INFO 3605
Fundamentals of LAN Technologies
Lecture 13.1 – IPv4 Subnetting

Naresh Seegobin (M.Sc. CompSci, M.Sc. ProjMgmt, CCNA)

naresh.seegobin@sta.uwi.edu

Different networks at home

- You may want to have a guest network for your visitors for Internet access only, but don't want them accessing your local computers.

LAN(port) Subnet
192.168.1.0/24

WLAN(AP) Subnet
192.168.2.0/24

OpenWrt Router
LAN(port) + WLAN(AP)
192.168.1.1 / 192.168.2.1

LAN Host 1
192.168.1.2

WLAN Host 3
192.168.2.101

WLAN Host 1
192.168.2.100

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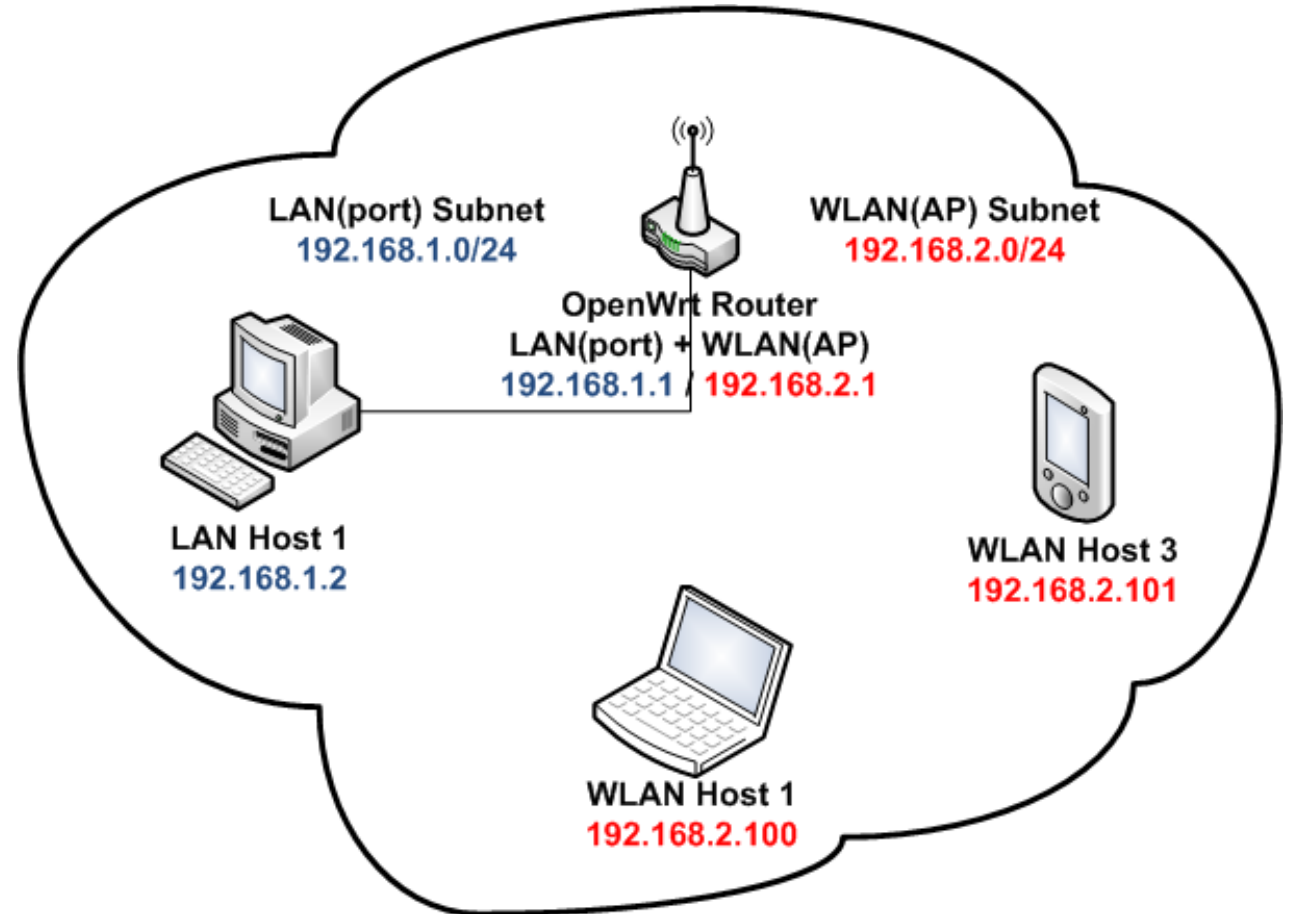
Objectives

• Understand the reasons for subnetting.

• Describe the subnetting process.

• Ability to divide a network into subnetworks.

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Some Review Questions

- Host A is a PC, connected to switch SW1 and assigned to VLAN 1. Which of the following are typically assigned an IP address in the same subnet as host A? (Choose two answers.)
    - a. The local router's WAN interface
    - b. The local router's LAN interface
    - c. All other hosts attached to the same switch
    - d. Other hosts attached to the same switch and also in VLAN 1

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    a. The local router's WAN interface

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Some Review Questions

- Why does the formula for the number of hosts per subnet ($2^H - 2$) require the subtraction of two hosts?

   a. To reserve two addresses for redundant default gateways (routers)

   b. To reserve the two addresses required for DHCP operation

   c. To reserve addresses for the subnet ID and default gateway (router)

   d. To reserve addresses for the subnet broadcast address and subnet ID

Some Review Questions

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   d. To reserve addresses for the subnet broadcast address and subnet ID

IP Subnetting

- Subnetting defines methods of further subdividing the IPv4 address space into groups that are smaller than a single IP network.

- IP subnetting is a flexible way to take a single Class A, B or C IP network and further subdivide it into smaller groups of IP addresses.

  - subnet is just shorthand for subdivided network.

- Subnetting allows you to use fewer IP addresses.

IP Subnetting

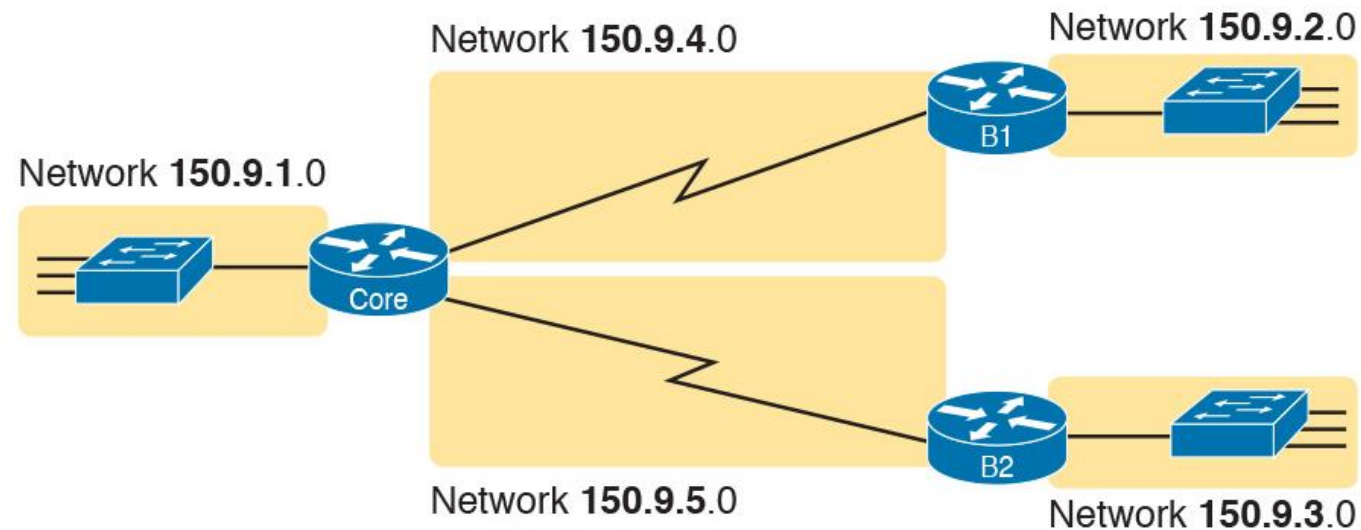- Example That Uses Five Class B Networks
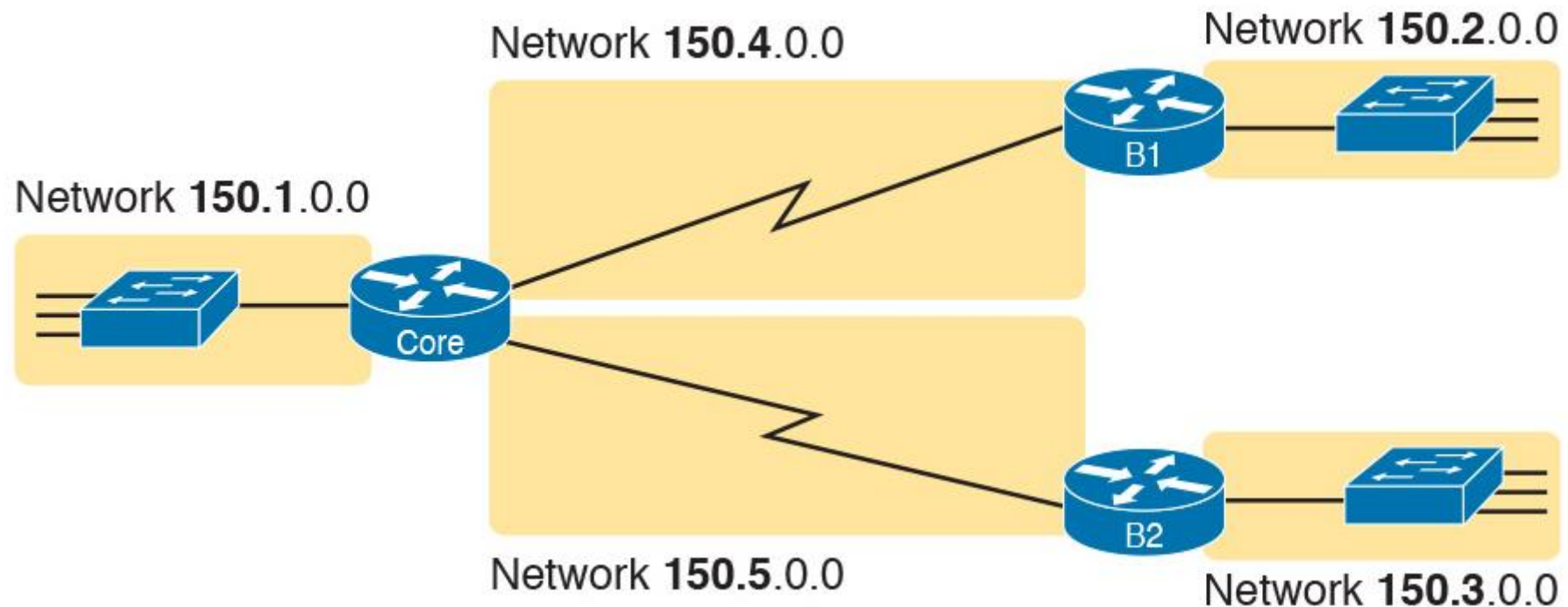
IP Subnetting

- A lot of IP addresses are wasted especially if they are paid public IP addresses.

- E.g. the WAN links that use 150.4.x.x and 150.5.x.x, supports 65,534 IP addresses, but the WAN link only needs 2. The rest are wasted.

- By design, LANs do not grow more than a hundred devices. So we do not need all 65,534 IP addresses available to one LAN.

IP Subnetting

- One group of the 254 addresses that begin with 150.9.1
- One group of the 254 addresses that begin with 150.9.2
- One group of the 254 addresses that begin with 150.9.3
- One group of the 254 addresses that begin with 150.9.4
- One group of the 254 addresses that begin with 150.9.5

Network **150.9.4**.0

Network **150.9.2**.0

Network **150.9.1**.0

Network **150.9.5**.0

Network **150.9.3**.0

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Subnetting

- A Class A, B, or C TCP/IP network can be further divided, or subnetted, by a system administrator.
    - Why should this be done?
    - Hosts can be in various locations that need routing
- Why we cannot use an address such as 192.168.1.0 or 192.168.1.255 for a host?
    - The .0 address is the network address
    - The .255 address is the broadcast address, every client will be listening to this address for broadcasts

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Subnetting

- Using 192.168.123.1 to 192.168.123.254 for 150 hosts
- Can be divided into 4 subnets
- The number of networks increase but the number of hosts decrease
- The subnet mask 255.255.255.192 gives 4 networks with 62 hosts each
    - Why 62 and not 64?
    - 1 address is for the network the other is the broadcast address for that network
-       255.   255.   255.   192   is the same as 1111111.11111111.1111111.11000000

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Subnetting

- The first two digits of the last octet become network addresses, so you get the additional networks
  - **00**000000 (0),
  - **01**000000 (64),
  - **10**000000 (128) and
  - **11**000000 (192).
- The last 6 binary digits can be used for host addresses
  - 2^6 = 64 hosts, actually 62 (1 for network address, 1 for broadcast address)

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Subnetting

- So using a subnet mask of 255.255.255.192,
- Your 192.168.123.0 network bbecomes 4 networks:
  - 192.168.123.**0**, -> .00000000
  - 192.168.123.**64**, -> .01000000
  - 192.168.123.**128** and -> .100000000   **These are your networks**
  - 192.168.123.**192** -> .1100000000
- The corresponding host ranges are:
  - 192.168.123.1-62
  - 192.168.123.65-126
  - 192.168.123.129-190
  - 192.168.123.193-254

Inverse Mask

- Take Subnet Mask and apply XOR to 255.255.255.255

- 255.   255.   255.   192   is the same as
  1111111.11111111.1111111.11000000

  XOR

- 255.   255.   255.   255 or
- 11111111.11111111.11111111.11111111

  128 64 32 16 8 4 2 1

- 00000000.00000000.00000000.00111111 or
- 0.   0.   0.   63   **This is your Network Size**

Subnetting

- And what is your broadcast address for these networks?
- **Network Address + Inverse Mask = Broadcast Address**
- **Host Range = Network Address + 1 to Broadcast Address -1**

Network	Host Range	Broadcast Address
192.168.123.**0**	192.168.123.1-62	192.168.123.**63**
192.168.123.**64**	192.168.123.65-126	192.168.123.**127**
192.168.123.**128**	192.168.123.129-190	192.168.123.**191**
192.168.123.**192**	192.168.123.193-254	192.168.123.**255**

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Subnet Example

- Two addresses:
    - 192.168.123.71 and
    - 192.168.123.133.
- If both are using a class C subnet, will they see one another?
- If you use a subnet mask of 255.255.255.192, will they see one another?
- 192.168.123.71 belongs to which network?
- 192.168.123.133 belongs to which network?

Subnet Formula

- Number of subnets = 2^n where n is the number of bits borrowed to make the subnet mask

- Number of hosts = $2^n - 2$ where n is the number of bits in your subnet mask

Binary Mask				Prefix Length	Subnet Mask
11111111	00000000	00000000	00000000	/8	255.0.0.0
11111111	10000000	00000000	00000000	/9	255.128.0.0
11111111	11000000	00000000	00000000	/10	255.192.0.0
11111111	11100000	00000000	00000000	/11	255.224.0.0
11111111	11110000	00000000	00000000	/12	255.240.0.0
11111111	11111000	00000000	00000000	/13	255.248.0.0
11111111	11111100	00000000	00000000	/14	255.252.0.0
11111111	11111110	00000000	00000000	/15	255.254.0.0
11111111	11111111	00000000	00000000	/16	255.255.0.0
11111111	11111111	10000000	00000000	/17	255.255.128.0
11111111	11111111	11000000	00000000	/18	255.255.192.0
11111111	11111111	11100000	00000000	/19	255.255.224.0
11111111	11111111	11110000	00000000	/20	255.255.240.0
11111111	11111111	11111000	00000000	/21	255.255.248.0
11111111	11111111	11111100	00000000	/22	255.255.252.0
11111111	11111111	11111110	00000000	/23	255.255.254.0
11111111	11111111	11111111	00000000	/24	255.255.255.0
11111111	11111111	11111111	10000000	/25	255.255.255.128
11111111	11111111	11111111	11000000	/26	255.255.255.192
11111111	11111111	11111111	11100000	/27	255.255.255.224
11111111	11111111	11111111	11110000	/28	255.255.255.240
11111111	11111111	11111111	11111000	/29	255.255.255.248
11111111	11111111	11111111	11111100	/30	255.255.255.252
11111111	11111111	11111111	11111110	/31	255.255.255.254
11111111	11111111	11111111	11111111	/32	255.255.255.255

http://www.cisco.com/web/about/ac123/ac147/archived_issues/ipj_9-1/ip_addresses.html

Class A Subnet

Network Bits	Subnet Mask	Bits Borrowed	Subnets	Hosts/Subnet
8	255.0.0.0	0	1	16777214
9	255.128.0.0	1	2	8388606
10	255.192.0.0	2	4	4194302
11	255.224.0.0	3	8	2097150
12	255.240.0.0	4	16	1048574
13	255.248.0.0	5	32	524286
14	255.252.0.0	6	64	262142
15	255.254.0.0	7	128	131070
16	255.255.0.0	8	256	65534
17	255.255.128.0	9	512	32766
18	255.255.192.0	10	1024	16382
19	255.255.224.0	11	2048	8190
20	255.255.240.0	12	4096	4094
21	255.255.248.0	13	8192	2046
22	255.255.252.0	14	16384	1022
23	255.255.254.0	15	32768	510
24	255.255.255.0	16	65536	254
25	255.255.255.128	17	131072	126
26	255.255.255.192	18	262144	62
27	255.255.255.224	19	524288	30
28	255.255.255.240	20	1048576	14
29	255.255.255.248	21	2097152	6
30	255.255.255.252	22	4194304	2

http://www.tutorialspoint.com/ipv4/ipv4_subnetting.htm

Class B Subnet

Network Bits	Subnet Mask	Bits Borrowed	Subnets	Hosts/Subnet
16	255.255.0.0	0	0	65534
17	255.255.128.0	1	2	32766
18	255.255.192.0	2	4	16382
19	255.255.224.0	3	8	8190
20	255.255.240.0	4	16	4094
21	255.255.248.0	5	32	2046
22	255.255.252.0	6	64	1022
23	255.255.254.0	7	128	510
24	255.255.255.0	8	256	254
25	255.255.255.128	9	512	126
26	255.255.255.192	10	1024	62
27	255.255.255.224	11	2048	30
28	255.255.255.240	12	4096	14
29	255.255.255.248	13	8192	6
30	255.255.255.252	14	16384	2

http://www.tutorialspoint.com/ipv4/ipv4_subnetting.htm

Class C Subnet

Network Bits	Subnet Mask	Bits Borrowed	Subnets	Hosts/Subnet
24	255.255.255.0	0	1	254
25	255.255.255.128	1	2	126
26	255.255.255.192	2	4	62
27	255.255.255.224	3	8	30
28	255.255.255.240	4	16	14
29	255.255.255.248	5	32	6
30	255.255.255.252	6	64	2

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IP Address Breakdown

/24	/25	/26	/27	/28	/29	/30
8+8+8	8+8+8+1	8+8+8+2	8+8+8+3	8+8+8+4	8+8+8+5	8+8+8+6
255.255.255.0	255.255.255.128	255.255.255.192	255.255.255.224	255.255.255.240	255.255.255.248	255.255.255.252
256 Hosts	128 Hosts	64 Hosts	32 Hosts	16 Hosts	8 Hosts	4 Hosts
					0-7	0-3
				0-15		4-7
					8-15	8-11
						12-15
					16-23	16-19
				16-31		20-23
					24-31	24-27
		0-63				28-31
					32-39	32-35
				32-47		36-39
					40-47	40-43
						44-47
					48-55	48-51
				48-63		52-55
	0-127				56-63	56-59
						60-63
					64-71	64-67
				64-79		68-71
					72-79	72-75
						76-79
		64-127			80-87	80-83
				80-95		84-87
					88-95	88-91
						92-95
					96-103	96-99
			96-111			100-103

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IP Address Breakdown

/24	/25	/26	/27	/28	/29	/30
8+8+8	8+8+8+1	8+8+8+2	8+8+8+3	8+8+8+4	8+8+8+5	8+8+8+6
255.255.255.0	255.255.255.128	255.255.255.192	255.255.255.224	255.255.255.240	255.255.255.248	255.255.255.252
256 Hosts	128 Hosts	64 Hosts	32 Hosts	16 Hosts	8 Hosts	4 Hosts

/24	/25	/26	/27	/28	/29	/30
0-255		64-127	80-95	80-95	80-87	76-79
						80-83
						84-87
					88-95	88-91
						92-95
				96-111	96-103	96-99
						100-103
					104-111	104-107
						108-111
				112-127	112-119	112-115
						116-119
					120-127	120-123
						124-127
		128-191	128-143	128-143	128-135	128-131
						132-135
					136-143	136-139
						140-143
				144-159	144-151	144-147
						148-151
					152-159	152-155
						156-159
				160-175	16-167	160-163
						164-167
					168-175	168-171
						172-175
						176-179
						176-183

IP Address Breakdown

/24	/25	/26	/27	/28	/29	/30
8+8+8	8+8+8+1	8+8+8+2	8+8+8+3	8+8+8+4	8+8+8+5	8+8+8+6
255.255.255.0	255.255.255.128	255.255.255.192	255.255.255.224	255.255.255.240	255.255.255.248	255.255.255.252
256 Hosts	128 Hosts	64 Hosts	32 Hosts	16 Hosts	8 Hosts	4 Hosts
					168-175	168-171
						172-175
				176-191	176-183	176-179
						180-183
	128-255				184-191	184-187
						188-191
				192-207	192-199	192-195
						196-199
					200-207	200-203
		192-255				204-207
				208-223	208-215	208-211
						212-215
					216-223	216-219
						220-223
				224-239	224-231	224-227
						228-231
					232-239	232-235
						236-239
				240-255	240-247	240-243
						244-247
					248-255	248-251
						252-255

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What do you know now?

- A Class B network needs to be subnetted such that it supports 100 subnets and 100 hosts/subnet. Which of the following answers list a workable combination for the number of network, subnet, and host bits? (Choose two answers.)
    a. Network = 16, subnet = 7, host = 7
    b. Network = 16, subnet = 8, host = 8
    c. Network = 16, subnet = 9, host = 7
    d. Network = 8, subnet = 7, host = 17

What do you know now?

- A Class B network needs to be subnetted such that it supports 100 subnets and 100 hosts/subnet. Which of the following answers list a workable combination for the number of network, subnet, and host bits? (Choose two answers.)

  a. Network = 16, subnet = 7, host = 7
  b. Network = 16, subnet = 8, host = 8
  c. Network = 16, subnet = 9, host = 7
  d. Network = 8, subnet = 7, host = 17

Summary

- Key facts about subnets.

- Rules about what places in a network topology need a subnet.

- Location of the network, subnet and host parts of an IPv4 address.

End of Lecture 13.1, Further Reading, References

- Odom, Wendell. *CCENT/CCNA ICND1 100-105 official cert guide.* Indianapolis, IN: Cisco Press, 2016.

- http://www.networkworld.com/article/2260776/lan-wan/chapter-1--network-overview.html

- http://support.microsoft.com/kb/164015

- https://www.apnic.net/__data/assets/pdf_file/0020/8147/501302.pdf

- http://www.cisco.com/web/about/ac123/ac147/archived_issues/ipj_9-1/ip_addresses.html

- http://www.tutorialspoint.com/ipv4/ipv4_subnetting.htm

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