FAST National University of Computing and Emerging Sciences

Islamabad Campus

Computer Networks

Course Semester Project

VLSM Subnetting Configuration

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VLSM Subnetting Configuration

Network Information

- **Public IP Address:** 114.192.168.19/24
- **Private IP Address:** 192.168.1.6

Host Requirements per Subnet

Network	Required Hosts
A	10,921
B	14,068
C	11,243
D	2,154
E	7,579
F	83,492
G	3,447
H	851
I	835
J	874
L	8,644
M	6,021
N	849

Table 1: Original Host Requirements

Sorted Host Requirements (Max → Min)

Network	Required Hosts
F	83,492
B	14,068
C	11,243
A	10,921
L	8,644
E	7,579
M	6,021
G	3,447
D	2,154
J	874
H	851
N	849
I	835

Table 2: Sorted Host Requirements

Allocation Policy

- **Supernet:** 114.192.0.0/14 (covers 114.192.0.0 → 114.195.255.255)
- **Allocation Order:** Largest to smallest (minimizes fragmentation)
- **Algorithm:** For each required hosts R, choose the smallest H where $2^H - 2 \geq R$, then prefix $= 32 - H$

Detailed Calculations for Each Network

Network F (Largest)

Required: 83,492 hosts

Choosing H:

- Test $2^{16} - 2 = 65,534$ (too small)
- Test $2^{17} - 2 = 131,070$ (OK) $\rightarrow$ H = 17

Calculations:

$$\begin{aligned} \text{Prefix} &= 32 - 17 = /15 \\ \text{Mask} &= 255.254.0.0 \\ \text{Total addresses} &= 2^{17} = 131,072 \\ \text{Usable addresses} &= 2^{17} - 2 = 131,070 \\ \text{Waste} &= 131,070 - 83,492 = 47,578 \end{aligned}$$

Assigned Network: 114.192.0.0/15

Last Usable Calculation:

$$\begin{aligned} \text{Last usable offset} &= 2^{17} - 2 = 131,070 \\ \text{Decompose: } 131,070 &= 511 \times 256 + 254 \quad (N = 511, M = 254) \\ \text{Network octets: } & A = 114, B = 192, C = 0, D = 0 \\ C + N &= 0 + 511 = 511 \\ 511 &= 1 \times 256 + 255 \quad \text{(carry 1 to B, set C=255)} \\ B &= 192 + 1 = 193, \quad C = 255 \\ D + M &= 0 + 254 = 254 \quad \text{(no carry)} \end{aligned}$$

Results:

- First usable: 114.192.0.1
- Last usable: 114.193.255.254
- Broadcast: 114.193.255.255
- Next start: 114.194.0.0

Network B

Required: 14,068 hosts

Choosing H: $2^{14} - 2 = 16,382 \geq 14,068 \rightarrow$ H = 14

Calculations:

$$\begin{aligned} \text{Prefix} &= 32 - 14 = /18 \\ \text{Mask} &= 255.255.192.0 \\ \text{Total addresses} &= 2^{14} = 16,384 \\ \text{Usable addresses} &= 2^{14} - 2 = 16,382 \\ \text{Waste} &= 16,382 - 14,068 = 2,314 \end{aligned}$$

Assigned Network: 114.194.0.0/18

Last Usable Calculation:

$$\begin{aligned}\text{Last usable offset} &= 2^{14} - 2 = 16,382\\ \text{Decompose: } 16,382 &= 63 \times 256 + 254 \quad (N = 63, M = 254)\\ \text{Network} &= 114.194.0.0 \quad (C = 0, D = 0)\\ C + N &= 0 + 63 = 63 \quad \text{(no carry)}\\ D + M &= 0 + 254 = 254\end{aligned}$$

Results:

- First usable: 114.194.0.1
- Last usable: 114.194.63.254
- Broadcast: 114.194.63.255
- Next start: 114.194.64.0

Network C

Required: 11,243 hosts
Choosing H: $2^{14} - 2 = 16,382 \geq 11,243 \rightarrow \text{H} = 14$
Calculations:

$$\begin{aligned}\text{Prefix} &= 32 - 14 = /18\\ \text{Mask} &= 255.255.192.0\\ \text{Total addresses} &= 2^{14} = 16,384\\ \text{Usable addresses} &= 16,382\\ \text{Waste} &= 16,382 - 11,243 = 5,139\end{aligned}$$

Assigned Network: 114.194.64.0/18
Last Usable Calculation:

$$\begin{aligned}\text{Offset} &= 16,382 = 63 \times 256 + 254 \quad (N = 63, M = 254)\\ \text{Network} &= 114.194.64.0\\ C + 63 &= 64 + 63 = 127, \quad D + 254 = 254\end{aligned}$$

Results:

- First usable: 114.194.64.1
- Last usable: 114.194.127.254
- Broadcast: 114.194.127.255
- Next start: 114.194.128.0

Network A

Required: 10,921 hosts
Choosing H: $2^{14} - 2 = 16,382 \geq 10,921 \rightarrow \text{H} = 14$
Calculations:

$$\begin{aligned}\text{Prefix} &= /18\\ \text{Usable} &= 16,382\\ \text{Waste} &= 16,382 - 10,921 = 5,461\end{aligned}$$

Assigned Network: 114.194.128.0/18
Last Usable Calculation:

$$\text{Offset} = 16,382 = 63 \times 256 + 254$$
$$C + 63 = 128 + 63 = 191, \quad D + 254 = 254$$

Results:

- First usable: 114.194.128.1
- Last usable: 114.194.191.254
- Broadcast: 114.194.191.255
- Next start: 114.194.192.0

Network L

Required: 8,644 hosts
Choosing H: $2^{14} - 2 = 16,382 \geq 8,644 \rightarrow \text{H} = 14$
Calculations:

$$\text{Prefix} = /18$$
$$\text{Usable} = 16,382$$
$$\text{Waste} = 16,382 - 8,644 = 7,738$$

Assigned Network: 114.194.192.0/18
Last Usable Calculation:

$$\text{Offset} = 16,382 = 63 \times 256 + 254$$
$$C + 63 = 192 + 63 = 255, \quad D + 254 = 254$$

Results:

- First usable: 114.194.192.1
- Last usable: 114.194.255.254
- Broadcast: 114.194.255.255
- Next start: 114.195.0.0

Network E

Required: 7,579 hosts
Choosing H: $2^{13} - 2 = 8,190 \geq 7,579 \rightarrow \text{H} = 13$
Calculations:

$$\text{Prefix} = 32 - 13 = /19$$
$$\text{Mask} = 255.255.224.0$$
$$\text{Total addresses} = 2^{13} = 8,192$$
$$\text{Usable addresses} = 8,190$$
$$\text{Waste} = 8,190 - 7,579 = 611$$

Assigned Network: 114.195.0.0/19
Last Usable Calculation:

$$\text{Offset} = 2^{13} - 2 = 8,190 = 31 \times 256 + 254 \quad (N = 31, M = 254)$$
$$\text{Network} = 114.195.0.0$$
$$C + 31 = 0 + 31 = 31, \quad D + 254 = 254$$

Results:

- First usable: 114.195.0.1
- Last usable: 114.195.31.254
- Broadcast: 114.195.31.255
- Next start: 114.195.32.0

Network M

Required: 6,021 hosts
Choosing H: $2^{13} - 2 = 8,190 \geq 6,021 \rightarrow \text{H} = 13$
Calculations:

$$\begin{aligned} \text{Prefix} &= /19 \\ \text{Usable} &= 8,190 \\ \text{Waste} &= 8,190 - 6,021 = 2,169 \end{aligned}$$

Assigned Network: 114.195.32.0/19
Last Usable Calculation:

$$\begin{aligned} \text{Offset} &= 8,190 = 31 \times 256 + 254 \\ C + 31 &= 32 + 31 = 63, \quad D + 254 = 254 \end{aligned}$$

Results:

- First usable: 114.195.32.1
- Last usable: 114.195.63.254
- Broadcast: 114.195.63.255
- Next start: 114.195.64.0

Network G

Required: 3,447 hosts
Choosing H: $2^{12} - 2 = 4,094 \geq 3,447 \rightarrow \text{H} = 12$
Calculations:

$$\begin{aligned} \text{Prefix} &= 32 - 12 = /20 \\ \text{Mask} &= 255.255.240.0 \\ \text{Total addresses} &= 2^{12} = 4,096 \\ \text{Usable addresses} &= 4,094 \\ \text{Waste} &= 4,094 - 3,447 = 647 \end{aligned}$$

Assigned Network: 114.195.64.0/20
Last Usable Calculation:

$$\begin{aligned} \text{Offset} &= 2^{12} - 2 = 4,094 = 15 \times 256 + 254 \quad (N = 15, M = 254) \\ \text{Network} &= 114.195.64.0 \\ C + 15 &= 64 + 15 = 79, \quad D + 254 = 254 \end{aligned}$$

Results:

- First usable: 114.195.64.1
- Last usable: 114.195.79.254
- Broadcast: 114.195.79.255
- Next start: 114.195.80.0

Network D

Required: 2,154 hosts
Choosing H: $2^{12} - 2 = 4,094 \geq 2,154 \rightarrow \text{H} = 12$
Calculations:

$$\begin{aligned} \text{Prefix} &= /20 \\ \text{Usable} &= 4,094 \\ \text{Waste} &= 4,094 - 2,154 = 1,940 \end{aligned}$$

Assigned Network: 114.195.80.0/20
Last Usable Calculation:

$$\begin{aligned} \text{Offset} &= 4,094 = 15 \times 256 + 254 \\ C + 15 &= 80 + 15 = 95, \quad D + 254 = 254 \end{aligned}$$

Results:

- First usable: 114.195.80.1
- Last usable: 114.195.95.254
- Broadcast: 114.195.95.255
- Next start: 114.195.96.0

Network J

Required: 874 hosts
Choosing H: $2^{10} - 2 = 1,022 \geq 874 \rightarrow \text{H} = 10$
Calculations:

$$\begin{aligned} \text{Prefix} &= 32 - 10 = /22 \\ \text{Mask} &= 255.255.252.0 \\ \text{Total addresses} &= 2^{10} = 1,024 \\ \text{Usable addresses} &= 1,022 \\ \text{Waste} &= 1,022 - 874 = 148 \end{aligned}$$

Assigned Network: 114.195.96.0/22
Last Usable Calculation:

$$\begin{aligned} \text{Offset} &= 2^{10} - 2 = 1,022 = 3 \times 256 + 254 \quad (N = 3, M = 254) \\ \text{Network} &= 114.195.96.0 \\ C + 3 &= 96 + 3 = 99, \quad D + 254 = 254 \end{aligned}$$

Results:

- First usable: 114.195.96.1
- Last usable: 114.195.99.254
- Broadcast: 114.195.99.255
- Next start: 114.195.100.0

Network H

Required: 851 hosts
Choosing H: $2^{10} - 2 = 1,022 \geq 851 \rightarrow \text{H} = 10$
Calculations:

$$\begin{aligned} \text{Prefix} &= /22 \\ \text{Usable} &= 1,022 \\ \text{Waste} &= 1,022 - 851 = 171 \end{aligned}$$

Assigned Network: 114.195.100.0/22
Last Usable Calculation:

$$\begin{aligned} &\text{Offset} = 1,022 = 3 \times 256 + 254 \\ &C + 3 = 100 + 3 = 103, \quad D + 254 = 254 \end{aligned}$$

Results:

- First usable: 114.195.100.1
- Last usable: 114.195.103.254
- Broadcast: 114.195.103.255
- Next start: 114.195.104.0

Network N

Required: 849 hosts
Choosing H: $2^{10} - 2 = 1,022 \geq 849 \rightarrow \text{H} = 10$
Calculations:

$$\begin{aligned} \text{Prefix} &= /22 \\ \text{Usable} &= 1,022 \\ \text{Waste} &= 1,022 - 849 = 173 \end{aligned}$$

Assigned Network: 114.195.104.0/22
Last Usable Calculation:

$$\begin{aligned} &\text{Offset} = 1,022 = 3 \times 256 + 254 \\ &C + 3 = 104 + 3 = 107, \quad D + 254 = 254 \end{aligned}$$

Results:

- First usable: 114.195.104.1
- Last usable: 114.195.107.254
- Broadcast: 114.195.107.255
- Next start: 114.195.108.0

Network I (Smallest)

Required: 835 hosts
Choosing H: $2^{10} - 2 = 1,022 \geq 835 \rightarrow \text{H} = 10$
Calculations:

$$\begin{aligned} \text{Prefix} &= /22 \\ \text{Usable} &= 1,022 \\ \text{Waste} &= 1,022 - 835 = 187 \end{aligned}$$

Assigned Network: 114.195.108.0/22
Last Usable Calculation:

$$\begin{aligned} \text{Offset} &= 1,022 = 3 \times 256 + 254 \\ C + 3 &= 108 + 3 = 111, \quad D + 254 = 254 \end{aligned}$$

Results:

- First usable: 114.195.108.1
- Last usable: 114.195.111.254
- Broadcast: 114.195.111.255
- Next start: 114.195.112.0

Complete VLSM Allocation Table

Net	Req	Prefix	Mask	Total	Usable
F	83,492	/15	255.254.0.0	131,072	131,070
B	14,068	/18	255.255.192.0	16,384	16,382
C	11,243	/18	255.255.192.0	16,384	16,382
A	10,921	/18	255.255.192.0	16,384	16,382
L	8,644	/18	255.255.192.0	16,384	16,382
E	7,579	/19	255.255.224.0	8,192	8,190
M	6,021	/19	255.255.224.0	8,192	8,190
G	3,447	/20	255.255.240.0	4,096	4,094
D	2,154	/20	255.255.240.0	4,096	4,094
J	874	/22	255.255.252.0	1,024	1,022
H	851	/22	255.255.252.0	1,024	1,022
N	849	/22	255.255.252.0	1,024	1,022
I	835	/22	255.255.252.0	1,024	1,022

Table 3: VLSM Allocation - Part 1

Net	Subnet	First Usable	Last Usable	Broadcast
F	114.192.0.0/15	114.192.0.1	114.193.255.254	114.193.255.255
B	114.194.0.0/18	114.194.0.1	114.194.63.254	114.194.63.255
C	114.194.64.0/18	114.194.64.1	114.194.127.254	114.194.127.255
A	114.194.128.0/18	114.194.128.1	114.194.191.254	114.194.191.255
L	114.194.192.0/18	114.194.192.1	114.194.255.254	114.194.255.255
E	114.195.0.0/19	114.195.0.1	114.195.31.254	114.195.31.255
M	114.195.32.0/19	114.195.32.1	114.195.63.254	114.195.63.255
G	114.195.64.0/20	114.195.64.1	114.195.79.254	114.195.79.255
D	114.195.80.0/20	114.195.80.1	114.195.95.254	114.195.95.255
J	114.195.96.0/22	114.195.96.1	114.195.99.254	114.195.99.255
H	114.195.100.0/22	114.195.100.1	114.195.103.254	114.195.103.255
N	114.195.104.0/22	114.195.104.1	114.195.107.254	114.195.107.255
I	114.195.108.0/22	114.195.108.1	114.195.111.254	114.195.111.255

Table 4: VLSM Allocation - Part 2

Net	Waste	Next Start
F	47,578	114.194.0.0
B	2,314	114.194.64.0
C	5,139	114.194.128.0
A	5,461	114.194.192.0
L	7,738	114.195.0.0
E	611	114.195.32.0
M	2,169	114.195.64.0
G	647	114.195.80.0
D	1,940	114.195.96.0
J	148	114.195.100.0
H	171	114.195.104.0
N	173	114.195.108.0
I	187	114.195.112.0

Table 5: VLSM Allocation - Part 3

Summary Statistics

Metric	Value
Total Required Hosts	150,978
Total Allocated Addresses	199,680
Total Usable Addresses	199,652
Total Waste	48,674 addresses (24.4%)
Supernet Used	114.192.0.0 to 114.195.111.255
Supernet Range	114.192.0.0/14
Remaining Space	114.195.112.0 to 114.195.255.255

Table 6: VLSM Summary Statistics

Conclusion

This VLSM subnetting configuration demonstrates efficient IP address allocation using Variable Length Subnet Masking. The design successfully accommodates all 13 networks (A through N) with their varying host requirements ranging from 835 to 83,492 hosts.

Key Achievements:

- Successfully allocated all required subnets within the 114.192.0.0/14 supernet
- Minimized address wastage through proper VLSM implementation
- Maintained contiguous address allocation for easier routing
- Reserved future expansion space (114.195.112.0 to 114.195.255.255)

Efficiency Analysis:

- **Address Utilization:** 75.6% of allocated addresses are usable
- **Waste Percentage:** 24.4% waste is acceptable for VLSM given the diverse host requirements
- **Scalability:** Sufficient remaining address space for future network expansion

Implementation Notes:

1. The largest network (F) requires a /15 prefix to accommodate 83,492 hosts
2. Four networks (B, C, A, L) use /18 prefixes for host counts between 8,644 and 14,068
3. Two networks (E, M) use /19 prefixes for moderate-sized networks
4. Two networks (G, D) use /20 prefixes for smaller networks
5. Four networks (J, H, N, I) use /22 prefixes for the smallest host requirements

Routing Considerations:

The contiguous allocation scheme allows for potential route summarization at the routing protocol level, which can reduce routing table size and improve network performance. Networks can be summarized as follows:

- Network F: 114.192.0.0/15 (standalone large network)
- Networks B, C, A, L: Can be summarized under 114.194.0.0/16
- Networks E, M, G, D, J, H, N, I: Can be summarized under 114.195.0.0/16