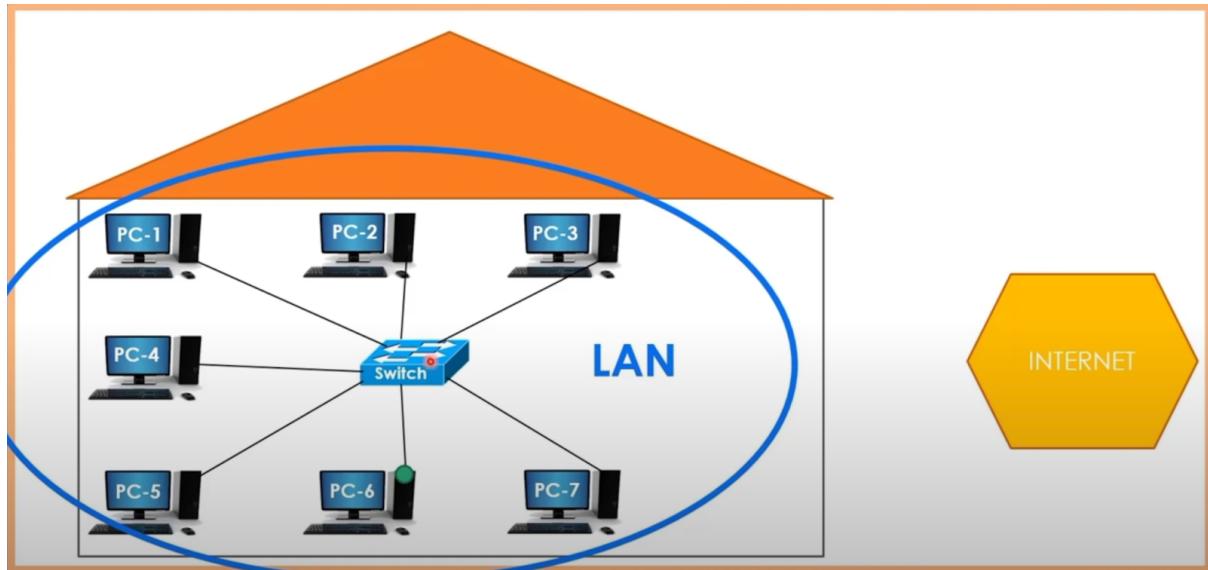


# How does the internet work? (Full Course) Summary

Source: <https://youtu.be/zN8YNNHcaZc>

## What is the switch and why do we need it?



Switch : device we use for computers in the same environment(office, house, or at close distance to each other) to communicate with each other.

We use cables to connect all the computers to the switch. Generally we use a copper cable(구리 케이블) or fiber-optic cable(광케이블).

We always use cables to connect computers to the switch. A **switch cannot use wireless technology**. If we want to use wireless technology, we can use an access point device instead of a switch device.

Access Point Device => wireless

Switch => cable

switch나 access point device로 연결된 컴퓨터들은 network를 생성함. 이것을 LAN(Local Area Network)이라고 부름. LAN을 생성하기 위해서 컴퓨터들은 물리적으로 가까운 위치에 있어야 한다. 각각 미국과 러시아에 있는 컴퓨터를 LAN으로 연결할 수 없다.

The messages generated by computers are called a Packet (or Frame).

If a computer can send a packet to another computer => these two computers are on the same network and they can communicate with each other.



(8-ports Switch)

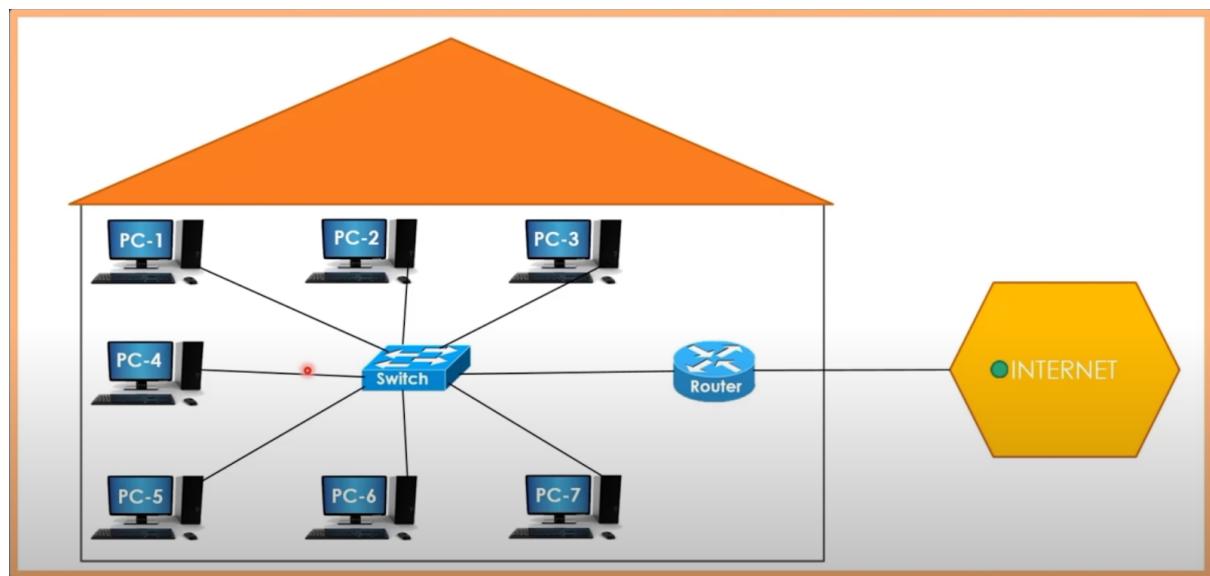
This is what a switch actually looks like. In general, the higher the number of the ports, the higher the price. These ports are called LAN ports.

How exactly does this communication (between computer and switch) happen?

컴퓨터 A가 컴퓨터 B와 communicate한다고 하자. 컴퓨터 A가 B에게 packet을 전송한다.

1. 컴퓨터 A에서 switch로 cable을 따라 packet이 이동.
2. switch 내부의 하드웨어로 packet이 이동.
3. switch가 packet 내부를 들여다보고 destination(컴퓨터 B)을 파악.
4. switch가 컴퓨터 B로 packet을 보냄.

## What is the router?



Router의 메인 task는 컴퓨터를 인터넷에 연결하는 것. Router 없이는 컴퓨터를 인터넷에 연결할 수 없다.

Switch - (cable) - Router - (special cable) - Internet

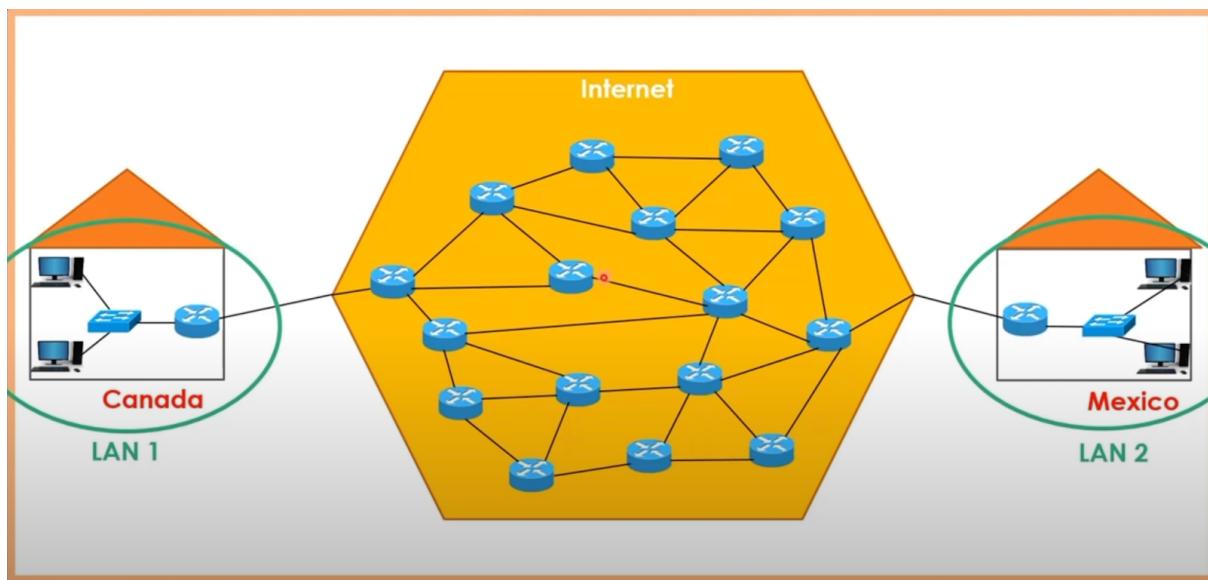
router와 internet을 연결하는 cable은 ISP(Internet Service Provider)에서 구매해야 한다.  
switch와 router를 연결하는 cable은 주로 copper cable이다.

같은 LAN의 컴퓨터끼리 통신하는데에는 router가 필요하지 않다. switch나 access point device로 충분하다.

If a computer can send packets to the internet, this means that this computer can connect to the internet without any problem.

컴퓨터가 인터넷에 연결되기 위해서는 router가 반드시 필요하다. 컴퓨터가 router에 연결되기 위해서는 switch를 거쳐야만 한다.

## What does the internet represent (Part-1, 2)?



A router is the device we use to communicate with the computer in different LANs.

Internet : the structure that connects almost all the LANs in the world.

Internet은 많은 router와 다른 device들로 구성되어 있다.

## Home-router



Combo device that is a mixture of router and switch. Most home-routers nowadays also have an access point feature. In this way, you can use wireless technology as well if you want.

LAN을 구성할 때 두 개의 devices(switch, router)가 아닌 한 개의 device(home-router)만 사용할 수 있다.

하나의 home-router는 작은 environment(집, 작은 오피스) 등에서 사용하기에 충분하다. 그러나 environment에 device가 매우 많다면, 우리는 switch와 router를 분리된 device로 사용해야 한다.

## Why are there so many routers instead of a single router?

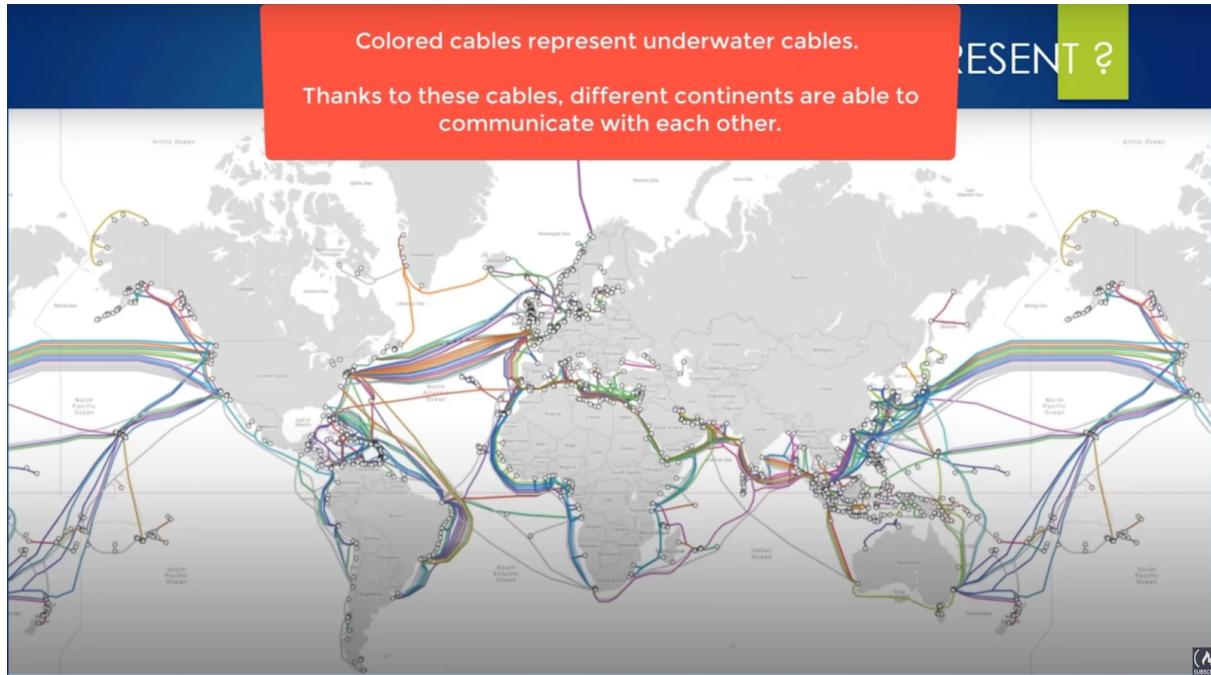
왜 인터넷에는 router가 많을까? 왜 하나의 router만을 사용해서는 안될까?

세 가지 문제가 있다:

- Load Balancing: 하나의 router만을 사용하면, 인터넷에 연결되는 모든 device를 하나의 router에 연결해야 하고, 이렇게 많은 device를 연결하는 router를 설계하는 것은 불가능하다.
- Single Point of a Failure: 모든 load를 single point(하나의 router)에 부과해서는 안된다. 이를 ‘Single Point of Failure’라 한다. 모든 load가 부과된 하나의 router가 고장난 상황을 생각해보자. 하나의 router가 고장난 결과로 전체 internet을 사용할 수 없게 된다.
- 하나의 거대한 router에 모든 LAN을 연결하기 위해서는 어마어마하게 긴 cable이 필요하다.

따라서 internet을 구성하기 위해 하나의 router만을 사용하는 것은 매우 problematic한 design이고, 이 모든 문제의 해결 방안은 많은 router를 distributed structure로 사용하는 것이다.

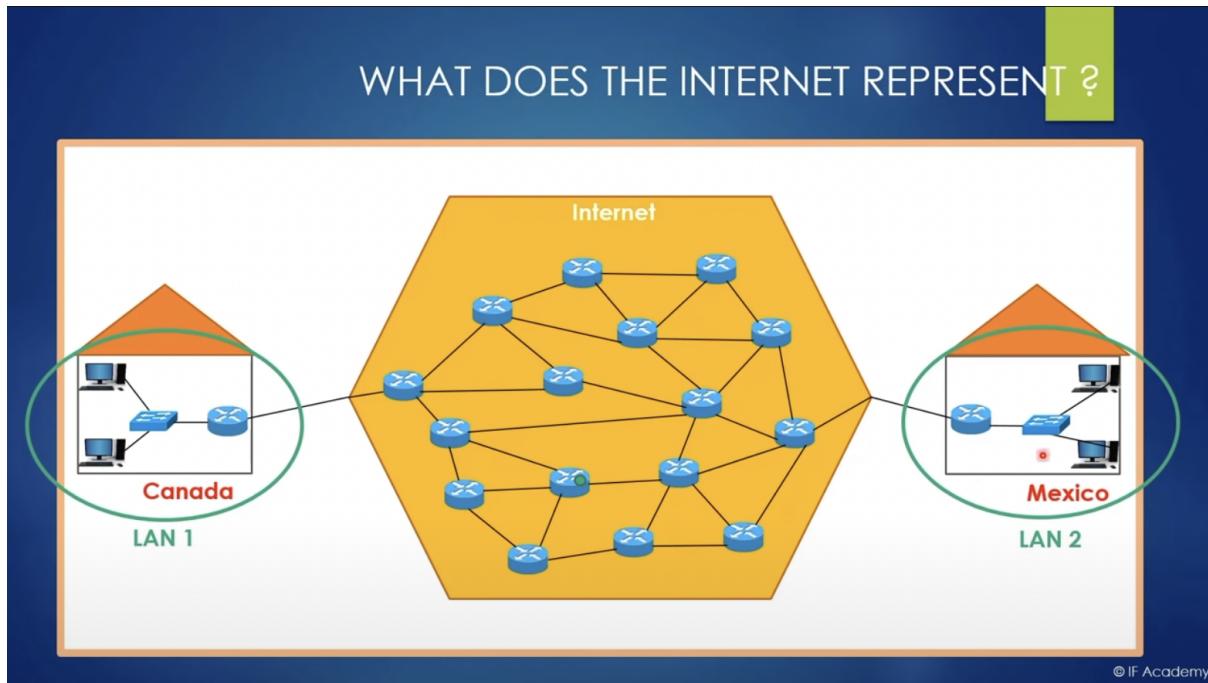
- 여러 개의 router를 사용하면, 하나의 router를 사용할 때에 비해 overloading을 피할 수 있다. 또한 cable mess도 적어진다.
- 하나 또는 여러 개의 router가 고장나더라도 여전히 전체 internet은 연결될 수 있다.
- 어마어마하게 긴 cable을 사용할 필요가 없다.



이러한 cable 중 하나를 고장내더라도, internet은 매우 잠깐 동안 멈출 뿐이다.

이러한 underwater cable은 모두 fiber-optic cable이다. fiber-optic cable이 가장 빠른 data transmission cable type이기 때문이다. 또한 fiber-optic cable과 달리, copper cable은 길이가 늘어남에 따라 data transmission errors의 확률이 높아지기 때문이다.

## What does the internet represent (Part-3)?



We have to send a packet from LAN 1 to LAN 2.

Each router must have a special table called 'Routing Table'. The Routing Table tells us which route the packet should choose.

Forwarding : The router learns the packet's destination then it looks at the routing table and learns over which port the packet will be sent.

각 router들이 destination에 도착할 때까지 forwarding을 한다.

Routers have special processors inside. These processors create Routing Tables by using special algorithms.

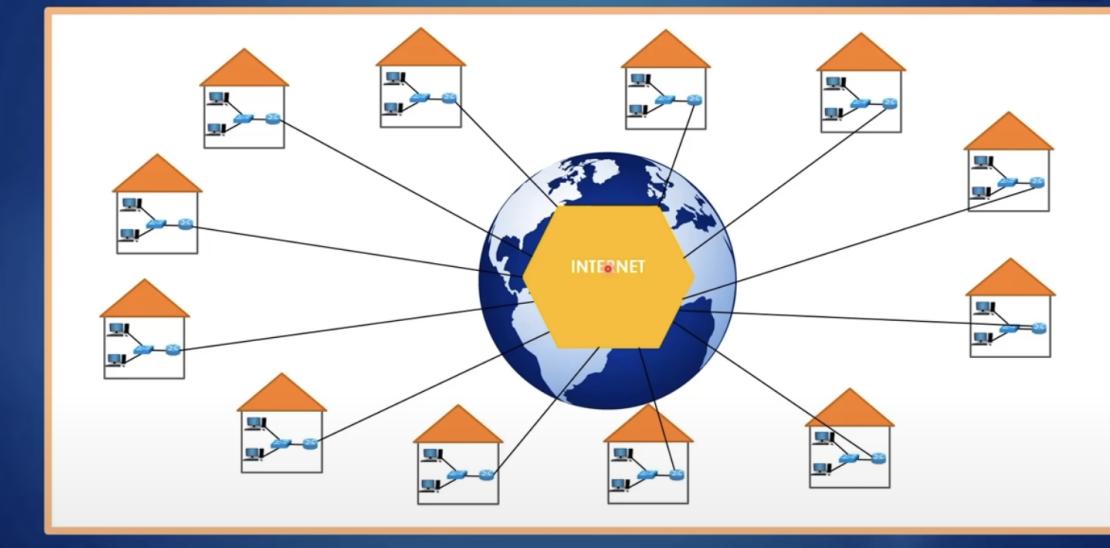
Route Filtering: When a router makes this decision, it always ignores the path that the packet came from. It makes no sense to forward the packet back the way it came from.

A router always wants to deliver the packet to its destination in the fastest way possible.

When routers create their routing tables, they are not only concerned with the number of points in order to choose the shortest route. 따라서 직관적으로 생각되는 shortest route와 다를 수 있다. (예: 하나의 router를 거치는 대신 두 개의 router를 거쳐 destination에 도달하기)

We can communicate in milliseconds with the device on the other side of the world.

## WHAT DOES THE INTERNET REPRESENT ?

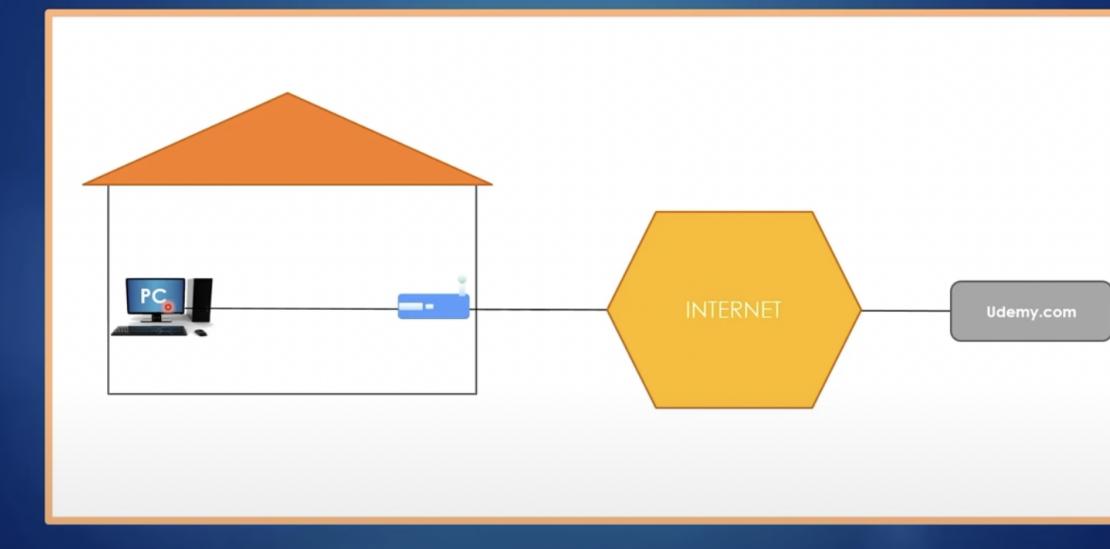


The internet is the network of the networks. There are many small or medium-sized LANs spread all over the world. The combination of all these networks stands for the internet itself.

The internet is a huge system that includes all LANs in the world.

## Connecting to the Internet from a Computer's Perspective

### MEANING OF CONNECTING TO THE INTERNET



The connection situation of the internet is determined by whether the related computer can send a packet to the internet or not.

As soon as you click a video on youtube.com, your computer generates a request packet and sends this packet to youtube.com. The packet firstly sends to its home-router, and then the home-router sends the packet to youtube.com over the internet.

A request message gives information to youtube.com about you wanting to watch the related video. And after youtube.com receives your request message about watching a specific video, Youtube sends the related video to you over the internet.

**Streaming** : When you watch a video on Youtube, Youtube sends the video to you piece by piece. (Why do we use Streaming? Imagine that you wouldn't be able to watch a 1-hour video if you don't download the whole video. This is horrible.)

As a result, connecting to the internet means you can send some packets to the internet and you can receive some packets from the internet. In this situation, the router or home-router plays a very important role. The home-router gives the packets it receives from the computer to the internet. And gives the packets it receives from the internet to the computer.

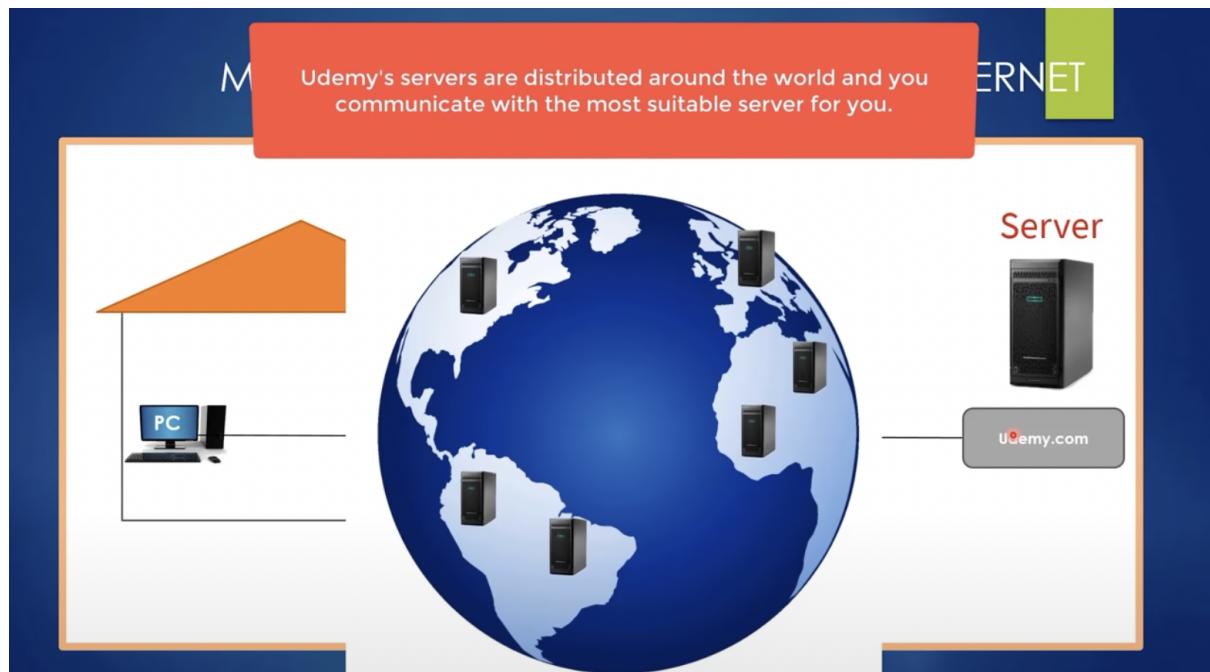
In summary, packet transmission is the basis of connecting to the internet or communicating with a computer on the other side of the world.

## Server

When we enter youtube.com, we communicate with a very powerful computer that actually belongs to youtube.com. We call this special computer server.

Servers do not differ fundamentally from normal computers. However, since the servers will exchange packets with thousands of normal computers at the same time, servers have to be much more powerful than normal computers in terms of hardware.

Single Point of Failure, Load Balancing problems are also important to servers. So usually servers are distributed around the world and you communicate with the most suitable server for you. All these servers have the same information.



## Wide Area Network (WAN)

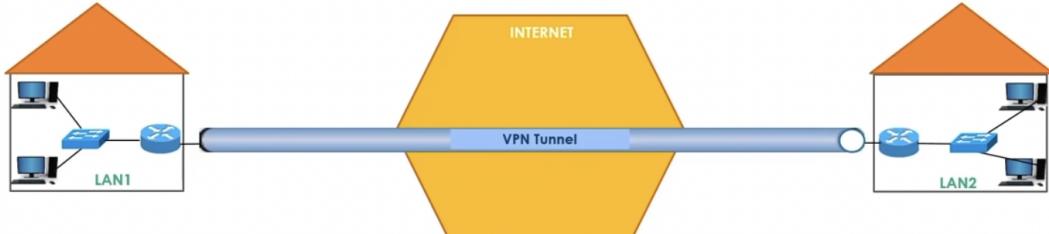
Thanks to WAN, we can ensure that LANs located in different parts of the world communicate as if they were in the same environment.

Thanks to the internet, we can already enable LAN1 and LAN2 to communicate. If offices are already able to communicate over the internet, then why do we need a WAN?  
=> The internet is a public network and everyone owns the internet. There's a security problem. There is always a possibility that a packet on the internet could be seen and modified by others.

There are various methods of setting up a WAN. The most popular and cost effective method is WAN by using VPN. People often use VPN to access restricted websites.

## WIDE AREA NETWORK

The tunneling feature of the VPN provides us privacy, anonymity, and security on the Internet.



The tunneling feature of the VPN provides us privacy, anonymity, and security to us by creating a special network connection over a public network.

VPN tunnel does not represent the transmission of the packet through a physical tunnel. Tunneling just represents high-security communication between two locations.

A packet reaches its destination by passing through many routers, just as you know. But security is maximum thanks to VPN Tunneling.

For VPN Tunneling, encryption is very important. Encryption + Encapsulation. Tunneling is a special encapsulation method. 도착지 LAN의 router에서는 Decapsulation + Decryption.

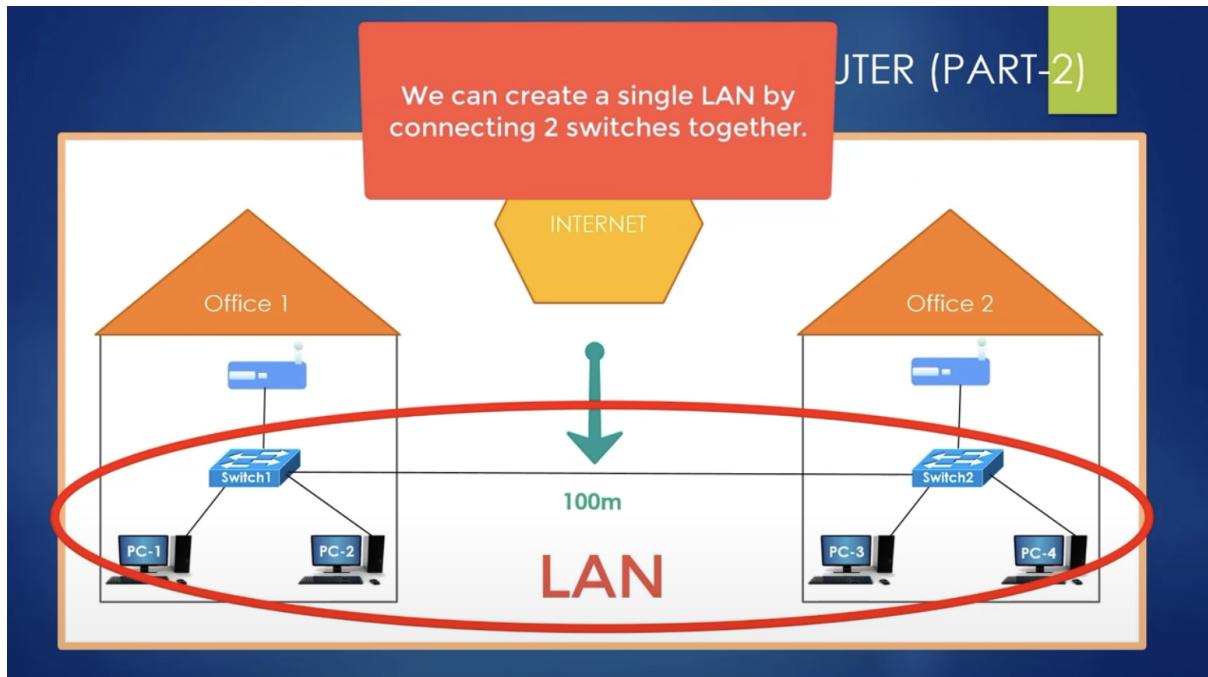
There is no such thing as 100% security. Every system has a vulnerability.

'End to End Encryption' between end-points. End to End Encryption was not used in the past, and malicious users have exploited this vulnerability extensively in the past.

Q: What is the biggest WAN in the world?

A: The Internet itself. But a company's WAN created with VPN is different from the internet.

## What is the Router? (Part-2)



We use switches to create LANs therefore we can create a LAN by connecting these switches to each other even if they are not in the same environment. To create this type of LAN, the distance must be short.

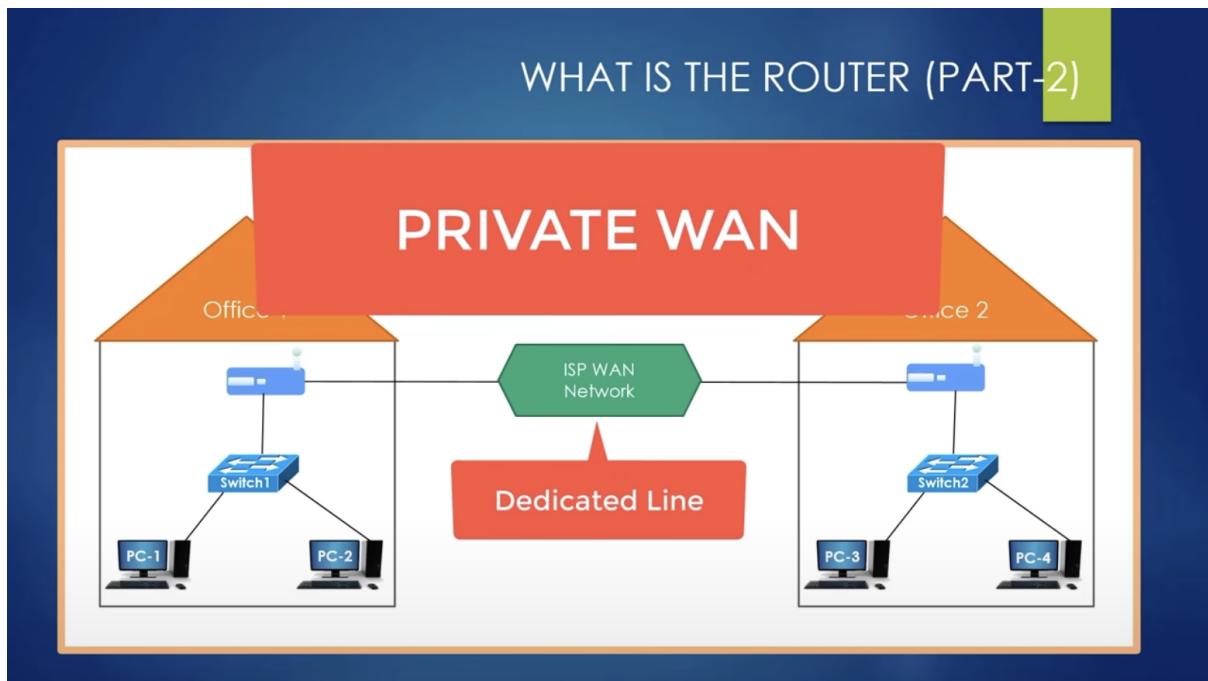
This is a special type of LAN. We called it Campus Area Network (CAN).

WAN and LAN are different kinds of network types.

Q: Which one is more secure? WAN with VPN? or LAN?

A: LAN. Because in LAN, packets never pass over the internet. However there is a condition that a WAN is almost as secure as a LAN. We call private WAN for this type of WAN.

## Private WAN



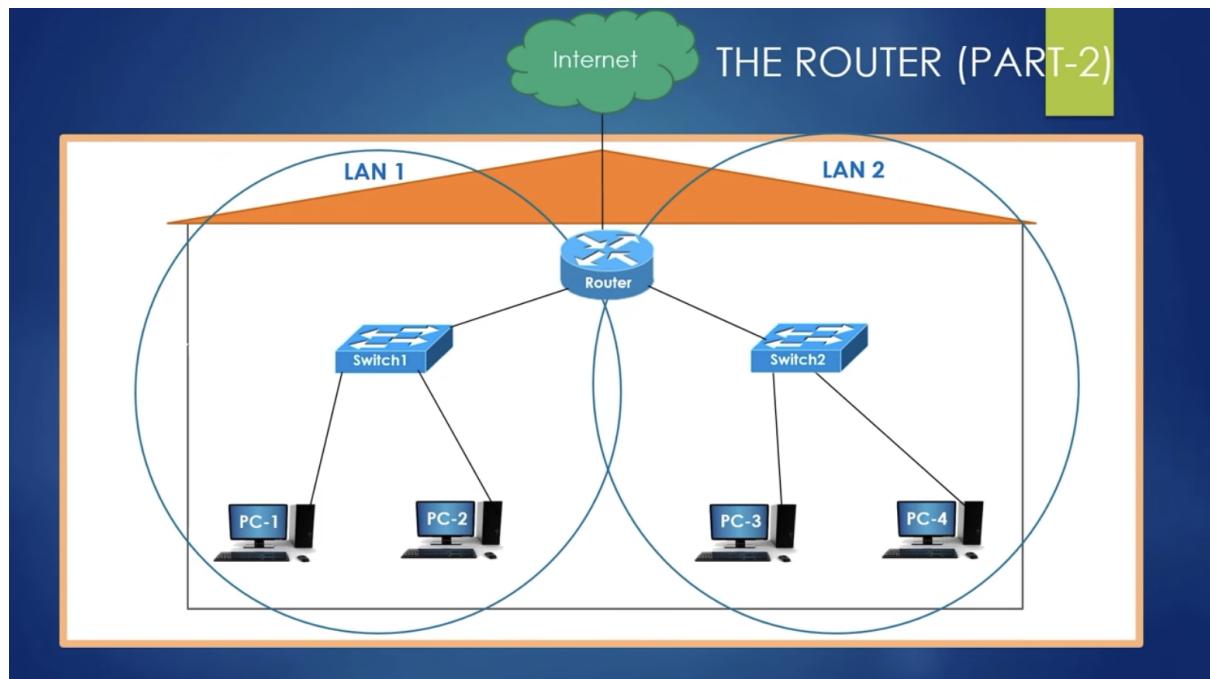
Private WAN is different from WAN with VPN. Private WAN can be quite costly, especially over long distances. Imagine the cost of a 500 km dedicated line.

WAN with VPN uses public internet. But Private WAN don't.

## Router

LAN => Switches / WAN => Routers

We cannot create a WAN using a traditional switch device.



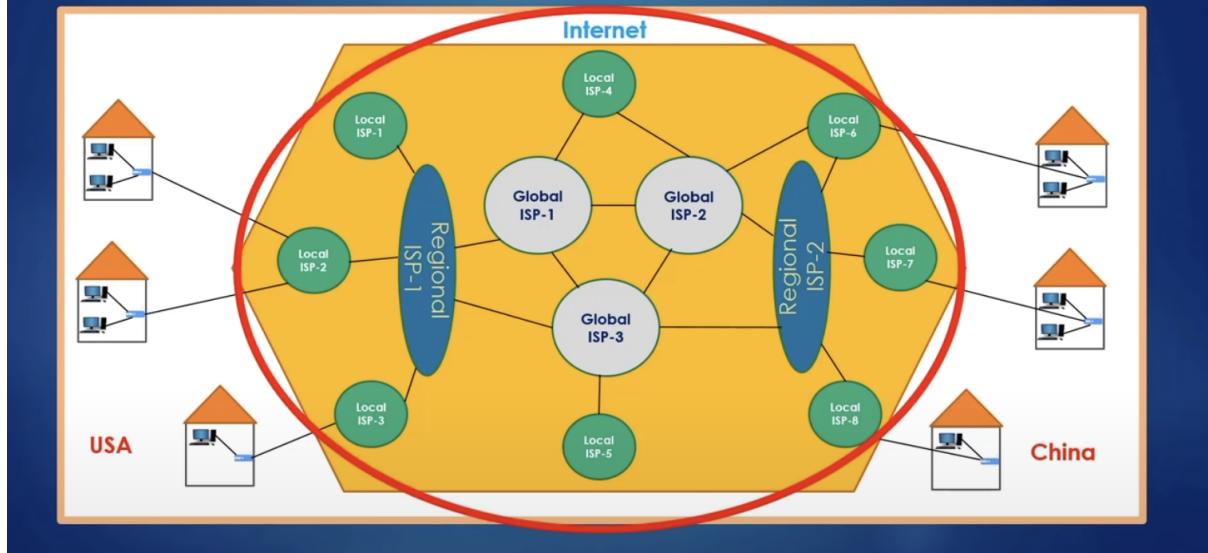
The main task of the router is to connect different networks. The location of these networks does not matter.

Router connects different networks. For this reason, each cable connected to a port on the router represents a different network. Router가 단절점, Router와 연결된 각 케이블이 단절선.

## Internet Service Provider (ISP) - Part1

Internet Service Provider (ISP) is responsible for the transmission of packets from one location to another.

## INTERNET SERVICE PROVIDER (ISP)

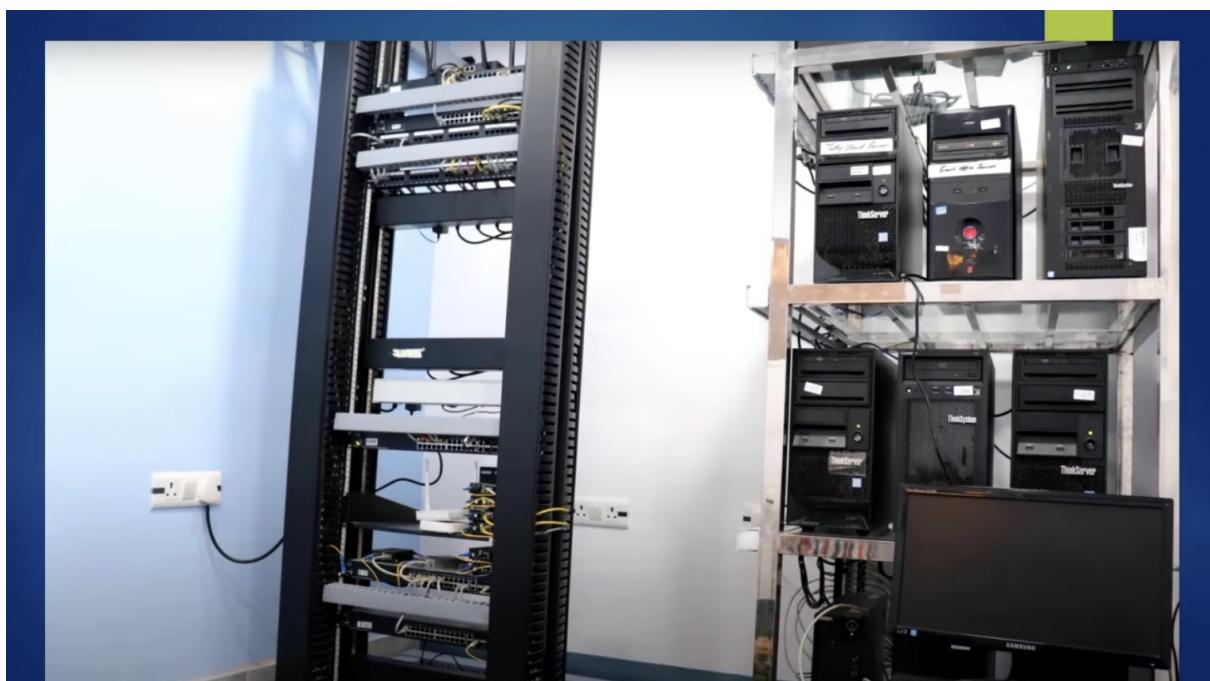


(In the above picture, each ISP is responsible for certain routers)

ISP is the mechanism that controls all these routers in this structure. Each ISP is responsible for specific routers. Certain ISPs are responsible for certain routers.

ISPs represent companies that enable us to connect to the internet for money. There are many ISPs in real life (unlike the picture above).

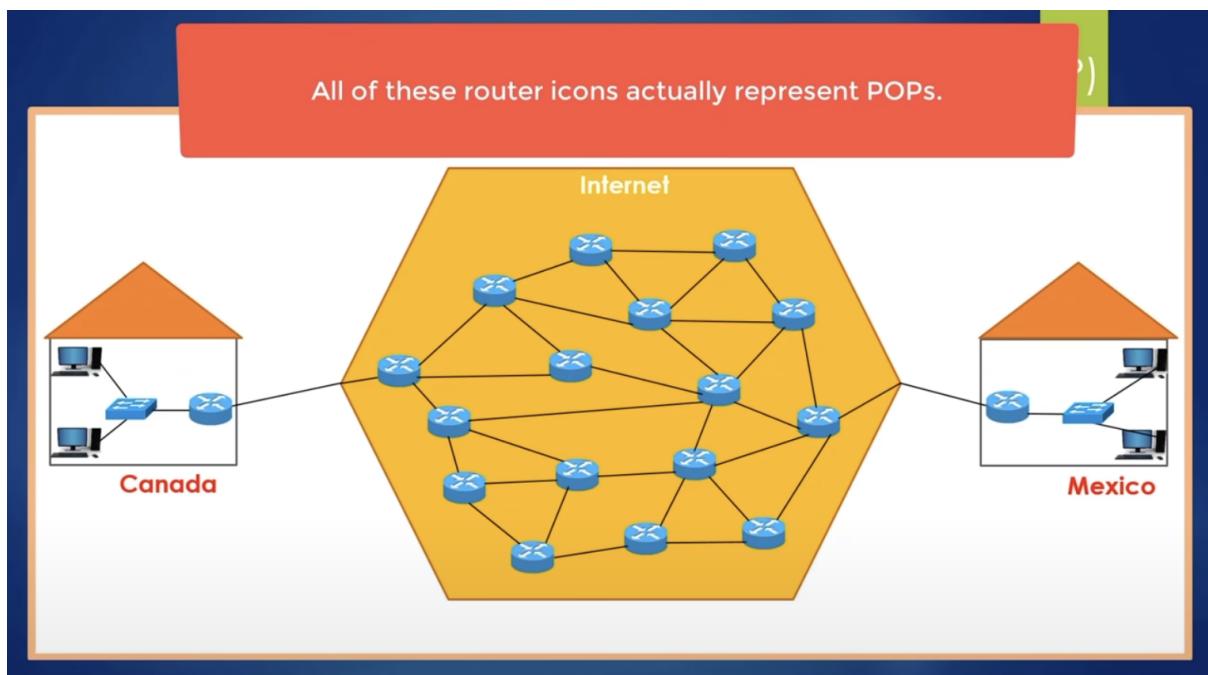
A single router may be sufficient for a local ISP.



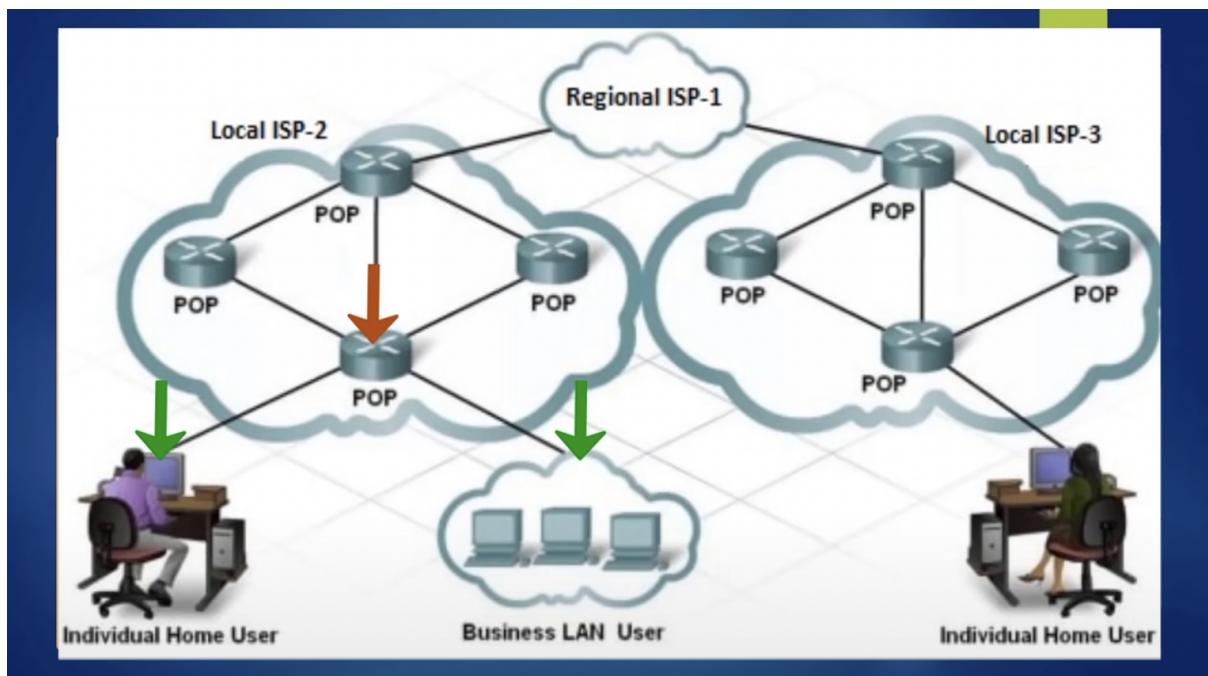
(Example of a small local ISP office)

Point of Presence (POP) : small local ISP offices

In a POP, there can be routers, switches, servers, and so on.



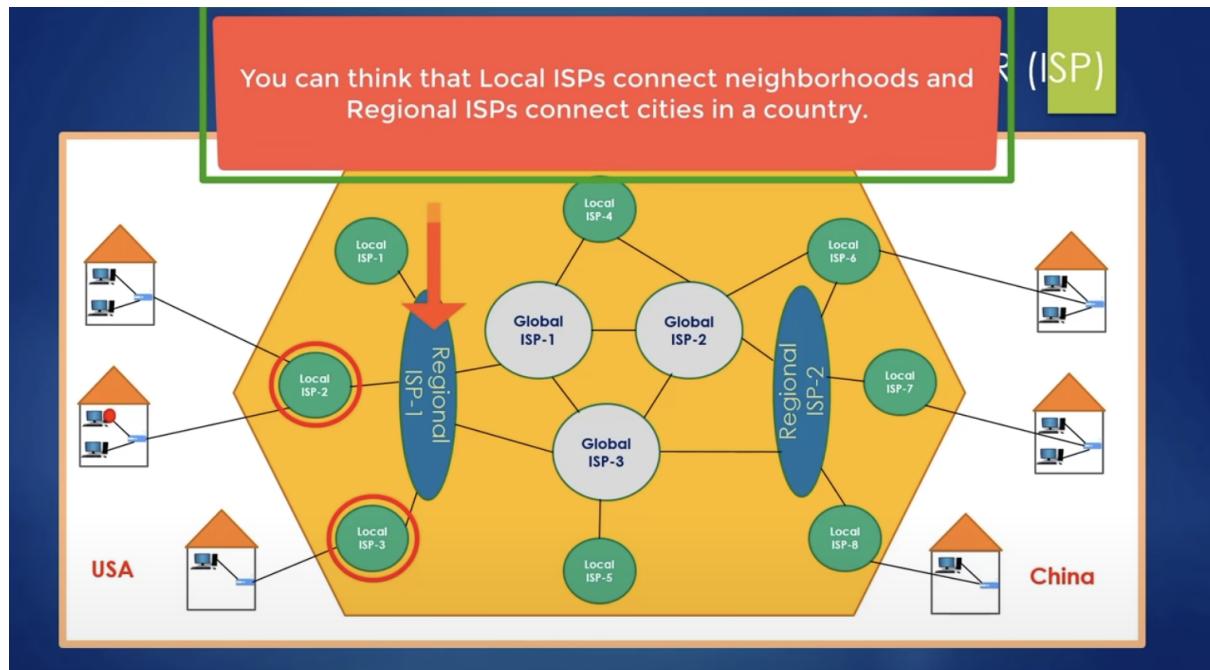
(All of these router icons actually represent POPs)



You might think that every POP of Local ISP is responsible for a neighborhood.

Some local ISPs can have more than one POP. However some local ISPs can only have one POP. This depends on the size of the local ISP. For example if a local ISP connects four

different neighborhoods, it may have four different POPs. But if a local ISP connects only one neighborhood, it has only one POP.



Local ISPs connect neighborhoods and Regional ISPs connect cities in a country.  
Regional ISPs are ISPs that connect different cities within the same country.

Network of a country => Local ISPs + Regional ISPs



Why don't we connect local ISP directly with local ISP? Because the hierarchy is broken. If we connect all local ISPs, we increase the complexity.

Global ISP : ISP that connects different countries

If a local ISP connects directly with a global ISP, its location can be very suitable for this purpose.

## Internet Service Provider (ISP) - Part2

We are in South Korea right now. Imagine we build a company called abcx.com. Since we don't have much money, we only have 1 server in the US.

So to be able to reach abcx.com, our request message must pass over at least one global ISP.

And after the server of the abcx.com receives the request message, in exchange for it, abcx.com creates a response message. This response message contains all information related to the web page like images, videos, links, HTML file, and so on.

There is no way to know the exact path of the message beforehand, since routers can make different choices each time.

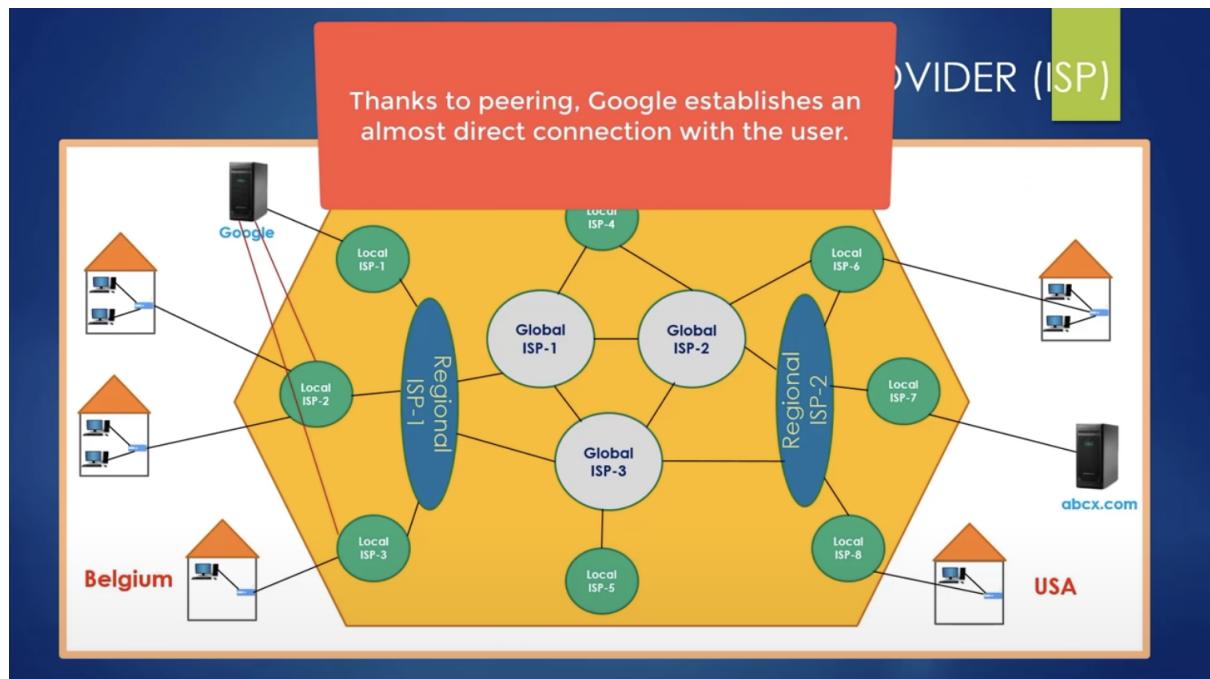
- 1) User sends a request message to the Server.
- 2) Server sends a response message to the User.

Assume that you constantly refresh the web page on the browser. This process happens again every time you refresh the page.

## What Happens When We Enter google.com?

Google has a lot of servers distributed all around the world for effective communication for users (unlike abcx.com).

Large companies want to communicate with their customers in the fastest and most efficient way, and the distributed server structure is a very good solution.



Google sometimes finds its communication with users slow. So google uses Peering. Thanks to peering, Google establishes an almost direct connection with the user. Local ISPs can connect directly with google servers without using ISP infrastructures.

Due to the direct connection, the packet passes through much less POP. So security increases so much!

When we watch a video on Youtube, we are actually using Google's servers.

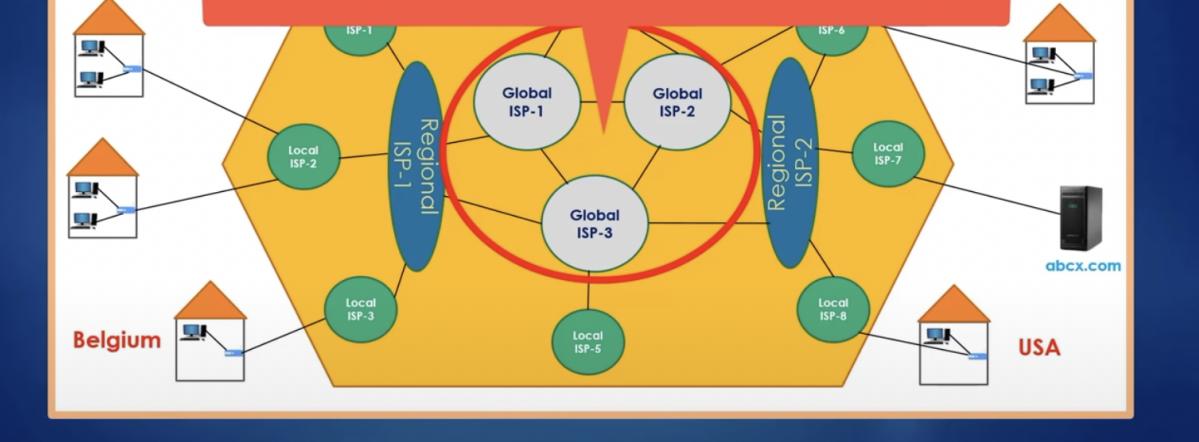
While watching Udemy videos, we may occasionally encounter freezes and interruptions. It is because Udemy's infrastructure is not as strong as Google's in general.

## General Informations About ISP

Global ISPs are responsible for international communication.

## INTERNET SERVICE PROVIDER (ISP)

### Internet Backbone



We call the internet backbone to the network that global ISPs set up with each other.

We don't have to connect with a local ISP in order to connect to the internet. We can directly connect to a regional ISP or global ISP if these ISPs have a server for your location. We can get service from any ISP serving our location. This is our choice.