What is Networking?

Module Introduction

Hi, my name is Victor Escobedo and I'm a corporate operations engineer. I'm excited to spend the next few lessons with you before my colleague and friend Jeon takes the reins and wraps up the rest of the lessons on the internet. Before we dive in though, I'd like to tell you a little bit about myself. My passion for IT began way back when I was nine years old, and my dad brought home our first computer. He was a mechanical engineer and started using the computer to help him with his cat work. This was the first time I was exposed to computers and later realized you can install new software on it, including computer games. As I tinkered with the computer, surely to my dad's dismay, I became more and more interested in how it worked and eventually started to open up the case and peek inside. I found pieces that could be removed and even some that shouldn't, learning through trial and error along the way. I couldn't really explain what it was but I just found the mechanics of how it all worked together so fascinating. Looking back, these were the seeds that inspired my career. But, you see where I grew up, going to college and pursuing a career wasn't exactly talked about or heavily encouraged. I'm a first generation Mexican American, and there weren't a lot of people I knew pursuing a career in tech. My friends and family were mostly worried about graduating high school and making sure they had jobs, not really thinking about careers. My school didn't have the resources to offer many technical classes and even though my father was working in mechanical engineering, computers were a tool to him like a mill, ruler, or a hammer. My parents encouraged me to work hard and pursue computers but they couldn't really give advice about college or a career in tech to no real fault of their own, they just didn't have the necessary experience. When I decided to go to college, I decided to try my hand at computer science since it could feed my curiosity for how computers worked at a more fundamental level. I realized that having this foundational knowledge really allowed me to understand some of the higher level concepts that were important in a career in tech. So while in school, I took on my first IT job for local small company. I've been working in IT now for 12 years, with the last 7 years being here at Google. I now work on managing deployment of large internal IT projects for the company. Applying the knowledge I picked up over the years in my initial IT helpdesk roles to make sure that I understand how I'm impacting our users and various support teams. Now that you know a little bit about me, let's dig into the internet. The internet made it possible for us to connect with almost anyone in the world. Before the internet, you had to use paper maps and write down step by step directions to get where you wanted to go. If you wanted to see what your friends were up to, you'd have to call them, actually talk to them. If you wanted to learn something new, you had to go to a library and hope they have a book on the subject you wanted to learn. People didn't really discover new restaurants unless they heard about it from someone else or it was advertised. There was no Yelp or other website that rates restaurants like we have today. For some of us, life without the internet seems unimaginable, we get it, it's become an integral part of our lives. In the next few lessons, you'll be learning about what the internet is, how it came to be, and how it has impacted us both in negative and positive ways.

Basics of Networking

When most people think of the Internet, they think of a magical cloud that lets you access your favorite websites, shop online, and you assumingly endless stream of cat pictures, but there isn't any magic involved. There's no mysterious entity that grants us a cat picture on-demand. The Internet is just an interconnection of computers around the world, like a giant spider web that brings all of us together. We call the interconnection of computers a network. Computers in a network can talk to each other and send data to one another. You can create a simple network with just two computers. In fact, you might already have your own network at home connecting all of your home devices. Let's think on a bigger scale. What about the computers at your school or workplace? Are they in a network? They sure are. All of the computers there are linked together in a network. Can we link your home, school, and workplace's networks together? We absolutely can. Your workplace connects to a bigger network, and that network connects to an even bigger network and on and on. Eventually, you've got billions of computers that are interconnected, making up what we call the Internet. You, like most people, probably access the Internet through a browser like Mozilla Firefox, Google Chrome, Microsoft Edge, or something else. This is done through the World Wide Web. But don't make the mistake of thinking the Internet is the World Wide Web. The Internet is the physical connection of computers and wires around the world. The web is the information on the Internet. We use it to access the Internet through a link like www.google.com. The World Wide Web isn't the only way we can access the Internet. Your email, chat, and file-sharing programs are also ways you can access the Internet. In the IT field, managing, building, and designing networks is known as networking. Networking is a super important and large field in IT. There are specialized jobs, college degree programs, and tons of literature dedicated entirely to networking. If you work in the IT field, it's super critical that you understand the fundamentals of networking. The Internet is composed of a massive network of satellites, cellular networks, and physical cables buried underneath the ground. We don't actually connect to the Internet directly. Instead, computers called servers connect directly to the Internet. Servers store the websites that we use, like Wikipedia, Google, Reddit, and BBC. These websites serve content. The machines that we use, like our mobile phones, laptops, video game consoles, and more are called clients. Clients request the content like pictures, websites from the servers. Clients don't connect directly to the Internet. Instead, they connect to a network run by an Internet service provider or ISP, like CenturyLink, Level 3, Comcast, Telefonica and things like that. ISPs have already built networks and run all the unnecessary physical cabling that connects millions of computers together in one network. They also connect to other networks and other ISPs. These other networks connect to the networks of Google, Reddit, universities, basically all the other networks in the world. Together, they form one giant network of computers called the Internet. But how do the clients know how to get to servers? Well, how would you send a letter to someone? You'd put your address on the letter and send it to the address of the person you're sending the letter to. Computers have addresses just like houses. Computers on a network have

an identifier called an IP address. An IP address is composed of digits and numbers like 100.1.4.3. When we want to access a website, we're actually going to their IP address, like 172.217.6.46. Devices that can connect to a network have another unique identifier called a MAC address. MAC addresses are generally permanent and hard-coded onto a device. A sample MAC address can be something like this. When you send or receive data through a network, you need to have both an IP and a MAC address. You might be wondering why we need to have two different numbers to identify something. That's a good question. Think again of the letter analogy we use before. An IP address is your house address, while the MAC address is the name of this recipient of the letter. You want to make sure your letter gets to the right location and to the right person. A more simplified example of the letter delivery would go like this. I'm in New York city and I got a letter that I want to send to a friend, May. May's halfway across the world in Tokyo. Our letter, we'll go through lots of places before it reaches her. I put her name and address on there and I also put my name and address on there too. When I drop my letter off at the post office, the mail person looks at it. He thinks, I don't know how to get to Tokyo from here, but there's a truck that's headed to Texas. He puts my letter in that truck at the post office in Texas. A mail person looks at the letter and says, I don't know how to get to Tokyo from here, but we have a truck going to San Francisco. She puts my letter in that truck. At the post office in San Francisco, yet another mail person looks at my letter. He says, there's a plane headed to Tokyo and puts the letter on that plane. When it finally reaches Tokyo, the postman there says, I know where May lives and delivers the letter to her. Obviously, there are many more nuance to mail delivery than what I described, but this process is similar to how information gets routed across the Internet. One thing to call out is that data that's sent through a network is sent through packets. There's little bits of data and you guessed it, ones and zeros. It doesn't matter if it's pictures, email, music, or text. When we move data through the network, we break them down into packets. When a packet gets to its destination, it will rearrange itself back in order. Think of a packet like a letter. Let's actually look at this process again, but this time we'll use IP addresses and MAC addresses. Natalie has a computer with IP address 113.8.81.2 and she wants to go to google.com and search for pictures of cats. Before she does that, her computer has to send a packet to ask google.com if it can access their website. Our packet knows google.com's IP address is 172.217.6.46, but it doesn't know how to get there just yet. The packet travels from one place to another at each destination where it asks, hey, do you know where google.com is? Eventually it'll be routed to another destination that can get the packet closer and closer to google.com. Once it reaches a destination that can deliver the packet to aserver@google.com, Google will send Natalie a packet saying she can access an unlimited number of cat pictures.

Networking Hardware

Now that we understand what networks are. Let's talk about how they're connected. There are a lot of ways you can connect computers to a network, we'll only cover a few of the major ones in this course. First, there's an ethernet cable which lets you physically connect to the network through a cable. On the back of the desktop we worked in the previous lessons, there's a network ports that you plug your ethernet cable into. Another way to connect to a network is through Wi-Fi, which is wireless networking. Most modern computing systems have wireless capabilities like mobile phones, smart televisions and laptops. We connect to wireless networks through radios and antennas. The last method will go over uses fiber optic cables to connect to a network. This is the most expensive method since fiber optic cables allow greater speeds than all the other methods, fiber optic gets its name because the cables contain glass fibers that move data through light instead of electricity. This means that we send ones and zeros through a beam of light instead of an electrical current through a copper wire. How cool is that? But our cables have to connect to something. We don't just have millions of cables going in and out of computers to connect them together. Instead, computers connect to a few different devices that help organize our network together. The first device that your computer connects to is a router. A router connects lots of different devices together and helps route network traffic, let's say we have four computers, A, B, C and D connected together through a router in the same network. You want to send a file from computer A to computer B. A packets go through the router and the router utilizes network protocols to help determine where to send the packet. So now our packet gets routed from computer A to computer B, sweet. What if we wanted to send a packet to a computer not in our network? What if we wanted to send a packet to our friend Alejandro's computer. Alejandro is on a different network altogether. Fortunately, our router knows how to handle that to the packet will get routed outside our network to our ISPS network using networking protocols, it's able to figure out where Alejandro's computer is. During this process, our packet is traveling across many different routers, switches and hubs, switches and hubs are also devices that help our data travel. Think of switches like mail rooms in a building, routers get our letters to the building, but once we're inside we use the mail room to figure out where to send a letter. Hubs are like company memos, they don't know who to send the memo to, so they send it to everyone. Working with network devices is important to understand because it's likely that one day you'll have users reporting problems accessing the Internet, you'll want to investigate your way up the network stack, a technology stack. In this case a network stack is just a set of hardware or software that provides the infrastructure for a computer. So the network stack is all the components that makes up computer networking. You might need to investigate the network stack in your job. You'd start with making sure the end user computers are working properly. Then you turn your attention to other possible points of failure, like the cabling, switches and routers that work together to access the Internet.

TCP/IP

There are lots and lots of network protocols used, and they're all necessary to help us get our packets in the right place. Think of network protocols like a set of rules for how we transfer data in a network. Imagine if you sent a letter to your friend Sasha, who lives in California, but your post office sends it out to another Sasha who lives out in New York. That would hopefully never happen since the post office has rules that they follow to make sure your letter is sent to the correct address. Our networking protocols do the same thing. There are rules that make sure our packets are routed efficiently, aren't corrupted, are secure, go to the right machine, and are named appropriately. You get the idea. We'll cover specific network protocols later on. But there are two protocols that you need to know. The Transmission Control Protocol and the Internet Protocol, or TCPIP for short, which had become the predominant protocols of the Internet. The Internet Protocol, or IP, is responsible for delivering our packets to the right computers. Remember those addresses that computers use to find something on a network? They're called IP addresses or Internet Protocol Addresses. The Internet Protocol helps us route information. The Transmission Control Protocol, or TCP, is a protocol that handles reliable delivery of information from one network to another. This protocol was an important part of the creation of the internet since it led us share information with other computers. For now, you've got a high level understanding of how the Internet works with TCP, IP.

The Web

Lots of different ways to use the internet, we all know that. But I want to cover one of the more prevalent ways that people access the internet, through the web. All websites can be accessed through the web. Websites are basically text documents that we format with HTML or HyperText Markup Language. It's a coding language used by web browsers. Web pages are generally made up of very basic components. They contain multimedia content like text, images, audio and video. When you want to navigate to a website, you would type in URL like, www.reddit.com. A URL which stands for Uniform Resource Locator is just a web address similar to a home address. Notice the www in the URL, it stands for World Wide Web. The second portion, reddit.com is something we call a domain name. Anyone can register a domain name, it's just our website name. Once a name is taken it will be registered to ICANN, the Internet Corporation for Assigned Names and Numbers. Once a domain name is registered with, ICANN, no one else can take that name unless it becomes available again. The last part of the URL, in this case is dot com. But you can also use different domain endings like reddit.net or reddit.org. The different domain name endings are standards for what type of website it might be. So a domain that ends in .edu is mainly used for educational institutions. Remember how computers use IP addresses to find another computer. Well, you can do the same if you wanted to find a computer on the internet. Let's go ahead and type 172.217.6.46 into a web browser and hit enter. Wait a minute, what happened? How come we're at Google's homepage? It turns out the IP address 172.217.6.46 maps to Google's homepage through a critical web protocol Domain Name System or DNS. DNS acts like our internet directory. And let's just use human readable way words to map to an IP address. The computer doesn't know what Google.com is. It only knows how to get to an IP address with DNS. It's able to map google's IP address with Google.com. Every time you go on a website, your computer is performing a DNS look up to find the IP address of the website name you typed in. This trick can be a good first step in diagnosing certain kinds of DNS issues. So if you're able to access a website by its IP address but not its human readable domain name, then there's a good bet that there's probably a problem somewhere in the DNS configuration your network is using. Understanding IP addresses can come in handy in all sorts of other situations you might encounter as an IT support specialist. The source of internet requests are usually identified by IP addresses in server logs. Many pieces of IT infrastructure need to have some kind of IP address configuration applied to them in order to work. DNS is a huge system and we'll be discussing more about it later. Now that you understand the basics of how the internet works. I'll sign off for now, and leave you in the very capable hands of my friend and colleague Jeone Spicuzza. I'll see you again in course to the bits and bytes of computer networking. But in the next lessons, Jeone is going to talk about the incredible boom of the internet age.

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Victor: First job experiences

My first IT job I was essentially a glorified spam filter. They hired me part time to go through the spam folder and then find anything that got mislabeled the spam and forward it to people's inboxes. So I did that for about a week and then I was like this is insane, there is no way that huge companies are paying people to sit in the back of the room and do this. So I started installing at the time, I was like spam assassin is like open source mail filter. Yeah, and then I basically like automated that away and I told my boss about it and I was like hey this is like we don't need this anymore, I don't need to do that anymore. So then I started doing other things and I'm like I would create new accounts that would delete all accounts. And I kind of just did that. I grew into eventually becoming like the full time sys admin for for the company there. When I graduated I started looking at other large companies that I might be excited to work for. So Google was one of them and I threw my resume together and I sent it over for one of the IT jobs that they had here and I didn't really think I was going to get it. I was literally in the means of moving to Seattle when they told me like can you start in four weeks? So I had to figure it out. I had four weeks to change my plans entirely and I started here and I learned like what IT really looked like in a huge environment.

History of the Internet

You've learned what the Internet is and a little bit about how it works. Now, we're going to take a step back and learn why it was created. But before we do that, I'd like to introduce myself. My name is Gian Picasa and I'm a Program Manager in Android Security. I help protect Android's two billion plus users by managing new security features for each of Android's deserts or versions of Android. I've always loved technology and I worked in IT since I was 16 and throughout university, I would fill my past time reading about new tech and building servers from old computer parts in my basement. My earliest memory of working on tech is waiting for my parents to go to sleep so I could quietly dial up the Internet while the phone was free and just browse websites all night long and read about random tech things. My first jobs were as a one-person IT crew at three non-profit organizations. It was both stressful and really exciting to be responsible for everything, from configuring and administrating backup servers to just showing new employees how to access email and use their computers. I'm really excited to be here with you. I was never a really great test taker and my grades reflected that. But I knew with hard work and perseverance, I could build a great career in IT and so can you. Let's get started and dig in a bit more on the Internet. The Internet has become an essential part of our lives. Our bank accounts, entertainment, news and education are all on the Internet. It's important to learn why that is, since some of the original designs of the Internet have reached their limitations. As an IT support specialist, you should understand what the future of the Internet holds and why. Let's go back in time to the 1950s where it all started. Remember, back then computers were huge and bulky. If you're a programmer, you needed to directly interact with these massive computers that would get real old real fast, especially if you had several people who wanted to use the only computing resource available. The late 1960s, the US government spun up a project called DARPA. It went on to create the earliest version of the Internet that we've seen today with the ARPANET. Eventually, computer programmers were able to share a single computing resource by being able to remotely access the computer. But there were still a big problem. Networks couldn't talk to each other. It wasn't until the 1970s that we had a critical breakthrough in computer networking that fix this problem. It was thanks to computer scientists, Vinton Cerf and Bob Kahn who created the method we call the Transmission Control Protocol and the Internet Protocol, or TCP/IP. First, only a handful of computers in universities, governments and businesses adopt TCP/IP, then hundreds. Then in the span of 50 years, billions of computers. TCP/IP is the protocol that we use on the Internet today. Finally, people around the world could send data to one another. But there were still a problem. The information they sent was just text, it wasn't centralized and it was pretty bland. Then in the 1990s, a computer scientist by the name of Tim Berners-Lee invented the worldwide web. It utilized different protocols for displaying information in webpages and became the predominant way of communication and accessing the Internet. Anyone who had an Internet connection at that time was able to access the information source of the World Wide Web. It's been 30 years since the creation of the World Wide Web. We've gone from sending simple email messages in the viewing basic web pages to having video chats and instant news updates, order food, buy books, and even cars in a matter of seconds, taking the online course like this wasn't even possible until recently. The creation of the Internet that we know today was the culmination of knowledge and engineering from many brilliant scientists and organizations.

Limitations of the Internet

We've mentioned IP addresses a lot in this course, but we haven't actually gone into detail about them. There are actually different versions of IP addresses. The current protocol, Internet protocol version four, or IPV4, is an address that consists of 32 bits separated into four groups. IPV4 addresses can be something like 73.55.242.3. Even though it might seem like a lot of possible IPV4 addresses, there are less than 4.3 billion IPV4 addresses. There are way more than 4.3 billion websites out on the web today. Some IPV4 addresses are even reserved for special purposes. The number of usable IP addresses is even less. A device that wants to connect to the Internet needs to have an IP address. But devices around the world have already exceeded those numbers. Where have we been getting IP addresses? IP addresses have been able to keep up with the amount of devices in the world thanks to IPV6 or Internet Protocol version 6 addresses, IPV6 addresses consists of 128 bits, four times the amount that IPV4 uses, which means way more devices can have IP addresses. The adoption of IPV6 addresses has been slow but steady. Eventually, you'll start seeing more and more IPV6 addresses in the wild. An example of IPV4 address can be something like 172.14.24.1. But an IPV6 address can be something like what you see here. Quite a bit of a difference, don't you think? Here's an analogy for how big this difference is between IPV4 and IPV6. With IPV6, there are two to the 128th power possible IP addresses. Two to the 128th power is an insanely huge number, so huge that scientists had trouble describing with words just how big this number is. Here's an analogy. Think of a grain of sand. If you scoop up a handful, do you know how many grains you have in your hand? Probably a lot, but that's not even close to the number we're talking about. Now, take all the grains of sand in the entire world. Assuming there are roughly seven and a half times ten to the 18th power grains of sand in the world that still wouldn't be enough IPV6 addresses. Now, let's take all the sand from multiple Earths. Now you're close to what that number would be. It's a crazy large number. Just know that we won't be running out of IPV6 addresses anytime soon. Another mitigation tool that we've been able to use is NAT or Network Address Translation. This lets organizations use one public IP address and many private IP addresses within the network. Think of that like a receptionist that a company. You what number to dial to get to the company. Once you reach the receptionist, he can transfer your call to one of the private numbers inside the company. Now, instead of companies using hundreds of public IP addresses, they can just use one IP address. Remember the routers we talked about earlier? One task you might need to perform when you're an IT support specialist is to configure NAT on a router to facilitate communication between your company's network and the outside world.

Changing Careers

A lot of the skills from my previous jobs, such as at the call center that I can apply now, is my attention to detail. Having the soft skills of being creative, thinking outside of the box, those have all helped me in my new position. >> All the jobs that I've had prior to IT, their main fundamental was customer service. It's that same customer service fundamental that has transferred to my current IT position. >> I definitely think that working, especially for the police department, did get me prepared for this. Because when you're working in a 911 center, you really never know what's going to happen. >> I was already in a really high position as a restaurant manager, and that's when I felt like I plateaued. I couldn't do that for the rest of my life. And here I am as an IT consultant entry level. I have health insurance. I have plenty of time off.