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Classless Inter-Domain Routing (CIDR)

Classless Inter-Domain Routing was introduced in 1993 to replace the classful network design.

Instead of allocating network addresses using address classes based on 8 bit groups it uses **variable length subnet masking**.
It also introduced a new method of denoting network masks.

Example:
A **class C** network would have a subnet mask of **255.255.255.0** which means that **24 bits** are used for the network.

In **CIDR** notation this is designated by a **/24** following the IP address. So:

IP address **192.168.1.168** subnet mask **255.255.255.0** is written as: **192.168.1.168/24** in **CIDR** notation.

Table: CIDR and Subnet Examples

Address Class	No of Network Bits	No of Host Bits	Subnet mask	CIDR notation
A	8	24	255.0.0.0	/8
A	9	23	255.128.0.0	/9
A	12	20	255.240.0.0	/12
A	14	18	255.252.0.0	/14
B	16	16	255.255.0.0	/16
B	17	15	255.255.128.0	/17
B	20	12	255.255.240.0	/20
B	22	10	255.255.252.0	/22
C	24	8	255.255.255.0	/24
C	25	7	255.255.255.128	/25
C	28	4	255.255.255.240	/28
C	30	2	255.255.255.252	/30

Worked Examples

1. Write the IP address 222.1.1.20 mask 255.255.255.192 in CIDR notation

Decimal 192 =11000000 binary which means that 2 bits of this octet are used for the subnet. Now add the 24 bits 255.255.255 and we have 26 bits. So we write:

222.1.1.20/26

2. Write the IP address 135.1.1.25 mask 255.255. 248.0 In CIDR notation

Decimal 248 =11111000 binary which means that 5 bits of this octet are used for the subnet. Now add the 16 bits 255.255. and we have 21 bits. So we write:

135..1.1.25/21

IP Address	10.10.10.10
Subnet Mask	255.0.0.0
IP Address	172.168.10.1
Subnet Mask	255.255.0.0
IP Address	192.168.1.1
Subnet Mask	255.255.255.0

*Network portion *Host portion

Subnet Mask

Subnet mask is used to separate the network **address** from the host address in IP address. As we discussed earlier an IP address is the combination of network address and host address, subnet mask helps us and programs which use IP address in identifying the network portion and the host portion.

Just like IP address, subnet mask is also 32 bits in length and uses same notations which IP address uses to present itself.

Subnet mask assigns an individual bit for each bit of IP address. If IP bit belongs to network portion, assigned subnet mask bit will be turned on. If IP bit belongs to host portion, assigned subnet mask bit will be turned off.

In binary notation, 1 (one) represents a turned on bit while 0 (zero) represents a turned off bit. In dotted-decimal notation, a value range 1 to 255 represents a turned on bit while a value 0 (zero) represents a turned off bit.

An IP address is always used with subnet mask. Without subnet mask, an IP address is an ambiguous address in IP network.

There are two versions of IP in use today, **IPv4** and **IPv6**. The original IPv4 protocol is still used today on both the internet, and many corporate networks. However, the **IPv4** protocol only allowed for $\mathbf{2^{32}}$ addresses. This, coupled with how addresses were allocated, led to a situation where there would not be enough unique addresses for all devices connected to the internet.

IPv6 was developed by the Internet Engineering Task Force (IETF), and was formalized in 1998. This upgrade substantially increased the available address space and allowed for $\mathbf{2^{128}}$ addresses. In addition, there were changes to improve the efficiency of IP packet headers, as well as improvements to routing and security.

An **IPv4** subnet mask consists of **32** bits; it is a sequence of ones (*1*) followed by a block of zeros (*0*). The ones indicate bits in the address used for the network prefix and the trailing block of zeros designates that part as being the host identifier.

The following example shows the separation of the network prefix and the host identifier from an address (*192.0.2.130*) and its associated */24* subnet mask (*255.255.255.0*). The operation is visualized in a table using binary address formats.

	Binary form	Dot-decimal notation
IP address	11000000.00000000.00000010.10000010	**192.0.2.130**
Subnet mask	11111111.11111111.11111111.00000000	**255.255.255.0**
Network prefix	11000000.00000000.00000010.00000000	**192.0.2.0**
Host identifier	00000000.00000000.00000000.10000010	**0.0.0.130**

Applying a subnet mask to an IP address separates network address from host address. The network bits are represented by the 1's in the mask, and the host bits are represented by 0's. Performing a bitwise logical AND operation on the IP address with the subnet mask produces the network address. **For example, applying the Class C subnet mask to our IP address 216.3.128.12 produces the following network address:**

```
IP:   1101 1000 . 0000 0011 . 1000 0000 . 0000 1100
(216.003.128.012)

Mask: 1111 1111 . 1111 1111 . 1111 1111 . 0000 0000
(255.255.255.000)

      ---------------------------------------------

      1101 1000 . 0000 0011 . 1000 0000 . 0000 0000
(216.003.128.000)
```

How Do IP Address and Subnet Mask Work?

In TCP/IP configuration, we cannot determine whether a part of the IP address is used as network or host address unless we get more information from a subnet mask table. If the subnet mask example is 255.255.255.0, and since 255 in binary notation equals 11111111, so the subnet mask is:

11111111.11111111.11111111.0000000.

Lining up the IP address and the subnet mask together, the network and host portions of the address can be separated:

11000000.10101000.01111011.10000100 -- IP address (192.168.123.132)

11111111.11111111.11111111.00000000 -- Subnet mask (255.255.255.0)

The first 24 bits are identified as the **network address**, with the last 8 bits (the remaining zeros in the subnet mask) identified as the **host address**. This gives you the following:

11000000.10101000.01111011.00000000 -- Network address
(192.168.123.0)

00000000.00000000.00000000.10000100 -- Host address
(000.000.000.132)

So now you know, for this example using a 255.255.255.0 subnet mask, that the network address is 192.168.123.0, and the host address is 0.0.0.132. When a packet arrives on the 192.168.123.0 subnet, and it has a destination address of 192.168.123.132, your computer will receive it from the network and process it.

Example 1:

In the picture below, the first three parts of the IP address belongs to the IP network, which is determined by the subnet mask. 0 is the lowest address that is available in the fourth part of the IP address. The computer thus belongs to the IP network 101.102.103.0. The fourth part (.5) of the IP address shows which host address that the computer is using on the IP network.

Example 2:

Similarly, the next computer below belongs to the IP network 211.139.157.0. It is using the host address 9 on the IP network, and its IP address is 211.139.157.9

Subnetting

تقسيم الشبكة

1. How many networks I need?
2. How many host in each network?
3. What are the valid subnets?
4. What is the broadcast address?
5. What are the valid hosts in each subnet?

Example 1:

Suppose we have the following address and address mask:

Address : 192 . 168 . 10 . 0

Mask   : 255 . 255 . 255 . 128

كم عدد الشبكات في هذا العنوان ؟

نحول ال mask من الصيغة العشرية الى الصيغة الثنائية وكالاتي:

255	255	255	128
11111111 .	11111111 .	11111111 .	10000000

↑

عدد الواحدات هنا =1

N = NUMBER OF ONE'S IN THE LAST OCTET

X = NUMBER OF NETWORKS

$$X = 2^N = 2^1 = 2$$

هذا يعني ان عدد الشبكات التي استطيع ان اصممها وابنيها =2

كم عدد الاجهزة في كل شبكة ؟

N = Number of 0's in the Last Octet

X = Number of Devices in Each Network

$$X = 2^7 - 2 = 128 - 2 = 126$$

هذا يعني استطيع ان اصمم 2 شبكة وفي كل شبكة 126 جهاز

الرقم 7 جاء من احتساب عدد الاصفار في اخر octet

اما لماذا مطروح منه 2 لان الجهاز الاول والاخير غير مستخدم

---

256 – 128 = 128

Range of Net 1 : 0 → 128-1 =127

Range of Net 2 : 0+ 128=128 → 265-1= 255

	Network 1	Network 2
Network	0	128
First Host	1	129
Last Host	126	254
Broadcast	127	255

192 . 168 . 10 . 0	192 . 168 . 10 . 128
192 . 168 . 10 . 1	192 . 168 . 10 . 129
192 . 168 . 10 . 2	192 . 168 . 10 . 130
192 . 168 . 10 . 3	192 . 168 . 10 . 131
.	.
.	.
.	.
192 . 168 . 10 . 126	192 . 168 . 10 . 254

احيانا يكتب العنوان كالاتي بدون ال mask

192 . 168 . 10 . 0 / 25

هذا يعني ان ال mask لهذا العنوان فيه 25 واحد كما موضح:

255 . 255 . 255 . 128

11111111 . 11111111 . 11111111 . 10000000

Number of one's = 25

Home work

Suppose we have the following address and address mask:

Address : 192 . 168 . 10 . 0

Mask : 255 . 255 . 255 . 192

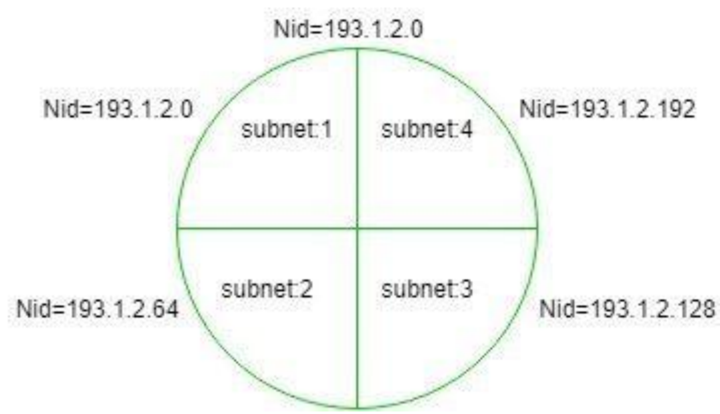
Answer the following:

1. How many networks I need?
2. How many host in each network?
3. What are the valid subnets?
4. What is the broadcast address?
5. What are the valid hosts in each subnet?

Finding Network ID of a Subnet (using Subnet Mask)

In order to find network id (NID) of a Subnet, one must be fully acquainted with the Subnet mask.

Subnet Mask:
It is used to find which IP address belongs to which Subnet. It is a 32 bit number, containing 0's and 1's. Here network id part and Subnet ID part is represented by all 1's and host ID part is represented by all 0's.
Example:
If Network id of a entire network = 193.1.2.0 (it is class C IP). For more about class C IP see Classful Addressing.



In the above diagram entire network is divided into four parts, which means there are four subnets each having two bits for Subnet ID part.

```
Subnet-1: 193.1.2.0 to 193.1.2.63
Subnet-2: 193.1.2.64 to 193.1.2.127
Subnet-3: 193.1.2.128 to 193.1.2.191
Subnet-4: 193.1.2.192 to 193.1.2.255
```

The above IP is class C, so it has 24 bits in network id part and 8 bits in host id part but you choose two bits for subnet id from host id part, so now there are two bits in subnet id part and six bits in host id part, i.e.,

```
24 bits in network id + 2 bits in subnet id = 26 (1's) and
6 bits in host id = 6 (0's)
```

Therefore,

```
Subnet Mask = 11111111.11111111.11111111.11000000
                 = 255.255.255.192
```

If any given IP address performs bit wise AND operation with the subnet mask, then you get the network id of the subnet to which the given IP belongs.

Example-1:

```
If IP address = 193.1.2.129 (convert it into binary form)
              = 11000001.00000001.00000010.10000001
Subnet mask   = 11111111.11111111.11111111.11000000
Bit Wise AND  = 11000001.00000001.00000010.10000000
Therefore, Nid = 193.1.2.128
```

Hence, this IP address belongs to subnet:3 which has Nid = 193.1.2.128

Example-2:

```
If IP address = 193.1.2.67 (convert it into binary form)
              = 11000001.00000001.00000010.01000011
Subnet Mask   = 11111111.11111111.11111111.11000000
Bit Wise AND  = 11000001.00000001.00000010.01000000
Therefore, Nid = 193.1.2.64
```

Hence, this IP address belongs to subnet:2 which has Nid = 193.1.2.64

Exercise 1

Now that you have an understanding of subnetting, put this knowledge to use. In this example, you are given two address / mask combinations, written with the prefix/length notation, which have been assigned to two devices. Your task is to determine if these devices are on the same subnet or different subnets. You can use the address and mask of each device in order to determine to which subnet each address belongs.

Device A: 172.16.17.30/20

Device B: 172.16.28.15/20

Determine the Subnet for Device A:

```
172.16.17.30  -   10101100.00010000.00010001.00011110
255.255.240.0 -   11111111.11111111.11110000.00000000
                  -----------------| sub|------------
subnet =          10101100.00010000.00010000.00000000 =
172.16.16.0
```

Looking at the address bits that have a corresponding mask bit set to one, and setting all the other address bits to zero (this is equivalent to performing a logical "AND" between the mask and address), shows you to which subnet this address belongs. In this case, DeviceA belongs to subnet 172.16.16.0.

Determine the Subnet for Device B:

```
172.16.28.15  -   10101100.00010000.00011100.00001111
255.255.240.0 -   11111111.11111111.11110000.00000000
                  -----------------| sub|------------
subnet =          10101100.00010000.00010000.00000000 =
172.16.16.0
```

From these determinations, DeviceA and DeviceB have addresses that are part of the same subnet.

Q1: Find the subnet number of the IP address: 10 . 0 . 20 . 5

Use the mask address : 255 . 0 . 0 . 0

10 . 0 . 20 . 5

255 . 0 . 0 . 0 + bitwise addition

---

10 . 0 . 0 . 0

00001010 . 00000000 . 00010100 . 00000101 ← 10.0.20.5

11111111 . 00000000 . 00000000 . 00000000 ← 255. 0.0.0

-------------- . ------------- . ------------- . -------------- + bitwise add

10 0 0 0

Hence subnet number is : 10 . 0 . 0 . 0

Q2: Find the subnet number of the IP address: 172 . 200 . 10 . 5

Use the mask address 255 . 255 . 255 . 0

10101100 . 11001000 . 00001010 . 00000101 ← 172.200.10.5

11111111 . 11111111 . 11111111 . 00000000 ←255.255.255.0

-------------- . ------------- . ------------- . ------------- + bitwise add

172 200 10 0

Hence the subnet number is : 172 . 200 . 10 . 0

Q3: Given the following IP address : 192 . 168 . 1 . 0 / 28

1. **Find the number of subnets.**
2. **Find the number of valid Hosts.**

Solution:

Since the first octet of the IP address is 192

Hence the class is C

Since there is /28 in the IP address, hence there are 28 one's in the subnet mask, and as follows:

11111111 . 11111111 . 11111111 . **1111**0000

-------------- ------------- ------------- ------

8 one's 8 one's 8 one's 4 one's (4^{th} octet)

1.Number of subnets = 2^x (where x is the number of subnet bits in the 4^{th} octet , i.e number of one's in the 4^{th} octet).

$$= 2^4 = 16$$

2. number of valid Hosts = $2^y - 2$ (where y is the number of host bits in the 4^{th} octet , i.e number of zeros)

$$= 2^4 - 2 = 16 - 2 = 14$$

Q4: Given the following IP address : 150 . 150 . 0 . 0 / 30

1. **Find the number of subnets.**
2. **Find the number of valid Hosts.**

Solution:

Since the first octet of the IP address is 150

Hence the class is C

Since there is /30 in the IP address, hence there are 30 one's in the subnet mask, and as follows:

11111111 . 11111111 . 11111111 . **111111**00

-------------- ------------- ------------- ----------

8 one's 8 one's 8 one's 6 one's (4^{th} octet)

1.Number of subnets = 2^x (where x is the number of subnet bits in the 4^{th} octet , i.e number of one's in the 4^{th} octet).

= 2^6 = 16,384

2. number of valid Hosts = $2^y - 2$ (where y is the number of host bits in the 4^{th} octet , i.e number of zeros)

= $2^2 - 2 = 4 - 2 = 2$

Q5: Given the following IP address : 192 . 168 . 20 . 73

Find all subnets created when the following subnet mask is applied : 255 . 255 . 255 . 240

Solution:

We apply the formula : **256 – (octet 4**)

= 265 – 240 = 16

16 + 0 = 16

16 + 16 = 32

32 + 16 = 48

48 + 16 = 64

64 + 16 = 80 ← we neglect 80 because it exceeded 73

The subnet numbers are:

192 . 168 . 20 . 0

192 . 168 . 20 . 16

192 . 168 . 20 . 32

192 . 168 . 20 . 48

192 . 168 . 20 . 64

Q6: Given the following IP address : 192 . 168 . 2 . 0 / 24

Find all subnets created when the following subnet mask is applied : 255 . 255 . 255 . 224

Applying the Formula: **265 – (octet 4**) = 265 – 224 = 32

32 + 0 = 32

32 + 32 = 64

64 + 32 = 96 .

.

.

.

The subnets are :

192 . 168 . 2 . 0

192 . 168 . 2 . 32

192 . 168 . 2 . 64

192 . 168 . 2 . 96

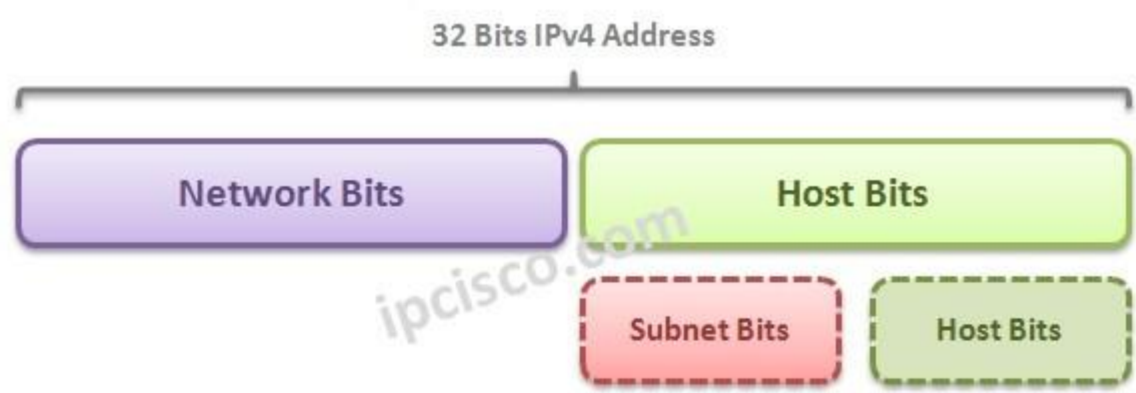
↓

192 . 168 . 2 . 224

وذلك باضافه 32 في كل مره وصولا الى اقل او يساوي 224

IP Subnetting

there are two parts in an IP Address**. One of them is Network part and the another is Host part. With** IP Subnetting**, we are adding one more part. This is** "Subnet Part"**. From the Host part, we borrow some bits and we will use this part for Subnet.**



As a basic definition, **Subnetting** is dividing the network into smaller network groups and by doing this, using the **IP Address** Block more efficient.

For Subnetting, **Subnet Masks** are used. Subnets masks are 32 bit addresses like IP Addresses. Subnet Masks are used with IP Addresses. The 1s represents the network parts, and 0s represents the host parts.

We can show Subnet Masks with four octets like **IP addresses** (255.255.255.0) or we can show it like /X . Here, for the 255.255.255.0 Subnet Mask, we can use /24. This means that the first 24 bit is full of 1s and it is network part.

Q1. Write the IP address 222.1.1.20 mask 255.255.255.192 in CIDR notation

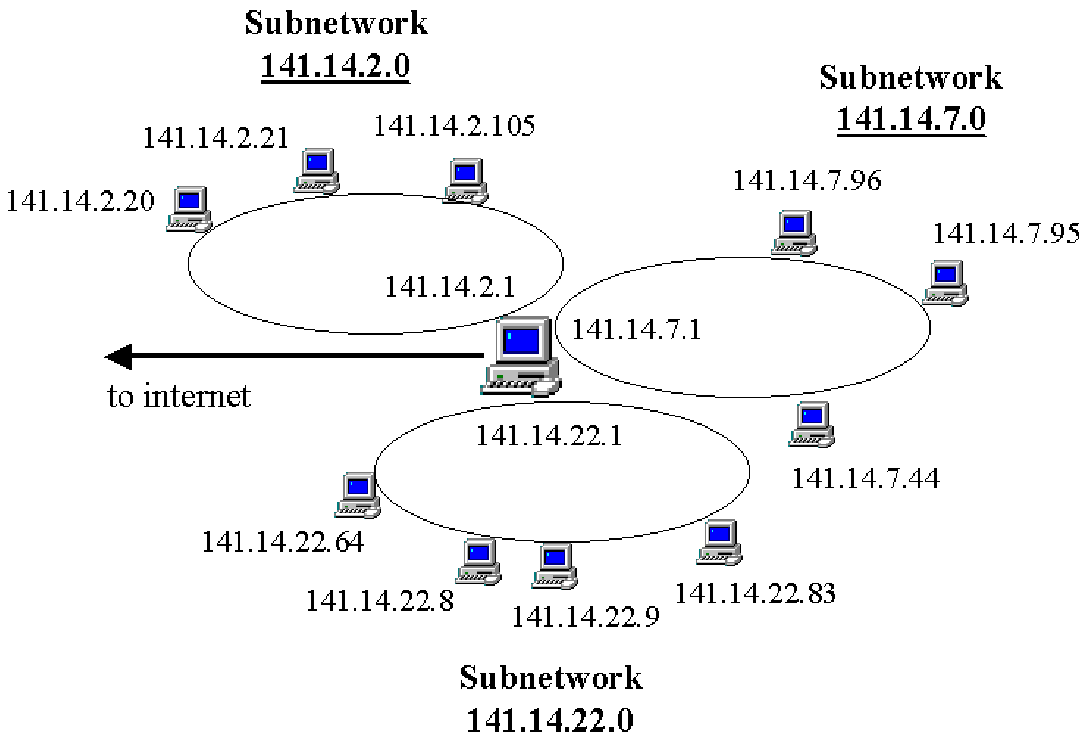
Decimal 192 =11000000 binary which means that 2 bits of this octet are used for the subnet. Now add the 24 bits 255.255.255 and we have 26 bits. So we write:

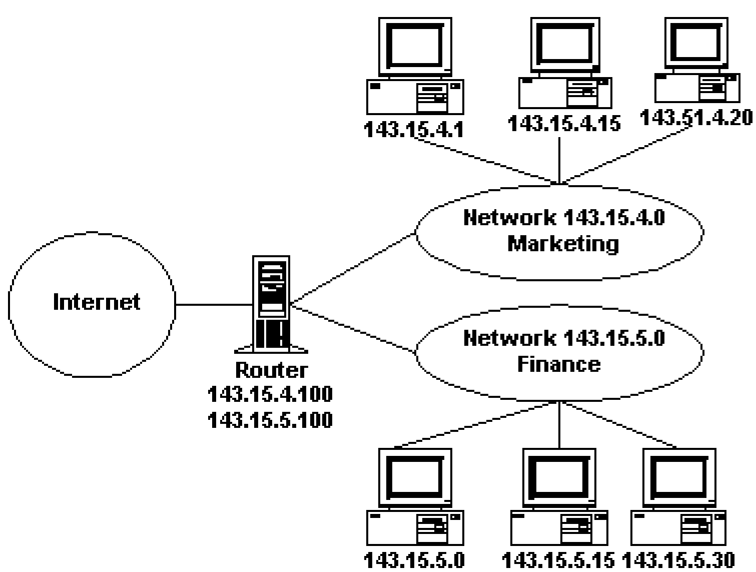
222.1.1.20/26

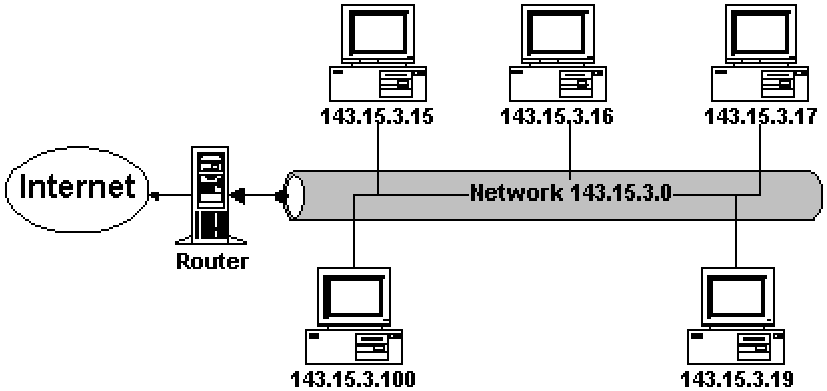
Q2. Write the IP address 135.1.1.25 mask 255.255. 248.0 in CIDR notation

Decimal 248 =11111000 binary which means that 5 bits of this octet are used for the subnet. Now add the 16 bits 255.255. and we have 21 bits. So we write:

135..1.1.25/21


Subnetwork
141.14.2.0
Subnetwork
141.14.7.0
141.14.2.21
141.14.2.105
141.14.2.20
141.14.7.96
141.14.7.95
141.14.2.1
141.14.7.1
to internet
141.14.22.1
141.14.7.44
141.14.22.64
141.14.22.8
141.14.22.9
141.14.22.83
Subnetwork
141.14.22.0


143.15.4.1
143.15.4.15
143.51.4.20
Network 143.15.4.0
Marketing
Internet
Router
143.15.4.100
143.15.5.100
Network 143.15.5.0
Finance
143.15.5.0
143.15.5.15
143.15.5.30


143.15.3.15
143.15.3.16
143.15.3.17
Internet
Router
Network 143.15.3.0
143.15.3.100
143.15.3.19