

Computer Networks

Root of All Evil Edition

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February 21, 2022

2022-02-21

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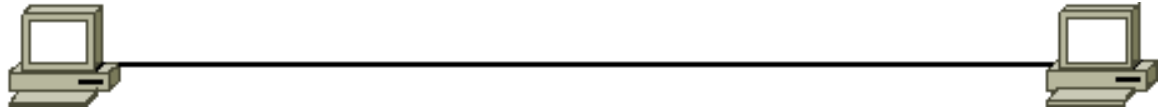
Lets talk about computer networks over a simplified example.

We will learn about various forms of addressing that is used to route packages in a modern network.

A Tale of Two Computers



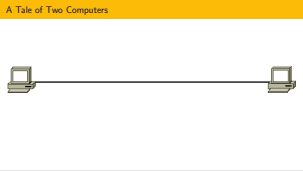
A Tale of Two Computers



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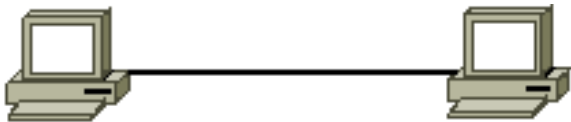
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└─ A Tale of Two Computers



This and the following slides are increasingly complex situations that explain how networks work. If you want data to go from one computer to the other, simplest solution is to connect them with a wire (Ethernet cable maybe).

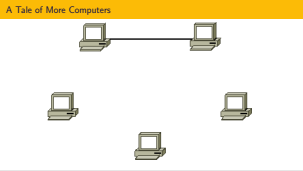
A Tale of More Computers



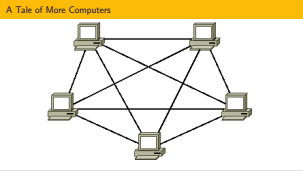
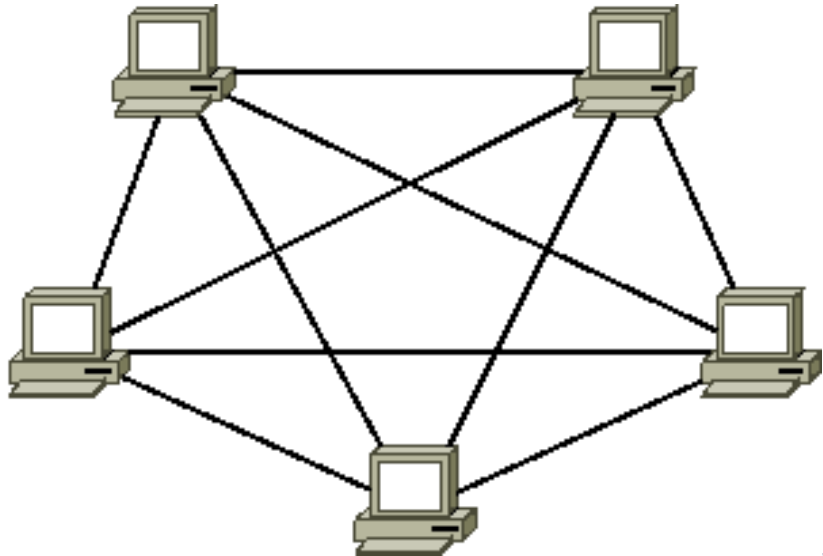
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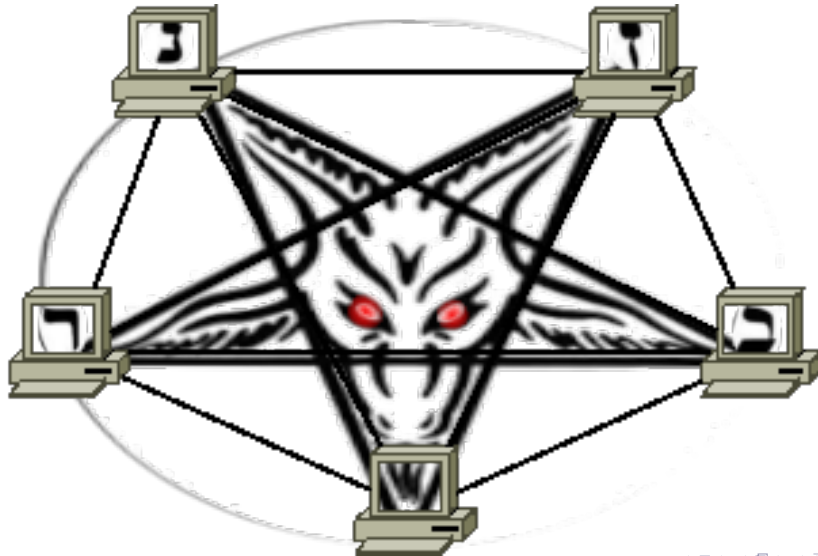
└ A Tale of More Computers



A Tale of More Computers



A Tale of More Computers



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└ A Tale of More Computers



Do you see a problem with this approach?

I mean besides the obvious infernal infestation angle Do you want demons to possess your network?!? Cause this is how you get demonic possession. The packages circling the pentagram network summon Baphomet. Remember that ransomware incident last year... yeah.

There is the obvious cable and network interface costs associated with connecting all computers to all others.

What if more computers are added? How will we handle it?

A Tale of More Computers

It gets exponentially harder to scale

$$Connections = \frac{N \times (N-1)}{2}$$

Cable and Network interface costs. . .

General chaos... Not good.

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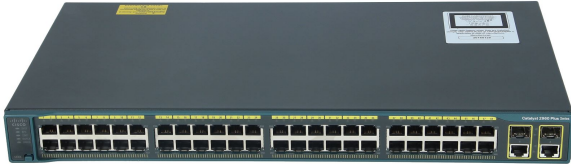
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└ A Tale of More Computers

It gets exponentially harder to scale
Connections = $\frac{N \times (N-1)}{2}$
Cable and Network interface costs...
General chaos... Not good.

A Switch Comes to Town - Data Link

Like a post office
We need addresses
MAC F4:93:7F:E8:58:E3



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A Switch Comes to Town - Data Link

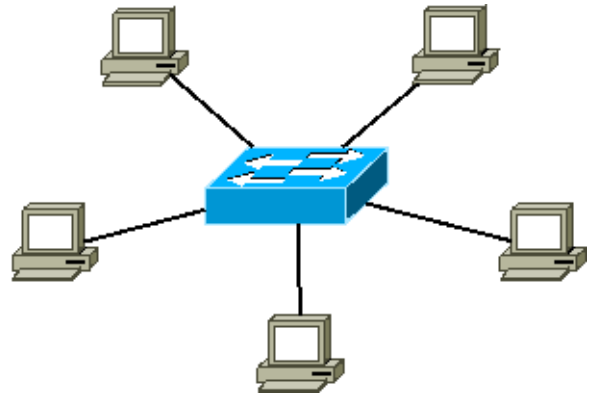
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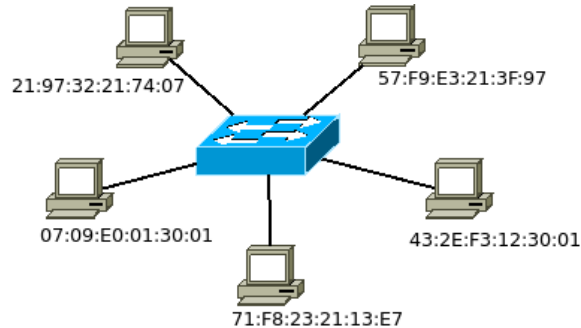


A Switch Comes to Town - Data Link

Like a post office

We need addresses

MAC F4:93:7F:E8:58:E3



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A Switch Comes to Town - Data Link

With a switch you can form an actually useful network (not like just wiring computers to each other).

A switch is like a post office.

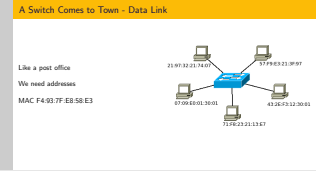
It can deliver data between nodes directly connected to it.

What we need is a way to address each node. The switch will track which node is connected to which wire and send the data to proper nodes.

That is where Physical or MAC addresses come in.

MAC addresses are assigned in the factory. They are static. So unless you spoof your mac address you can't change it.

Fun fact, you can find out the device manufacturer by looking up MAC address.



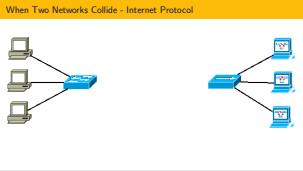
When Two Networks Collide - Internet Protocol



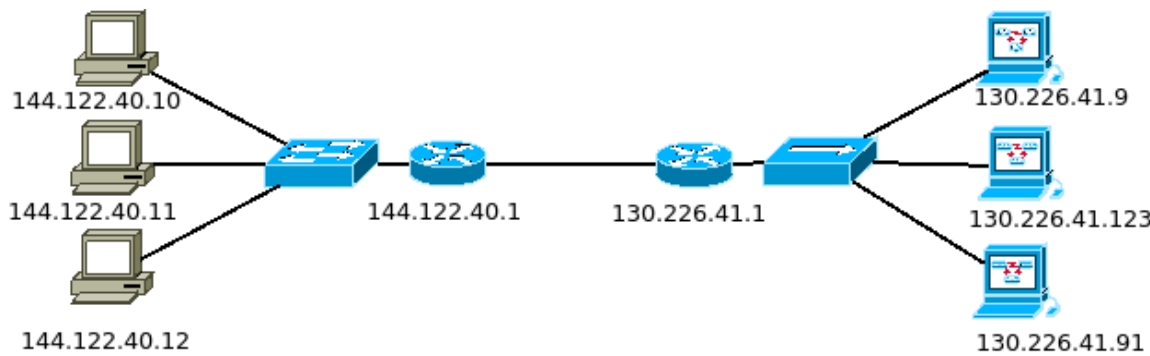
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└ When Two Networks Collide - Internet Protocol



When Two Networks Collide - Internet Protocol

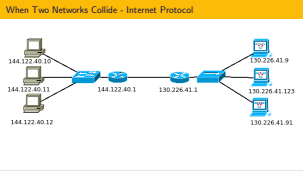


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When Two Networks Collide - Internet Protocol

Since I am a sadistic bastard, I want to make your life more miserable. One way to do that is to consider the situation where nodes are not in the same network. The MAC addresses will no longer be useful (there are gazillions of them), and we can't know the physical location of each device. Here is where IP addressing comes in. The IP addresses are assigned hierarchically. Thus you can estimate where a node will be.



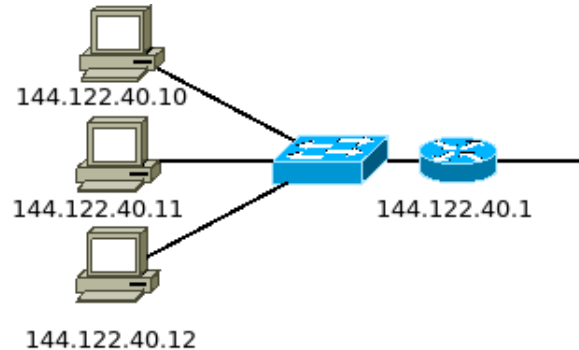
IP Addressing

IP address

Prefix: A Network

Suffix: A Node

144.122.98. 32

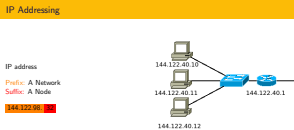


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IP Addressing

IP addresses indicate both the network and the specific node in a network. IP addresses are 32 binary bits. Usually first so many bits specify the network prefix. For the sake of simplicity I am not going into details such as subnet masks. Just know that IP address allow you to identify a network (through prefix) and a node in that network (suffix)

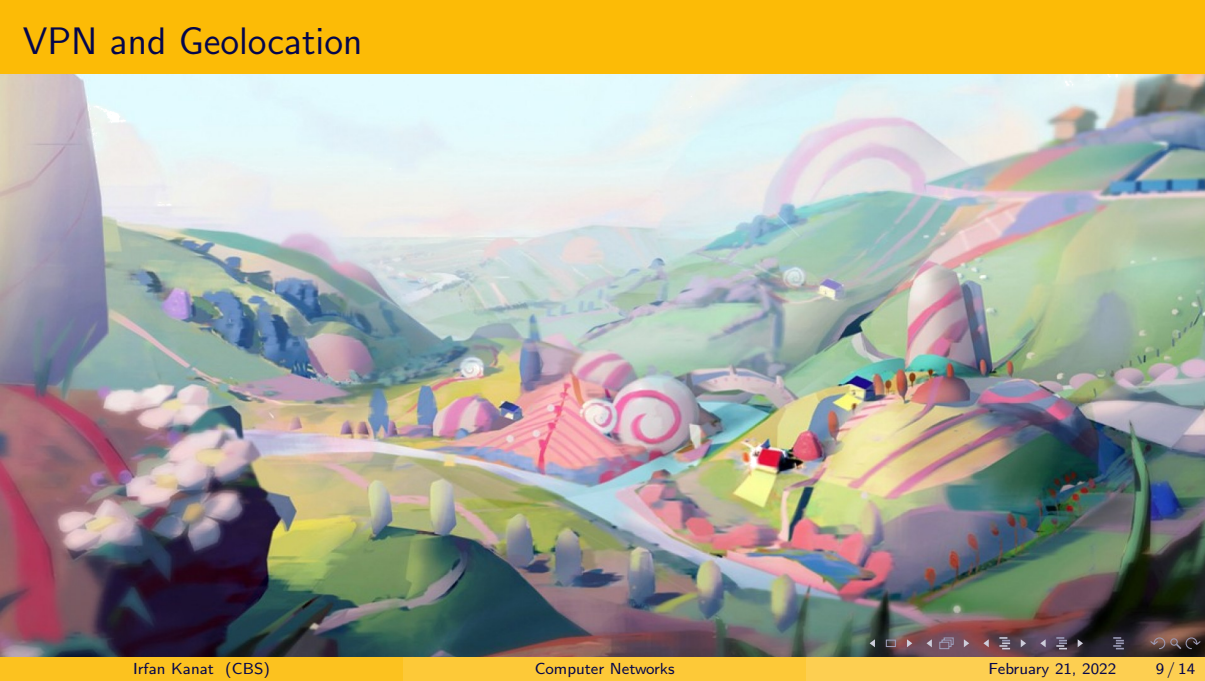


Why do we need IP addresses?

MAC addresses are static.

If you had to keep track of all nodes with these static addresses, the forwarding/routing tables would grow huge.

IP addresses are dynamic. They get assigned when you join a network. They are a bit like zip codes. They are hierarchically organized into networks. So to forward to next hop, all you need to know is general direction the network lies in.



VPN and Geolocation

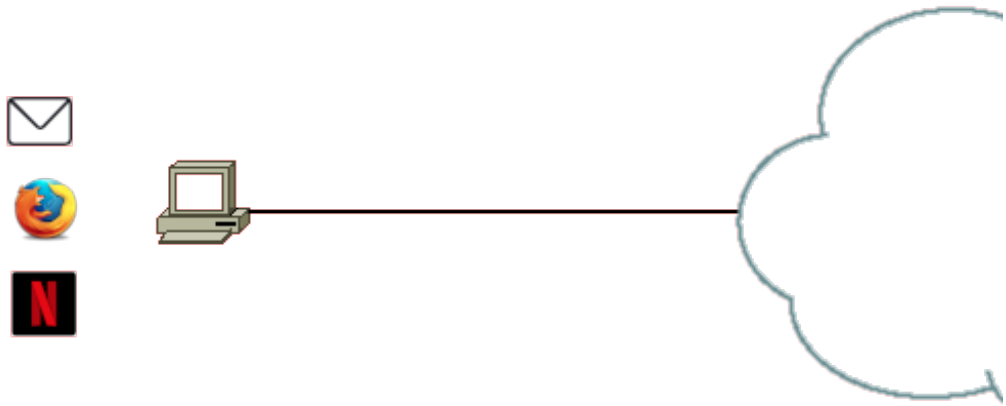
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└─VPN and Geolocation

Set up a VPN (easiest way is to use builtin opera vpn) then locate your device.
<https://www.iplocation.net/find-ip-address>

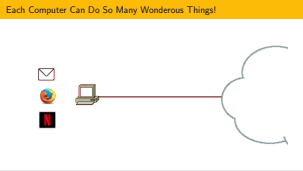
Each Computer Can Do So Many Wonderful Things!



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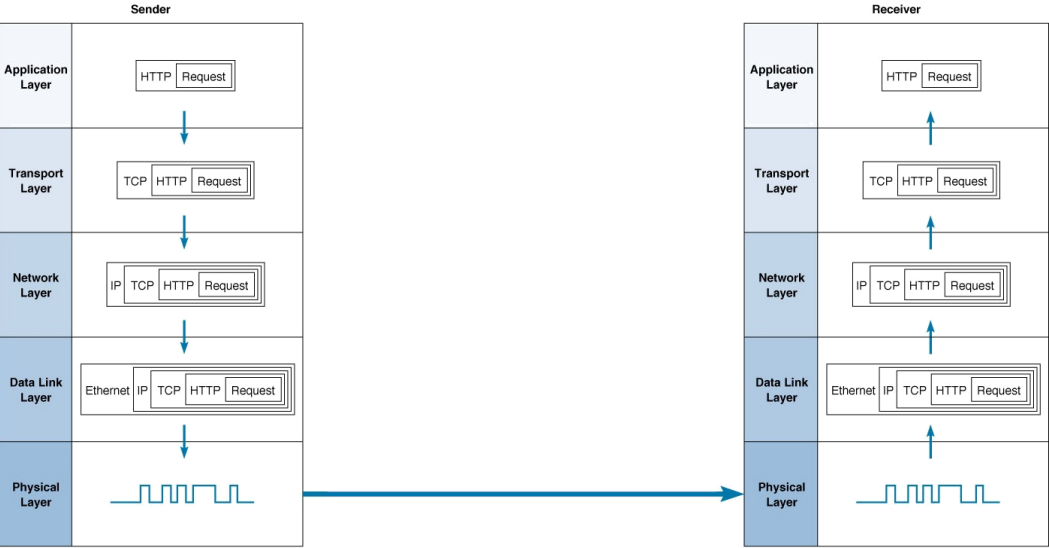
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Each Computer Can Do So Many Wonderful Things!



OK so we finally managed to get data to the computer where it is needed.
What if the computers did more than just one thing? Reading e-mail, watching netflix, browsing the web... How will the computer know which application gets the data?
GUESS WHAT WE NEED? YES. MORE ADDRESSES...
Each application gets a port address

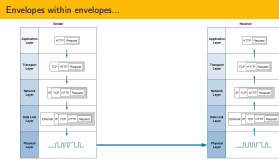
Envelopes within envelopes...



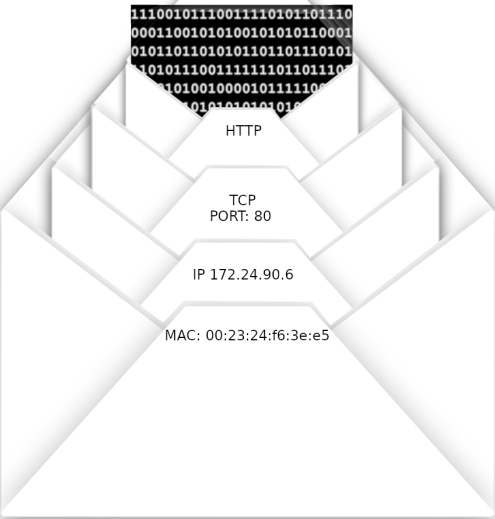
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└ Envelopes within envelopes...



Envelopes within envelopes...



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└ Envelopes within envelopes...



Any time your computer sends or receives data from the network, it comes in multiple envelopes. Each layer of the stack receives the data from the layer above, puts in the layer specific addressing and passes it on. When determining where a package needs to go, the network uses these addresses.



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└ Address Resolution

Explain to them that with so many addresses, we need ways to resolve addresses

URL to IP nslookup

IP to MAC arp

You may need to run nmap on local network to buff up arp table. I recommend doing it in this order

arp Show that there are just a few entries

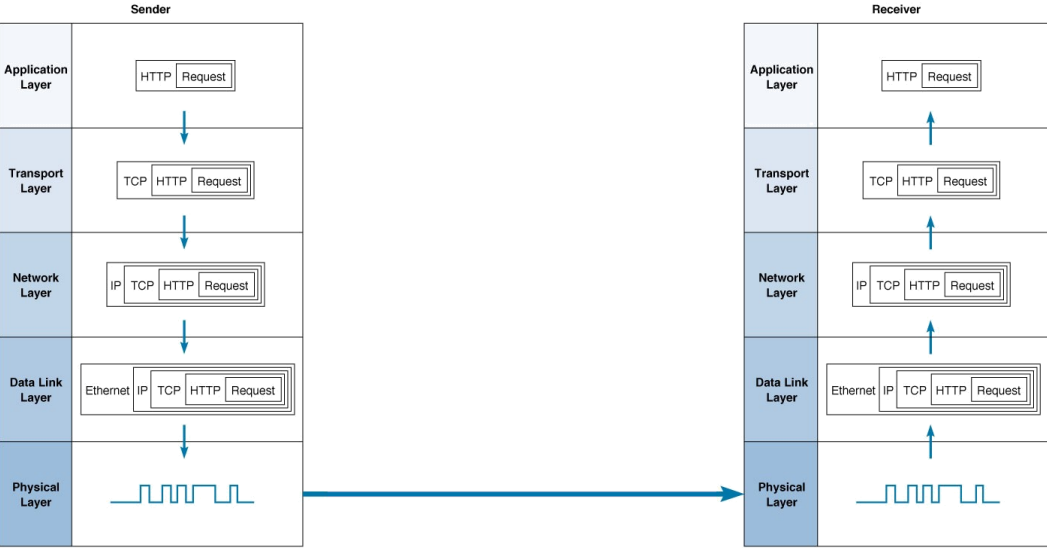
nmap 192.168.1.1/24

replace IP address with current IP

arp

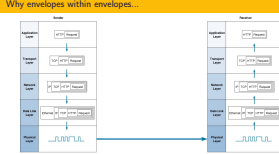
Show that there are many more entries

Why envelopes within envelopes...



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Why envelopes within envelopes...



Why bother with layers? What is the advantage?

It allows abstracting away complexities of the communication. From a programmer's perspective, all he needs to do is deal with TCP/IP protocol and he can forget about the intricacies of how the signals are encoded and such.

Each layer can house multiple protocols. These protocols handle mundane details. Since each interface is standard, we don't need to know the details. But we can still chain different technologies together to get data to where it needs to be.

It allows you to change protocols in each layer without disrupting the whole. This is the reason why a 40-year-old idea can keep up with latest advances.

Perhaps talk a bit about how IPv4 is being replaced under our noses.