VLSM (Variable Length Subnet Masking) - Complete Study Notes

Introduction to VLSM

Variable Length Subnet Masking (VLSM) is also known as **Variable Length Subnetting**. It allows network administrators to create subnets of different sizes from a single network, providing flexibility in IP address allocation.

Why Do We Need VLSM?

VLSM enables us to:

- Convert large networks into smaller networks
- Create subnets of different sizes according to requirements
- Make one subnet bigger and another smaller based on actual needs
- Optimize IP address utilization

Real-World Analogy

Consider a 1TB hard drive:

- Traditional subnetting: Divide into 4 equal parts of 250GB each
- VLSM approach: Create flexible partitions - one 500GB drive and others smaller
- Same principle applies to networks - create subnets of varying sizes

Key Principles of VLSM

1. Network Bit Protection Rule

NEVER disturb the network bits - only use host bits for subnetting

- Changing network bits = wrong destination (like going to Bombay instead of Delhi)
- Always work within the assigned network boundary

2. Host Bit Manipulation

- Use only the host portion of the IP address
- Reserve bits systematically to create subnets
- Each reserved bit divides the remaining space

Practical Example: University Network

Network Setup

- **Given Network**: 200.10.20.0 (Class C)
- **Total Hosts**: 256 addresses (0-255)
- **Usable Hosts**: 254 (excluding network ID and broadcast address)

Requirements

- **Department 1**: More than 100 users
- **Department 2**: More than 50 users
- **Department 3**: More than 50 users

Step-by-Step VLSM Implementation

Step 1: Initial Network Analysis

```
Network: 200.10.20.0
Binary:  11001000.00001010.00010100.00000000
         └──────────────────────────────────┘ └──────┘
           Network Bits (24)       Host Bits (8)
```

Step 2: Create Subnet 1 (Largest Requirement)

Reserve the first bit (MSB) = 0

```
200.10.20.0
Binary: 0 | 0 0 0 0 0 0 0
        ↑ └─────────────┘
   Fixed=0   Variable bits
```

Subnet 1 Range Calculation:

- First address: 0 0 0 0 0 0 0 0 = 200.10.20.0
- Last address: 0 1 1 1 1 1 1 1 = 200.10.20.127

Subnet 1 Details:

- **Range**: 200.10.20.0 to 200.10.20.127
- **Total IPs**: 128
- **Usable IPs**: 126 (excluding network ID: 0, broadcast: 127)
- **Requirement Met**: ✓ More than 100 users

Step 3: Divide Remaining Space

The remaining half needs to be split into two subnets (S2 and S3).

Reserve the second bit for further division:

```
Remaining space starts with: 1 | ? ? ? ? ? ? ?
                             ↑ └─────────────┘
                          Fixed=1  To be divided
```

Step 4: Create Subnet 2

Fix second bit = 0

```
200.10.20.128
Binary: 1 0 | 0 0 0 0 0 0
        └─┘ └─────────┘
      Fixed  Variable
```

Subnet 2 Range Calculation:

- First address: 1 0 0 0 0 0 0 0 = 200.10.20.128
- Last address: 1 0 1 1 1 1 1 1 = 200.10.20.191

Subnet 2 Details:

- **Range**: 200.10.20.128 to 200.10.20.191
- **Total IPs**: 64
- **Usable IPs**: 62 (excluding network ID: 128, broadcast: 191)
- **Requirement Met**: ✓ More than 50 users

Step 5: Create Subnet 3

Fix second bit = 1

```
200.10.20.192
Binary: 1 1 | 0 0 0 0 0 0
        └─┘ └─────────┘
      Fixed  Variable
```

Subnet 3 Range Calculation:

- First address: 1 1 0 0 0 0 0 0 = 200.10.20.192
- Last address: 1 1 1 1 1 1 1 1 = 200.10.20.255

Subnet 3 Details:

- **Range**: 200.10.20.192 to 200.10.20.255
- **Total IPs**: 64
- **Usable IPs**: 62 (excluding network ID: 192, broadcast: 255)
- **Requirement Met**: ✓ More than 50 users

Complete Subnet Summary

Subnet	Network ID	Range	Broadcast	Total IPs	Usable IPs	Subnet Mask
S1	200.10.20.0	0-127	200.10.20.127	128	126	255.255.255.128 (/25)
S2	200.10.20.128	128-191	200.10.20.191	64	62	255.255.255.192 (/26)
S3	200.10.20.192	192-255	200.10.20.255	64	62	255.255.255.192 (/26)

Subnet Mask Calculation

Understanding Subnet Masks in VLSM

Class C Default Mask: 255.255.255.0 (24 continuous 1s)

Subnet 1 Mask Calculation

- **Fixed bits**: 24 (default) + 1 (reserved) = 25 bits
- **Binary**: 11111111.11111111.11111111.10000000
- **Decimal**: 255.255.255.128

Subnets 2 & 3 Mask Calculation

- **Fixed bits**: 24 (default) + 2 (reserved) = 26 bits
- **Binary**: 11111111.11111111.11111111.11000000
- **Decimal**: 255.255.255.192

IP Address Utilization Analysis

Total Usable IP Calculation

- **Original network**: 254 usable IPs
- **After VLSM**: 126 + 62 + 62 = 250 usable IPs

- **IPs lost**: 4 (2 per subnet × 2 additional subnets created)

Formula for IP Loss in VLSM

Total IPs lost = 2n (where n = number of subnets)

- Each subnet loses 2 IPs (network ID + broadcast)
- Creating 3 subnets = 2 × 3 = 6 IPs lost
- Net usable: 256 - 6 = 250 IPs

Alternative VLSM Approaches

Approach 1: Largest First (Used in example)

1. Create largest subnet first (S1: 128 IPs)
2. Divide remaining space equally (S2 & S3: 64 IPs each)

Approach 2: Equal Division First

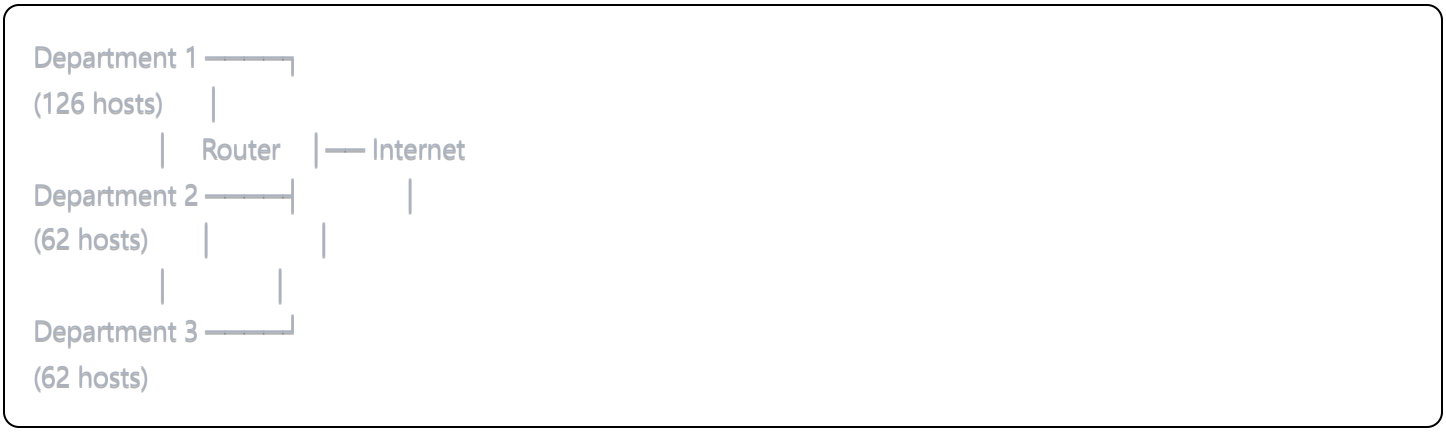
1. Divide network into equal halves first
2. Further subdivide one half as needed
3. Results in same outcome but different process

Router Configuration Considerations

Routing Requirements

- **Router placement**: Between subnets to enable communication
- **Subnet mask awareness**: Router must know each subnet's mask
- **Routing decisions**: Based on destination IP and subnet mask

Network Topology



Key Learning Points

1. Flexibility Benefits

- **Efficient utilization**: Match subnet size to actual requirements
- **Scalability**: Can accommodate varying department sizes
- **Cost optimization**: Better use of allocated IP space

2. Planning Considerations

- **Requirement analysis**: Determine exact host count needs
- **Future growth**: Allow for expansion in subnet sizing
- **Mask consistency**: Ensure proper subnet mask configuration

3. Common Mistakes to Avoid

- **Network bit modification**: Never change the network portion
- **Overlapping ranges**: Ensure subnets don't overlap
- **Insufficient planning**: Account for network ID and broadcast addresses

Practice Problems

Problem Type 1: Range Calculation

Given a network and requirements, calculate:

- Subnet ranges
- Network IDs
- Broadcast addresses
- Subnet masks

Problem Type 2: Efficiency Analysis

Calculate:

- Total usable IPs before and after VLSM
- IP address utilization percentage
- Optimal subnet sizing

Problem Type 3: Alternative Configurations

Explore different ways to:

- Divide the same network
- Meet varying requirements
- Optimize for different scenarios

Conclusion

VLSM provides essential flexibility in network design by allowing subnets of different sizes within a single network. This technique optimizes IP address utilization while meeting specific organizational requirements. Understanding binary manipulation and careful planning are key to successful VLSM implementation.

The ability to create variable-sized subnets makes VLSM an indispensable tool for network administrators dealing with diverse departmental needs and efficient resource allocation.