Subnetting/Summarization

thinqtanklearning.com — Networking fundamentals · reference sheet

IPV4 POSITIONAL NOTATION

Position	7	6	5	4	3	2	1	0
Power of two	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Decimal weight	128	64	32	16	8	4	2	1
String	0	1	1	0	1	1	0	0

`0 1 1 0 1 1 0 0` = 64 + 32 + 8 + 4 = 108_{10}

IPV4 CALCULATIONS

Calculating the number of hosts per subnet

$2^h - 2$ = hosts per subnet (subtract two for the network and broadcast IDs)

h = the number of binary 0's in the subnet mask

Examples

Subnet mask **255.255.252.0** or

`11111111.11111111.11111100.00000000`

$2^{10} - 2$ = **1022 hosts per subnet**

Calculate the mask for a network that needs **49 hosts**…

$2^h - 2 \geq 49$ and solve for **h** → **h = 6** ($2^6 - 2 = 62$ per subnet)

Required mask is **255.255.255.192** or

`11111111.11111111.11111111.11000000`

Calculating the number of subnets

2^n = total number of subnets

n = the number of borrowed bits (bits changed from 0's in the mask to 1's to create the subnets)

Examples

Original mask **255.255.255.0** or

`11111111.11111111.11111111.00000000`

New mask **255.255.255.192** or

`11111111.11111111.11111111.11000000`

2^2 = **4 subnets created**

Calculate the new mask needed to create **10 subnets** from your original mask of 255.255.255.0…

$2^n \geq 10$ and solve for **n** → **n = 4** ($2^4 = 16$ subnets)

Required mask is **255.255.255.240** or

`11111111.11111111.11111111.11110000`

Defining the subnets

Define the makeup of the subnets by calculating *block size*. To calculate *block size*, subtract the value of the subnetted portion of the mask from 256.

Example

Original mask **255.255.255.192**

Block size = 256 − 192 = 64 in the 4th octet

∴ each address in the 4th octet divisible by 64 is a net ID

List of networks: `192.168.10.0, …10.64, …10.128, …10.192`

Example

`175.156.104.143 /21` 256 − 248 = **8** in the 3rd octet

`255.255.248.0`

Network ID	175.156.104.0
Broadcast ID	175.156.111.255
Host range	175.156.104.1 – …111.254

Subnets step by 8 in the 3rd octet: `…96.0, …104.0, …112.0`

CLASSFUL IPV4 FACTS

"Class A" address space

- Most significant bit in first octet fixed at 0 (`0xxxxxxx`)
- Range – 0.0.0.0/1 (0.0.0.0 – 127.255.255.255)
- RFC 1700 – 0.0.0.0/8 is unusable and 0.0.0.0 is "Unknown Host"
- RFC 5735 – 127.0.0.0/8 (127.0.0.0 – 127.255.255.255) reserved for "Loopback Testing"
- Classful subnet mask is 255.0.0.0 or /8
- RFC 1918 – 10.0.0.0/8 (10.0.0.0 – 10.255.255.255)

"Class B" address space

- Two most significant bits in first octet fixed at 10 (`10xxxxxx`)
- Range – 128.0.0.0/2 (128.0.0.0 – 191.255.255.255)
- RFC 5735 – 169.254.0.0/16 (169.254.0.0 – 169.254.255.255) "APIPA"
- Classful subnet mask is 255.255.0.0 or /16
- RFC 1918 – 172.16.0.0/12 (172.16.0.0 – 172.31.255.255)

"Class C" address space

- Three most significant bits in first octet fixed at 110 (`110xxxxx`)
- Range – 192.0.0.0/3 (192.0.0.0 – 223.255.255.255)
- Classful subnet mask is 255.255.255.0 or /24
- RFC 1918 – 192.168.0.0/16 (192.168.0.0 – 192.168.255.255)

"Class D" address space (multicast)

- Four most significant bits in first octet fixed at 1110 (`1110xxxx`)
- Range – 224.0.0.0/4 (224.0.0.0 – 239.255.255.255)
- For details refer to RFC 5771
- Link-Local range 224.0.0.0/24 (224.0.0.0 – 224.0.0.255)
- Internetwork Control 224.0.1.0/24 (224.0.1.0 – 224.0.1.255)
- RFC 2365 – Private range 239.0.0.0/8 (239.0.0.0 – 239.255.255.255)
- RIPv2 224.0.0.9 · EIGRP 224.0.0.10
- All OSPF routers 224.0.0.5 · OSPF DR/BDR 224.0.0.6
- No default mask defined

"Class E" address space (experimental)

- Range – 240.0.0.0/4 (240.0.0.0 – 255.255.255.255)
- Reserved for experimental use · no default mask defined
- RFC 5735 – 255.255.255.255 reserved for "All-networks Broadcast"

IPV4 SUBNETTING TERMS

CIDR (RFC 1518, 1519, 4632) **– Classless Inter-Domain Routing**

- Introduced in 1993 to extend the life of IPv4 addressing by removing the assumed and required 8-bit, 16-bit or 24-bit mask.
- Can be used to define smaller "subnetted" blocks of addressing, or "aggregate" blocks of subnets (summarization).

VLSM (RFC 950) **– Variable Length Subnet Masking**

- Through the use of classless routing protocols, networks and/or subnetworks can have variable length masks throughout the enterprise.

Network ID – always the first address in any subnet or network, and used by routers to identify networks. Network IDs cannot be assigned to hosts.

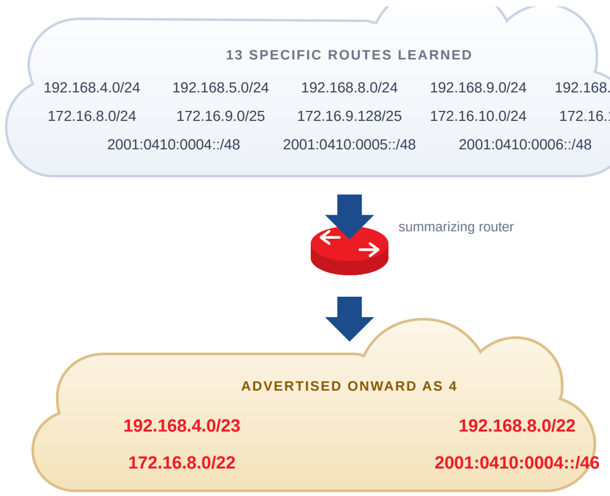
Broadcast ID – always the last address in any subnet, and used to address packets destined for all hosts within the subnet. Often referred to as a subnet broadcast address. Broadcast IDs cannot be assigned to hosts.

Host range – the assignable addresses within a network or subnet. Always the addresses between the Network ID and the Broadcast ID.

IPV4 MASK / PREFIX NOTATION

Bits	0	1	2	3	4	5	6	7	8
Decimal	0	128	192	224	240	248	252	254	255
2nd octet	/8	/9	/10	/11	/12	/13	/14	/15	/16
3rd octet	/16	/17	/18	/19	/20	/21	/22	/23	/24
4th octet	/24	/25	/26	/27	/28	/29	/30	/31	/32

IPV4 / IPV6 SUMMARIZATION



Route summarization (supernet) – an IP network formed from the combination of two or more smaller networks with a common CIDR prefix. The process of summarization is often referred to as supernetting, prefix aggregation, route aggregation or route summarization.

Summarization reduces the size of routing tables, and reduces the effect of topology changes and the amount of routing advertisements needed.

Calculating summaries using the bit comparison method

Addresses are converted to binary format and aligned in a list.

Address	1st octet	2nd octet	3rd octet	4th octet
172.16.8.0	10101100	00010000	00001000	00000000
172.16.9.0	10101100	00010000	00001001	00000000
172.16.9.128	10101100	00010000	00001001	10000000
172.16.10.0	10101100	00010000	00001010	00000000
172.16.11.0	10101100	00010000	00001011	00000000

Address	1st word	2nd word	3rd word
2001:410:4	0010000000000001	0000010000010000	0000000000000100
2001:410:5	0010000000000001	0000010000010000	0000000000000101
2001:410:6	0010000000000001	0000010000010000	0000000000000110

Common bit patterns are located **(shown in red)**. The number of common bits is counted to determine the summary prefix. The summary route is found by setting non-common bits to zero.

1st octet	2nd octet	3rd octet	4th octet	Address	Prefix
10101100	00010000	00001000	00000000	172.16.8.0	/22

1st word	2nd word	3rd word	Address	Prefix
2001	0410	0004	2001:410:4::	/46

IPV4 WILDCARD NOTATION

- Wildcard masks are used in networking to indicate which parts of a mask are examined.
- Wildcard masks can be thought of as an inverse mask in many cases.

Wildcard mask calculation

Subtract each octet of the standard mask from 255 to create an inverse wildcard mask.

255.255.128.0 → 255.255.255.255
− 255.255.128.0
0.0.127.255

IPV6 FACTS

Basic IPv6 addressing facts

- There are no class distinctions.
- All subnet masking is noted in prefix form (/64).
- There are no more broadcast addresses.
- There is a specification for "Unique Local Unicast Addressing" (RFC 4193) which is not routable on the Internet. There is no longer defined "private" IP addressing — all IPv6 addresses are globally routable.

RFC 4291 (IPv6 addressing architecture)

- `::1` is reserved for "Loopback Testing"
- `::` is reserved for "Unspecified Address"
- `FE80::/10` is reserved for "Link-Local Unicast"
- `FF00::/8` is reserved for multicast

8 bits	4 bits	4 bits	112 bits
11111111	Flag bits	Scope bits	Group ID
	0 R T P	RFC 4291	

- `FF02::9` RIPv2 (RIPng) · `FF02::A` EIGRP for IPv6
- `FF02::5` OSPFv3 routers · `FF02::6` OSPFv3 DR/BDR
- `2000::/3` current "Global Unicast" range

3 bits	45 bits	16 bits	64 bits
001	Global routing prefix	Subnet ID	Interface ID

IANA → RIR → LIR/ISP · Site · Host

IPV6 POSITIONAL NOTATION

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F

IPv6 addresses are **128 bits** in length, written in blocks of 8 words (16 bits) represented in hexadecimal format and separated by a colon.

2001:05DE…	0010 0000 0000 0001 : 0000 0101 1101 1110

SUMMARIZING A BLOCK — THE METHOD IN FOUR STEPS

1. List and align. Write every network you want to summarize in binary, one per line, octets aligned.

2. Find the common bits. Read left to right and stop at the first column where the bits stop agreeing.

3. Count them. The number of columns that agreed is the prefix length — /22 in the example above.

4. Zero the rest. Set every non-common bit to zero and convert back. That is the summary address.

A summary always advertises the whole range it covers — check nothing outside your block falls inside it before you use one.