SLEZSKÁ
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Computer network and internet

IPv4: subnetting

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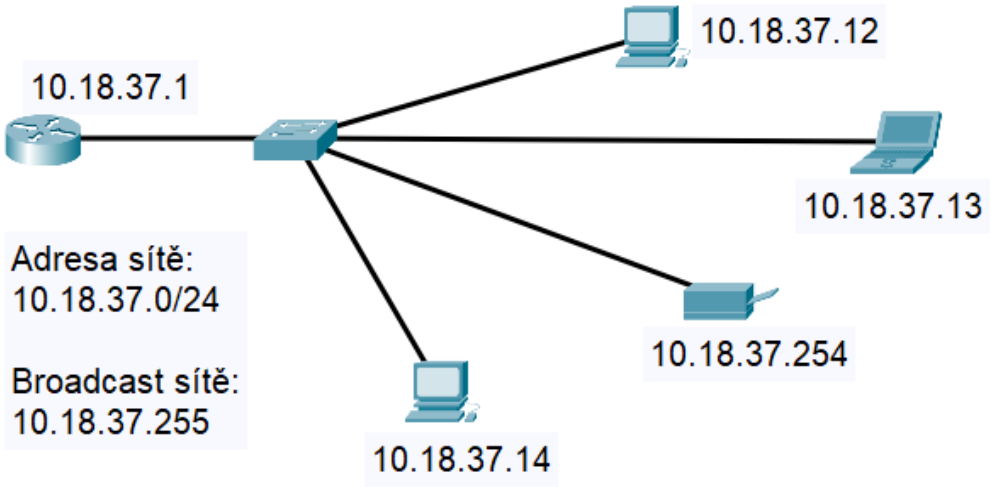
Example

- Net address: 10.18.37.0 bin.: ...`00100101.00000000` mask: 255.255.255.0

Example

- Net address: 10.18.37.0 bin.: ...00100101.00000000 mask: 255.255.255.0

- broadcast: 10.18.37.255 bin.: ...00100101.11111111



Example

- Net address: 10.18.37.0 bin.: ...00100101.00000000 mask: 255.255.255.0
- first client: 10.18.37.1 bin.: ...00100101.00000001
- ...
- last client: 10.18.37.254 bin.: ...00100101.11111110
- broadcast: 10.18.37.255 bin.: ...00100101.11111111

- => 8 bits in the host portion, i.e. $2^8 - 2 = 256 - 2 =$ **254** addresses for devices

Example

- Net address: 10.18.160.0 bin.: ...1010**0000.00000000** mask: 255.255.240.0
- bin.: ...1111**0000.00000000**

Example

- Net address: 10.18.160.0 bin.: ...1010**0000.00000000** mask: 255.255.240.0
- first client: 10.18.160.1 bin.: ...1010**0000.00000001** bin.: ...1111**0000.00000000**
- ...
- last client: 10.18.175.254 bin.: ...1010**1111.11111110**
- broadcast: 10.18.175.255 bin.: ...1010**1111.11111111**

- => 12 bits in the host portion, i.e. 2^{12} - 2 = 4096 – 2 = **4094** addresses for devices
- (not only PCs and switches, including router)

Classes

- First attempt to determine where the boundary between the network and host portions of the address is

Class A (1.0.0.0/8 to 127.0.0.0/8)
- první bity: 0xxxxxxx...
- počet sítí: 127
- počet hostitelů v síti: 16 777 214

Class B (128.0.0.0/16 – 191.255.0.0/16)
- první bity: 10xxxxx...
- počet sítí: 16 384
- počet hostitelů v síti: 65 534

Class C (192.0.0.0/24 – 223.255.255.0/24)
- první bity: 110xxxxx...
- počet sítí: 2 097 152
- počet hostitelů v síti: 254

- Private Address Blocks
  - 10.0.0.0/8
  - 172.16.0.0/12
  - 192.168.0.0 /16

- What if we want to divide such a network into smaller subnets? Subnetting.

Classes – subnetting

- Devide the network 10.0.0.0/8 to subnets, the new boundary is /16, i.e. the mask is 255.255.0.0

Subnet address	Rozsah pro klienty	Broadcast
10.0.0.0/16	10.0.0.1 - 10.0.255.254	10.0.255.255
10.1.0.0/16	10.1.0.1 - 10.1.255.254	10.1.255.255
10.2.0.0/16	10.2.0.1 - 10.2.255.254	10.2.255.255
10.3.0.0/16	10.3.0.1 - 10.3.255.254	10.3.255.255
10.4.0.0/16	10.4.0.1 - 10.4.255.254	10.4.255.255
10.5.0.0/16	10.5.0.1 - 10.5.255.254	10.5.255.255
10.6.0.0/16	10.6.0.1 - 10.6.255.254	10.6.255.255
10.7.0.0/16	10.7.0.1 - 10.7.255.254	10.7.255.255
...	...	...
10.255.0.0/16	10.255.0.1 - 10.255.255.254	10.255.255.255

Subnetting – procesure:

- determine the prefix length
- create the table:

Subnet address	First usable address	Last usable address	Subnet broadcast
First subnet			
…			
Last subnet			

- list all subnets
- specify broadcasts (e.g. subtract number one from the following subnet)
- fill in the addresses of the first and last client (addresses between the subnet and the broadcast)

Example

- Devide the network 192.168.1.0/24 to subnets, we need two subnets = 1 bit, the new boundary is /25, mask 255.255.255.128
- Last octet in the first subnet: **0000 0000**
  Last octet in the second subnet: **1000 0000**

Subnet address	First client	Last client	Subnet broadcast
192.168.1.0/25			
192.168.1.128/25			

Example

- Devide the network 192.168.1.0/24 to subnets, we need two subnets = 1 bit, the new boundary is /25, mask 255.255.255.128
- Last octet in the first subnet: **0000 0000**
  Last octet in the second subnet: **1000 0000**

Subnet address	First client	Last client	Subnet broadcast
192.168.1.0/25			192.168.1.127
192.168.1.128/25			192.168.1.255

Example

- Devide the network 192.168.1.0/24 to subnets, we need two subnets = 1 bit, the new boundary is /25, mask 255.255.255.128
- Last octet in the first subnet: **0000 0000**
  Last octet in the second subnet: **1000 0000**

Subnet address	First client	Last client	Subnet broadcast
192.168.1.0/25	192.168.1.1	192.168.1.126	192.168.1.127
192.168.1.128/25	192.168.1.129	192.168.1.254	192.168.1.255

prefix length	/24	/25	/26	/27	/28	/29	/30
No. of addresses	256 - 2	128 - 2	64 - 2	32 - 2	16 - 2	8 - 2	4 - 2

- Original network: 192.168.1.0/24
- we need 4 subnets => 4 = 2^2 (2 bits)
- Subnet address: the bits are 00, 01, 10, 11
- e.g. **01**00 0000 -> 64

Subnet address	First client	Last client	Subnet broadcast
192.168.1.0/26			

prefix length	/24	/25	/26	/27	/28	/29	/30
No. of addresses	256 - 2	128 - 2	64 - 2	32 - 2	16 - 2	8 - 2	4 - 2

- Original network: 192.168.1.0/24
- we need 4 subnets => 4 = 2^2 (2 bits)
- Subnet address: the bits are 00, 01, 10, 11
- e.g. **01**00 0000 -> 64

Subnet address	First client	Last client	Subnet broadcast
192.168.1.0/26			
192.168.1.64/26			
192.168.1.128/26			
192.168.1.192/26			

prefix length	/24	/25	/26	/27	/28	/29	/30
No. of addresses	256 - 2	128 - 2	64 - 2	32 - 2	16 - 2	8 - 2	4 - 2

- Original network: 192.168.1.0/24
- we need 4 subnets => 4 = 2^2 (2 bits)
- Subnet address: the bits are 00, 01, 10, 11
- e.g. **01**00 0000 -> 64

Subnet address	First client	Last client	Subnet broadcast
192.168.1.0/26			192.168.1.63
192.168.1.64/26			192.168.1.127
192.168.1.128/26			192.168.1.191
192.168.1.192/26			192.168.1.255

prefix length	/24	/25	/26	/27	/28	/29	/30
No. of addresses	256 - 2	128 - 2	64 - 2	32 - 2	16 - 2	8 - 2	4 - 2

- Original network: 192.168.1.0/24
- we need 4 subnets => 4 = 2^2 (2 bits)
- Subnet address: the bits are 00, 01, 10, 11
- e.g. **01**00 0000 -> 64

Subnet address	First client	Last client	Subnet broadcast
192.168.1.0/26	192.168.1.1	192.168.1.62	192.168.1.63
192.168.1.64/26	192.168.1.65	192.168.1.126	192.168.1.127
192.168.1.128/26	192.168.1.129	192.168.1.190	192.168.1.191
192.168.1.192/26	192.168.1.193	192.168.1.254	192.168.1.255

prefix length	/24	/25	/26	/27	/28	/29	/30
No. of addresses	256 - 2	128 - 2	64 - 2	32 - 2	16 - 2	8 - 2	4 - 2

- Original network: 192.168.128.0/24
- we need 5 addresses inside each subnet => 3 bits in the host portion mean = 2^3 – 2 addresses = 6
- remaining bits for the subnet 8 – 3 = 5 bits (i.e. 2^5 subnets), the second one is 0000 1000 -> 8

Subnet address	First client	Last client	Subnet broadcast
192.168.128.0/29			

prefix length	/24	/25	/26	/27	/28	/29	/30
No. of addresses	256 - 2	128 - 2	64 - 2	32 - 2	16 - 2	8 - 2	4 - 2

- Original network: 192.168.128.0/24
- we need 5 addresses inside each subnet => 3 bits in the host portion mean = 2^3 – 2 addresses = 6
- remaining bits for the subnet 8 – 3 = 5 bits (i.e. 2^5 subnets), the second one is 0000 1000 -> 8

Subnet address	First client	Last client	Subnet broadcast
192.168.128.0/29			
192.168.128.8/29			
192.168.128.16/29			
192.168.128.24/29			
192.168.128.32/29			
192.168.128.40/29			
...			
192.168.128.248/29 (255-8)			

prefix length	/24	/25	/26	/27	/28	/29	/30
No. of addresses	256 - 2	128 - 2	64 - 2	32 - 2	16 - 2	8 - 2	4 - 2

- Original network: 192.168.128.0/24
- we need 5 addresses inside each subnet => 3 bits in the host portion mean = $2^3 - 2$ addresses = 6
- remaining bits for the subnet 8 – 3 = 5 bits (i.e. 2^5 subnets), the second one is 0000 1000 -> 8

Subnet address	First client	Last client	Subnet broadcast
192.168.128.0/29			192.168.128.7
192.168.128.8/29			192.168.128.15
192.168.128.16/29			192.168.128.23
192.168.128.24/29			192.168.128.31
192.168.128.32/29			192.168.128.39
192.168.128.40/29			192.168.128.47
...			
192.168.128.248/29 (255-8)			192.168.128.255

prefix length	/24	/25	/26	/27	/28	/29	/30
No. of addresses	256 - 2	128 - 2	64 - 2	32 - 2	16 - 2	8 - 2	4 - 2

- Original network: 192.168.128.0/24
- we need 5 addresses inside each subnet => 3 bits in the host portion mean = $2^3 - 2$ addresses = 6
- remaining bits for the subnet 8 – 3 = 5 bits (i.e. 2^5 subnets), the second one is 0000 1000 -> 8

Subnet address	First client	Last client	Subnet broadcast
192.168.128.0/29	.1	.6	192.168.128.7
192.168.128.8/29	.9	.14	192.168.128.15
192.168.128.16/29	.17	.23	192.168.128.23
192.168.128.24/29	.25	.30	192.168.128.31
192.168.128.32/29	.33	.38	192.168.128.39
192.168.128.40/29	.41	.46	192.168.128.47
...			
192.168.128.248/29 (255-8)	.249	.254	192.168.128.255

prefix length	/24	/25	/26	/27	/28	/29	/30
No. of addresses	256 - 2	128 - 2	64 - 2	32 - 2	16 - 2	8 - 2	4 - 2

- Original network: 172.16.0.0/16
- we need 500 addresses in each subnet => 9 bits in the host portion mean $2^9 - 2$ addresses = 510
- remaining bits for the subnet 16 – 9 = 7,
- for the second subnet: the third octet is **0000 0010 -> 2**

Subnet address	First client	Last client	Subnet broadcast
172.16.0.0/23			
172.16.2.0/23 (+2)			
172.16.4.0/23 (+2)			
… (+2)			
172.16.254.0/23 (256-2)			

prefix length	/24	/25	/26	/27	/28	/29	/30
No. of addresses	256 - 2	128 - 2	64 - 2	32 - 2	16 - 2	8 - 2	4 - 2

- Original network: 172.16.0.0/16
- we need 500 addresses in each subnet => 9 bits in the host portion mean $2^9 - 2$ addresses = 510
- remaining bits for the subnet 16 – 9 = 7,
- for the second subnet: the third octet is **0000 0010 -> 2**

Subnet address	First client	Last client	Subnet broadcast
172.16.0.0/23			172.16.1.255
172.16.2.0/23 (+2)			172.16.3.255
172.16.4.0/23 (+2)			172.16.5.255
… (+2)			
172.16.254.0/23 (256-2)			172.16.255.255

prefix length	/24	/25	/26	/27	/28	/29	/30
No. of addresses	256 - 2	128 - 2	64 - 2	32 - 2	16 - 2	8 - 2	4 - 2

- Original network: 172.16.0.0/16
- we need 500 addresses in each subnet => 9 bits in the host portion mean $2^9 - 2$ addresses = 510
- remaining bits for the subnet 16 – 9 = 7,
- for the second subnet: the third octet is **0000 0010 -> 2**

Subnet address	First client	Last client	Subnet broadcast
172.16.0.0/23	172.16.0.1	172.16.1.254	172.16.1.255
172.16.2.0/23 (+2)	172.16.2.1	172.16.3.254	172.16.3.255
172.16.4.0/23 (+2)	172.16.4.1	172.16.5.254	172.16.5.255
… (+2)			
172.16.254.0/23 (256-2)	172.16.254.1	172.16.255.254	172.16.255.255

network portion	host portion	
network portion	subnet portion = p	host portion = h

- **Number of subnets**:
  - number of bits dedicated to the subnet = p, then 2^p is the number of subnets
- **Number of hosts (clients) inside the network**:
  - number of bits in the host portion = h, then $2^h - 2$ is the number of hosts inside subnets
- **Magic Number**:
  - find the last bit of the subnet (the last 1 of the mask, position m), then the distance between subnets is 2^m

Example:

192.168.54.0/24, use 3 bits for subnets, mask (last byte): xxxxx.**1110 0000**

- => $2^3 = 8$ subnets
- 5 bits for the host portion => $2^5 - 2 = 30$ hosts inside the subnet
- magic number: from the mask **1110 0000** => $2^5 = 32$, the following subnet is 192.168.54.32

Subnetting

základ	0	1	2	3	4	5	6	7
power of 2	1	2	4	8	16	32	64	128

- base: 172.16.0.0/16 we need 50 subnets .... fits in 64 = 2^6 (6 bits for subnets)
- original mask: 255.255.0.0 255.255.00000000.0 /16
  new mask: 255.255.252.0 255.255.11111100.0 /22
- Magic number: last 1 in the mask $2^2 = 4$ ...the third octet of the address

Subnet address	First client	Last client	Subnet broadcast
172.16.0.0/22			
172.16.4.0/22 (+4)			
172.16.8.0/22 (+4)			
172.16.12.0/22 (+4)			
172.16.16.0/22 (+4)			
.....			
172.16.252.0/22 (256-4)			

Subnetting

základ	0	1	2	3	4	5	6	7
power of 2	1	2	4	8	16	32	64	128

- base: 172.16.0.0/16 we need 50 subnets .... fits in 64 = 2^6 (6 bits for subnets)
- original mask: 255.255.0.0 255.255.00000000.0 /16
  new mask: 255.255.252.0 255.255.11111100.0 /22
- Magic number: last 1 in the mask $2^2 = 4$ ...the third octet of the address

Subnet address	First client	Last client	Subnet broadcast
172.16.0.0/22			172.16.3.255
172.16.4.0/22 (+4)			172.16.7.255
172.16.8.0/22 (+4)			172.16.11.255
172.16.12.0/22 (+4)			172.16.15.255
172.16.16.0/22 (+4)			172.16.19.255
.....			
172.16.252.0/22 (256-4)			172.16.255.255

Subnetting

základ	0	1	2	3	4	5	6	7
power of 2	1	2	4	8	16	32	64	128

- base: 172.16.0.0/16 we need 50 subnets .... fits in 64 = 2^6 (6 bits for subnets)
- original mask: 255.255.0.0 255.255.00000000.0 /16
  new mask: 255.255.252.0 255.255.11111100.0 /22
- Magic number: last 1 in the mask $2^2 = 4$ ...the third octet of the address

Subnet address	First client	Last client	Subnet broadcast
172.16.0.0/22	172.16.0.1	172.16.3.254	172.16.3.255
172.16.4.0/22 (+4)	172.16.4.1	172.16.7.254	172.16.7.255
172.16.8.0/22 (+4)	172.16.8.1	172.16.11.254	172.16.11.255
172.16.12.0/22 (+4)	172.16.12.1	172.16.15.254	172.16.15.255
172.16.16.0/22 (+4)	172.16.16.1	172.16.19.254	172.16.19.255
.....			
172.16.252.0/22 (256-4)	172.16.252.1	172.16.255.254	172.16.255.255

- base: 10.0.0.0/8 we need 1000 subnets .... fits in 1024 = 2^{10} (10 bits for subnets)
- original mask: 255.0.0.0 255.00000000.00000000.0 /8
  new mask: 255.255.192.0 255.11111111.11000000.0 /18
- Magic number: the last 1 in the mask 2^6 = 64 ...start inside the third octet, follow to the second octet

Subnet address	First client	Last client	Subnet broadcast
10.0.0.0/18			
10.0.64.0/18			
10.0.128.0/18			
10.0.192.0/18			
10.1.0.0/18 (192+64=256, přen. vlevo)			
10.1.64.0/18			
10.1.128.0/18			
10.1.192.0/18			
10.2.0.0/18 (192+64=256, přen. vlevo)			
...			
10.255.192.0/18			

- base: 10.0.0.0/8 we need 1000 subnets .... fits in 1024 = 2^{10} (10 bits for subnets)
- original mask: 255.0.0.0 255.00000000.00000000.0 /8
  new mask: 255.255.192.0 255.11111111.11000000.0 /18
- Magic number: the last 1 in the mask $2^6 = 64$ ...start inside the third octet, follow to the second octet

Subnet address	First client	Last client	Subnet broadcast
10.0.0.0/18			10.0.63.255
10.0.64.0/18			10.0.127.255
10.0.128.0/18			10.0.191.255
10.0.192.0/18			10.0.255.255
10.1.0.0/18 (192+64=256, přen. vlevo)			10.1.63.255
10.1.64.0/18			10.1.127.255
10.1.128.0/18			10.1.191.255
10.1.192.0/18			10.1.255.255
10.2.0.0/18 (192+64=256, přen. vlevo)			10.2.63.255
...			
10.255.192.0/18			10.255.255.255

- base: 10.0.0.0/8 we need 1000 subnets .... fits in 1024 = 2^{10} (10 bits for subnets)
- original mask: `255.0.0.0` `255.00000000.00000000.0` `/8`
  new mask: `255.255.192.0` `255.11111111.11000000.0` `/18`
- Magic number: the last 1 in the mask $2^6 = 64$ ...start inside the third octet, follow to the second octet

Subnet address	First client	Last client	Subnet broadcast
10.0.0.0/18	10.0.0.1	10.0.63.254	10.0.63.255
10.0.64.0/18	10.0.64.1	10.0.127.254	10.0.127.255
10.0.128.0/18	10.0.128.1	10.0.191.254	10.0.191.255
10.0.192.0/18	10.0.192.1	10.0.255.254	10.0.255.255
10.1.0.0/18 (192+64=256, přen. vlevo)	10.1.0.1	10.1.63.254	10.1.63.255
10.1.64.0/18	10.1.64.1	10.1.127.254	10.1.127.255
10.1.128.0/18	10.1.128.1	10.1.191.254	10.1.191.255
10.1.192.0/18	10.192.64.1	10.1.255.254	10.1.255.255
10.2.0.0/18 (192+64=256, přen. vlevo)	10.2.0.1	10.2.63.254	10.2.63.255
...			
10.255.192.0/18	10.255.192.1	10.255.255.254	10.255.255.255