Routing and IP Addresses

Contents

Overview

When information is sent via the Internet, we want to make sure it reaches its intended target.
IP routing refers to the way in which information is *redirected* through a network using the **I**nternet **P**rotocol (IP).

IP Addresses

Similar to the postal system, IP addresses provide a unique way to identify a specific node.
Since this must be unique, each IP address can only be assigned to one device at a time.

The current standard of IP address is **IPv4**.

Structure

IPv4 addresses are a *32-bit*, **binary** address.
The address is split by full stops in to 4 *octets*, each containing 8 bits of information.
Let's assume we have a computer in a network which has the following IP address:

```
11000000.10101000.00000000.00000001
```

Binary

Since this is a binary address, it can only contain **0** or **1**.
The position of the **1**s is what is important.

Each position in the octet refers to a *index of 2*, so we can consider each octet as a **sum**, wherever there is a **1** we add that index of 2.

Let's take the first octet as our example:

Index	7	6	5	4	3	2	1	0
Value	128	64	32	16	8	4	2	1
Binary	1	1	0	0	0	0	0	0
Sum	128 +	64 +	0 +	0 +	0 +	0 +	0 +	0 = 192

There is a **1** in the 1st and 2nd position, this relates to 2^7=128 and 2^6=64 respectively.
So adding 128 + 64 = 192, giving us the value of our first octet.

The whole example IP address from above is therefore `192.168.0.1`, feel free to check this for yourself.

The **maximum** value for an octet is `11111111` = `255`, and the **minimum** is `00000000` = `0`.

CIDR Notation

You may have noticed that all devices on your home network all begin with the same few octets, this is because your IP address is made up of two parts:

- **network prefix** - identifies the network which a device is connected to.
- **host identifier** - identifies the specific device within a network.

Within a single network, the **network prefix** cannot be changed, we say that it is static.
We specify how many bits of data must be static by using **C**lassless **I**nter-**D**omain **R**outing (CIDR) Notation.

```
192.168.0.0/24
```

This is **CIDR Notation**, it tells us that the first **24** bits of the IP address belong to the network prefix, meaning they cannot change. This leaves **8** bits of the IP address for the host identifier.

So, `192.168.0.1` and `192.168.0.237` are two different devices which are uniquely identified and part of the same network.

Ports

Sometimes we don't need access to the whole node, just to a small, *self-contained* program which we call a **service**.
We can assign a service to a port, although most services come with a default port.

Java applications are services which can be hosted on the internet from a computer, they usually run on port `8080`.
We specify which port to access by appending `:` followed by the port number to the IP address.

Hence, we could access a Java application by going to the following address:

```
192.168.0.1:8080
```

IPv6

Since IPv4 addresses must contain *32-bits* of information, we will eventually run out.

A new type of IP address is being slowly deployed to replace IPv4, it is called **IPv6**.
IPv6 uses a *128-bit* address instead of IPv4's *32-bit*, this gives far more potential addresses so we should not run out of IPv6 addresses for a long time.

Structure

IPv6 are expressed in 8 groups, of 4 hexadecimal digits which are separated by a colon (`:`).
Each hexadecimal digit corresponds to a *4-bit* binary number, each group is therefore *16-bit*.
A chart showing the conversion can be found here.
An example could be:

```
2001:0db8:0000:0000:8a2e:0370:7334:0001
```

Since this is very long, we can remove any preceeding **0**s from a group, so we can shorten the example to:

```
2001:db8::8a2e:370:7334:1
```

The `::` refers to one or more groups of `0000`.

IPv4 addresses can be written in IPv6 format.

Tutorial

Using the terminal on our machines, we're going to look at the current IP configurations of our machine.

Windows

Open up `powershell`.
This can be done by pressing the `windows key` and `R` at the same time, and then typing in `powershell`.

Once you have opened powershell, type the following and press `Enter`

```
ipconfig
```

You should be able to see your IPv4 and IPv6 addresses, as well as a few other details about your network.

Linux/MacOS

Open up a `terminal`.
This can be done by searching your applications for the word `terminal`.

Once you have opened a terminal, type the following and press `Enter`

```
ifconfig
```

Here `inet` refers to your IPv4 address and `inet6` refers to your IPv6 address.

Exercises

Convert the following **binary** addresses:

10101010.11110000.01010101.00011000

▶ Answer
01111111.00000000.00000000.00000001

▶ Answer
Convert the following **decimal** addresses:

74.125.43.99

▶ Answer
192.178.7.254

▶ Answer
What is the lowest and hightest possible IPv4 address in the range specified by the following CIDR notation?

34.45.0.0/19

▶ Answer