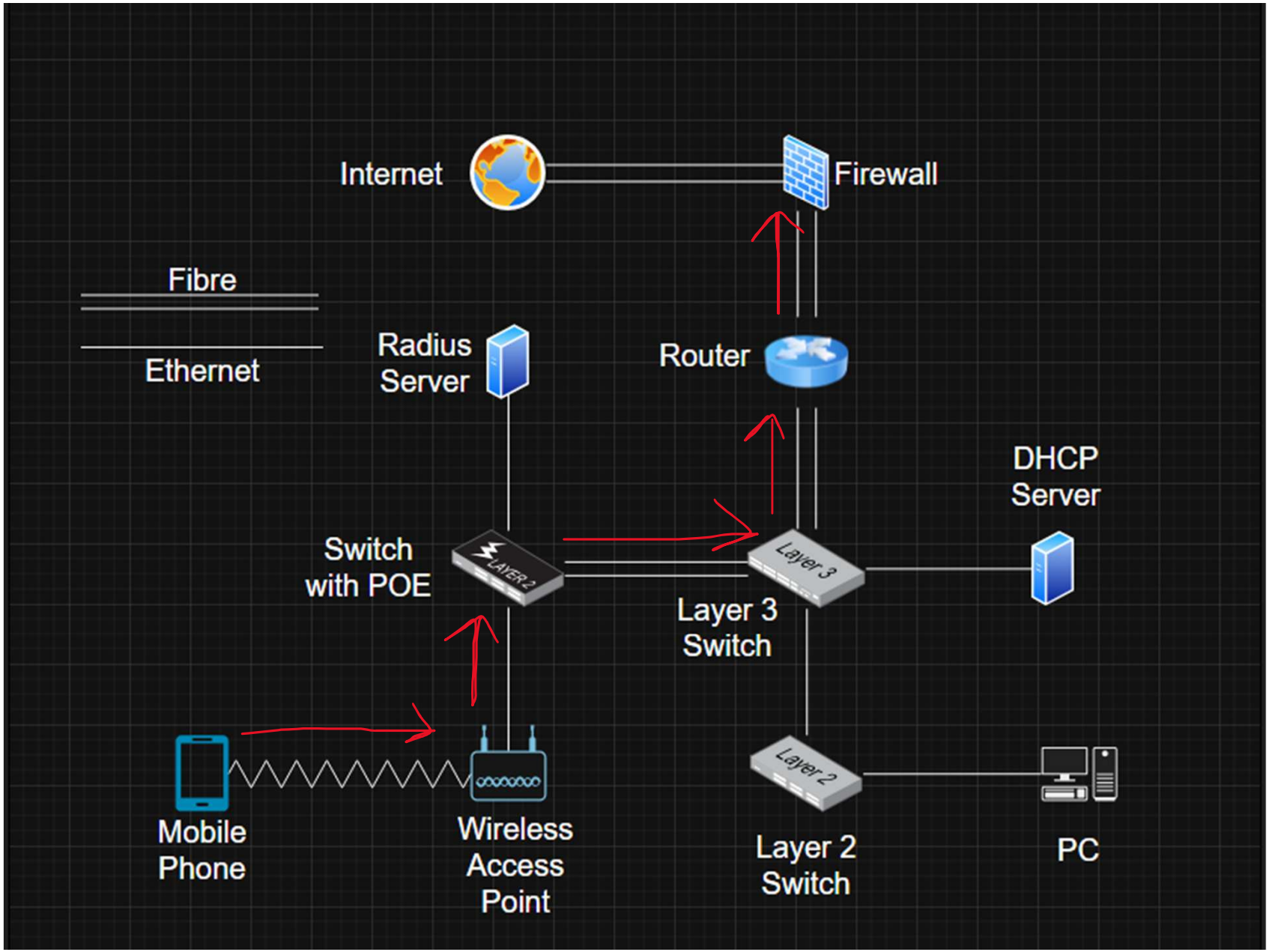

Internet
Firewall
Fibre
Ethernet
Radius Server
Router
DHCP Server
Switch with POE
LAYER 2
Layer 3
Layer 3 Switch
Mobile Phone
Wireless Access Point
Layer 2
Layer 2 Switch
PC

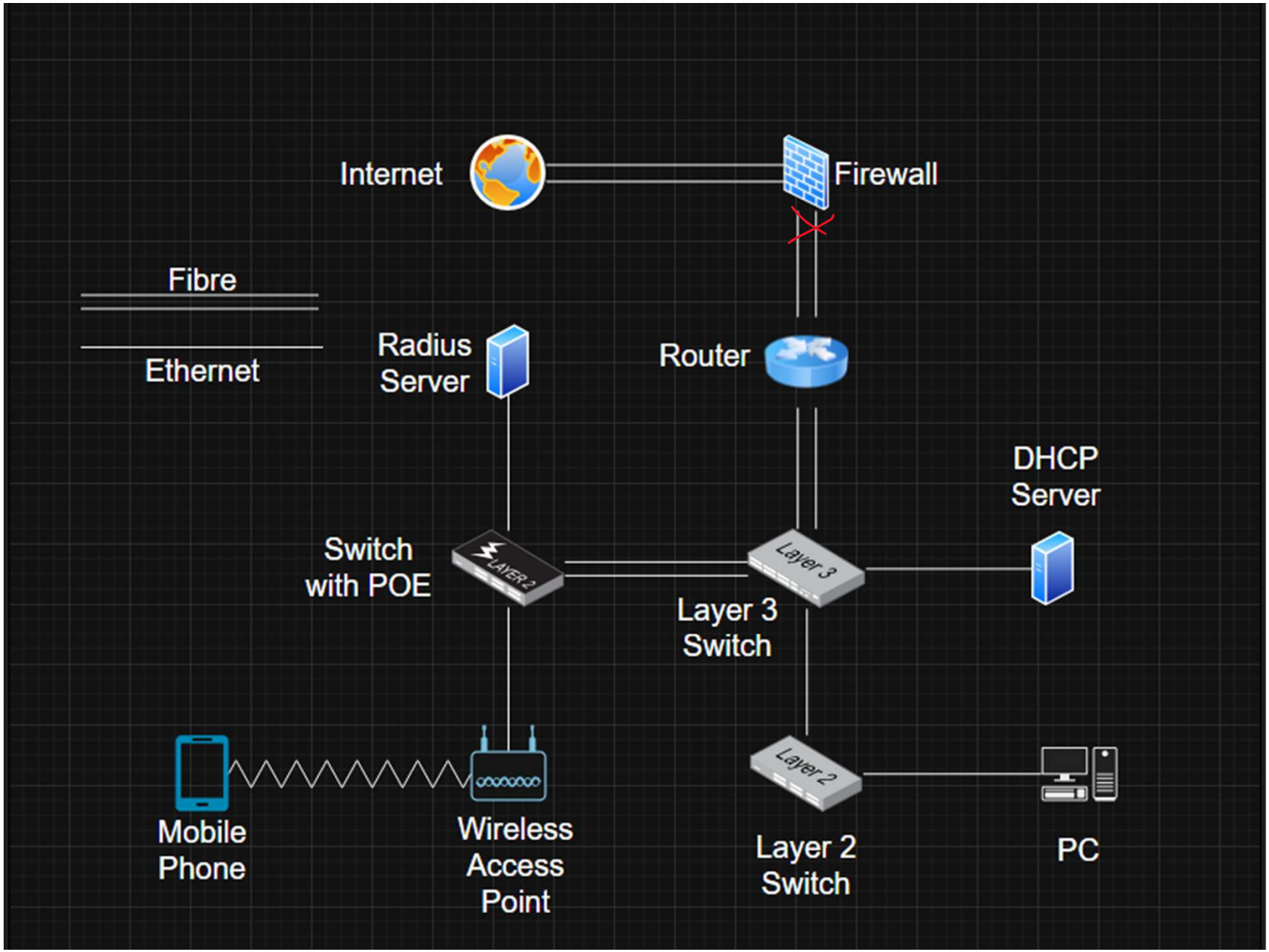
What about your phone?


Internet
Firewall
Fibre
Ethernet
Radius Server
Router
DHCP Server
Switch with POE
LAYER 2
Layer 3
Layer 3 Switch
Mobile Phone
Wireless Access Point
Layer 2
Layer 2 Switch
PC


Internet
Firewall
Fibre
Ethernet
Radius Server
Router
DHCP Server
Switch with POE
LAYER 2
Layer 3
Layer 3 Switch
Mobile Phone
Wireless Access Point
Layer 2
Layer 2 Switch
PC

You want to access something on your pc from your phone?


Internet
Firewall
Fibre
Ethernet
Radius Server
Router
DHCP Server
Switch with POE
LAYER 2
Layer 3
Layer 3 Switch
Mobile Phone
Wireless Access Point
Layer 2
Layer 2 Switch
PC


Internet
Firewall
Fibre
Ethernet
Radius Server
Router
DHCP Server
Switch with POE
LAYER 2
Layer 3
Layer 3 Switch
Mobile Phone
Wireless Access Point
Layer 2
Layer 2 Switch
PC

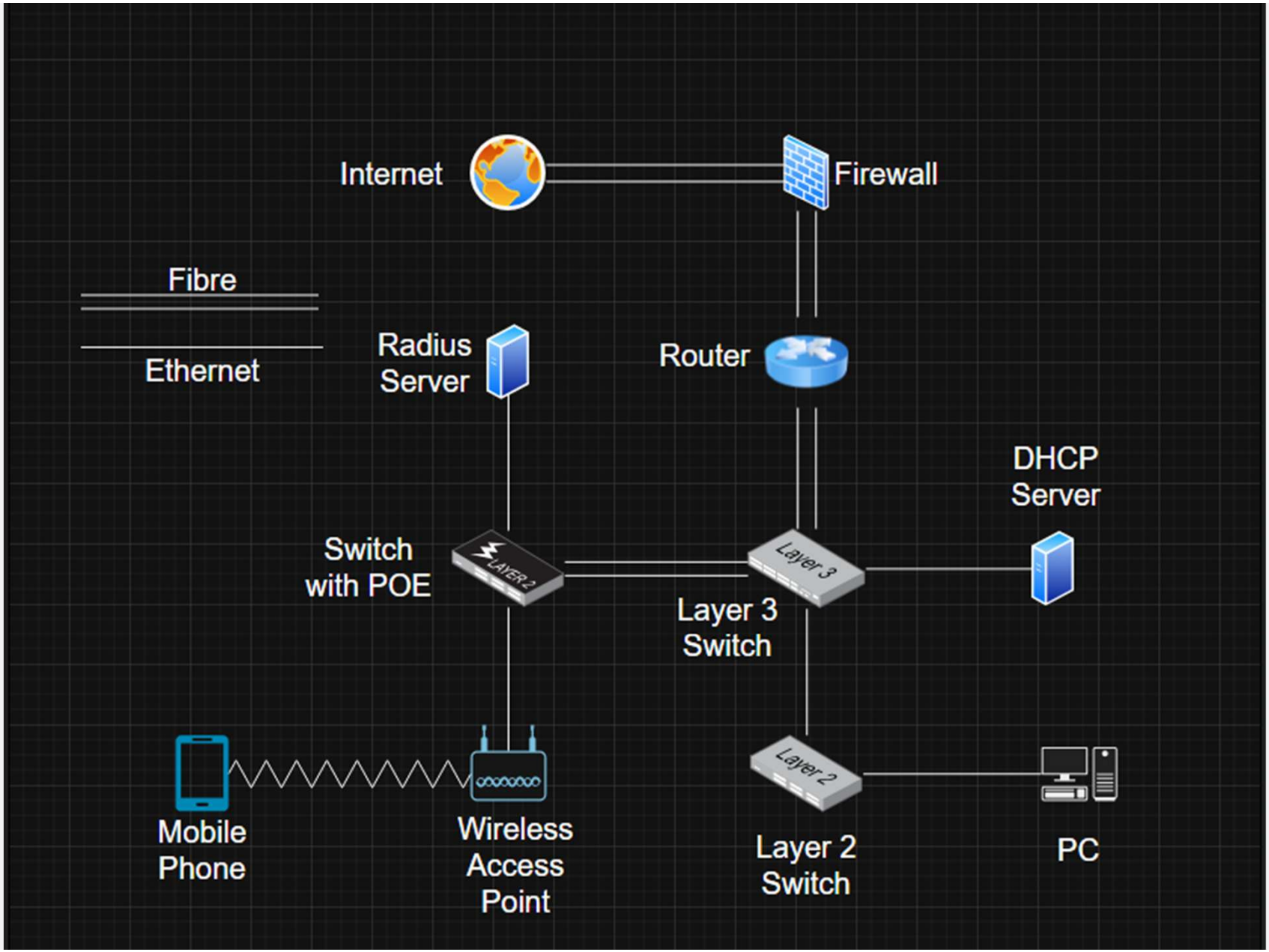
Science and Technology Facilities Council

Thank you

X:
@STFC_matters

LinkedIn:
STFC

YouTube:
SciTechUK


Internet
Firewall
Fibre
Ethernet
Radius Server
Router
DHCP Server
Switch with POE
LAYER 2
Layer 3
Layer 3 Switch
Mobile Phone
Wireless Access Point
Layer 2
Layer 2 Switch
PC