PART 1

1. **Now, give it a try by converting the binary number 01010110 to decimal following the same steps as above. Explain how you got your answer and show your work.**

Power of 2		128	64	32	16	8	4	2	1
Bit		0	1	0	1	0	1	1	0
Cumulative Amount	(64+16+4+2) 86	0	64	0	16	0	4	2	0

Decimal number is 86. I got my answer by adding together the decimal value associated with each 1 in the bit position and adding nothing when the bit is 0.

2. **Now give it a try by converting decimal number 155 to binary by filling in the box below.**

Power of 2		128	64	32	16	8	4	2	1
Bit		1	0	0	1	1	0	1	1
Cumulative Amount	155-128-16-8-2-1= 0	128	0	0	16	8	0	2	1

3. **Convert the following IP Address to binary: 192.172.34.11**

192

Power of 2		128	64	32	16	8	4	2	1
Bit		1	1	0	0	0	0	0	0
Cumulative Amount	192-128 -64=0	128	64	0	0	0	0	0	0

172

Power of 2		128	64	32	16	8	4	2	1
Bit		1	0	1	0	1	1	0	0
Cumulative Amount	172-128-32-8-4 = 0	128	0	32	0	8	4	0	0

34

Power of 2		128	64	32	16	8	4	2	1
Bit		0	0	1	0	0	0	0	0
Cumulative Amount	32-32=0	0	0	32	0	0	0	0	0

11

Power of 2		128	64	32	16	8	4	2	1
Bit		0	0	0	0	1	0	1	1
Cumulative Amount	11-8-2-1=0	0	0	0	0	8	0	2	1

4. **Convert the following binary to decimal quad-dotted notation: 11100000.00011000.00000001.00001111**

11100000

Power of 2		128	64	32	16	8	4	2	1
Bit		1	1	1	0	0	0	0	0
Cumulative Amount	128+64+32 = 224	128	64	32	0	0	0	0	0

00011000

Power of 2		128	64	32	16	8	4	2	1
Bit		0	0	0	1	1	0	0	0
Cumulative Amount	16+8 = 24	0	0	0	16	8	0	0	0

00000001

Power of 2		128	64	32	16	8	4	2	1
Bit		0	0	0	0	0	0	0	1
Cumulative Amount	1	0	0	0	0	0	0	0	1

00001111

Power of 2		128	64	32	16	8	4	2	1
Bit		0	0	0	0	1	1	1	1
Cumulative Amount	8+4+2+1= 15	0	0	0	0	8	4	2	1

PART 2

1. **What class does the following IP Address belong to 192.1.1.0?**

- **Class C because it falls within 192.0.0.0 - 223.255.255.255**

2. **What class does the following IP Address belong to 10.255.255.0?**

- **Class A because it falls within 1.0.0.0 - 126.255.255.255**

3. **What class does the following IP Address belong to 222.224.224.254?**

- **Class C because it falls within 192.0.0.0 - 223.255.255.255**

4. What class does the following IP Address belong to 4.4.4.4?

- **Class A because it's within 1.0.0.0 - 126.255.255.255**

5. What class does the following IP Address belong to 2.2.2.1?

- **Class A because its within 1.0.0.0 - 126.255.255.255**

1. What is the maximum number of hosts in a /22?

Using the formula 32 – (subnet mask bits), I get 32-22=10. Then, using the formula 2^x -2, where x is the number of host bits, I get 2^10 -2= 1,022. So the maximum number of hosts available in a /22 network is **1,022**.

2. What is the maximum number of hosts in a /16?

Using the formula 32 – (subnet mask bits), I get 32-16=16. Then, using the formula 2^x -2, where x is the number of host bits, I get 2^16 -2= 65,534. So the maximum number of hosts available in a /22 network is **65,534**.

3. What is the maximum number of hosts in a /8?

Using the formula 32 – (subnet mask bits), I get 32-8=24. Then, using the formula 2^x -2, where x is the number of host bits, I get 2^24 -2= 16,777,214. So the maximum number of hosts available in a /22 network is **16,777,214**.

4. What is the maximum number of hosts in a /10?

Using the formula 32 – (subnet mask bits), I get 32-10=22. Then, using the formula 2^x -2, where x is the number of host bits, I get 2^22 -2= 4,194,302. So the maximum number of hosts available in a /22 network is **4,194,302**.

5. What is the maximum number of hosts in a /19?

Determine:

- **Number of hosts**
- **The network address**
- **The broadcast address**
- **The host minimum address (AKA the first host address in the subnet)**
- **The host maximum address (AKA the last host address in the subnet)**

for each of the following addresses. Show your work for full points.

1. 192.168.10.44/29

		128	64	32	16	8	4	2	1
Bit		1	1	0	0	0	0	0	0
Cumulative	128+64= 192	128	64	0	0	0	0	0	0

		128	64	32	16	8	4	2	1
Bit		1	0	1	0	1	0	0	0
Cumulative	128+32+8= 168	128	64	0	0	8	0	0	0

		128	64	32	16	8	4	2	1
Bit		0	0	0	0	1	0	1	0
Cumulative	8+2= 10	0	0	0	0	8	0	2	0

		128	64	32	16	8	4	2	1
Bit		0	0	1	0	1	1	0	0
Cumulative	32+8+4= 44	0	0	32	0	8	4	0	0

		128	64	32	16	8	4	2	1
Bit		0	0	1	0	1	0	0	0
Cumulative	32+8= 40	0	0	32	0	8	0	0	0

		128	64	32	16	8	4	2	1
Bit		0	0	1	0	1	1	1	0
Cumulative	32+8+4+2= 46	0	0	32	0	8	4	2	0

IP Address(dec)	192	168	10	44
IP Address(binary)	11000000	10101000	00001010	00101100
Subnet Mask(bin)	11111111	11111111	111111111	11111000
Network Addr(bin)	11000000	10101000	00001010	00101000
Network Addr(symbol)	NNNNNNNN	NNNNNNNNN	NNNNNNNN	NNNNNHHH
Network Addr(dec)	192	168	10	40
Host Min Addr(bin)	11000000	10101000	00001010	00101001
Host Min Addr(dec)	192	168	10	41
Host Max Addr(bin)	11000000	10101000	00001010	00101110
Host Max Addr(dec)	192	168	10	46
Broadcast Addr (bin)	11000000	10101000	00001010	00101111
Broadcast Addr (dec)	192	168	10	47

Using the general formula of 32 – subnet mask bits yields the number of host bits. In the problem (32 – 29 = 3), there are 3 host bits. Now using the formula $2^x - 2 = number\ of\ hosts$ where x is the number of host bits. In this example 2^3 = 8 – 2 = 6 $hosts$. Verifying that value by subtracting the host minimum address from the broadcast address better yield the same results. In this example 192.168.10.47 – 192.168.10.41 yields 6.

192.168.10.44/29 :
Number of hosts = 6
The network address = 192.168.10.40
The broadcast address = 192.168.10.47
The host minimum address = 192.168.10.41
The host maximum address = 192.168.10.46

2. 10.10.5.20/18

		128	64	32	16	8	4	2	1
Bit		0	0	0	0	1	0	1	0
Cumulative	8+2= 10	0	0	0	0	8	0	2	0

		128	64	32	16	8	4	2	1
Bit		0	0	0	0	0	1	0	1
Cumulative	4+1= 5	0	0	0	0	0	4	0	1

		128	64	32	16	8	4	2	1
Bit		0	0	0	1	0	1	0	0
Cumulative	16+4= 20	0	0	0	16	0	4	0	0

		128	64	32	16	8	4	2	1
Bit		0	0	1	1	1	1	1	1
Cumulative	32+16+8+4 +2+1 = 63	0	0	32	16	8	4	2	1

		128	64	32	16	8	4	2	1
Bit		1	1	1	1	1	1	1	0
Cumulative	128+64+32 +8+4+2= 254	128	64	32	16	8	4	2	0

IP Address(dec)	10	10	5	20
IP Address(binary)	00001010	00001010	00000101	00010100
Subnet Mask(bin)	11111111	11111111	11000000	00000000
Network Addr(bin)	00001010	00001010	00000000	00000000
Network Addr(symbol)	NNNNNNNN	NNNNNNNNN	NNHHHHHH	HHHHHHHH
Network Addr(dec)	10	10	0	0
Host Min Addr(bin)	00001010	00001010	00000000	00000001
Host Min Addr(dec)	10	10	0	1
Host Max Addr(bin)	00001010	00001010	00111111	11111110
Host Max Addr(dec)	10	10	63	254
Broadcast Addr (bin)	00001010	00001010	00111111	11111111
Broadcast Addr (dec)	10	10	63	255

Using the general formula of 32 – subnet mask bits yields the number of host bits. In the problem (32 – 18 = 14), there are 14 host bits. Now using the formula $2^x - 2 = number\ of\ hosts$ where x is the number of host bits. In this example 2^{14} = 16,384 – 2 = 16,382 h$osts$. Verifying that value by subtracting the host minimum address from the broadcast address better yield the same results. In this problem 10.10.63.255 – 10.10.0.1 (00001010000010100011111111111111 - 00001010000010100000000000000001 = 011111111111110) yields 16,382.

10.10.5.20/18 :
Number of hosts = 16,382
The network address = 10.10.0.0
The broadcast address = 10.10.63.255
The host minimum address = 10.10.0.1
The host maximum address = 10.10.63.254

3. 146.187.130.81/23

		128	64	32	16	8	4	2	1
Bit		1	0	0	1	0	0	1	0
Cumulative	128+16+2= 146	128	0	0	16	0	0	2	0

		128	64	32	16	8	4	2	1
Bit		1	0	1	1	1	0	1	1
Cumulative	128+32+16 +8+2+1= 187	128	0	32	16	8	0	2	1

		128	64	32	16	8	4	2	1
Bit		1	0	0	0	0	0	1	0
Cumulative	128+2 = 130	128	0	0	0	0	0	2	0

		128	64	32	16	8	4	2	1
Bit		0	1	0	1	0	0	0	1
Cumulative	64+16+1 = 81	0	64	0	16	0	0	0	1

		128	64	32	16	8	4	2	1
Bit		1	0	0	0	0	0	1	1
Cumulative	128+2+1 = 131	128	0	0	0	0	0	2	1

		128	64	32	16	8	4	2	1
Bit		1	1	1	1	1	1	1	0
Cumulative	128+64+32 +8+4+2= 254	128	64	32	16	8	4	2	0

IP Address(dec)	146	187	130	81
IP Address(binary)	10010010	10111011	10000010	01010001
Subnet Mask(bin)	11111111	11111111	11111110	00000000
Network Addr(bin)	00001010	00001010	10000010	00000000
Network Addr(symbol)	NNNNNNNN	NNNNNNNNN	NNNNNNHH	HHHHHHHH
Network Addr(dec)	146	187	130	0
Host Min Addr(bin)	10010010	10111011	10000010	00000001
Host Min Addr(dec)	146	187	130	1
Host Max Addr(bin)	10010010	10111011	10000011	11111110
Host Max Addr(dec)	146	187	131	254
Broadcast Addr (bin)	10010010	10111011	10000011	11111111
Broadcast Addr (dec)	146	187	131	255

Using the general formula of 32 – subnet mask bits yields the number of host bits. In the problem (32 – 23 = 9), there are 9 host bits. Now using the formula $2^x - 2 = number\ of\ hosts$ where x is the number of host bits. In this example $2^9 = 512 - 2 = 510\ hosts$. Verifying that value by subtracting the host minimum address from the broadcast address better yield the same results. In this problem 146.187.131.255 – 146.187.130.1 (10010010101110111000001111111111 - 10010010101110111000001000000001 = 0111111110) yields 510.

146.187.130.81/23 :
Number of hosts = 510
The network address = 146.187.130.0
The broadcast address = 146.187.131.255
The host minimum address = 146.187.130.1
The host maximum address = 146.187.131.254

4. 145.16.25.18/21

		128	64	32	16	8	4	2	1
Bit		1	0	0	1	0	0	0	1
Cumulative	128+16+1= 145	128	0	0	16	0	0	0	1

		128	64	32	16	8	4	2	1
Bit		0	0	0	1	0	0	0	0
Cumulative	16	0	0	0	16	0	0	0	0

		128	64	32	16	8	4	2	1
Bit		0	0	0	1	1	0	0	1
Cumulative	16+8+1 = 25	0	0	0	16	8	0	0	1

		128	64	32	16	8	4	2	1
Bit		0	0	0	1	0	0	1	0
Cumulative	16+2 = 18	0	0	0	16	0	0	2	0

		128	64	32	16	8	4	2	1
Bit		1	0	0	0	0	0	1	1
Cumulative	128+2+1 = 131	128	0	0	0	0	0	2	1

		128	64	32	16	8	4	2	1
Bit		0	0	0	1	1	0	0	0
Cumulative	16+8 = 24	0	0	0	16	8	0	0	0

		128	64	32	16	8	4	2	1
Bit		0	0	0	1	1	1	1	1
Cumulative	16+8+4+2+1 = 31	0	0	0	16	8	4	2	1

IP Address(dec)	145	16	25	18
IP Address(binary)	10010001	00010000	00011001	00010010
Subnet Mask(bin)	11111111	11111111	11111000	00000000
Network Addr(bin)	10010001	00010000	00011000	00000000
Network Addr(symbol)	NNNNNNNN	NNNNNNNNN	NNNNNNHH	HHHHHHHH
Network Addr(dec)	145	16	24	0
Host Min Addr(bin)	10010001	00010000	00011000	00000001
Host Min Addr(dec)	145	16	24	1
Host Max Addr(bin)	10010001	00010000	00011111	11111110
Host Max Addr(dec)	145	16	31	254
Broadcast Addr (bin)	10010001	00010000	00011111	11111111
Broadcast Addr (dec)	145	16	31	255

Using the general formula of 32 – subnet mask bits yields the number of host bits. In the problem (32 – 21 = 9), there are 11 host bits. Now using the formula $2^x - 2 = number\ of\ hosts$ where x is the number of host bits. In this example $2^{11} = 2048 - 2 = 2046\ hosts$. Verifying that value by subtracting the host minimum address from the broadcast address better yield the same results. In this problem 145.16.31.255 – 145.16.24.1 (10010001000100000001111111111111 - 10010001000100000001100000000001 = 011111111110) yields 2,046.

145.16.25.18/21 :
Number of hosts = 2,046
The network address = 145.16.24.0
The broadcast address = 145.16.31.255
The host minimum address = 145.16.24.1
The host maximum address = 145.16.31.254

COMPLEX SUBNETS:

1. Jason Smith is opening a small coffee shop and he hopes to attract college students in the area to his shop. He knows one of the ways to get students into his coffee shop is to give them access to Wi-Fi. His IP has assigned him is 192.168.5.0 /24; however, he would like to keep his four department's networks separate from the student network. Jason would like to have a total of five different networks for his business. What steps would you take to create five different networks for Jason Smith, and what would the network IDs be?

Create a chart similar to above to illustrate the networks. The four departments are accounting, human resources, marketing, and management. The student network will simply be students.

Network IP	192	168	5	0	Dec of sub
Network Binary	11000000	10101000	00000101	00000000	
Subnet Mask	11111111	11111111	11111111	xxx00000	
Case 000	11000000	10101000	00000101	00000000	0
Case 001	11000000	10101000	00000101	00100000	32
Case 010	11000000	10101000	00000101	01000000	64
Case 011	11000000	10101000	00000101	01100000	96
Case 100	11000000	10101000	00000101	10000000	128
Case 101	11000000	10101000	00000101	10100000	160
Case 110	11000000	10101000	00000101	11000000	192
Case 111	11000000	10101000	00000101	11100000	224

Subnet Mask of /27: 11111111.11111111.11111111.11100000 = 255.255.255.224

N #		Network Address	Host Range	Subnet Mask	Broadcast Address
1	/27	192.168.5.0	192.168.5.1-192.168.5.30	255.255.255.224	192.168.5.31
2	/27	192.168.5.32	192.168.5.33-192.168.5.62	255.255.255.224	192.168.5.63
3	/27	192.168.5.64	192.168.5.65-192.168.5.94	255.255.255.224	192.168.5.95
4	/27	192.168.5.96	192.168.5.97-192.168.5.126	255.255.255.224	192.168.5.127
5	/27	192.168.6.128	192.168.5.129-192.168.5.158	255.255.255.224	192.168.5.159

2. Which network would allow Jason to host the most students?

- **Network #1 would allow the most students. This is an arbitrary pick since each network supports 30 hosts.**

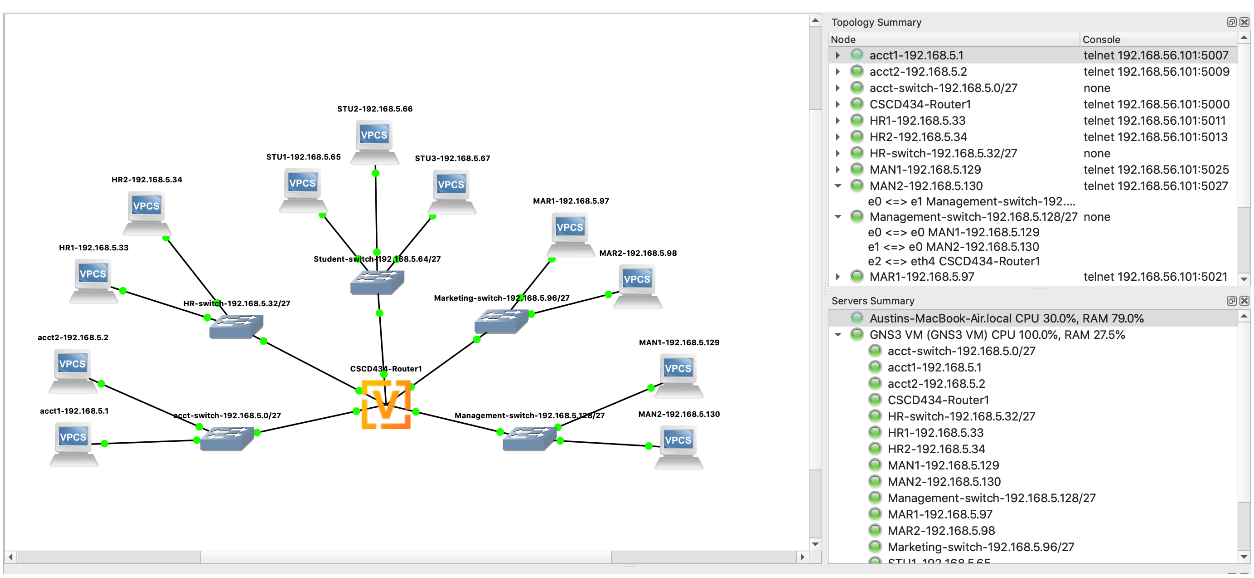
3. Which network would allow Jason to host the fewest students?

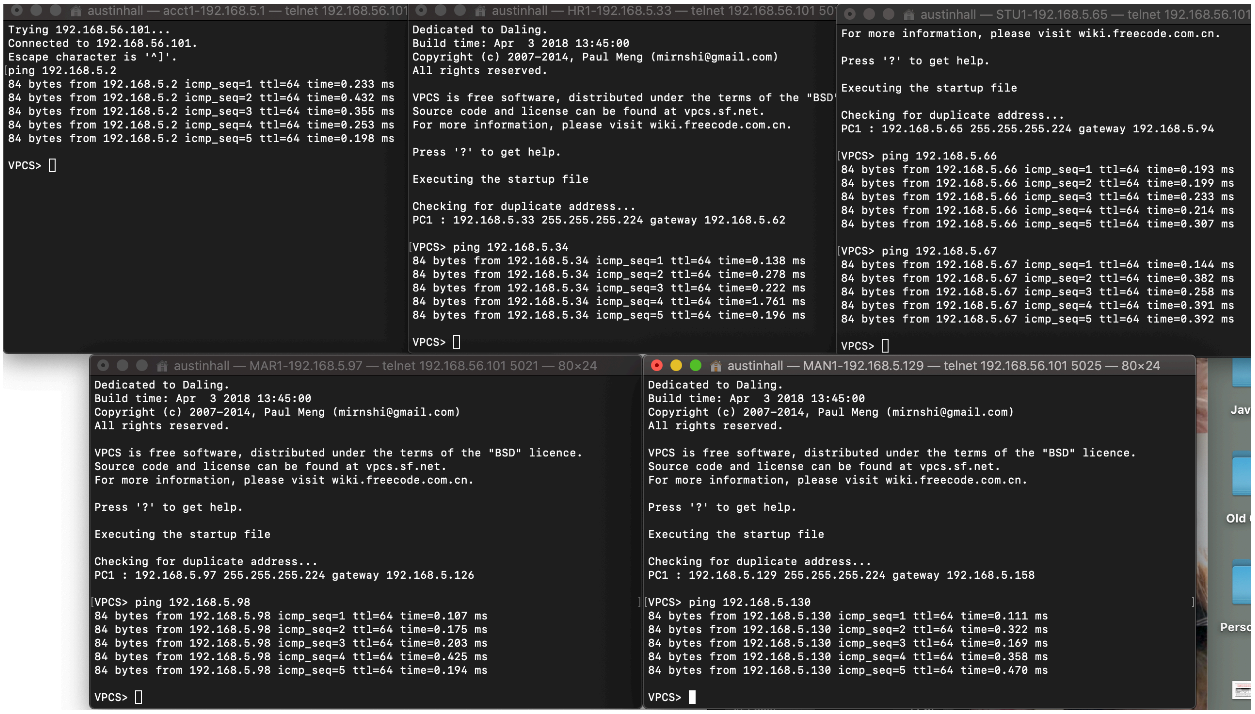
- **Network #2 would allow the most students. This is an arbitrary pick since each network supports 30 hosts.**

4. How many subnets did you have to create to meet Jason's network needs?

- **8 subnets**

5. Create the network using GNS2. Create at least two machines for each department's subnet and at least three machines for the student's subnet. Each department will have its own switch and the switches will call connect together with a vyOS router. Similar to this image. Obviously, your IP addresses will be different.




austinhall — acct1-192.168.5.1 — telnet 192.168.56.101
Trying 192.168.56.101...
Connected to 192.168.56.101.
Escape character is '^]'.
ping 192.168.5.2
84 bytes from 192.168.5.2 icmp_seq=1 ttl=64 time=0.233 ms
84 bytes from 192.168.5.2 icmp_seq=2 ttl=64 time=0.432 ms
84 bytes from 192.168.5.2 icmp_seq=3 ttl=64 time=0.355 ms
84 bytes from 192.168.5.2 icmp_seq=4 ttl=64 time=0.253 ms
84 bytes from 192.168.5.2 icmp_seq=5 ttl=64 time=0.198 ms
VPCS>
austinhall — HR1-192.168.5.33 — telnet 192.168.56.101 50
Dedicated to Daling.
Build time: Apr 3 2018 13:45:00
Copyright (c) 2007-2014, Paul Meng (mirnshi@gmail.com)
All rights reserved.
VPCS is free software, distributed under the terms of the "BSD"
Source code and license can be found at vpcs.sf.net.
For more information, please visit wiki.freecode.com.cn.
Press '?' to get help.
Executing the startup file
Checking for duplicate address...
PC1 : 192.168.5.33 255.255.255.224 gateway 192.168.5.62
VPCS> ping 192.168.5.34
84 bytes from 192.168.5.34 icmp_seq=1 ttl=64 time=0.138 ms
84 bytes from 192.168.5.34 icmp_seq=2 ttl=64 time=0.278 ms
84 bytes from 192.168.5.34 icmp_seq=3 ttl=64 time=0.222 ms
84 bytes from 192.168.5.34 icmp_seq=4 ttl=64 time=1.761 ms
84 bytes from 192.168.5.34 icmp_seq=5 ttl=64 time=0.196 ms
VPCS>
austinhall — STU1-192.168.5.65 — telnet 192.168.56.101
For more information, please visit wiki.freecode.com.cn.
Press '?' to get help.
Executing the startup file
Checking for duplicate address...
PC1 : 192.168.5.65 255.255.255.224 gateway 192.168.5.94
VPCS> ping 192.168.5.66
84 bytes from 192.168.5.66 icmp_seq=1 ttl=64 time=0.193 ms
84 bytes from 192.168.5.66 icmp_seq=2 ttl=64 time=0.199 ms
84 bytes from 192.168.5.66 icmp_seq=3 ttl=64 time=0.233 ms
84 bytes from 192.168.5.66 icmp_seq=4 ttl=64 time=0.214 ms
84 bytes from 192.168.5.66 icmp_seq=5 ttl=64 time=0.307 ms
VPCS> ping 192.168.5.67
84 bytes from 192.168.5.67 icmp_seq=1 ttl=64 time=0.144 ms
84 bytes from 192.168.5.67 icmp_seq=2 ttl=64 time=0.382 ms
84 bytes from 192.168.5.67 icmp_seq=3 ttl=64 time=0.258 ms
84 bytes from 192.168.5.67 icmp_seq=4 ttl=64 time=0.391 ms
84 bytes from 192.168.5.67 icmp_seq=5 ttl=64 time=0.392 ms
VPCS>
austinhall — MAR1-192.168.5.97 — telnet 192.168.56.101 5021 — 80×24
Dedicated to Daling.
Build time: Apr 3 2018 13:45:00
Copyright (c) 2007-2014, Paul Meng (mirnshi@gmail.com)
All rights reserved.
VPCS is free software, distributed under the terms of the "BSD" licence.
Source code and license can be found at vpcs.sf.net.
For more information, please visit wiki.freecode.com.cn.
Press '?' to get help.
Executing the startup file
Checking for duplicate address...
PC1 : 192.168.5.97 255.255.255.224 gateway 192.168.5.126
VPCS> ping 192.168.5.98
84 bytes from 192.168.5.98 icmp_seq=1 ttl=64 time=0.107 ms
84 bytes from 192.168.5.98 icmp_seq=2 ttl=64 time=0.175 ms
84 bytes from 192.168.5.98 icmp_seq=3 ttl=64 time=0.203 ms
84 bytes from 192.168.5.98 icmp_seq=4 ttl=64 time=0.425 ms
84 bytes from 192.168.5.98 icmp_seq=5 ttl=64 time=0.194 ms
VPCS>
austinhall — MAN1-192.168.5.129 — telnet 192.168.56.101 5025 — 80×24
Dedicated to Daling.
Build time: Apr 3 2018 13:45:00
Copyright (c) 2007-2014, Paul Meng (mirnshi@gmail.com)
All rights reserved.
VPCS is free software, distributed under the terms of the "BSD" licence.
Source code and license can be found at vpcs.sf.net.
For more information, please visit wiki.freecode.com.cn.
Press '?' to get help.
Executing the startup file
Checking for duplicate address...
PC1 : 192.168.5.129 255.255.255.224 gateway 192.168.5.158
VPCS> ping 192.168.5.130
84 bytes from 192.168.5.130 icmp_seq=1 ttl=64 time=0.111 ms
84 bytes from 192.168.5.130 icmp_seq=2 ttl=64 time=0.322 ms
84 bytes from 192.168.5.130 icmp_seq=3 ttl=64 time=0.169 ms
84 bytes from 192.168.5.130 icmp_seq=4 ttl=64 time=0.358 ms
84 bytes from 192.168.5.130 icmp_seq=5 ttl=64 time=0.470 ms
VPCS>

SECTION 3:

1. What is the difference between TCP and UDP?

- There are a lot of differences between TCP and UDP, but a few main ones. TCP is a connection oriented protocol and requires a 3-way handshake before data transfer can occur, whereas UDP is connectionless and will just send the data. TCP reads data as streams of bytes, and the message is transmitted to segment boundaries but UDP messages contain packets that were sent one by one. TCP rearranges data packets into a specific order but UDP has no fixed order since each packet is independent. TCP is a lot slower than UDP since error recovery is not attempted.

2. What is ARP and what is ARP used for?

- Address Resolution Protocol (ARP) is a communication protocol. It is used for mapping a dynamic IP address to a permanent physical machine address on a LAN. Essentially, it is used to translate 32 bit IP address to a 48 bit MAC address, and vice versa. It's necessary because the underlying ethernet hardware communicates using ethernet addresses, not IP addresses.

3. What is DHCP and what is used for?

- Dynamic Host Configuration Protocol (DHCP) is a network management protocol. A DHCP server dynamically assigns an IP address and other network configuration parameters to each device on a network so they can communicate with other IP networks. Without DHCP, a network administrator would have to manually assign IPs to each computer connecting to a network.

4. What is APIPA and what is it used for?

- Automatic Private IP Addressing (APIPA) is a feature of Windows-based operating systems that enables a computer to automatically assign itself an IP address when there is no DHCP server available to perform that function. It works by (when there's no DHCP) searching in the IP range 169.254.1.0 to 169.254.254.255 for a usable address.

5. What is IP address 127.0.0.1 typically used for?

- 127.0.0.1 is the loopback IP address, also known as the local host. The localhost isn't connected to an outside network nor does it ever travel to a router, it's typically used to test the communication or transportation medium on a local network card and/or for testing network applications