

Computer Networks

How They Work

Address & Phone Number

Conceptually, the operation of a computer network is very similar to two networks that have been in place over a hundred years – the postal service and telephone networks.

For both of these networks, there is an exchange of information (voice, written letters). More importantly, the source and destination is defined by a unique identifier (a phone number or a mailing address).

Network Addressing

Similar to either phone service or postal mail, the delivery of information on a computer network relies on the addresses of both the source and destination (computers).

We will examine the protocols (rules) and technology involved in the addressing process. There is also a set of protocols for dealing with the data itself, and if you are interested in this, you can do some extra research on your own.

MAC Address

The network identification process begins when various types of hardware are manufactured. Any hardware that is capable of connecting to a network must have a unique identifier, called the MAC (Media Access Control) Address.

It is usually represented in one of two ways:

01:23:45:67:89:ab

01-23-45-67-89-ab

MAC Address

The MAC address has a total of 2^{48} combinations:
 $2^{48} = 281,474,976,710,656$

In theory, this should mean every MAC address is unique. Due to the manufacturing process, however, each company is assigned a bank of addresses.

Each company gets 16,777,216 addresses. When they reach their limit, they start over at 0.

It is still highly unlikely you will ever encounter a duplicate MAC address.

Dynamic Host Configuration Protocol (DHCP)

A MAC Address only allows basic interaction with the network. In order to make proper use of the network, the device requires an IP Address.

To obtain an IP Address, the device *negotiates* with a DHCP server on the network (usually a router or a dedicated computer). An IP Address is associated with the MAC Address of the device for some period of time (called a lease).

For the duration of the lease, the device can make full use of the network.

Internet Protocol (IP) Address

Although there are other networking protocols (both dead and still in use), IP Addressing is dominant.

Each network, and in turn, each device on a network, is assigned an IP Address. Each address is normally represented as a collection of four numbers, each from 0 to 255.

000.000.000.000 to 255.255.255.255

Internet Protocol (IP) Address

These actually numbers represent a single, 32-bit binary number, which allows for about 4 billion unique addresses.

This may seem like a lot, but more than half have already been taken. This is partially due to the number of computer networks in the world, and also due to inefficiencies in how the numbers are distributed.

A new protocol, called IPv6, increases this total, and is slowly being accepted as the new standard.

What is in a Name?

For example, the IP Address of the BHS Web Page is 72.1.193.252, yet this probably isn't familiar to you.

What about Google?

google.ca 74.125.159.104

In fact, most people never interact with an IP Address. The most common network usage, browsing web sites, is done by name.

Domain Name Servers (DNS)

It would be very difficult, if not impossible, to remember the IP Address for your favourite web pages.

A Domain Name Server provides a translation service, converting a web address (for people) into an IP address (for the network).

Each computer connected to the network is told of one (or more) DNS IP addresses by the DHCP Server on the network.

Basic Networking Order

- computer notifies network that it wants to join network by broadcasting MAC address
- DHCP server on network assigns an IP address to that MAC address and notifies computer
 - also provides location of DNS server
- computer requests data using a domain name (e.g., www.ocdsb.ca)
- DNS server converts domain name into IP address
- computer contacts IP address for information

Networking Tools

Most computer systems (Windows, MacOS, Linux) have some basic networking tools available to the user.

For advanced users, much more powerful and sophisticated tools are available for purchase or download.

In Windows, the simplest access to these tools is through a command prompt window.

Networking Tools

`ipconfig`

displays basic network information

`ipconfig /all`

displays detailed network information

`ping xxx.xxx.xxx.xxx`
`ping www.name.com`

sends test data to the specified computer to determine (a) if it is alive, and (b) how long it takes for the message to make a round-trip

`tracert xxx.xxx.xxx.xxx`
`tracert name.com`

sends test data to the specified computer and tracks the data through all computers required to reach the specified computer.

Networking Tools

There are also many web sites dedicated to providing network tools. For example:

<http://network-tools.com>

provides many tools used to diagnose and investigate the connections on the internet.