

Considerations in designing Subnet Masks

The network administrator has to carefully give thought to the plan that aim to address the deployment of an organizational private network. The following are key queries that need be on the minds of the network administrator:

- i) Today, how many subnets does my organization need?
- ii) In the future, how many subnets shall my organization need?
- iii) Today, what shall be my largest subnets and how many hosts shall that subnet comprise?
- iv) In the future, what shall be the largest subnets and how many hosts shall those subnets comprise?

Subnetting an Organizational Network

In creating subnets in a network the network administrator has three critical steps to consider:-

Step One

The network administrator needs to consider the maximum number of subnets needed then round them up to the nearest power of two. For instance, if an organization requires 9 subnets, then 8 or 23 subnets would not suffice,

therefore the network administrator will be required to round that subnet figure up to 16 or 24. While undertaking this decision, the network administrator should always consider and allow adequate capacity for future growth. For example, if 14 subnets are needed for an organization when creating it, then 16 subnets might not be enough in the near future when the 17th subnet needs to be deployed. In this case, the network administrator might be required to allow for more growth and select 25 or 32 as the maximum number of subnets.

Step Two

The network administrator needs consider enough number of hosts on the largest subnet. If the largest host supports 50 hosts then 2^5 or 32 hosts does not provide enough hosts to the network administrator. The administrator shall therefore be required to round it up to 2^6 or 64 hosts to allow for growth in the future.

Step Three

The final step in the addressing plan is for the network administrator to consider the organizations address allocation and ensuring that the plan avails enough bits required to be deployed in the address plan.

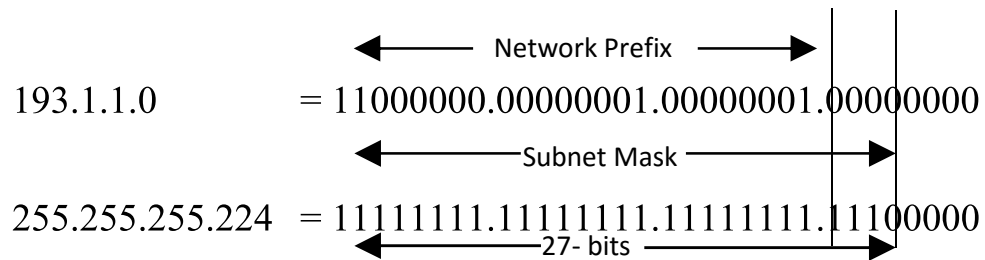
Problem

The School of Computing (SCAI), Kibabii University has been assigned the network number 193.1.1.0/24 by the system administrator and needs to define six subnets for all its computer labs. The largest subnet is required to support 25 hosts. You as a consultant network administrator are required to define the subnet masks for the network.

Solution

The first step is to determine the number of bits required to define the six subnets. Since a network address can only be subnetted along binary boundaries, subnets must be created in blocks of powers of two i.e. 2 (2^1), 4 (2^2), 8 (2^3), 16 (2^4), etc. Therefore, it is impossible to define an IP address block such that it contains exactly six subnets. For this example, therefore, the network administrator must define a block of 8 (2^3) and have two unused subnets that can be reserved for future growth. Since $8 = 2^3$, three bits are required to enumerate the eight subnets in the block.

In this example, the organization is subnetting a /24 so it will need three more bits, or a /27, as the subnet mask (extended-network-prefix). A 27-bit subnet mask can be expressed in dotted-decimal notation as 255.255.255.224.



The subnet mask we have defined in the problem above leaves us with 5 bits to define host addresses on each subnet. This in turn means that each subnet with 27 bit prefix represents (2^5) 32 individual IP addresses. However, as discussed earlier that all-0s and all-1s host addresses cannot be allocated, there are 30 $(2^5 - 2)$ available host addresses on each subnet that can be assigned.

The next step is to define each of the subnet numbers where we number the 8 subnets from 0 to 7. Let us denote XXX_2 as the binary representation of the subnets 0 to 7 such that we have 0(000₂), 1(001₂), 2(010₂), 3(011₂), 4(100₂), 5(101₂), 6(110₂) and 7(111₂).

The following list gives the eight subnets we have derived:-

Base Net: **11000001.00000001.00000001.00000000** = 193.1.1.0/24

Subnet 0: **11000001.00000001.00000001.00000000** = 193.1.1.0/27

Subnet 1: **11000001.00000001.00000001.00100000** = 193.1.1.32/27

Subnet 2: **11000001.00000001.00000001.01000000** = 193.1.1.64/27

Subnet 3: **11000001.00000001.00000001.01100000** = 193.1.1.96/27

Subnet 4: **11000001.00000001.00000001.10000000** = 193.1.1.128/27

Subnet 5: **11000001.00000001.00000001.10100000** = 193.1.1.160/27

Subnet 6: **11000001.00000001.00000001.11000000** = 193.1.1.192/27

Subnet 7: **11000001.00000001.00000001.11100000** = 193.1.1.224/27

The part of the address that is in bold is the subnet mask address that we have derived while the underlined parts are the 3 bits representing the subnet mask number field.

Note that the subnet masks are correct if all are multiples of subnet number 1. For instance in this example, all subnets are multiples of subnet number 1 which is 32 i.e. 0, 32, 64, 96, 128, 160, 192, and 224.

The final step is to define the host address for each subnet mask. We have taken 3 bits from a possible 8 bits to define the subnet masks for our network. We therefore are left with 5 bits with which to use to define the host IP addresses. However we need to note that out the 8 bits available, 2 bits which represents all 0s and all 1s are not available for allocation because they represent the base network address and the broadcast network respectively. Therefore, we shall have $(2^5) = 32 - 2 = 30$ host IP Addresses.

To define the host number of n of a particular subnet, we need to place the binary representation of n into the subnet's host IP address field. For example, to define the host IP address 9 on subnet number 4, we simply place the binary representation of 9 (01001_2) into the last 5 bits of subnet 4's host IP address field.

Therefore the host IP addresses for the subnet masks are as follows:-

Subnet 0: **11000001.00000001.00000001.000**00000 = 193.1.1.0/27

Host #1: 11000001.00000001.00000001.000**00001** = 193.1.1.1/27

Host #2: 11000001.00000001.00000001.000**00010** = 193.1.1.2/27

Host #3: 11000001.00000001.00000001.000**00011** = 193.1.1.3/27

Host #4: 11000001.00000001.00000001.000**00100** = 193.1.1.4/27

Host #5: 11000001.00000001.00000001.000**00101** = 193.1.1.5/27

Host #6: 11000001.00000001.00000001.000**00110** = 193.1.1.6/27

Host #7: 11000001.00000001.00000001.000**00111** = 193.1.1.7/27

Host #8: 11000001.00000001.00000001.000**01000** = 193.1.1.8/27

Host #9: 11000001.00000001.00000001.000**01001** = 193.1.1.9/27

Host #10: 11000001.00000001.00000001.000**01010** = 193.1.1.10/27

Host #11: 11000001.00000001.00000001.000**01011** = 193.1.1.11/27

Host #12: 11000001.00000001.00000001.000**01100** = 193.1.1.12/27

Host #13: 11000001.00000001.00000001.000**01101** = 193.1.1.13/27

Host #14: 11000001.00000001.00000001.000**01110** = 193.1.1.14/27

Host #15: 11000001.00000001.00000001.000**01111** = 193.1.1.15/27

Host #16: 11000001.00000001.00000001.000**10000** = 193.1.1.16/27

Host #17: 11000001.00000001.00000001.000**10001** = 193.1.1.17/27

Host #18: 11000001.00000001.00000001.000**10010** = 193.1.1.18/27

Host #19: 11000001.00000001.00000001.000**10011** = 193.1.1.19/27

Host #20: 11000001.00000001.00000001.000**10100** = 193.1.1.20/27

Host #21: 11000001.00000001.00000001.000**10101** = 193.1.1.21/27

Host #22: 11000001.00000001.00000001.000**10110** = 193.1.1.22/27

Host #23: 11000001.00000001.00000001.000**10111** = 193.1.1.23/27

Host #24: 11000001.00000001.00000001.000**11000** = 193.1.1.24/27

Host #25: 11000001.00000001.00000001.000**11001** = 193.1.1.25/27

Host #26: 11000001.00000001.00000001.000**11010** = 193.1.1.26/27

Host #27: 11000001.00000001.00000001.000**11011** = 193.1.1.27/27

Host #28: 11000001.00000001.00000001.000**11100** = 193.1.1.28/27

Host #29: 11000001.00000001.00000001.000**11101** = 193.1.1.29/27

Host #30: 11000001.00000001.00000001.000**11110** = 193.1.1.30/27

Subnet 1: **11000001.00000001.00000001.001**00000 = 193.1.1.32/27

Host #1: 11000001.00000001.00000001.001**00001** = 193.1.1.33/27

Host #2: 11000001.00000001.00000001.001**00010** = 193.1.1.34/27

Host #3: 11000001.00000001.00000001.001**00011** = 193.1.1.35/27

Host #4: 11000001.00000001.00000001.001**00100** = 193.1.1.36/27

Host #5: 11000001.00000001.00000001.001**00101** = 193.1.1.37/27

Host #6: 11000001.00000001.00000001.001**00110** = 193.1.1.38/27

Host #7: 11000001.00000001.00000001.001**00111** = 193.1.1.39/27

Host #8: 11000001.00000001.00000001.001**01000** = 193.1.1.40/27

Host #9: 11000001.00000001.00000001.001**01001** = 193.1.1.41/27

Host #10: 11000001.00000001.00000001.001**01010** = 193.1.1.42/27

Host #11: 11000001.00000001.00000001.001**01011** = 193.1.1.43/27

Host #12: 11000001.00000001.00000001.001**01100** = 193.1.1.44/27

Host #13: 11000001.00000001.00000001.001**01101** = 193.1.1.45/27

Host #14: 11000001.00000001.00000001.001**01110** = 193.1.1.46/27

Host #15: 11000001.00000001.00000001.001**01111** = 193.1.1.47/27

Host #16: 11000001.00000001.00000001.001**10000** = 193.1.1.48/27

Host #17: 11000001.00000001.00000001.001**10001** = 193.1.1.49/27

Host #18: 11000001.00000001.00000001.001**10010** = 193.1.1.50/27

Host #19: 11000001.00000001.00000001.001**10011** = 193.1.1.51/27

Host #20: 11000001.00000001.00000001.001**10100** = 193.1.1.52/27

Host #21: 11000001.00000001.00000001.001**10101** = 193.1.1.53/27

Host #22: 11000001.00000001.00000001.001**10110** = 193.1.1.54/27

Host #23: 11000001.00000001.00000001.001**10111** = 193.1.1.55/27

Host #24: 11000001.00000001.00000001.001**11000** = 193.1.1.56/27

Host #25: 11000001.00000001.00000001.001**11001** = 193.1.1.57/27

Host #26: 11000001.00000001.00000001.001**11010** = 193.1.1.58/27

Host #27: 11000001.00000001.00000001.001**11011** = 193.1.1.59/27

Host #28: 11000001.00000001.00000001.001**11100** = 193.1.1.60/27

Host #29: 11000001.00000001.00000001.001**11101** = 193.1.1.61/27

Host #30: 11000001.00000001.00000001.001**11110** = 193.1.1.62/27

Subnet 2: **11000001.00000001.00000001.010**00000 = 193.1.1.64/27

Host #1: 11000001.00000001.00000001.010**00001** = 193.1.1.65/27

Host #2: 11000001.00000001.00000001.010**00010** = 193.1.1.66/27

Host #3: 11000001.00000001.00000001.010**00011** = 193.1.1.67/27

Host #4: 11000001.00000001.00000001.010**00100** = 193.1.1.68/27

Host #5: 11000001.00000001.00000001.010**00101** = 193.1.1.69/27

Host #6: 11000001.00000001.00000001.010**00110** = 193.1.1.70/27

Host #7: 11000001.00000001.00000001.010**00111** = 193.1.1.71/27

Host #8: 11000001.00000001.00000001.010**001000** = 193.1.1.72/27

Host #9: 11000001.00000001.00000001.010**001001** = 193.1.1.73/27

Host #10: 11000001.00000001.00000001.010**001010** = 193.1.1.74/27

Host #11: 11000001.00000001.00000001.010**001011** = 193.1.1.75/27

Host #12: 11000001.00000001.00000001.010**01100** = 193.1.1.76/27

Host #13: 11000001.00000001.00000001.010**01101** = 193.1.1.77/27

Host #14: 11000001.00000001.00000001.010**01110** = 193.1.1.78/27

Host #15: 11000001.00000001.00000001.010**01111** = 193.1.1.79/27

Host #16: 11000001.00000001.00000001.010**10000** = 193.1.1.80/27

Host #17: 11000001.00000001.00000001.010**10001** = 193.1.1.81/27

Host #18: 11000001.00000001.00000001.010**10010** = 193.1.1.82/27

Host #19: 11000001.00000001.00000001.010**10011** = 193.1.1.83/27

Host #20: 11000001.00000001.00000001.010**10100** = 193.1.1.84/27

Host #21: 11000001.00000001.00000001.010**10101** = 193.1.1.85/27

Host #22: 11000001.00000001.00000001.010**10110** = 193.1.1.86/27

Host #23: 11000001.00000001.00000001.010**10111** = 193.1.1.87/27

Host #24: 11000001.00000001.00000001.010**11000** = 193.1.1.88/27

Host #25: 11000001.00000001.00000001.010**11001** = 193.1.1.89/27

Host #26: 11000001.00000001.00000001.010**11010** = 193.1.1.90/27

Host #27: 11000001.00000001.00000001.010**11011** = 193.1.1.91/27

Host #28: 11000001.00000001.00000001.010**11100** = 193.1.1.92/27

Host #29: 11000001.00000001.00000001.010**11101** = 193.1.1.93/27

Host #30: 11000001.00000001.00000001.010**11110** = 193.1.1.94/27

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Broadcast Addresses for the subnets

The broadcast address for Subnet #1 is the all 1's host address or:

11000001.00000001.00000001.00111111 = 193.1.1.63

The broadcast address for Subnet #2 is the all 1's host address or:

11000001.00000001.00000001.01011111 = 193.1.1.95

Notice that the broadcast address for Subnet #1 and Subnet#2 is exactly one less than the base address for Subnet#2 (193.1.1.64) and Subnet #3 (193.1.1.96) respectively. This is pattern defines the broadcast address for Subnet #n as one less than the base address for Subnet # (n+1).

Class Work

The I.T Department of Kibabii University has been assigned the network number 172.16.5.0/24 by a system administrator and needs to define three subnets for its computer labs. The largest subnet is required to support 5 hosts. You as a consultant network administrator are required to define the subnet masks and IP Addresses for the network.

NOTE: To **STRICTLY** be submitted in the next class lesson without failure.

