Networks and Subnetworks

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TRAINING
CENTER

<epam>

Agenda

- CLASSFUL NETWORKS
- CLASSLESS INTER-DOMAIN ROUTING
- SUBNET CALCULATING
- PRIVATE NETWORKS
- VLSM & FLSM

CLASSFUL NETWORKS

Classful Networks

September 1981

IPv4 with network classes was described in IETF (Internet Engineering Task Force) publication RFC 791.
Five classes were described.

A B C D E

Classful Networks

0??????? . ????????. ????????. ????????

A

0.0.0.0 - 127.255.255.255

Networks: $2^7 = 128$

Hosts: $2^{24} > 16$ million

Total: > 2 billion addresses

127.0.0.0 – network reserved for loopbacks to localhost.

127.0.0.1 – the most known address

Classful Networks

10?????? . ????????. ????????. ????????

B

128.0.0.0 - 191.255.255.255

Networks: 2^{14} = 16,384

Hosts: 2^{16} = 65,536

Total: > 1 billion addresses

169.254.0.0 – network for link-local addresses - address that is valid only for communications within the network segment, when mechanism of address configuration doesn't exist

Classful Networks

C

110????? . ????????. ????????. ????????

192.0.0.0 - 223.255.255.255

Networks: 2^{21} > 2 millions

Hosts: 2^8 = 256

Total: > 500 millions addresses

Classful Networks

D

1110???? . ????????. ????????. ????????

224.0.0.0 - 239.255.255.255

E

1111???? . ????????. ????????. ????????

240.0.0.0 - 255.255.255.255

Classful Networks

- Example:
  - You need 200 IP addresses – get a network from Class C range.
  - A bit more than 50 unused – they reserved for network growth
  - You need 2 000 IP addresses – get a network from Class B range or 8 networks from Class C?
  - Second choice seems to be more convenient, better allocate 9 for growth
  - You need 20 000 IP addresses – get a network from Class B range
  - Even if you grow twice over 20 000 addresses will be wasted
  - You need 2 000 000 IP addresses – get a network from Class A range
  - You use only 12% from network address space. Too bad

CLASSLESS INTER-DOMAIN ROUTING

CIDR

September 1993

Classless Inter-Domain Routing (CIDR) - is a method for allocating IP addresses and IP routing based on variable-length subnet masking (VLSM) which was designed to replace classful networks, slow the growth of routing tables and rapid exhaustion of IPv4 addresses (RFC 1518).

Network Mask

- Mask or netmask – is a bitmask that yields the routing prefix and helps to determine whether a host is on the local subnet or on a remote network, and defines subnet address, number of hosts in the subnet and first and last host addresses.

/24

11111111 . 11111111 . 11111111 . 00000000

255 . 255 . 255 . 0

/20

11111111 . 11111111 . 11110000 . 00000000

255 . 255 . 240 . 0

CIDR

- Example:
  - You need 200 IP addresses – get a network with /24
  - A bit more than 50 unused – they reserved for network growth
  - You need 2 000 IP addresses – get a network with /21
  - Only 40 unused addresses. If you will grow allocate /20 network
  - You need 20 000 IP addresses – get a network with /17
  - 32k of hosts – the most suitable size for your network
  - You need 2 000 000 IP addresses – get a network with /11
  - Only 97k hosts for growth. Need more – use /10 network and you will use more than 50% instead of 12%

DECIMAL TO BINARY
AND
BINARY TO DECIMAL

Decimal to Binary

192 . 168 . 156 . 3

11000000 . 10101000 . 10011100 . 00000011

?

Binary to Decimal

7 6 5 4 3 2 1 0

$1\,1\,0\,0\,0\,0\,0\,0 = 2^7 + 2^6 = 128 + 64 = 192$

7 6 5 4 3 2 1 0

$1\,0\,1\,0\,1\,0\,0\,0 = 2^7 + 2^5 + 2^3 = 128 + 32 + 8 = 168$

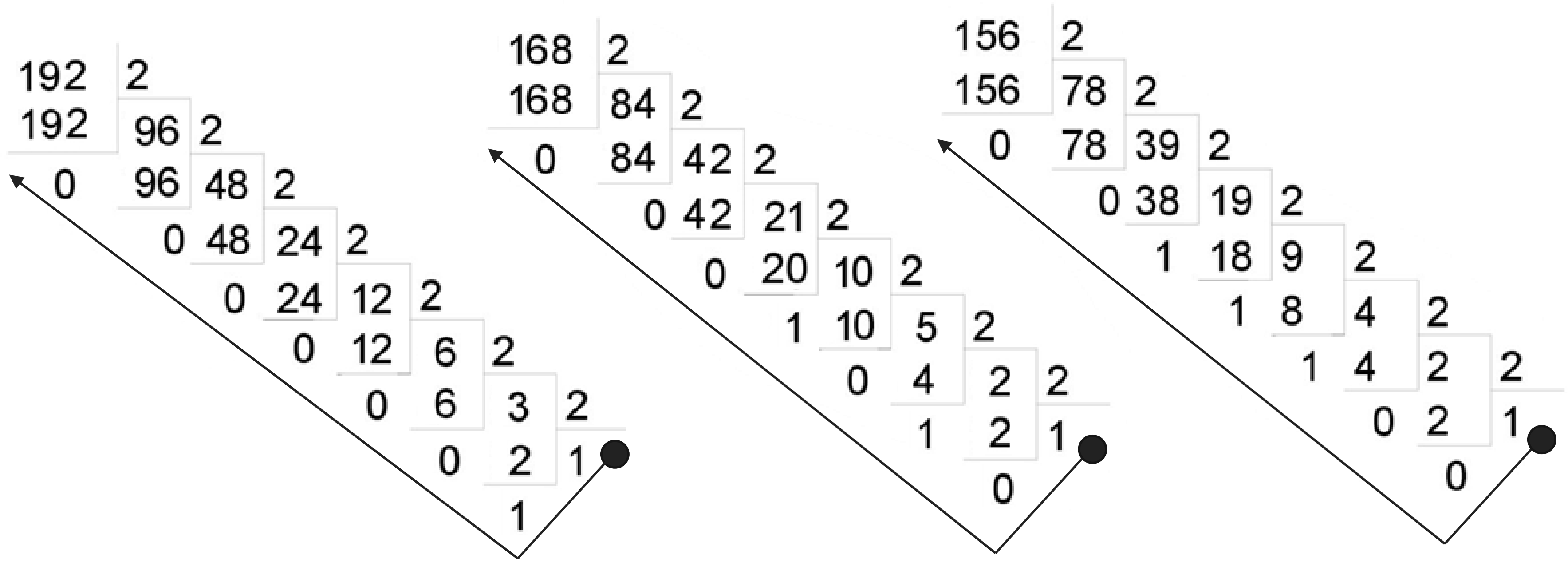
7 6 5 4 3 2 1 0

$1\,0\,0\,1\,1\,1\,0\,0 = 2^7 + 2^4 + 2^3 + 2^2 = 128 + 16 + 8 +4 = 156$

7 6 5 4 3 2 1 0

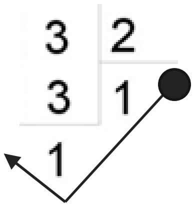
$0\,0\,0\,0\,0\,0\,1\,1 = 2^1 + 2^0 = 2 + 1 = 3$

Decimal to Binary



11000000 10101000 10011100

Decimal to Binary



11 – only 2 bits, but we need 8

11000000 = 192

00000011 = 3

Add zeros before the result of division

HOW TO CALCULATE SUBNETS

Subnet Calculating

- Subnetting – dividing network into smaller subnetworks.
- Subnetting attributes:

• Network ID	IP address of a subnet
• CIDR/Mask	Converting between prefix and mask
• Broadcast IP	Last IP address of a subnet
• First Host IP	IP address after the network ID
• Last Host IP	IP address before the broadcast IP
• Number of Hosts	Number of allocatable IP addresses
• Next Network ID	IP address of a next subnet

Subnet Calculating

192 . 168 . 156 . 3 /24

192 . 168 . 156 . 3 /21

Network ID

	192	.	168	.	156	.	3 /24
	11000000	.	10101000	.	10011100	.	00000011
AND	11111111	.	11111111	.	11111111	.	00000000
	11000000	.	10101000	.	10011100	.	00000000
	192	.	168	.	156	.	0

1 AND 1 = 1
1 AND 0 = 0
0 AND 1 = 0
0 AND 0 = 0

Subnet Attributes

192 . 168 . 156 . 3 /24

Network ID	192.168.156.0 /24
CIDR/Mask	11111111.11111111.11111111.00000000 = 255.255.255.0
Next Network ID	192.168.157.0 /24
Broadcast IP	192.168.156.255
First Host IP	192.168.156.1
Last Host IP	192.168.156.254
Number IP Addresses	$2^{32\text{-prefix}} - 2 = 254$

Network ID

	192 .	168 .	156 .	3 /21
	11000000 .	10101000 .	10011100 .	00000011
AND				
	11111111 .	11111111 .	11111000 .	00000000
	11000000 .	10101000 .	10011000 .	00000000
	192 .	168 .	152 .	0

1 AND 1 = 1
1 AND 0 = 0
0 AND 1 = 0
0 AND 0 = 0

Next Network ID

192	.	168	.	152	.	0 /21	

11000000 . 10101000 . 10011000 . 00000000

\+

00000000 . 00000000 . 00001000 . 00000000

11000000 . 10101000 . 10100000 . 00000000

192 . 168 . 160 . 0

Subnet Attributes

192 . 168 . 156 . 3 /21

Network ID	192.168.152.0 /21
CIDR/Mask	11111111.11111111.11111000.00000000 = 255.255.248.0
Next Network ID	192.168.160.0 /21
Broadcast IP	192.168.159.255
First Host IP	192.168.152.1
Last Host IP	192.168.159.254
Number IP Addresses	$2^{32\text{-prefix}} - 2 = 2046$

PRIVATE NETWORKS

Private Networks

February 1996

The Internet Assigned Numbers Authority (IANA) has reserved the following three blocks of the IP address space for private internets (RFC 1918):

10.0.0.0 - 10.255.255.255 (10/8 prefix)
172.16.0.0 - 172.31.255.255 (172.16/12 prefix)
192.168.0.0 - 192.168.255.255 (192.168/16 prefix)

1 A

16 B

256 C

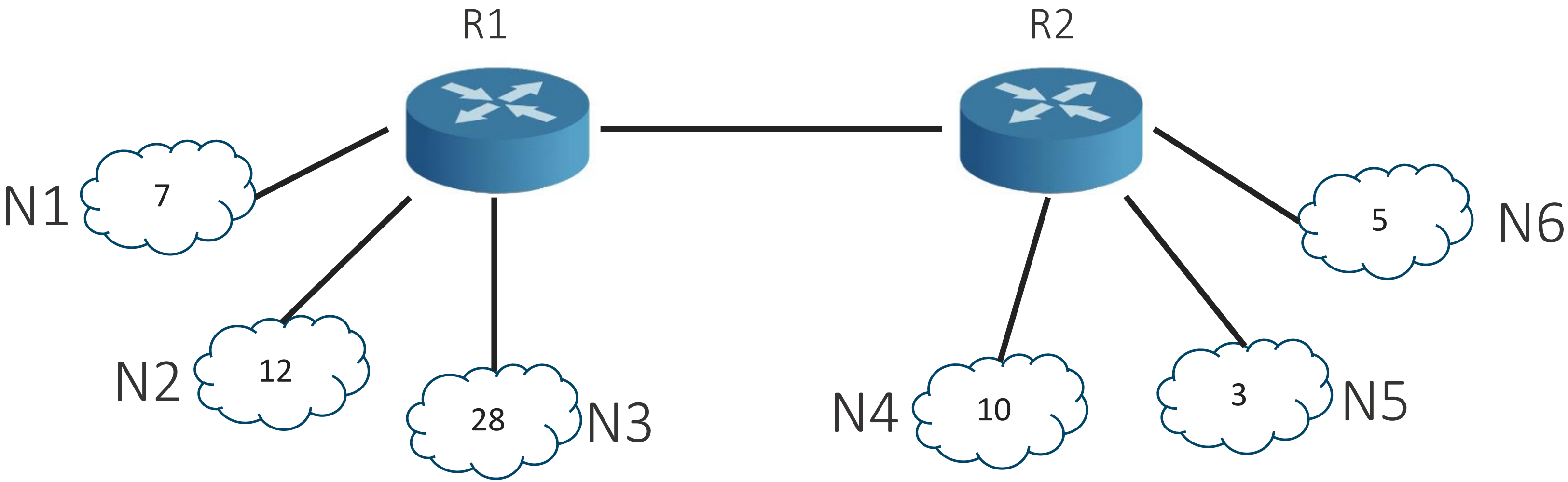
Private networks

- The obvious advantage of private networks is to conserve the globally unique address space by not using it where global uniqueness is not required.
- Private networks are not reachable over the Internet. Providers filter private addresses with firewalls, so it is difficult to initiate connection from the external host. It increases the safety of your data.
- Flexibility. You can configure networks according to your needs and capabilities.

FLSM AND VLSM

Example

192.168.156.0 /24



FLSM

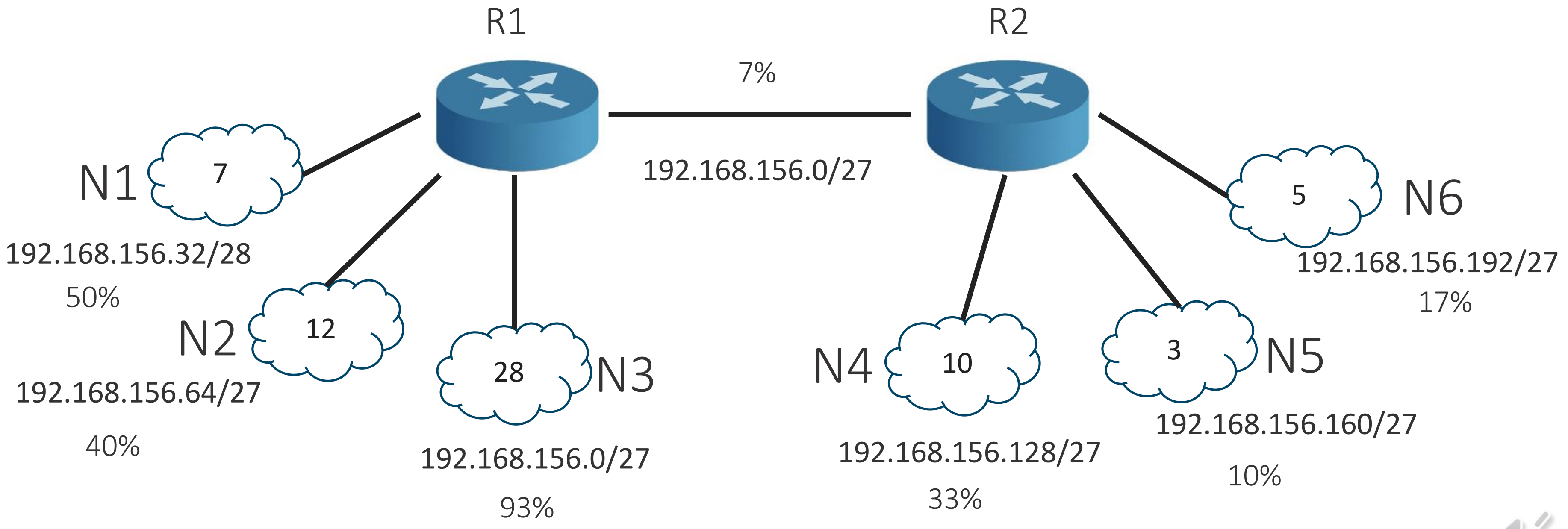
Fixed Length Subnet Mask (**FLSM**) is a strategy where every one of your networks within your infrastructure is the same size.

Since max number of hosts in all networks is 28 we use subnets with 27 prefix.

192.168.156.0/27 – for connection between routers
192.168.156.32/27 – for N1 network
192.168.156.64/27 – for N2 network
192.168.156.96/27 – for N3 network
192.168.156.128/27 – for N4 network
192.168.156.160/27 – for N5 network
192.168.156.192/27 – for N6 network
192.168.156.224/27 – reserved

FLSM

192.168.156.0 /24 Reserved: 13%



FLSM

- In this particular topology, a total of 67 IP addresses is required, but the 224 IP addresses were allocated, leaving just one /27 subnet for expansion. This is a very inefficient utilization of the assigned IP address space.

- Why engineers used this strategy if it is so inefficient? To transfer less bits

- The early routing protocols like RIPv1 saved bits on the wire by not including the subnet mask in advertisements — the subnet mask for all advertised networks was assumed to be the same mask assigned to the receiving interface.

- 192.168.156.0, 192.168.156.32 instead of 192.168.156.0 255.255.255.224, 192.168.156.32 255.255.255.224

VLSM

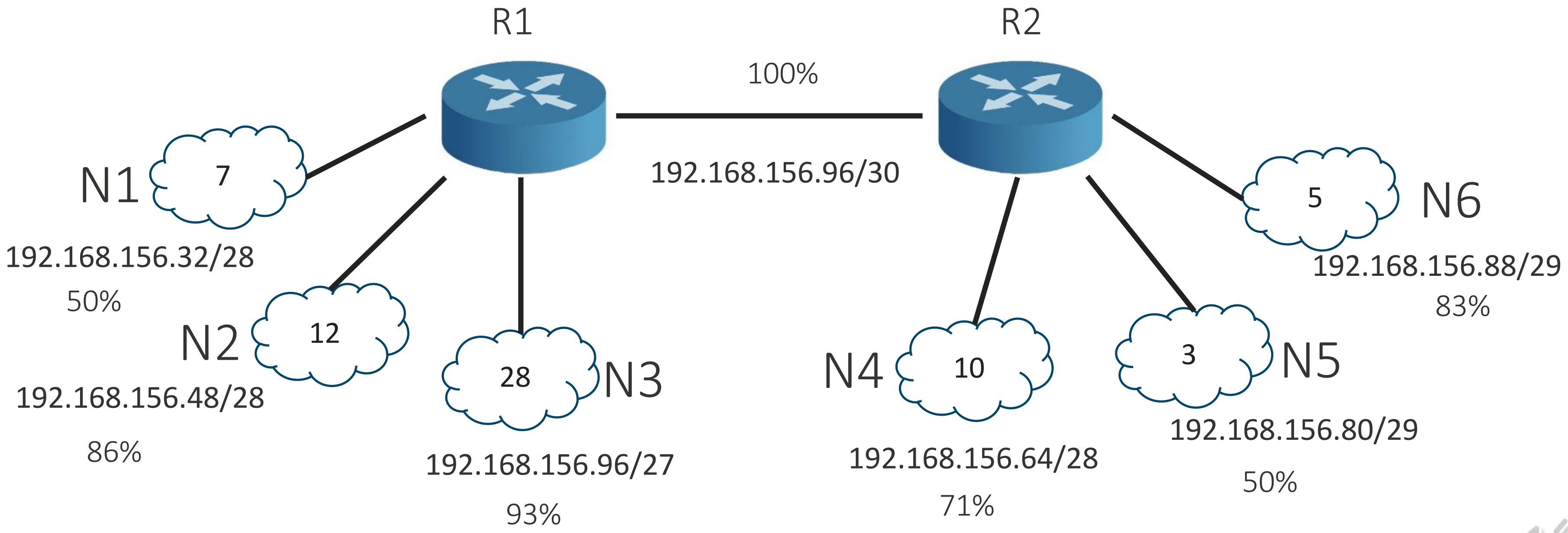
Variable Length Subnet Mask (**VLSM**) is a strategy that allows all subnet masks to be variable sizes.

The same IP assignment example above can be redone much more efficiently using VLSM

192.168.156.0/27 – for N3 network
192.168.156.32/28 – for N1 network
192.168.156.48/28 – for N2 network
192.168.156.64/28 – for N4 network
192.168.156.80/29 – for N5 network
192.168.156.88/29 – for N6 network
192.168.156.96/30 – for connection between routers
192.168.156.100/30 – unused network

VLSM

192.168.156.0 /24   Reserved: 61%



Summary

- Classful or Classless addressing is a way of assigning IP space with blocks of different size.
- FLSM or VLSM is a strategy of using IP blocks that you have.
- VLSM is more efficient than FLSM: for 67 IP addresses we allocate less than a half of /24 network
- FLSM is obsolete. If all your subnets have same prefix it is not FLSM, since all present routing protocols always sent mask. In case you want FLSM you have to use outdated protocol RIPv1, which works with Classful networks.

THANK YOU