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**BASIC SUMMARY**    **IP Addressing Reminder Notes**

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**Remember...** The computer thinks in BINARY

*for example*

When you press that 'A' key on the keyboard, the keyboard decoder outputs the binary value for the letter 'A' to the computer. The computer stores this value in binary as a series of electrical on or off states.

**'A' is represented by 01000001 (or 41h) etc....**

The networking address is no different to any other information stored on the computer.

An ip address of 165.140.20.03 is represented by

10100101 10001100 00010100 00000011

the ip mask of 255.255.255.128 is represented by

11111111 11111111 11111111 10000000

it can be seen from the above mask that there are 7 zeros at the end of the mask. The seven zeros (or seven bits) are, in this example, the **host bits** of the mask. The first twenty five bits (all ones), in this example, represent the **network bits**. This all important network mask informs the computer when to look to the local network and when to look outside the local network (connections not local to the computers own network). Any request to connect to an address in the host portion of the mask is considered local. Any request to connect to an address in the network portion is considered remote and the request is sent via the configured **gateway address**.

The **gateway address** is the address of a device on the local network that can relay the data to another network.

Hence, a typical example address configuration consists of a station address, a network mask and a gateway address ;

ip station address 165.140.20.03, network mask 255.255.255.128

gateway address 165.140.20.56

in this example any request from the computer to reach an address on 165.140.20.0 through 165.140.20.127 will be sent to the local network. Any address requests for any other address will be sent to the gateway 165.140.20.56.

The network address for the above example is the first address (called the zero subnet) that does not cross the mask boundary. In this example the 165.140.20.0 network is bounded by the 255.255.255.128 mask and ONLY addresses within the zero-bits of the mask are considered to be within this network (i.e. 165.140.20.0 through 165.140.20.127). If this is not making sense to you read on and read twice.....

**SEE ALSO** extracts from KCC General Datacomm Course 'Basic Ethernet/TCP/IP Overview' [slides](#)

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## **IP ADDRESS MASKING EXAMPLE**

one of the most misunderstood fundamental principles of IP ADDRESSING.....

### **ONCE AGAIN THINK BINARY !**

We need a convention to identify within an address whether a device is on our local network or on some remote network. If the device is local we can communicate directly, if not we need to communicate via a device to take the traffic from our local area to the required area. Just like the post office using the zip code or post code to sort the mail onto the right route and using the house number to identify the address locally.

***Using the example address shown earlier ;***

ip station address 165.140.20.03, network mask 255.255.255.128

gateway address 165.140.20.56

The ip address of 165.140.20.03 is represented by

165      140      20      3  
10100101 10001100 00010100 00000011

the ip mask of 255.255.255.128 is represented by

255      255      255      128  
11111111 11111111 11111111 10000000

One of the many ways to visualize the mask and network addresses is to overlay the two binary numbers to highlight the ' bits of interest ' ;

address	10100101	10001100	00010100	00000011
mask	11111111	11111111	11111111	10000000
	XXXXXXXX	XXXXXXXX	XXXXXXXX	XZZZZZZZ

netid ' x ' shows the bits of interest to network, maskbit = 1

hostid ' z ' shows the bits of interest to local hosts maskbit = 0

*i.e. using this network mask, 7 bits are highlighted as hostid available for host addressing and 25 bits are highlighted as netid available for network addressing. Giving us a network address (or netid) of ;*

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mask      11111111 11111111 11111111 10000000
netid     xxxxxxxx xxxxxxxx xxxxxxxx x
address   10100101 10001100 00010100 00000011
network is 10100101 10001100 00010100 0
in decimal = 165      140      20      0

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**and leaving a host address (or hostid) of;**

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mask      11111111 11111111 11111111 10000000
netid     xxxxxxxx xxxxxxxx xxxxxxxx x
hostid                    zzzzzzzz
address   10100101 10001100 00010100 00000011
host is                    0000011
in decimal = 3

```

**making the entire address 165.140.20.3 with a 255.255.255.128 mask.** Often written using the network mask length (prefix length) in bits;

**165.140.20.3/25 (ie 25 bits of network, 7 bits of host)**

**REMEMBER...** the network mask shows the bits of interest for the network and leaves the bits of interest for the local hosts as zero. The bits of interest for the local hosts show the range of addresses that will be handled directly (local) and the bits of interest for the network (all the one's in the mask), show all the addresses that will have to make use of a gateway address (to reach another network). In our example any request from the computer to reach an address on 165.140.20.0 through 165.140.20.127 will be sent to the local network. Any address requests for any other address will be sent via the gateway 165.140.20.56

Network masks **MUST** have contiguous 1's followed by contiguous 0's i.e. **IT IS NOT POSSIBLE** to have a mask = 11111111 11101111 01111111 00000000

The point in the mask where the stream of contiguous 1's turn into 0's is the dividing point between the network bits and the host bits. Due to this strict binary masking rule, the decimal will always be a power of 2 ;

11111111 11111111 11111110 00000000 255.255.254.0

11111111 11111111 11111111 10000000 255.255.255.128

11111111 11111111 11111111 11111100 255.255.255.252

11111111 11111111 11111111 11000000 255.255.255.192

11111111 11111110 00000000 00000000 255.254.0.0

Also notice in the above examples, because of the binary mask rule, the network mask will always highlight just one octet of the network address where the netid becomes hostid (where the bits of interest for the host is separated from the bits of interest for the network) often referred to as the OCTET OF INTEREST.

Practice using the OCTET OF INTEREST will result in speedy network address configuration and fast understanding of ip addressing.

For more details on gateway addressing etc... see the extracts from KCC GeneralDataComm course 'Basic Ethernet/TCP/IP Overview' and the various

slides in [www.kcccommunications.com/public](http://www.kcccommunications.com/public) .

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## CLASSFUL ADDRESSING the History.....

Traditionally the Internet made use of the CLASSFUL network addressing and assigned one of three mask classes ;

**CLASS A** first bit always = 0

1.0.0.0 to 126.255.255.255

therefore the mask was fixed as 255.0.0.0 or /8

**CLASS B** first two bits always = 10

128.1/0\*.0.0 to 191.255.255.255

therefore the mask was fixed as 255.255.0.0 or /16

**CLASS C** first three bits always = 110

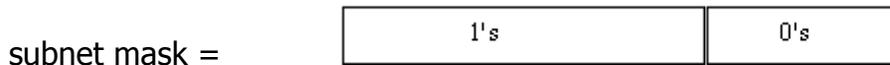
192.0.1/0\*.0 to 223.255.255.255

therefore the mask was fixed as 255.255.255.0 or /24

\* **NOTE**..... some older devices can not cope with subnet-zero (the 'all zeros' address in the subnet number) hence the 1/0\* indication above.... If not able to handle subnet-zero, the zero network is wasted. Most equipment today can handle subnet-zero and the full range of addressing.

The first (from 1985) method used to split up the enormous classfull assigned networks was to use a subnetting system that enabled a larger mask to make use of some host bits to form subnets. This old method split the address into three parts.... NetID, Subnet Number and Host Number (RFC 950 & RFC 1812);

32 bit addressing field (IPv4)



as seen above by moving the subnet mask into the hostid, the original allocated natural classfull masked network could be split up into several addressable subnets. In most cases, the subnet portion of the address is of no interest as the routing decisions are made on the entire mask regardless of class as detailed in the section above much like the VLSM and CIDR used today (RFC 1009 & RFC 1518/1519) since 1993 ([masking basics](#)). The three elements of NetID, Subnet Number and Host Number are often referred to when an ISP supplies a classfull subnet which is then split into VLSM networks for a company to use, so it is still necessary to know the terminology and method of quoting the subnet number as the difference between the classfull mask and the host bits in use.

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## CLASSLESS ADDRESSING

Since the early 1990's, the Internet has been able to support variable length subnetting and classless interdomain routing (VLSM and CIDR). This allows the use of a network mask that can be different on each and every network and leads to much less wasted address space, summarized routing tables and easier management;

For example; A small basic enterprise network with three sites (A, B and C). With links between sites A and B, A and C, and the following users ;

<b>SITE Reference</b>	<b>network connections</b>	<b>classful address</b>	<b>Mask</b>	<b>address space</b>
office A	120 users	195.40.1.0	255.255.255.0	254 addresses
office B	300 users	195.40.2.0 & 195.40.3.0	255.255.255.0	510 addresses
office C	55 users	195.40.4.0	255.255.255.0	254 addresses
link A to B	router A and B	195.40.5.0	255.255.255.0	254 addresses
link A to C	router A and C	195.40.6.0	255.255.255.0	254 addresses
<b>total network connections required</b>	<b>479</b>	<b>total address space allocated</b>		<b>1526</b>
<b>ADDRESSES WASTED</b>			<b>1047 !</b>	

*A vast waste of address space and the need to have routing tables carry SIX networks.*

*With the following VLSM example the routes could be carried in just two network summary addresses;*

***USING VLSM, the same example network ;***

<b>SITE Reference</b>	<b>network connections</b>	<b>VLSM address</b>	<b>Mask</b>	<b>address space</b>
office A	120 users	195.40.1.0	255.255.255.128	126 addresses
office B	300 users	195.40.2.0	255.255.254.0	510 addresses
office C	55 users	195.40.4.0	255.255.255.192	62 addresses
link A to B	router A and B	195.40.5.0	255.255.255.252	2 addresses
link A to C	router A and C	195.40.5.4	255.255.255.252	2 addresses
<b>total network connections required</b>	<b>479</b>	<b>total address space allocated</b>		<b>702</b>
<b>ADDRESSES WASTED</b>	<b>ONLY 223 !</b>			

The VLSM addressing also allows us to manage the network address space by allowing logical devices to share networks... as shown above all the serial links between sites can be organized to be in one major network..... all loopback addresses could be in one major network etc... Also note... with the example above there was a reduction in the number of major networks and therefore a reduction in the required routing tables and advertisements. NOTE also... many old routing protocols do not support classless routing (RIP 1, IGRP, BGP3...) the newer routing protocols send the network mask along with the routing information and do support VLSM (EIGRP, RIP2, OSPF, IS-IS, BGP4....)

Most sites will make use of private addressing or non-registered addressing together with VLSM to provide a very flexible and manageable addressing scheme. Registered addresses should still be used sparingly and only when the address is going to be visible to the outside world on the Internet.

If a proxy firewall or other means that prevent Internet traffic from bidirectionally connecting to internal LAN hosts, the machines behind the "filter" are considered to be hosts that do not require globally routable IP addresses, and the customer can use an RFC-specified Private Network (see RFC-1918) for internal networking. NSPs & ISPs will often assign a "/29" block (29-bit netmask, also equivalent to 6 hosts) to a customer for use on the router, firewall, and public servers (E-Mail, WWW, FTP, etc .).

Private addressing (as detailed in RFC 1918);

10.0.0.0/8

172.16.0.0/12

192.168.0.0/16

NAT (network Address Translation) is often used to translate from a private address to a public global address. PAT (Port Address Translation) is also used to translate many internal private addresses into a single global address with the use of port numbers..... see also [NAT&PAT](#)

Some ISP's still issue classful addressing and provide a small subnet for connection to the Internet through a firewall and DMZ etc... VLSM is often used to sub-divide subnetted natural networks. CIDR (classless interdomain routing) is now used as a solution to the problem of the depletion of available Internet addresses and the huge databases required to store all the routing information. By issuing a CIDR block of addresses instead of a wasteful class the NIC will now supply organizations and ISP's with a suitable address range. The CIDR blocks have been arranged by geographic region and make use of route summarization to minimize database sizes and routing advertising traffic etc. (REF RFC 1519 September 1993)

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*see also* [IPng \(IP version 6\)](#) for interest

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and other training notes on General DataComm and IP [slides](#)

## VLSM & IP ADDRESSING EXAMPLE QUESTIONS;

- 1 Given the network address of 112.44.0.0 and the network mask of 255.255.0.0  
Would the two stations with addresses 112.44.22.19/16 and 112.44.23.2/16 be on the same network ?
- 2 Workstations with addresses 172.16.22.1/22 and 172.16.23.9/22 share what network and broadcast address ?
- 3 How many network devices can be supported on a single network using network mask of 255.255.240.0 ?
- 4 Which of the following devices share the same network;  
A 192.168.78.25/29  
B 192.168.78.23/29  
C 192.168.78.33/29  
D 192.168.78.38/29  
E 192.168.78.41/29
- 5 Which of the following would best support a point to point link  
A 255.255.255.253  
B 255.255.255.0  
C 255.255.255.128  
D 255.255.255.252  
E 255.255.252.0
- 6 Which addresses should not be advertised to the Internet  
A 172.12.0.1  
B 192.168.0.23  
C 10.0.78.2  
D 127.0.0.1  
E 112.56.22.5
- 7 Given a class B network of 155.44.200.0, what mask could be used to provide 15 networks each supporting 120 users  
A 255.255.252.0  
B 255.255.248.0  
C 255.255.240.0  
D 255.255.255.128  
E 255.255.255.240
- 8 What would be used to share a single public address within a company  
A NAT  
B Private Addressing and NAT  
C Private Addressing and PAT  
D PAT  
E VLSM

- 9 How many hosts could be supported on a 22 bit network
- A 22
  - B 1024
  - C 4094
  - D 512
  - E 1022
- 10 What is the broadcast address and network for station 192.168.99.77/19
- 11 The network 182.16.192.0 with a mask of 255.255.240.0 will support
- A 256 stations
  - B 1024 stations
  - C 4094 stations
  - D 4096 stations
  - E 1022 stations
- 12 What is the broadcast and network address for host 112.48.160.183 255.255.255.192
- 13 What is the broadcast and network address for host 222.129.199.222/21
- 14 What is the zero subnet address where the station address is 164.20.227.6/19
- 15 What will be the source mac address in a packet received from 192.168.0.1 by 192.168.0.244/25
- A mac address of 192.168.0.1
  - B mac address of the 192.168.0.0/25 gateway
  - C mac address of the 192.168.0.128/25 gateway
  - D mac address of gateway for 192.168.0.244
  - E mac address of gateway for 192.168.0.1
- 16 What single summary address could be used for the following networks;
- 192.168.32.0/19
  - 192.168.0.0 255.255.240.0
  - 192.168.64.0/18
- 17 An ISP supplies a class B network of 136.210.0.0 to an enterprise that requires ten networks each to support 110 users. What is the network mask that would be configured in each workstation and what would be the NetID, Subnet Number ?
- 18 What destination network address would be seen in a packet leaving an Internet host that was destined for a workstation of a company that makes use of NAT to reach the internal network 192.168.10.0/24 ;
- A 192.168.10.0
  - B the inside-local address
  - C the inside-global address
  - D the outside-local address
  - E the outside-global address

- 19 What source network address would be seen in a packet leaving an Internet host that was destined for a workstation of a company that makes use of NAT to reach the internal network 192.168.10.0/24 ;
- A 192.168.10.0/24
  - B the inside-local address
  - C the inside-global address
  - D the outside-local address
  - E the outside-global address
- 20 An ISP supplies a class C network of 236.20.0.0 to an enterprise that requires three networks each to support 37 users. What is the network mask and network address that would be configured in each workstation and what would be the NetID, Subnet Number and Host Numbers ?
- 21 On network 10.210.44.0/22 with a gateway address of 10.210.46.1 What mac address would be seen in a packet leaving a workstation destined for 10.210.45.254 as the destination ?
- 22 Station addressed 10.210.46.112/21 with a gateway address of 10.210.46.1 What would be the destination mac address of a packet destined for 10.210.49.2 ;
- A mac address of 10.210.49.2
  - B mac address of 10.210.46.1
  - C mac address of 10.210.46.0/21
  - D unable to determine
- 23 A station with address 10.210.46.33/21 and gateway address of 10.210.46.1 What would be the destination mac address of a packet destined for 10.210.47.2 ;
- A mac address of 10.210.47.2
  - B mac address of 10.210.46.1
  - C mac address of 10.210.44.0/21
  - D unable to determine
- 24 Given the network 244.10.10.0/25 Select an addressing scheme to support 20 loopback addresses and addresses for 5 point to point links with room for expansion in either direction.
- 25 On network 192.168.33.192/26 a station is configured with an address of 192.168.33.220/26 and a gateway address of 192.168.33.180 What problems, if any, would be seen ?
- 26 On network 10.210.46.0/25 a station is configured with an address of 10.210.46.11, mask of 255.255.255.0 and a gateway address of 10.210.46.37 What problems, if any, would be seen ?