Activity 7.1 – Calculating IPv4 Subnets (Not assessed)

1. Background / Scenario

The ability to work with IPv4 subnets and determine network and host information based on a given IP address and subnet mask is critical to understanding how IPv4 networks operate. When given an IP address and subnet mask, you will be able to determine other information about the subnet.

1. Required Resources

* none

1. Calculate IPv4 Address Subnetting

When given an IPv4 address, the original subnet mask and the new subnet mask, you can determine:

* Network address of this subnet
* Broadcast address of this subnet
* Range of host addresses of this subnet
* Number of subnets created
* Number of hosts per subnet

The following example shows a sample problem along with the solution for solving this problem:

|  |  |
| --- | --- |
| Given: | |
| **Host IP Address:** | 172.16.77.120 |
| **Original Subnet Mask** | 255.255.0.0 |
| **New Subnet Mask:** | 255.255.240.0 |
| Find: | |
| **Number of Subnet Bits** | 4 |
| **Number of Subnets Created** | 16 |
| **Number of Host Bits per Subnet** | 12 |
| **Number of Hosts per Subnet** | 4,094 |
| **Network Address of this Subnet** | 172.16.64.0 |
| **IPv4 Address of First Host on this Subnet** | 172.16.64.1 |
| **IPv4 Address of Last Host on this Subnet** | 172.16.79.254 |
| **IPv4 Broadcast Address on this Subnet** | 172.16.79.255 |

Let’s analyze how this table was completed.

The original subnet mask was 255.255.0.0 or /16 because 172 is in the Class B address range.

The new subnet mask is 255.255.240.0 or /20. The resulting difference is 4 bits.

Therefore, 4 bits are borrowed from the remaining 16 bits available for hosts on a Class B network.

We can determine that 16 subnets were created because 24 = 16.

The new mask of 255.255.240.0 or /20 leaves 12 bits for hosts. With 12 bits left for hosts, we use the following formula: 212 - 2 = 4,096 – 2 = 4,094 hosts per subnet.

Binary ANDing will help you determine the subnet for network 172.16.77.20/20:

10101100 . 00010000 . 01001101 . 00010100

11111111 . 11111111 . 11110000 . 00000000

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10101100 . 00010000 . 01000000 . 00000000

which results in the network 172.16.64.0.

Finally, you need to determine the first host, last host, and broadcast address for each subnet.

One method to determine the host range is to use binary math for the host portion of the address. In our example, the last 12 bits of the address is the host portion.

10101100 . 00010000 . 01000000 . 00000000 (red = network bits, blue = host bits)

The most significant bit of the host portion is the leftmost bit, the least significant bit is the rightmost.

The first host would have all significant bits set to zero and the least significant bit set to 1.

10101100 . 00010000 . 01000000 . 00000001

The last host would have all significant bits of the host portion set to 1 and the least significant bit of the host portion set to 0.

10101100 . 00010000 . 01001111 . 11111110

The broadcast address would have all significant bits of the host portion set to 1.

10101100 . 00010000 . 01001111 . 11111111

Putting the above together as a table:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Description | 1st Octet | 2nd Octet | 3rd Octet | 4th Octet | Description |
| Network/Host | **nnnnnnnn** | **nnnnnnnn** | **nnnn**hhhh | hhhhhhhh | Subnet Mask |
| Binary | **10101100** | **00010000** | **0100**0000 | 00000001 | First Host |
| Decimal | 172 | 16 | 64 | 1 | First Host |
| Binary | **10101100** | **00010000** | **0100**1111 | 11111110 | Last Host |
| Decimal | 172 | 16 | 79 | 254 | Last Host |
| Binary | **10101100** | **00010000** | **0100**1111 | 11111111 | Broadcast |
| Decimal | 172 | 16 | 79 | 255 | Broadcast |

You can also work out information about other subnets. With a /20 prefix length, there are 16 subnets (numbered from 0 to 15). Each subnet has its own network address, starting from 172.16.0.0 and adding 16 each time for each subsequent subnet.

You can calculate the size of each subnet by finding the magic number. The magic number is the value of the rightmost bit that is a 1 in the subnet mask. For a /20 prefix length the subnet mask is:

Decimal: 255.255.240.0

Binary: 11111111 . 11111111 . 11110000 . 00000000

Computing the magic number:

Two options:

Option 1:

You can compute the magic number by finding the rightmost 1 in the subnet mask and calculating its value.

The rightmost 1 in the above subnet mask is in the 16 position of the third octet (the value of that bit is 16). This means that each subnet is a multiple of 16.

Finding the rightmost 1 in the subnet mask and its value:

16 8 4 2 1

11111111 . 11111111 . 1 1 1 1 0 0 0 0 . 00000000

Option 2:

An alternative way to computing the magic number is to take the last non-zero value in the decimal subnet mask (240) and subtract it from 256 (because there are 256 values ranging from 0 to 255 in this octet).

Subtraction method:

Subnet mask: 255.255.240.0

Magic number: 256 – 240 = 16

|  |  |  |
| --- | --- | --- |
|  | Network address | Binary |
| Subnet 0 | 172.16.0.0 | 10101100 . 00010000 . 00000000 . 00000000 |
| Subnet 1 | 172.16.16.0 | 10101100 . 00010000 . 00010000 . 00000000 |
| Subnet 2 | 127.16.32.0 | 10101100 . 00010000 . 00100000 . 00000000 |
| Subnet 3 | 172.16.48.0 | 10101100 . 00010000 . 00110000 . 00000000 |
| Subnet 4 | 172.16.64.0 | 10101100 . 00010000 . 01000000 . 00000000 |
| Subnet 5 | 172.16.80.0 | 10101100 . 00010000 . 01010000 . 00000000 |
| Subnet 6 | 172.16.96.0 | 10101100 . 00010000 . 01100000 . 00000000 |
| Subnets 7-13 | 172.16.112.0 – 172.16.208.0 | 10101100 . 00010000 . 01110000 . 00000000  -  10101100 . 00010000 . 11010000 . 00000000 |
| Subnet 14 | 172.16.224.0 | 10101100 . 00010000 . 11100000 . 00000000 |
| Subnet 15 | 172.16.240.0 | 10101100 . 00010000 . 11110000 . 00000000 |

* 1. Fill out the tables below with appropriate answers given the IPv4 address, original subnet mask, and new subnet mask.
     1. **Problem 1**: Worked out

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| --- | --- |
| Given: | |
| **Host IP Address:** | 192.168.200.139 |
| **Original Subnet Mask** | 255.255.255.0 |
| **New Subnet Mask:** | 255.255.255.224 |
| Find: | |
| **Number of Subnet Bits** | 3 |
| **Number of Subnets Created** | 8 |
| **Number of Host Bits per Subnet** | 5 |
| **Number of Hosts per Subnet** | 30 |
| **Network Address of this Subnet** | 192.168.200.128 |
| **IPv4 Address of First Host on this Subnet** | 192.168.200.129 |
| **IPv4 Address of Last Host on this Subnet** | 192.168.200.158 |
| **IPv4 Broadcast Address on this Subnet** | 192.168.200.159 |
| **IPv4 Network Address of the previous Subnet** | 192.168.200.96 |
| **IPv4 Network Address of the next Subnet** | 192.168.200.160 |

* + 1. **Problem 2**:

|  |  |
| --- | --- |
| Given: | |
| **Host IP Address:** | 10.101.99.228 |
| **Original Subnet Mask** | 255.0.0.0 |
| **New Subnet Mask:** | 255.255.128.0 |
| Find: | |
| **Number of Subnet Bits** | 17 |
| **Number of Subnets Created** | 512 |
| **Number of Host Bits per Subnet** | 15 |
| **Number of Hosts per Subnet** | 32766 |
| **Network Address of this Subnet** | 10.101.0.0 |
| **IPv4 Address of First Host on this Subnet** | 10.101.0.1 |
| **IPv4 Address of Last Host on this Subnet** | 10.101.127.254 |
| **IPv4 Broadcast Address on this Subnet** | 10.101.127.255 |
| **IPv4 Network Address of the next Subnet** | 10.101.128.0 |

* + 1. **Problem 3**:

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| Given: | |
| **Host IP Address:** | 172.22.32.12 |
| **Original Subnet Mask** | 255.255.0.0 |
| **New Subnet Mask:** | 255.255.224.0 |
| Find: | |
| **Number of Subnet Bits** | 3 |
| **Number of Subnets Created** | 8 |
| **Number of Host Bits per Subnet** | 23 |
| **Number of Hosts per Subnet** | 8388606 |
| **Network Address of this Subnet** | 172.22.32.0 |
| **IPv4 Address of First Host on this Subnet** | 172.22.32.1 |
| **IPv4 Address of Last Host on this Subnet** | 172.22.63.254 |
| **IPv4 Broadcast Address on this Subnet** | 172.22.63.255 |
| **IPv4 Network Address of the next Subnet** | 172.22.64.03 |

* + 1. **Problem 4**:

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| Given: | |
| **Host IP Address:** | 192.168.1.245 |
| **Original Subnet Mask** | 255.255.255.0 |
| **New Subnet Mask:** | 255.255.255.252 |
| Find: | |
| **Number of Subnet Bits** | 6 |
| **Number of Subnets Created** | 64 |
| **Number of Host Bits per Subnet** | 2 |
| **Number of Hosts per Subnet** | 4-2 = 2 |
| **Network Address of this Subnet** | 192.168.1.244 |
| **IPv4 Address of First Host on this Subnet** | 192.168.1.245 |
| **IPv4 Address of Last Host on this Subnet** | 192.168.1.246 |
| **IPv4 Broadcast Address on this Subnet** | 192.168.1.247 |
| **IPv4 Network Address of the next Subnet** | 192.168.1.248 |

* + 1. **Problem 5**:

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| Given: | |
| **Host IP Address:** | 128.107.0.55 |
| **Original Subnet Mask** | 255.255.0.0 |
| **New Subnet Mask:** | 255.255.255.0 |
| Find: | |
| **Number of Subnet Bits** | 8 |
| **Number of Subnets Created** | 64 |
| **Number of Host Bits per Subnet** | 8 |
| **Number of Hosts per Subnet** | 62 |
| **Network Address of this Subnet** | 128.107.0.0 |
| **IPv4 Address of First Host on this Subnet** | 128.107.0.1 |
| **IPv4 Address of Last Host on this Subnet** | 128.107.0.254 |
| **IPv4 Broadcast Address on this Subnet** | 128.107.0.255 |
| **IPv4 Network Address of the next Subnet** | 128.107.1.0 |

* + 1. **Problem 6**

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| Given: | |
| **Host IP Address:** | 192.135.250.180 |
| **Original Subnet Mask** | 255.255.255.0 |
| **New Subnet Mask:** | 255.255.255.248 |
| Find: | |
| **Number of Subnet Bits** | 5 |
| **Number of Subnets Created** | 32 |
| **Number of Host Bits per Subnet** | 3 |
| **Number of Hosts per Subnet** | 6 |
| **Network Address of this Subnet** | 192.135.250.176 |
| **IPv4 Address of First Host on this Subnet** | 192.135.250.177 |
| **IPv4 Address of Last Host on this Subnet** | 192.135.250.182 |
| **IPv4 Broadcast Address on this Subnet** | 192.135.250.183 |
| **IPv4 Network Address of the next Subnet** | 192.135.250.184 |

Reflection

Why is the subnet mask so important when analyzing an IPv4 address?

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