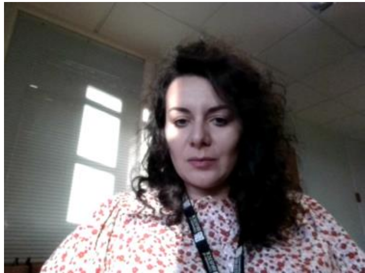
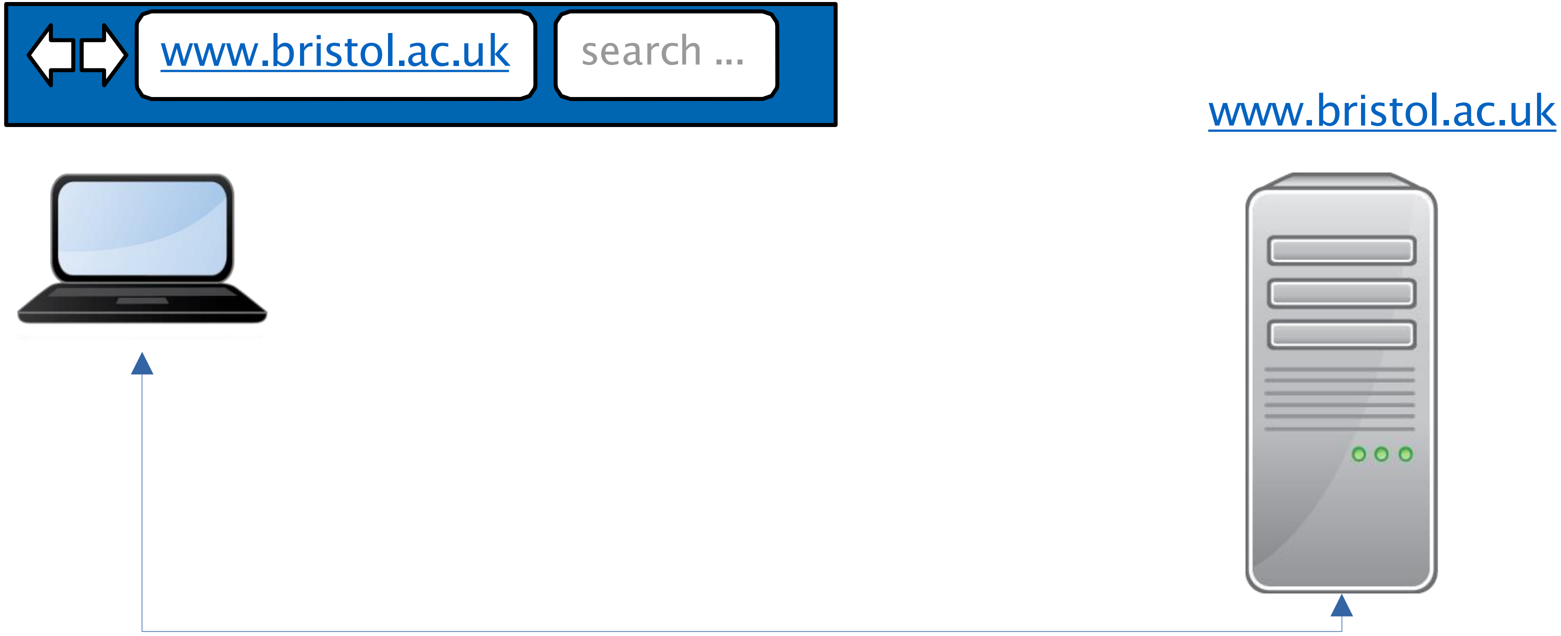
Computer System- B Security

Introduction to Network Security

Alma Oracevic



Networks-- Connecting to computers



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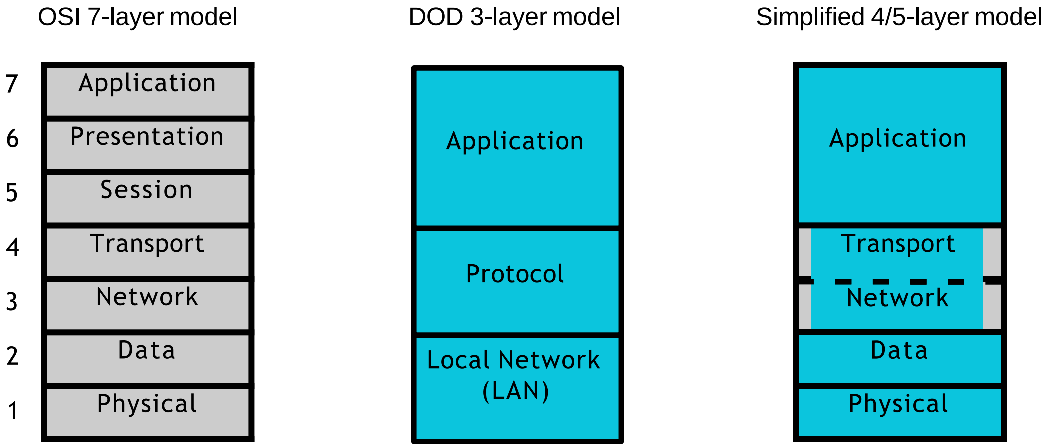
Network Protocol Concepts

- Protocols are sets of rules.
  - What do you want to do? (Application)
  - Where do you want to go? (Addressing)
  - How do you get there? (routing, carrier)
  - Did you get there? (Acknowledgments, Error checking)

Computer Networking Models

Models, also called protocol stacks, represented in layers, help to understand where things go right or wrong.



OSI 7-layer model

7 Application

6 Presentation

5 Session

4 Transport

3 Network

2 Data

1 Physical

DOD 3-layer model

Application

Protocol

Local Network (LAN)

Simplified 4/5-layer model

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Network

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Physical

OSI (Open Systems Interconnection) mnemonic: All People Seem To Need Data Processing. If you ever take a test on networking, you’ll have to know this, otherwise, use the simplified model.

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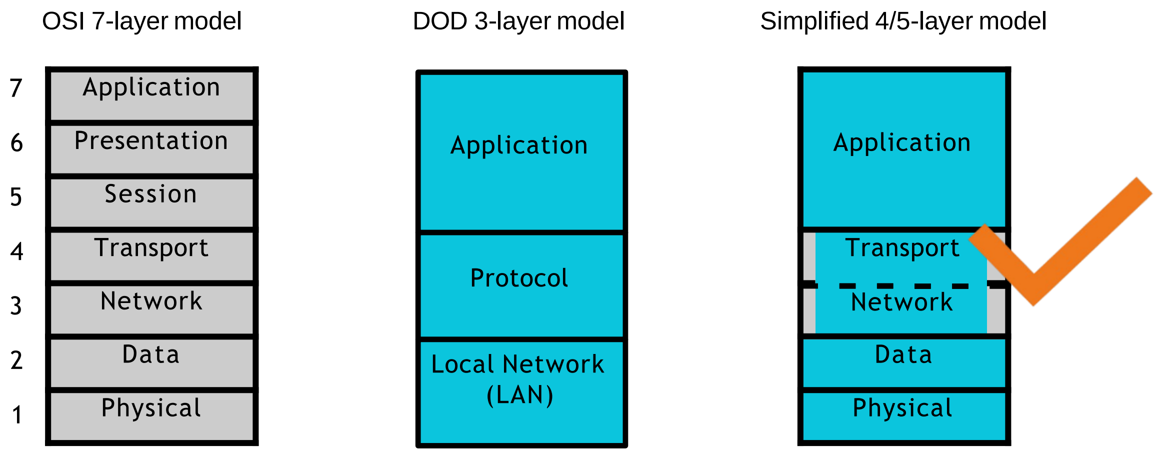

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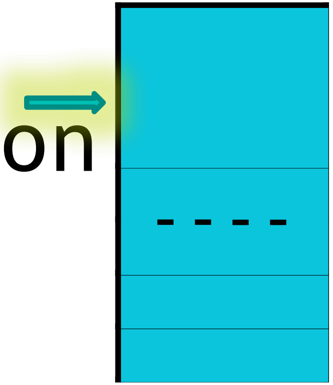

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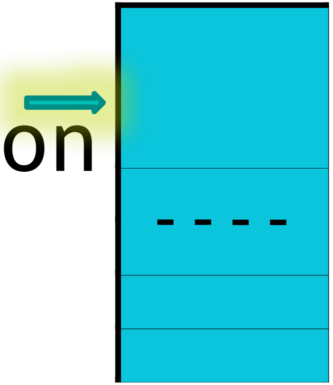

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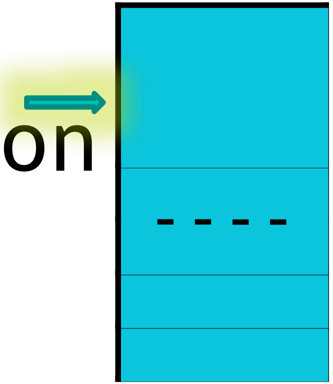

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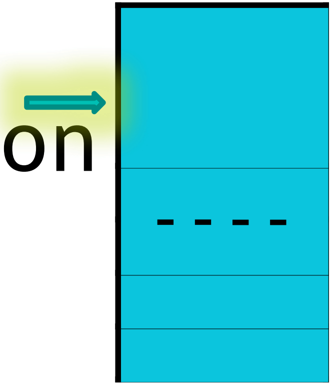

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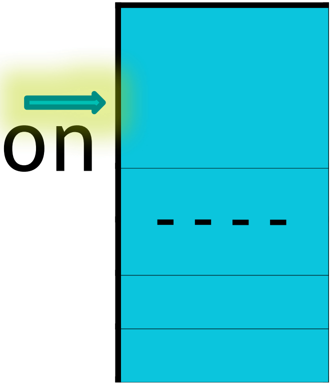

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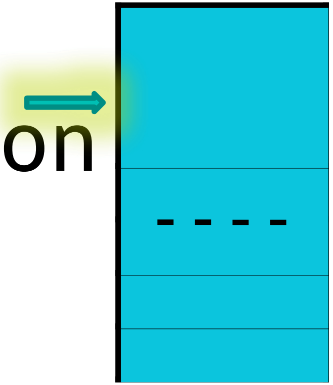

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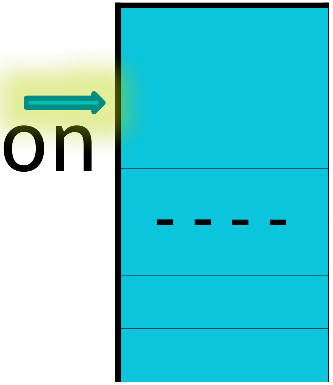

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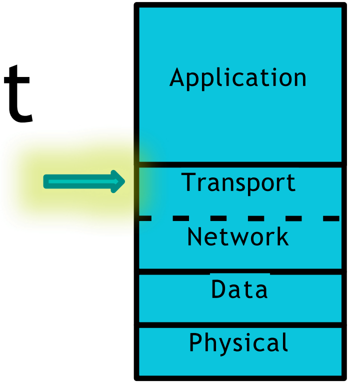

- Standard on how to establish and maintain a network connection for an application to exchange data.
- TCP and UDP are the most popular ones.
  - TCP stateful
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- For a particular application protocol, there is a corresponding TCP/UDP port. E.g. HTTP 80, DNS 53 etc.
- HTTP works over TCP, whereas DNS over UDP.

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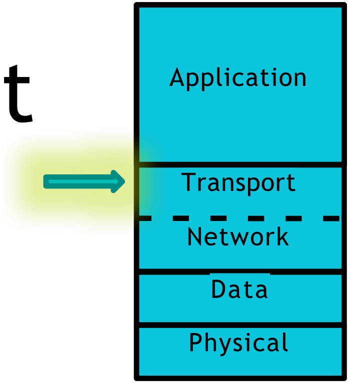

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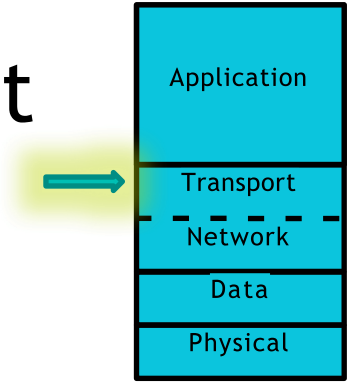

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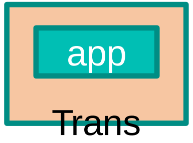
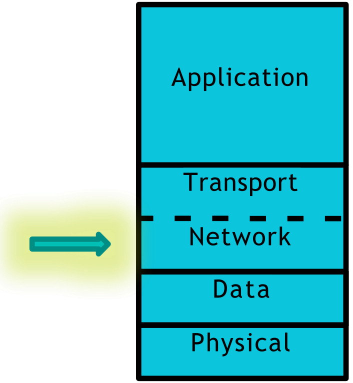


Walking down the stack- Network



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- IP v4 and v6 address schemes.
- Other examples: ICMP (ping), IGMP etc.
- Remember, we use DNS to get this IP address of Bristol.ac.uk, which is 137.222.0.38.

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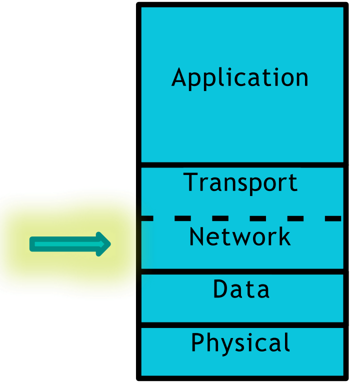

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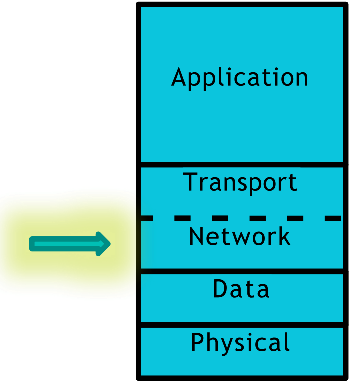

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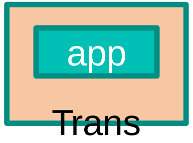

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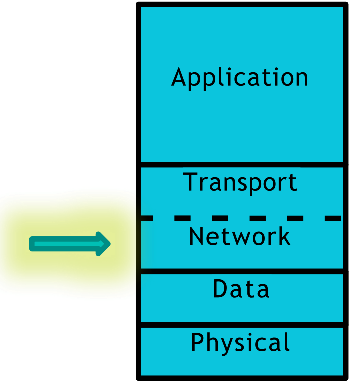

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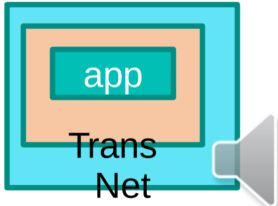

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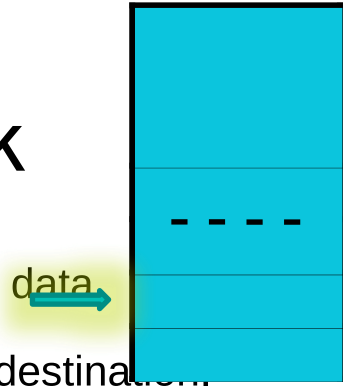

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  - –This is called the Media Access Control (or MAC) address, or sometimes ethernet address, physical address, adaptor address, hardware address, etc.
  - –It’s a 12-digit (48 bit) hexadecimal address that is unique to that ethernet adaptor **(but can be changed!)**. Ex. 00:30:65:83:fc:0a.
  - –The first three octets of any MAC address are IEEE-assigned Organizationally Unique Identifiers
  - –ARP (address resolution protocol) is used to get MAC, given an IP.
    - Switches/hubs operates at this layer.

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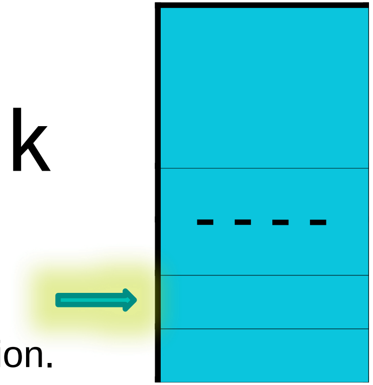

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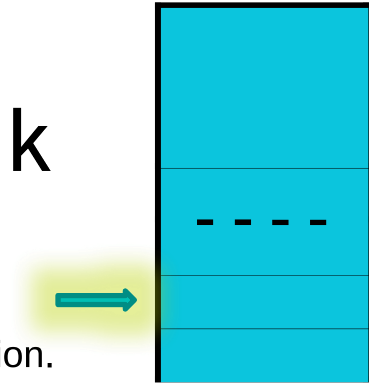

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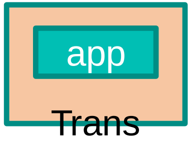

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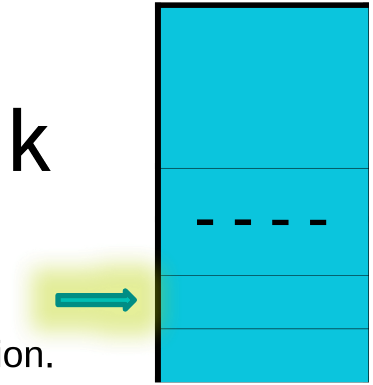

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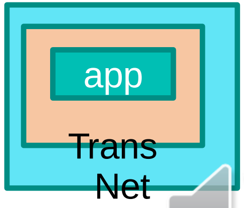

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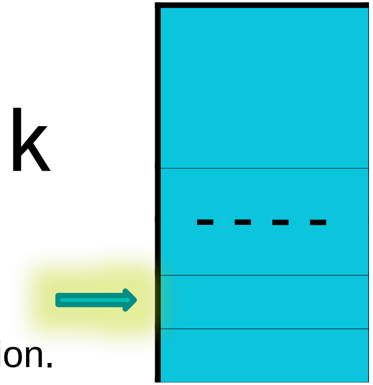

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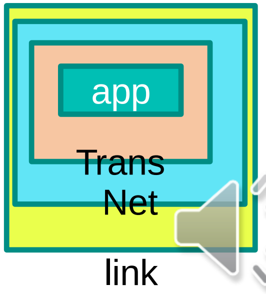

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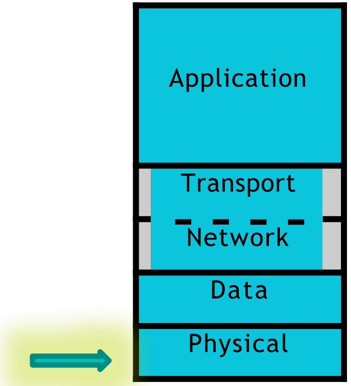

- Nowadays: Pretty much just Cat 5 (or Cat 5e or Cat6) twisted pair copper wire and microwave (wireless).
- Other: Fiber (multi-mode or single-mode) coaxial copper (thick- and thin-net), Cable Modem, plain phone (DSL), microwaves (wireless ethernet), etc.

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TCP generally checks data transmitted by comparing a checksum of the data with a checksum encoded in the packet

Ports

TCP supports multiple concurrent applications on the same server

Accomplishes this by having ports, 16 bit numbers identifying where data is directed

The TCP header includes space for both a source and a destination port, thus allowing TCP to route all data

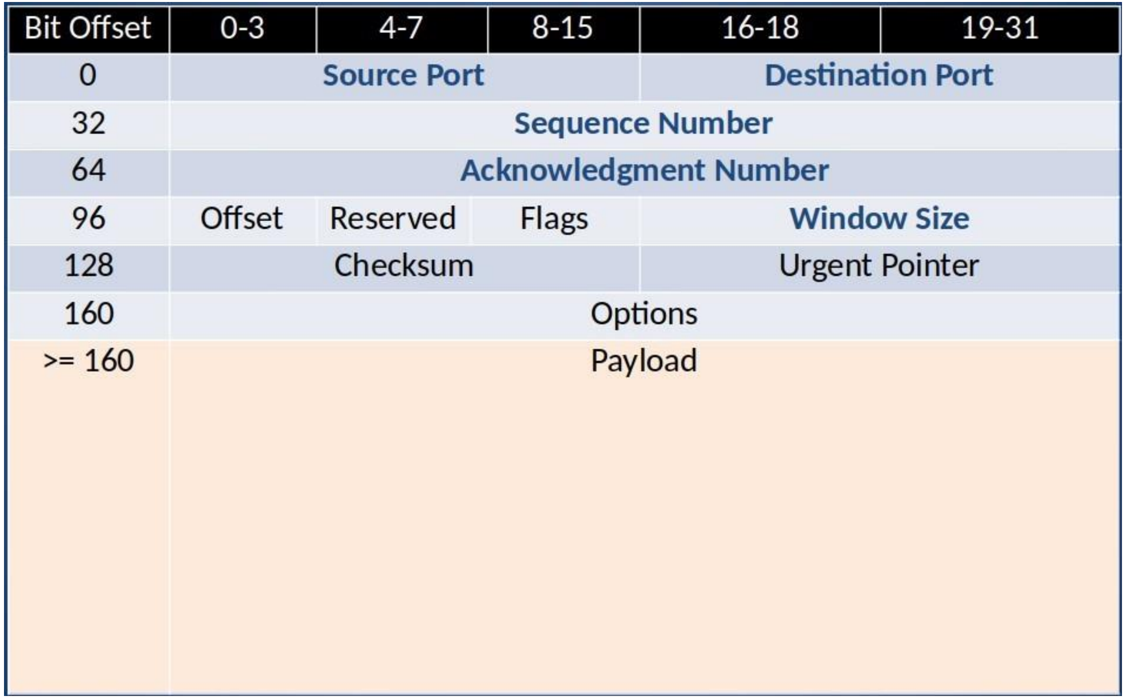
In most cases, both TCP and UDP use the same port numbers for the same applications

Ports 0 through 1023 are reserved for use by known protocols.

Ports 1024 through 49151 are known as user ports, and should be used by most user programs for listening to connections and the like

Ports 49152 through 65535 are private ports used for dynamic allocation by socket libraries

TCP Packet Format



Bit Offset	0-3	4-7	8-15	16-18	19-31
0	**Source Port**			**Destination Port**	
32	**Sequence Number**				
64	**Acknowledgment Number**				
96	Offset	Reserved	Flags	**Window Size**	
128	Checksum			Urgent Pointer	
160	Options				
>= 160	Payload				

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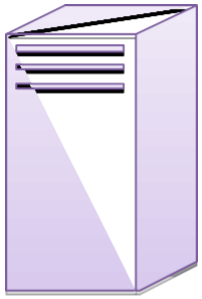

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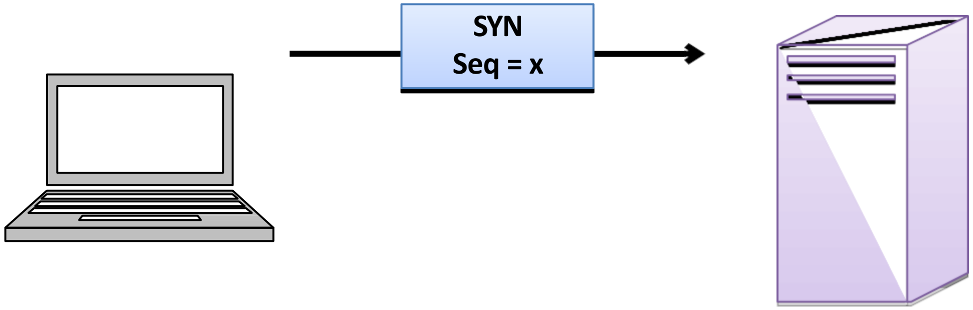

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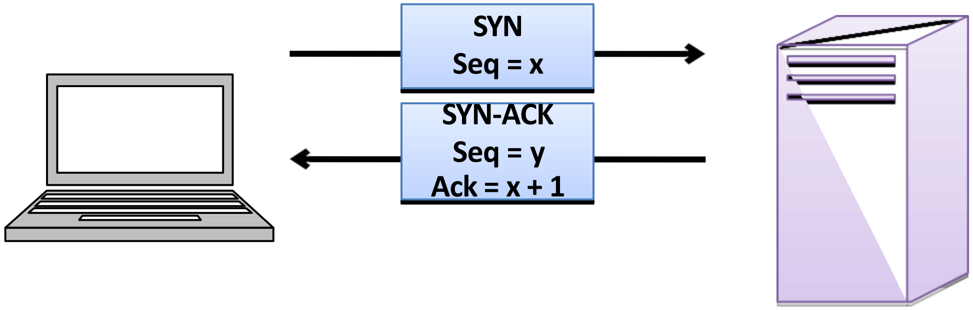

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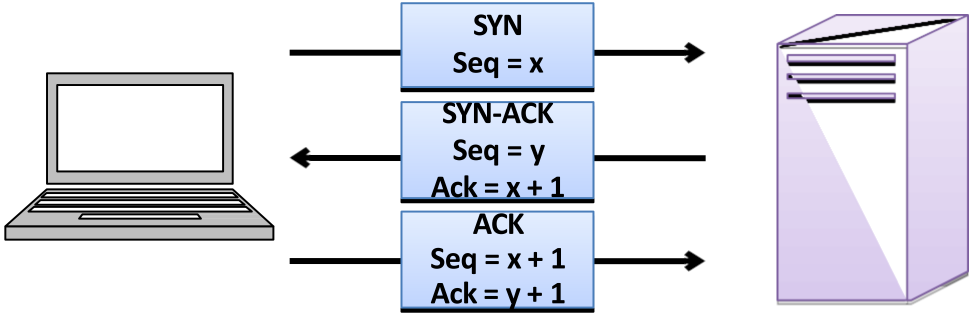
The client responds by sending an ACK to the server thus establishing connection



Denial of Service Attacks

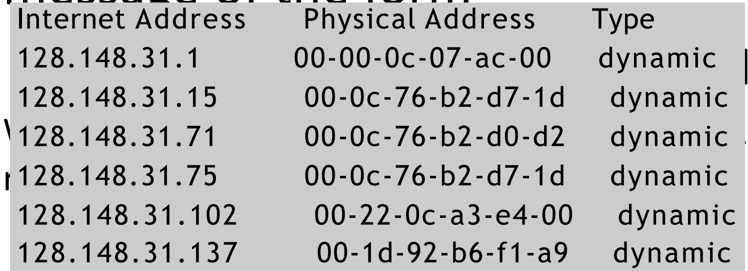
- Computer resources are limited (network bandwidth & memory).
- Server starts dropping packets once resources are unavailable.
- DoS attack aims at consuming such resources.
- E.g. several flooding attacks (syn flood, icmp flood etc.)

SYN Flood

- Rely on sending TCP connection requests faster than the server can process them
- Attacker creates a large number of packets with spoofed source addresses and setting the SYN flag on these
- The server responds with a SYN/ACK for which it never gets a response (waits for about 3 minutes each)
- Eventually the server stops accepting connection requests, thus triggering a denial of service.
-

ARP

- The address resolution protocol (ARP) connects the network layer to the data layer by converting IP addresses to MAC addresses
- ARP works by broadcasting requests and caching responses for future use The protocol begins with a computer broadcasting a message of the form



```
Internet Address      Physical Address      Type
128.148.31.1         00-00-0c-07-ac-00     dynamic
128.148.31.15         00-0c-76-b2-d7-1d     dynamic
128.148.31.71         00-0c-76-b2-d0-d2     dynamic
128.148.31.75         00-0c-76-b2-d7-1d     dynamic
128.148.31.102         00-22-0c-a3-e4-00     dynamic
128.148.31.137         00-1d-92-b6-f1-a9     dynamic
```

IP address1> tell <IP address2>

W P server receives this message, its broadcasts the

r

> is <MAC address>

The requestor’s IP address <IP address2> is contained in the link header

The Linux and Windows command arp - a displays the ARP table

ARP Spoofing

The ARP table is updated whenever an ARP response is received

Requests are not tracked

ARP announcements are not authenticated

Machines trust each other

A rogue machine can spoof other machines

ARP Poisoning (ARP Spoofing)

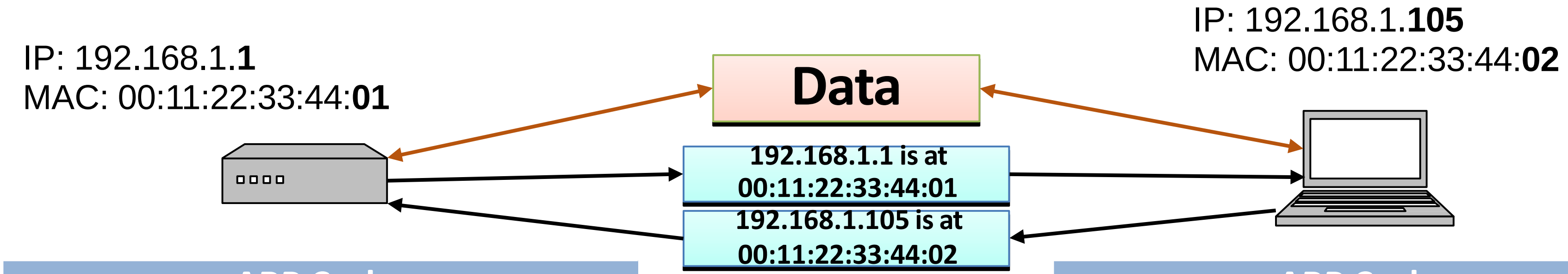
According to the standard, almost all ARP implementations are stateless

An arp cache updates every time that it receives an arp reply… even if it did not send any arp request!

It is possible to “poison” an arp cache by sending gratuitous arp replies

Using static entries solves the problem but it is almost impossible to manage!

ARP Caches



IP: 192.168.1.**1**
MAC: 00:11:22:33:44:**01**

Data

192.168.1.1 is at 00:11:22:33:44:01

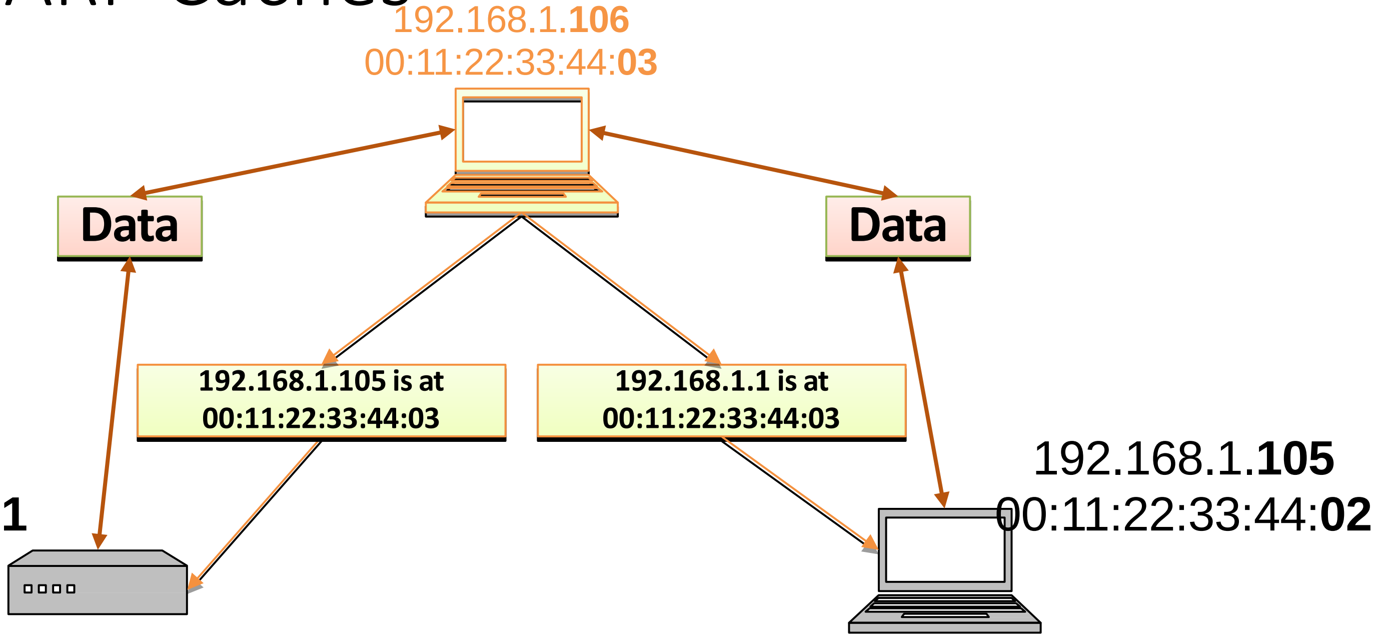
192.168.1.105 is at 00:11:22:33:44:02

IP: 192.168.1.**105**
MAC: 00:11:22:33:44:**02**

ARP Cache	
192.168.1.**105**	00:11:22:33:44:**02**

ARP Cache	
192.168.1.**1**	00:11:22:33:44:**01**

Poisoned ARP Caches



192.168.1.**106**
00:11:22:33:44:**03**

Data

Data

192.168.1.105 is at
00:11:22:33:44:03

192.168.1.1 is at
00:11:22:33:44:03

192.168.1.**1**
00:11:22:33:44:**01**

192.168.1.**105**
00:11:22:33:44:**02**

Poisoned ARP Cache	
192.168.1.**105**	00:11:22:33:44:**03**

Poisoned ARP Cache	
192.168.1.**1**	00:11:22:33:44:**03**

IP: Routing. “How do you get there from here?”

- As mentioned before, you can only send ethernet packets out of your ethernet interface, and ethernet packets stay on your local network.
- You can put an IP (Network layer) packet inside of an ethernet (data layer) packet, but somebody’s got to pass it along, and that somebody’s a router.
- Every IP number not on your local network will “belong” to your router in your ARP table.
- If you want to talk to someone outside your local network, you’ll send that ethernet packet to your router’s ethernet address and trust that it will work afterwards. It’s out of your hands now. You know what’s “local” or “not” by the subnet mask.

More routing.

- Routers keep tables of networks, often many and often large.
- Routers know: 1- Networks directly connected to them (sometimes one or two, sometimes a hundred or more), 2- Networks connected to their “friends and neighbors” and 3- The “default route” for everything else.

It really can’t be a networking class without ping and traceroute

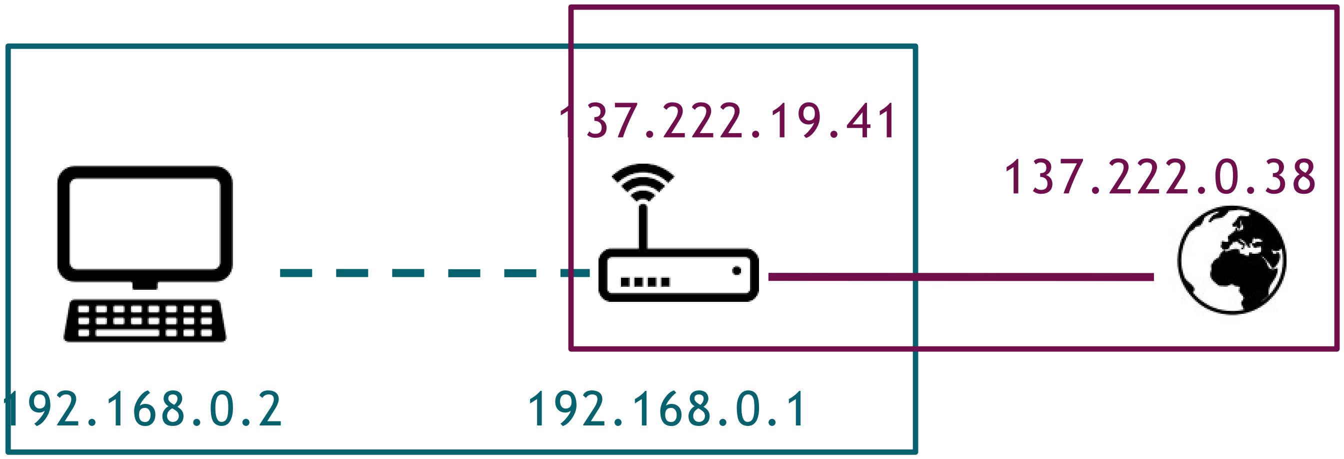
- Ping and Traceroute are two somewhat useful tools for looking at and learning about your network.
- Ping sends a small packet to a host which may or may not choose to reply to it, and times how long the packet takes to get back. Lack of a reply does (not) indicate a problem with the host or network.
- Traceroute asks all routers along the path between you and the destination host if they’d like to respond to you, and times how long each of 3 requests take to get back to you. Some routers may not respond, but may still pass the traceroute packet along, and many hosts will not reply to the traceroute inquiry at all.

IP and NAT

- Recall: computers communicate using **IP addresses** such as 137.222.0.38.
- However
- the world is running out of IPv4 addresses because the allocation system is stupid
- you don’t necessarily want the whole world to be able to reach your computer.

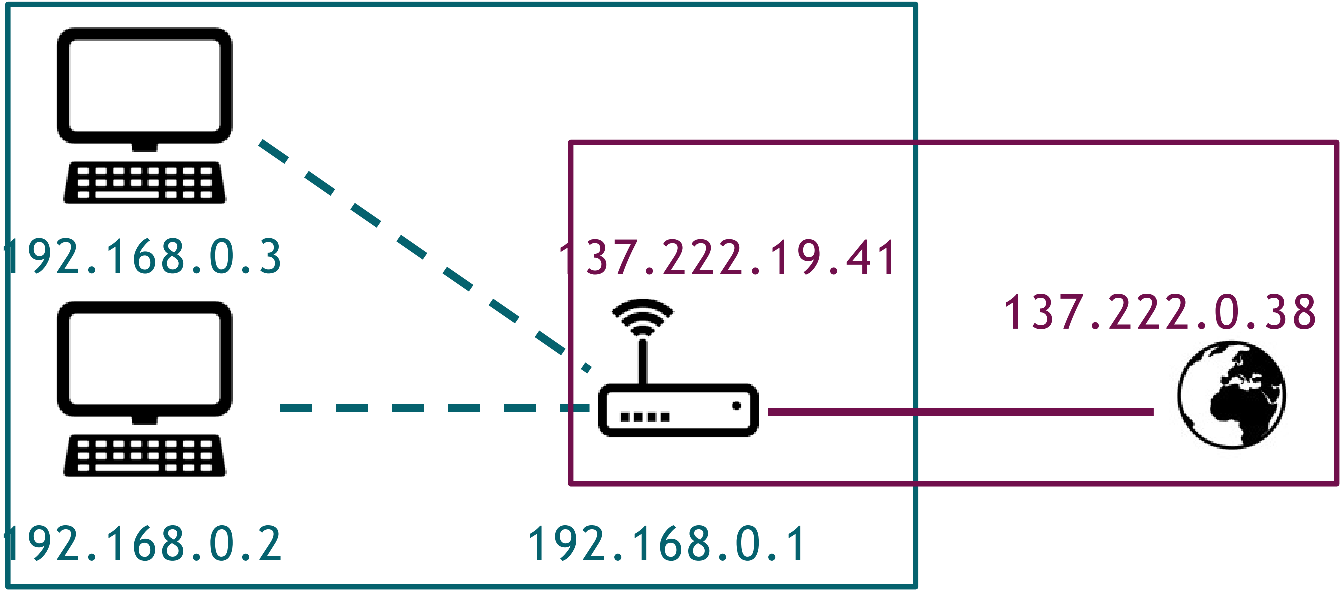
IP and NAT

- Routers (whether wireless or not) can split the network into two components and perform **Network Address Translation (NAT)**.



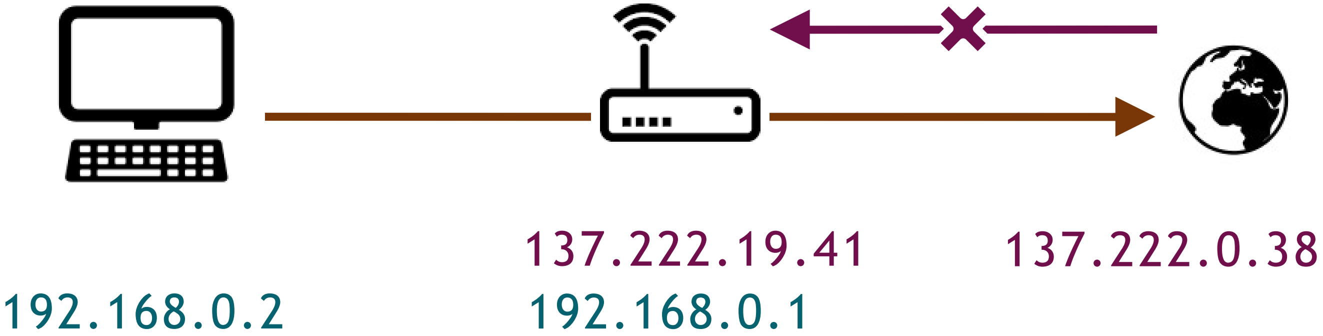
IP and NAT

- Consequence #1 of NAT: you can have several devices behind one NAT with only one external IP address.



IP and NAT

- Consequence #2: although you can initiate connections outbound, the world cannot initiate connections to you – the router wouldn’t know which device to forward to.
- (You cannot, without extra set-up, host a server behind a NAT.)



IP and NAT

- Consequence #3: if your router is secure, you are protected from a lot of incoming attacks because they can’t reach your PC in the first place.

- **A NAT automatically does some of the work of a firewall.**

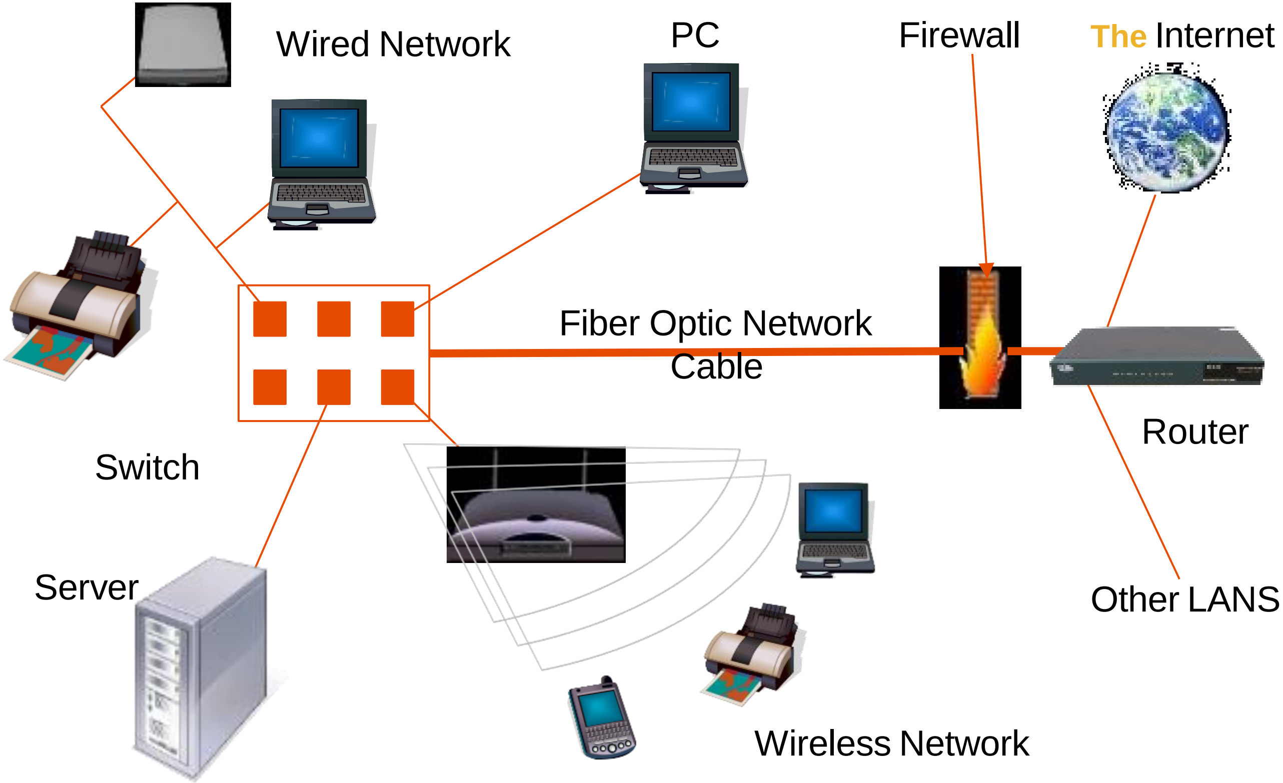
PAT and Port forwarding

Ports

- On the TCP / UDP layer, applications use **ports** to distinguish several applications running on the same machine.
- For example, HTTP (web) is port 80 or 443 (with TLS).

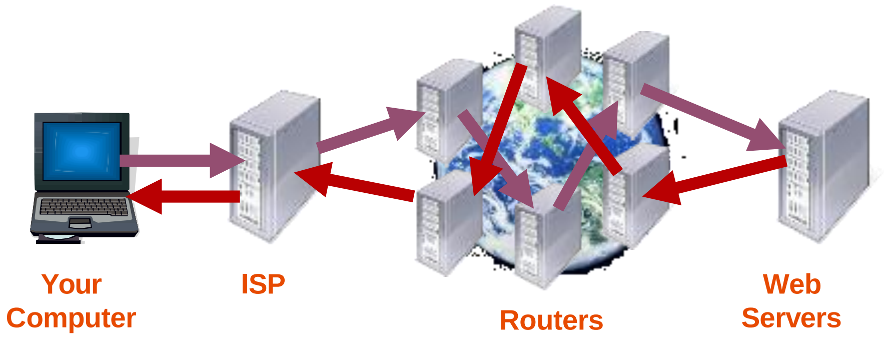
- To connect to another machine, you need an IP address and a port number.
- Port address translation (PAT) is like Nat, but at port level.
  - Same IP but different port numbers to distinguish computers.

The Network Diagram



The Internet

- **How Information Travel Through the Internet**
  - **When you connect to a Web site through an ISP and start exchanging information, there isn't a fixed connection between your computer and the Web server computer hosting the Web site. Instead, information is exchanged using the best possible path at that particular time. Special computers called routers determine these paths, avoiding slow links and favoring fast ones.**



Virtual Private Network (VPN)

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  - Data is sent over public network.
- A **virtual private network** (**VPN**) extends a private network across a public network, by using of cryptographic protocols.

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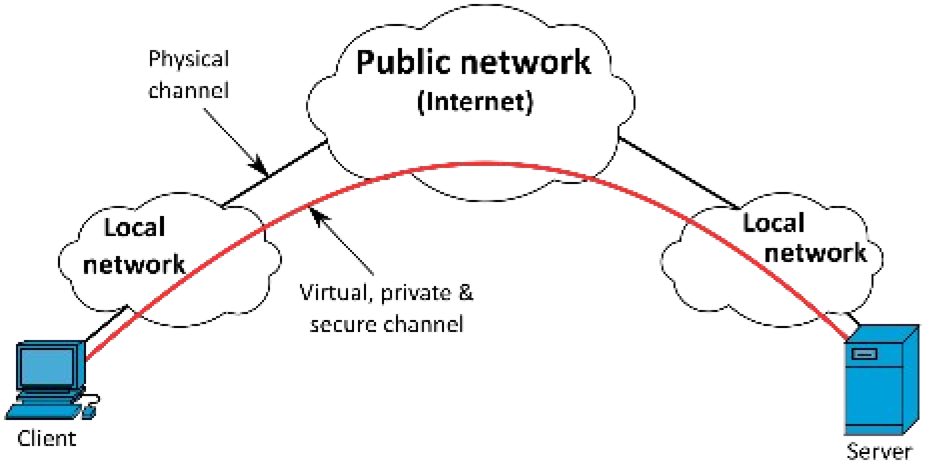

**Taken from https://en.wikipedia.org/wiki/Virtual_private_network

VPN across layers

- Network Layer (2/3)
  - IPSec
    - Transport mode: only the payload of the IP packet is usually encrypted or authenticated.
    - Tunnel mode: the entire IP packet is encrypted and authenticated. It is then encapsulated into a new IP packet with a new IP header.

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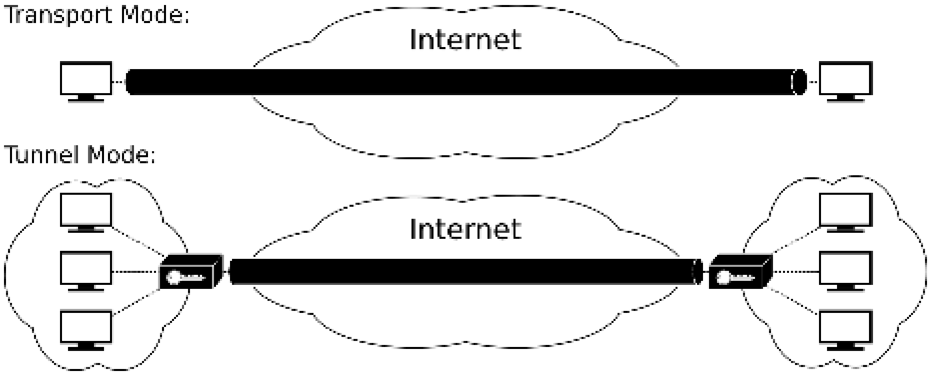

** https://en.wikipedia.org/wiki/IPsec

VPN across layers

- Transport layer
  - SSL/TLS
    - Provides encryption and authentication at application layer, which is the most common way to provide CIA security properties over the internet.