**PART (1) - Address assignment**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Subnet | Network address | Mask in dotted decimal form  (e.g. 255.255.0.0) | Number of hosts, including PCs and router interfaces | Number of unused addresses |
| A | 192.168.91.0 | 255.255.255.224 | 18 + 1 = 19 | 32 – 2 – 19 = 11 |
| B | 192.168.91.32 | 255.255.255.224 | 4 + 1 = 5 | 32 – 2 – 5 =  25 |
| C | 192.168.91.64 | 255.255.255.224 | 15 + 1 =16 | 32 - 2 - 16 =  14 |
| D | 192.168.91.96 | 255.255.255.224 | 2 + 1 = 3 | 32 - 2 - 3 =  27 |
| E | 192.168.91.128 | 255.255.255.224 | 0 + 2 = 2 | 32 – 2 – 2 =  28 |

Table 1. Subnet details.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Device | Interface | IP address | Mask in dotted decimal form  (e.g. 255.255.0.0 for /16) | Default Gateway |
| R1 | Fa0/0 | 192.168.91.30 | 255.255.255.224 | N/A |
| Fa0/1 | 192.168.91.62 | 255.255.255.224 | N/A |
| S0/0 | 192.168.91.158 | 255.255.255.224 | N/A |
| R2 | Fa0/0 | 192.168.91.94 | 255.255.255.224 | N/A |
| Fa0/1 | 192.168.91.126 | 255.255.255.224 | N/A |
| S0/0 | 192.168.91.157 | 255.255.255.224 | N/A |
| 1st PC subnet A | NIC | 192.168.91.1 | 255.255.255.224 | 192.168.91.30 |
| Last PC subnet A | NIC | 192.168.91.18 | 255.255.255.224 | 192.168.91.30 |
| 1st PC subnet B | NIC | 192.168.91.33 | 255.255.255.224 | 192.168.91.62 |
| Last PC subnet B | NIC | 192.168.91.36 | 255.255.255.224 | 192.168.91.62 |
| 1st PC subnet C | NIC | 192.168.91.65 | 255.255.255.224 | 192.168.91.94 |
| Last PC subnet C | NIC | 192.168.91.79 | 255.255.255.224 | 192.168.91.94 |
| 1st PC subnet D | NIC | N/A | N/A | N/A |
| Last PC subnet D | NIC | N/A | N/A | N/A |
| DNS server | NIC | 192.168.91.97 | 255.255.255.224 | 192.168.91.126 |
| Eagle server | NIC | 192.168.91.98 | 255.255.255.224 | 192.168.91.126 |

Table 2. Addressing table.

**PART (2) - Analysis of address space usage**

* **How many subnets available?**
* Based on my IP address range **((192.168.91.0 - 192.168.92.255) /27)** that I was provided with. I’ve chosen this address (**192.168.91.0**) which gives me **eight** different possibilities of subnets based on the mask length **27**. So after assigning the first 5 Network Address to **Subnets A, B, C, D, E.** They were **three** subnets remaining from this address which is not used and **eight** more from the other IP address (**192.168.92.255**) which gives me a total of (8+ 3 = 11) **eleven** more subnets.
* **Efficiency of the address space**
* I’ve used the traditional sub netting which is called Fixed Length Sub netting. Using this method for each bit borrowed in the fourth octet, the number of subnetworks available is doubled while reducing the number of host addresses per subnet. So borrowing three bits from the host part leaves me with 30 usable IP addressed for the hosts. But my subnets required less hosts. Although this meets the needs of my topology and divides the address space into an adequate number of subnets, it results in a significant waste of unused addresses. Which after calculating is (11+25+15+27+24+30+30+30 =192), 192 IP addresses are wasted from the IP address that I’ve used. Further calculation with the other IP address in the range would result in a higher number of waste IP addresses per subnet. Moreover this limits future growth by reducing the total number of subnets available. Applying this sub netting method is not very efficient and is wasteful.
* **How address space can be utilised more efficiently**
* Variable Length Subnet Mask (VLSM) was designed to avoid wasting addresses. This method is similar to traditional sub netting but the difference is that sub netting is not a single pass activity. With VSLM, the network is first sub netted, and then subnets are sub netted again. So basically the address space I had can be further divided. For subnet A the requirements were 5 host bits, since I have a total of eight different combinations of network addresses, My first network address has 5 host bits so I assign it to subnet A.

The second largest host bit again needs again 5 host bits so I assign the second network address to subnet C. Now subnets A & C have the same prefix length **/27**.

Going on the third largest host bit which is 3. My third network Address has 5 host bits, but I need 3 host bits so I borrow 2 more bits, leaving 3 bits in the host portion. Now we do further sub netting for subnet B to have less wastage. Doing that I get four further subnets in my subnet B that’s because I borrowed two more bits from the host portion which is (2^2 = 4), after this I allocate the first network address that was further sub netted in subnet B and check on my other Subnet D host bits, this again need 3 host bits so I allocate the second network address that was further sub netted in subnet B. Now subnet B & D has a new prefix length of **/29**.

The last subnet E needs 2 host bits so third network address that was sub netted in subnet B can be used and I borrow 1 more bit, leaving two host bits. Now this again can be further sub netted and leading to two more subnets. So I allocate the first sub netted address to Subnet E. This now has a new prefix length of **/30.**

**Calculating how many IP addresses has been wasted gives me:**

1. **Total unused addresses for Subnet A and C** : (30-19)+(30-16) = 25
2. **Total unused addresses for Subnet B and D :** (6-5)+(6-3) = 4
3. **Total unused addresses for Subnet E :** (2-2) = 0

* **This gives a total of :** 25+4+2 = 31 unused addresses

I used the first IP address in my range to do further VLSM my other IP address would also follow the same method which would lead to more space.

This method is much more efficient than Fixed Length method since we had less wastage of IP addresses and further sub netted addresses that weren’t used are free for future expansion.

**PART (3) - Application layer services**

* **POP** is (Post Office Protocol)

POP is an application layer protocol in the Open Systems Interconnection (OSI) model. It’s a most repeatedly used protocol and its intent is to allow a user’s workstation to access mail form a mailbox server.

For instance thinking of your device and remote server speaking coming back language so that they will discuss the way to get your mail to you.

To do this it needs a TCP/IP connection which is Simple Mail Transfer Protocol part (SMTP) part of TCP. Port 110 is related to POP but SSL/TLS was used to add security to POP which is encryption as a layer underneath the existing protocol, so this implicit SSL/TLS encrypted POP uses Port 995. According to *RFC-821[3],* “*The need of SMTP is really important because it provides two primary functions one is to allow transfer email (mail) from source to destination between mail servers and also used by end users to send email to a mail system*”.

According to the *RFC-918[1],* *“the operation of POP is that the convention for the server to tune for AN association. At the purpose once AN association is opened the server sends a welcome message and sits tight for directions. At the point when directions are gotten the server follows up on them and reacts with answers. When the customer opens an association, sits tight for the welcome, at that point sends the client and afterward the PASS directions to set up approval to get to letter drops. The client starts a mail studying exchange with either a RDEL (to see and erase all messages from a post box) or a RETR (to simply see all messages from a letter drop). The server opens and bolts the post box, and reacts with the quantity of characters in the letter drop. At that time the client requests the knowledge to be sent by issue the RCEV order. The server reacts by sending the mail information. At the purpose once all of the knowledge has been gotten the client sends the RCVD order. On the off chance that the exchange began with the RDEL order the server currently erases the mail information from the letter box. Regardless, the server closes and opens the letter box. The client ends the session with the QUIT order”.*

The current version of pop is POP3 and more about it is said in *RFC-1939[4]*.

**References for POP**

[1] J. K. Reynolds, Post Office Protocol -- POP /1, ISI RFC-918, October 1984,

Available from <https://tools.ietf.org/html/rfc918>

[3] Jonathan B. Postel, Simple Mail Transfer Protocol -- SMTP /1, ISI RFC-821, October 1984, Available from <https://tools.ietf.org/html/rfc821>

[4] J. Myers, Carnegie Mellon, M. Rosee, Post Office Protocol version 3—POP3 /1, ISI RFC-1939, May 1996, Available from <https://tools.ietf.org/html/rfc1939>

* **NNTP** is (Network New Transfer Protocol)

This is a service that is offered by the ISP (Internet Service Provider). It’s mainly used for distribution, inquiry, retrieval and posting of Netnews articles using a reliable stream-based mechanism. For clients who love news- reading this is one of the most appropriate for them due to the fact because this allows retrieval of news articles that is saved in a central database, giving only the subscribed users the potential to pick articles they swish to read on. NNTP is also an application layer protocol as cited in OSI reference model. The protocol uses TCP as its transport protocol and IP protocol for routing purposes. It offers the capability to post messages to newspapers, and downloading from them, whether or not that download be an ASCII one or binary one. Port 119 is the port related with the NNTP servers, which are additionally recognised as USENET newsgroups. More about USENET is said in *RFC 1036 [5].* According to *RFC-3977 [2] “the way nntp work is it operates over any dependable bi-directional 8-bit-wide statistics stream. When the connection is established, the NNTP server host**must ship**a greeting. The consumer host and server host then trade instructions and responses (respectively) until the connection is closed or aborted. If the connection used is TCP, then the server host starts the NNTP service with the aid of listening on a TCP port. When a client host desires to make use of the service, it must establish a TCP connection with the server host by using connection to that host on the equal port on which the server is listening”*. Following the write pattern of commands would be much more appropriate and will lead you to the correct desire connection.

**References for NNTP**

[2] C. Feather, Network News Transfer Protocol -- NNTP/1, IETF RFC-3977, October 2006, Available from <https://tools.ietf.org/html/rfc397>

[5] M. Horton, R. Adams,-- USENET/1, IETF RFC 1036, December 1987, Available from <https://tools.ietf.org/html/rfc1036>

**4. References**

[1] J. K. Reynolds, Post Office Protocol -- POP /1, ISI RFC-918, October 1984,

Available from <https://tools.ietf.org/html/rfc918>

[2] C. Feather, Network News Transfer Protocol -- NNTP/1, IETF RFC-3977, October 2006, Available from <https://tools.ietf.org/html/rfc3977>

[3] Jonathan B. Postel, Simple Mail Transfer Protocol -- SMTP /1, ISI RFC-821, October 1984, Available from <https://tools.ietf.org/html/rfc821>

[4] J. Myers, Carnegie Mellon, M. Rosee, Post Office Protocol version 3—POP3 /1, ISI RFC-1939, May 1996, Available from <https://tools.ietf.org/html/rfc1939>

[5] M. Horton, R. Adams,--USENET/1, IETF RFC 1036, December 1987, Available from https://tools.ietf.org/html/rfc1036