The Subnet Calculator

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***Abstract****—* **The increase of devices everywhere can only mean one thing, more ip addresses. Currently Internet Protocol Version 4 (IPv4) is the current version of ip addresses that run throughout the world. The protocol is limited however in how devices can be connected as there are only 32 bits, meaning 232 or 4,294,967,296 ip addresses can be used, and that’s not even considering reserved ip addresses. Now considering each household has multiple devices, if each of them were assigned a unique address, there wouldn’t be any more addresses available. Currently the solution is to utilize Network Address Translation (NAT)[1]. The NAT essentially gives one public ip address per household/area and then translates them to private ip addresses where each device has a different private ip address. When communication needs to exit the household/area, the NAT then translates it back to a public address out into the World Wide Web. In order to calculate the ip addresses, a good deal of knowledge is needed when deciding how many devices need to be allocated within a certain subnet. This is due to the fact that we don’t want certain networks to interact with each other for security purposes. Enter the Subnet Calculator, which will help network architects design their networks.**

***Keywords—*Octet, Network Address Translation(NAT), Subnet Mask, Network Address, Internet Protocol Version 4(IPv4), Internet Protocol Version 6(IPv6), Hosts, Static, Dynamic Host Configuration Protocol (DHCP) , AND gate, Network Address, Broadcast Address, MAC Address, Classless Inter-Domain Routing(CIDR), Network Interface Card (NIC), Spoof**

I. INTRODUCTION

First, let’s go over what exactly a subnet is. In an IP address whether its IPv4/IPv6, there lies a piece of data that is the subnet mask.[2] Now the the subnet mask is used to find where exactly the network starts, which is also known as the Network Address. Not only that, but the mask tells you how many ip addresses are available.

Table I

| IP Address | Subnet Mask | Network Address |
| --- | --- | --- |
| 192.168.1.1 | 255.255.255.0 | 192.168.1.0 |
| 172.16.1.8 | 255.255.0.0 | 172.16.0.0 |
| 224.89.45.6 | 255.0.0.0 | 224.0.0.0 |
| 10.200.6.32 | 255.255.255.128 | 10.200.6.0 |

Table I shows a given IP address, a mask and the resulting network address. But how exactly is the calculation done with the mask? The answer lies in converting both the IP address and the subnet mask into binary [3]. Once done, we then use the gate operation AND, with each corresponding bit of the IP address and the mask.

Let’s use the following IP address 192.168.1.1 and Subnet Mask 255.255.255.0

Table II

| Octet | Binary IP | Subnet Mask | Network Address  (Binary) | Network  Address  (Decimal) |
| --- | --- | --- | --- | --- |
| 1 | 11000000 | 11111111 | 11000000 | 192 |
| 2 | 10101000 | 11111111 | 10101000 | 168 |
| 3 | 00000001 | 11111111 | 00000001 | 1 |
| 4 | 00000001 | 00000000 | 00000000 | 0 |

Looking at Table II, will show how exactly the operation is done. Using a bit-wise operation AND, with the IP address and Subnet mask yields the network address 192.168.1.0.

II. HOSTS

Now that the network address is available, how exactly does that tell us how many devices are available. The Subnet Mask is what actually tells us how many devices can be on the network. However, since there are multiple types of devices out there, they are usually referred to as Hosts in the realm of IT.

If we look at the same subnet mask of 255.255.255.0, we can see that there are a total of 8 bits not being used. Which means that there are 28 ip addresses or 256 available; however in a subnet there are certain ip addresses that can not be used for devices.

In every subnet there are three IP addresses that are reserved, which are the Network Address, the Gateway Address and the Broadcast Address.

Normally under most general networks, the next ip address after the Network address is considered the Gateway. The last IP address in the subnet is reserved for the Broadcast. All of this means there are 253 addresses that are available to use for hosts in the 255.255.255.0 subnet.

III. CLASSLESS INTER-DOMAIN ROUTING

Instead of citing the subnet numbers over and over again, we can utilize the Classless Inter-domain routing Notation, or CIDR notation [4]. For example in the same subnet of 255.255.255.0, we notice that there are 24 bits that are being used, so normally to shorthand the notation we write /24 to signify the subnet mask instead.

Other than that there exists four different types of classes when referring to CIDR. They are denoted by Class A,B,C, and D.

Table III

| Class | Range |
| --- | --- |
| A | 0.0.0.0 - 127.0.0.0 |
| B | 128.0.0.0 - 191.255.0.0 |
| C | 192.0.0.0 - 223.255.255.0 |
| D | 224.0.0.0 - 239.255.255.255 |

Table 3 shows exactly where the ranges stop, and match up with /8, /16, and /24 to signify where in the subnet we need to mask, which is useful to know since we only need to calculate the subnet for a given octet and not all four octets despite how relatively simple it may be.

IV. DYNAMIC HOST CONFIGURATION PROTOCOL AND STATIC IP

After figuring out the calculations, a decision must be made of whether to assign the addresses automatically or manually.

Utilizing Dynamic Host Configuration Protocol will make it easier for administrators to assign IP addresses automatically[5]. However, that usually comes at a cost of security, and so network admins usually split the network utilizing different DHCP servers for different groups. For example we don’t want Human Resources to have access to the same network and resources as Finance and vice versa.

This is where Static IPs come in. Static IPs are assigned manually and are fixed for as long as the user/admin doesn’t change the ip address itself. Although more tedious, this allows the use of having one device dedicated to one ip address which is great for security reasons. Depending on how the network is set up, ip addresses can be tied to the MAC address of the host, since all hosts that have a Network Interface Card (NIC) will have a MAC address which is essentially a serial number. This however is not a full proof security measure as there are ways to spoof or fake the MAC address [6].

VI. FPGA APPLICATION

Even though there are easily accessible calculators on the internet, there are certain areas where we simply can not utilize them. For example if one were to be in an area that requires top secret clearance, devices that have any internet access that is not property of the government would not be able to be used. Even phone usage is limited. So developing a secure subnet calculator with no other malicious actors on it can have network administrators properly configure networks without having to manually calculate them. Even normal IT administrators can be able to see whether their devices are connected to the right subnet or not.

VIII. IMPLEMENTATION

When it comes to implementing a design, careful planning and testing is required to successfully complete any design. Breaking each component down into submodules and testing each one can help.

However, even then there can be some oversight. For example, IPv4 addresses have 32 bits. Now utilizing them at face value would require 32 inputs if they aren’t broken down into each of the octets. Not only that but the Subnet Mask can also be 32 inputs. A total of 64 inputs is not feasible on certain FPGA boards without any external connections. So in order to use just a module like the Subnet Calculator, we need to be able to break down the inputs to be able to utilize them onto a FPGA board.

VIII. CONCLUSION

In the realm of cybersecurity, obscuring networks is a known standard to keep any malicious actors at bay. Having a subnet calculator to calculate ip addresses in subnets helps decipher where the network starts and where it ends. It also helps in determining how many devices are on the network and which devices they are connected to. If communication needs to be set up in a timely manner, such as in the military, they need to be able to know which devices to put on the network statically and whether they are in the right subnet or not. Or if you're a hobbyist, the calculator will help when clarifying whether your hand calculations are correct. Just use a spare FPGA chip with LCD/LED screens to program a simple subnet calculator on it. Not only that but if we were to switch from IPv4 to IPv6 in the near future, the difficulty in trying to determine where the network starts drastically increases. Instead of capping out at /32, which is 32 bits, we would instead have to utilize up to /128, or 128 bits to try and calculate where the network starts.

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