

Custom Subnetting

Introduction To Networking

Jonathan Edwards 2023

Context

- IPv4 is widely in use despite the existence of IPv6
- IPv4 was designed originally to work in classes of address ranges
- Each class had its own assigned subnet mask
- **Class A** used 255.0.0.0 giving: **8 bit** network address and **24 bit** host ID
- **Class B** used 255.255.0.0 giving: **16 bit** network address and **16 bit** host ID
- **Class C** used 255.255.255.0 giving: **24 bit** network address and **8 bit** host ID
- At the time (early 1980s this was thought to be sufficient for all the needs we would ever have
- There was also a **class D** dedicated to multicasting and **class E** for “experimental” use

Context

- This is not very flexible and led to a lot of wasted address space
- E.g. you can have
 - 254 host addresses
 - or 65,535 host addresses
 - Or 16,777,215 host addresses... but what if we need 30, or 500, or 2000?
- So we dispense with the idea of classes, though the default subnet masks still apply
- *Any (valid) subnet mask can be used with any IP address (within reason)
- The 'split' between network address and host id can come 'mid octet' meaning it won't always be **255** or **0**
- Visually IP address's with custom subnet mask is much harder to understand

Benefits of subnetting

- **Reduces network traffic**

- large number of broadcasts would be needed for all the 4 billion IP addresses
- Improves performance

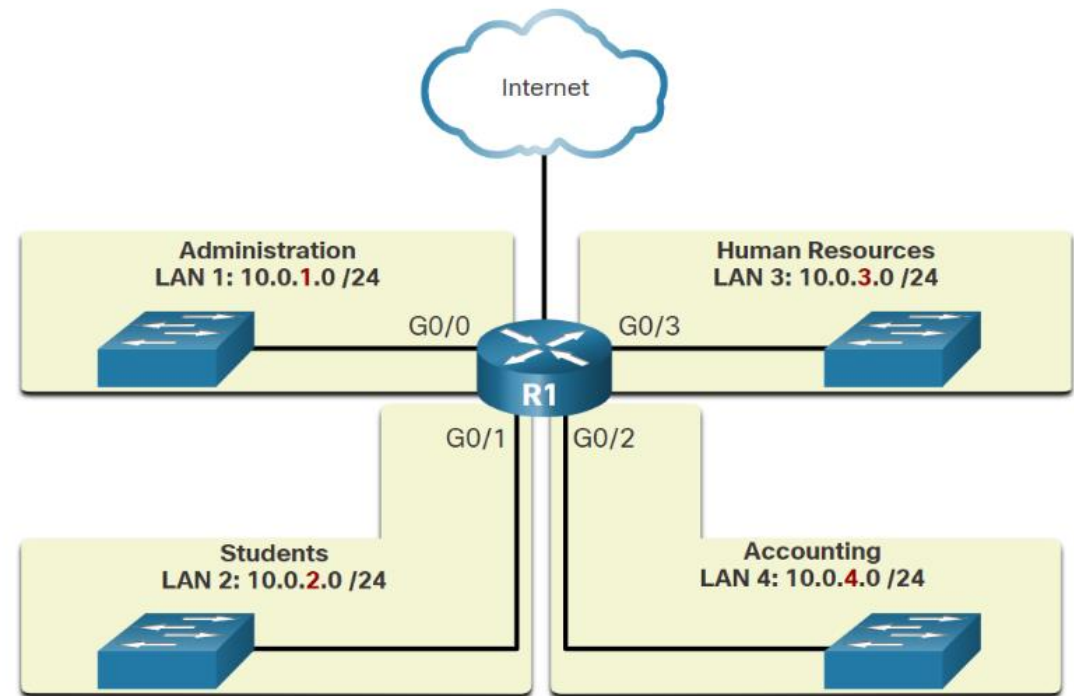
- **Optimised network performance**

- Routers can throw packets in the right general direction

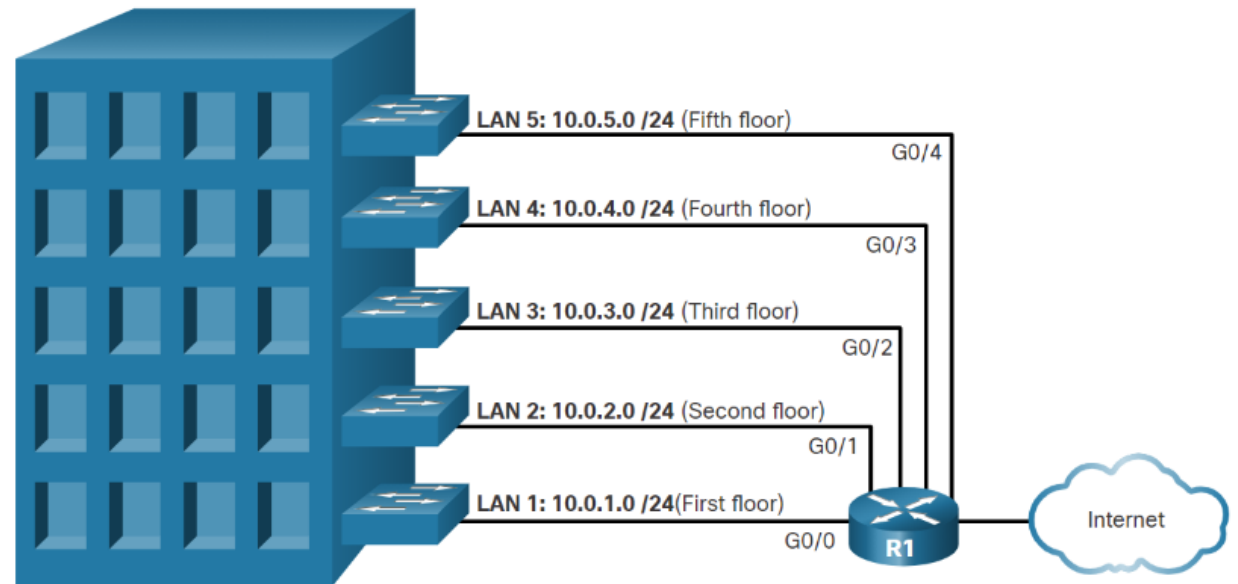
- **Simplified management**

- You just look after a part of the network
- Facilitated spanning of large geographical distances
- Improves security

Subnetting by Group or by Function

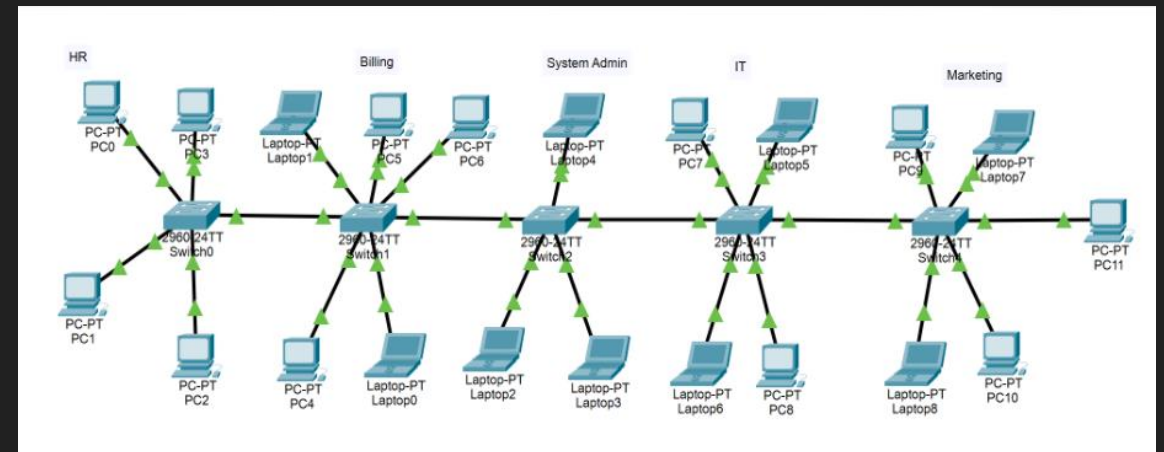


Subnetting by Location



Network Performance, Security, and Manageability

- Large networks have different sections with different functionality
 - E.g. The Billing department concerned with creating Bills, generating database queries, creating a lot of traffic
 - Whereas the admin staff, mostly word processing
 - Requires greater security
 - Creates less traffic
- We need to subnet because of:
 - Improved network performance
 - Improved security
 - Enhanced manageability
 - Increased efficiency in IP address allocation



Subnet Masks (a recap)

- Subnet masks are used to distinguish between the network address and the host id
- A subnet mask is a 'bitmask' that isolates the network identifier from the host identifier

For example:

192.168.45.3 = 11000000101010000010110100000011

255.255.255.0 = 11111111111111111111111100000000

The computer uses an AND gate operation to decipher the address:

IP address 11000000 10101000 00101101 00000011

Subnet Mask 11111111 11111111 11111111 00000000

AND gate 11000000 10101000 00101101 00000000 ..Reveals the network address

Essentially without a subnet mask an IP address is useless because we don't know what the network address is or what the host ID is.

CIDR notation

Classless Inter-Domain Routing (CIDR)

/8 255.0.0.0

11111111 00000000 00000000 00000000

/16 255.255.0.0

11111111 11111111 00000000 00000000

/24 255.255.255.0

11111111 11111111 11111111 00000000

/25 through to /30

/25 255.255.255.128

11111111 11111111 11111111 10000000

/26 255.255.255.192

11111111 11111111 11111111 11000000

/27 255.255.255.224

11111111 11111111 11111111 11100000

/28 255.255.255.240

11111111 11111111 11111111 11110000

/29 255.255.255.248

11111111 11111111 11111111 11111000

/30 255.255.255.252

11111111 11111111 11111111 11111100

A /25 subnet example

/25 (255.255.255.128)

11111111 11111111 11111111 10000000

192.168.0.00000000	Network address	.0
192.168.0.00000001	First valid host	.1
192.168.0.01111110	Last valid host	.126
192.168.0.01111111	Broadcast address	.127
192.168.0.10000000	Network address	.128
192.168.0.10000001	First valid host	.129
192.168.0.11111110	Last valid host	.254
192.168.0.11111111	Broadcast address	.255

A /25 subnet example

- So what have we achieved?
- Instead of having one network with a 255.255.255.0 subnet mask and 254 possible hosts...
- We now have:
 - **2** separate subnets
 - Each with **126** possible hosts
 - Each subnet has its own **network address** and its own **broadcast address**
 - We **cannot** simply rely on looking for a **0** or **255** to identify these addresses though

A /26 subnet example

11111111 11111111 11111111 11000000

192.168.0.00000000	Network address	.0
192.168.0.00000001	First valid host	.1
192.168.0.00111110	Last valid host	.62
192.168.0.00111111	Broadcast address	.63
192.168.0.01000000	Network address	.64
192.168.0.01000001	First valid host	.65
192.168.0.01111110	Last valid host	.126
192.168.0.01111111	Broadcast address	.127

A /26 subnet example

192.168.0.10000000	Network address	.128
192.168.0.10000001	First valid host	.129
192.168.0.10111110	Last valid host	.190
192.168.0.10111111	Broadcast address	.191
192.168.0.11000000	Network address	.192
192.168.0.11000001	First valid host	.193
192.168.0.11111110	Last valid host	.254
192.168.0.11111111	Broadcast address	.255

/26 subnet example

- So what have we achieved?
- Instead of one having network with a 255.255.255.0 subnet mask and 254 possible hosts...
- We now have:
 - **4** separate subnets
 - Each with **62** possible hosts
 - Each subnet has its own **network address** and it's own **broadcast address**
 - We **cannot** simply rely on looking for a **0** or **255** to identify these addresses though

/25 - /30

/25	2 subnets (2^1)	126 valid hosts on each	($2^7 - 2$)
/26	4 subnets (2^2)	62 valid hosts on each	($2^6 - 2$)
/27	8 subnets (2^3)	30 valid hosts on each	($2^5 - 2$)
/28	16 subnets (2^4)	14 valid hosts on each	($2^4 - 2$)
/29	32 subnets (2^5)	6 valid hosts on each	($2^3 - 2$)
/30	64 subnets (2^6)	2 valid hosts on each	($2^2 - 2$)

The need for clarity

- This highlights why we need to be careful to recognise the importance of understanding the address in binary

192.168.0.16 /24 is a valid host IP address **00010000**

192.168.0.16 /25 is a valid host IP address **00010000**

192.168.0.16 /26 is a valid host IP address **00010000**

192.168.0.16 /27 is a valid host IP address **00010000**

192.168.0.16 /28 is a network address! **00010000**

...as all the host ID bits are **ZERO**

An example scenario

- You are given a /24 (Class C) network address of **192.168.15.0 /24**
- You are asked to calculate an appropriate custom subnet mask, the number of subnets produced, and the number of valid hosts lps produced for each subnet
- You need a minimum of **5** subnets with between **25-30** hosts on each
- **3 bits** would give **8** combinations, and we need 5 networks so that is ok... we have 3 more for expansion
- The default subnet mask was **255.255.255.0**
- The new custom subnet mask is **255.255.255.224** after 'borrowing' another **3 bits...**
- 11111111.11111111.11111111.**111 00000**
(red borrowed bits)(Green-host id bits)

A /27 example

- Number of subnets: **8** [2^3]
- Number of valid hosts in each subnet: **30** [$2^5 - 2$]

Calculate all of the subnets...

- | | | |
|------------------|-------------------------------------|--------|
| ○ 192.168.15.0 | 192.168.15. 000 00000 | (.0) |
| ○ 192.168.15.32 | 192.168.15. 001 00000 | (.32) |
| ○ 192.168.15.64 | 192.168.15. 010 00000 | (.64) |
| ○ 192.168.15.96 | 192.168.15. 011 00000 | (.96) |
| ○ 192.168.15.128 | 192.168.15. 100 00000 | (.128) |
| ○ 192.168.15.160 | 192.168.15. 101 00000 | (.192) |
| ○ 192.168.15.192 | 192.168.15. 110 00000 | (.224) |
| ○ 192.168.15.224 | 192.168.15. 111 00000 | (.240) |

Subnet address	First valid host	Last valid host	Broadcast address
192.168.15.0	192.168.15.1	192.168.15.30	192.168.15.31
192.168.15.32	192.168.15.33	192.168.15.62	192.168.15.63
192.168.15.64	192.168.15.65	192.168.15.94	192.168.15.95
192.168.15.96	192.168.15.97	192.168.15.126	192.168.15.127
192.168.15.128	192.168.15.129	192.168.15.158	192.168.15.159
192.168.15.160	192.168.15.161	192.168.15.190	192.168.15.192
192.168.15.192	192.168.15.193	192.168.15.222	192.168.15.223
192.168.15.224	192.168.15.225	192.168.15.254	192.168.15.255

Think about future expansion needs

- When it is required to have for instance 5 networks
 - There is no problem if your calculation gives you say 8 networks
 - This is OK for expansion purposes
- The same applies when calculating the number of hosts per network,
 - You should always plan for future expansion
 - So if you were asked for 20 hosts per network, and you got 30 hosts per network, that is fine