MODULE 6

IP Subnet Addressing

IP networks can be divided into smaller networks called subnetworks (or subnets). Subnetting provides the network administrator with several benefits, including extra flexibility, more efficient use of network addresses, and the capability to contain broadcast traffic (a broadcast will not cross a router).

Subnets are under local administration. As such, the outside world sees an organization as a single network and has no detailed knowledge of the organization's internal structure.

A given network address can be broken up into many subnetworks. For example, 172.16.1.0,
172.16.2.0, 172.16.3.0, and 172.16.4.0 are all subnets within network 171.16.0.0. (All 0s in the host
portion of an address specifies the entire network.)

IP Subnet Mask

A subnet address is created by "borrowing" bits from the host field and designating them as the subnet field. The number of borrowed bits varies and is specified by the subnet mask.

Network Masks

A network mask helps you know which portion of the address identifies the network and which portion of the address identifies the node. Class A, B, and C networks have default masks, also known as natural masks, as shown here:

Class A: 255.0.0.0

Class B: 255.255.0.0

Class C: 255.255.255.0

An IP address on a Class A network that has not been subnetted would have an address/mask pair similar to: 8.20.15.1 255.0.0.0. To see how the mask helps you identify the network and node parts of the address, convert the address and mask to binary numbers.

8.20.15.1 = 00001000.00010100.00001111.00000001

255.0.0.0 = 11111111.00000000.00000000.00000000

Once you have the address and the mask represented in binary, then identifying the network and host ID is easier. Any address bits which have corresponding mask bits set to 1 represent the network ID. Any address bits that have corresponding mask bits set to 0 represent the node ID.

```
8.20.15.1 = 00001000.00010100.00001111.00000001
255.0.0.0 = 11111111.00000000.00000000.00000000
            -----------------------------------
             net id |      host id
```

netid = 00001000 = 8

hostid = 00010100.00001111.00000001 = 20.15.1

Understanding Subnetting

Subnetting allows you to create multiple logical networks that exist within a single Class A, B, or C network. If you do not subnet, you are only able to use one network from your Class A, B, or C network, which is unrealistic.

Each data link on a network must have a unique network ID, with every node on that link being a member of the same network. If you break a major network (Class A, B, or C) into smaller subnetworks, it allows you to create a network of interconnecting subnetworks. Each data link on this network would then have a unique network/subnetwork ID. Any device, or gateway, connecting *n* networks/subnetworks has *n* distinct IP addresses, one for each network / subnetwork that it interconnects.

In order to subnet a network, extend the natural mask using some of the bits from the host ID portion of the address to create a subnetwork ID. For example, given a Class C network of 204.17.5.0 which has a natural mask of 255.255.255.0, you can create subnets in this manner:

```
204.17.5.0 -      11001100.00010001.00000101.00000000
255.255.255.224 - 11111111.11111111.11111111.11100000
                  --------------------------|sub|----
```

By extending the mask to be 255.255.255.224, you have taken three bits (indicated by "sub") from the original host portion of the address and used them to make subnets. With these three bits, it is possible to create eight subnets. With the remaining five host ID bits, each subnet can have up to 32 host addresses, 30 of which can actually be assigned to a device *since* *host ids of all zeros or all ones are not allowed* (it is very important to remember this). So, with this in mind, these subnets have been created.

204.17.5.0 255.255.255.224 host address range 1 to 30
204.17.5.32 255.255.255.224 host address range 33 to 62
204.17.5.64 255.255.255.224 host address range 65 to 94
204.17.5.96 255.255.255.224 host address range 97 to 126
204.17.5.128 255.255.255.224 host address range 129 to 158
204.17.5.160 255.255.255.224 host address range 161 to 190
204.17.5.192 255.255.255.224 host address range 193 to 222
204.17.5.224 255.255.255.224 host address range 225 to 254

Note: There are two ways to denote these masks. First, since you are using three bits more than the "natural" Class C mask, you can denote these addresses as having a 3-bit subnet mask. Or, secondly, the mask of 255.255.255.224 can also be denoted as /27 as there are 27 bits that are set in the mask. This second method is used with CIDR. With this method, one of these networks can be described with the notation prefix/length. For example, 204.17.5.32/27 denotes the network 204.17.5.32 255.255.255.224.

Variable Lenght Subnet Mask (VLSM)

Variable Length Subnet Masking - VLSM - is a technique that allows network administrators to divide an IP address space into subnets of different sizes, unlike simple same-size Subnetting.

Variable Length Subnet Mask (VLSM) in a way, means subnetting a subnet. To simplify further, VLSM is the breaking down of IP addresses into subnets (multiple levels) and allocating it according to the individual need on a network. It can also be called a classless IP addressing. A classful addressing follows the general rule that has been proven to amount to IP address wastage.

CIDR

Classless Interdomain Routing (CIDR) was introduced to improve both address space utilization and routing scalability in the Internet. It was needed because of the rapid growth of the Internet and growth of the IP routing tables held in the Internet routers.

CIDR moves way from the traditional IP classes (Class A, Class B, Class C, and so on). In CIDR , an IP network is represented by a prefix, which is an IP address and some indication of the length of the mask. Length means the number of left-most contiguous mask bits that are set to one. So network 172.16.0.0 255.255.0.0 can be represented as 172.16.0.0/16. CIDR also depicts a more hierarchical Internet architecture, where each domain takes its IP addresses from a higher level. This allows for the summarization of the domains to be done at the higher level. For example, if an ISP owns network 172.16.0.0/16, then the ISP can offer 172.16.1.0/24, 172.16.2.0/24, and so on to customers. Yet, when advertising to other providers, the ISP only needs to advertise 172.16.0.0/16.

Example:

- the address specification 198.51.100.1/24 represents the given IPv4 address and its associated routing prefix 198.51.100.0, or equivalently, its subnet mask 255.255.255.0.
- the IPv4 block 198.51.100.0/22 represents the 1024 IPv4 addresses from 198.51.100.0 to 198.51.103.255.
- the IPv6 block 2001:db8::/48 represents the IPv6 addresses from 2001:db8:0:0:0:0:0:0 to 2001:db8:0:ffff:ffff:ffff:ffff:ffff.
- ::1/128 represents the IPv6 loopback address. Its prefix size is 128, i.e. the size of the address itself, indicating that this facility consists of only this one address.

Before CIDR notation, IPv4 networks usually used the dot-decimal notation, an alternative representation which uses the network address followed by the network's subnet mask. Thus, The CIDR notation 198.51.100.0/24 would be written as 198.51.100.0/255.255.255.0

The number of addresses of a subnet defined by the mask or prefix can be calculated as $2^{\text{address size - prefix size}}$, in which the address size for IPv6 is 128 and 32 for IPv4. For example, in IPv4, a prefix size of /29 gives: $2^{32-29} = 2^3 = 8$ addresses.

However, because at least one of these addresses is typically used for a gateway to other subnets, and because certain addresses are reserved as broadcast addresses, the number of addresses available for hosts is usually smaller.