

IPv6

In today life communication is essential we do not need to wait until the postman deliver our letters or packet. Every communications process is doing through the internet. However, your smartphones, computers, car or any device if we want to use them then we have to be connected on the network and this will give fast, reliable secure delivery. Also, you have to associate with an internet Service Provider. Any car needs a Register plate number for be able to circulate in the motor ways. Seemingly, on the network for be able to circulate you need plate number called IP address. This report is about IPv6 addresses however as will notice in all incoming definition of IPv6 always we have to mention is predecessor IPv4 addresses. We will star by defining IP concept continuing by doing some comparation between IPv4 and IPv4 address. In section 3 we work out how to convert both IPv4 to IPv6 and vice-verse then will describe type of IPv6.

Definition IPv4 vs IPv6

IPv4 NNNNNNNN.NNNNNNNN.NNNNNNNN.NNNNNNNN → 32 bits length → 2^{32} = amount of devices

IPv6 XXXX:XXXX:XXXX:XXXX:XXXX:XXXX:XXXX:XXXX → 128 bit length → 2^{128} = amount of devices

IP Address stand for Internet Protocol Address. Internet protocol are set of rules that make internet work. On internet the core rule is any device who one to navigate on internet will need an IP address. Today the are to type of IP address allocated by any Regional internet register IPv4 and IPv6.



IP address is a unique series of numbers which identify series of computers on the network. For example, in common life if you need to send a receive an information through the post office you need identify your home address also you have to identify the receiver address so the deliveryman will not have any problem when deliver the packets.

but the trouble is what will happen when life is became in way that everything will need IP address. Let put it in this way what will happened if the number of streets and houses start growing bigger and bigger? This mean we must implement new home address system like post code or street colour for able to fix the problem. Today the global community are running out of space, more and more imaginable devices are connected to the network because of this issue from early 1990s we start thinking of IPv6 system address.

IPv4 structure

The table below shown IPv4 structure

octet							
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1

N.				N.				N.				N.			
0															

We got 4 Number separate with the dot is with decimal numbers and this decimal can range from 1 to 255. So, as we know network device do not how to deal with decimal, they language is on Binary. Therefore, the range of 0-----255 can represent in binary as:

N.	N.
0.	255.
0000 0000	11111 1111

Each N.N is representing by bunch of eight binary digit then all bunch of N's is representing by sequence of "1" and "0" let say sequence of $8 + 8 + 8 + 8 + 8 = 32$ bits. So, IPv4 address scheme is 32 bits length this give $2^{32} = 4.294.967.296$ devices can be addressed a connected to the online community. According to the world populations prospect (2019) state that the world populations are expected to grow in 10% more between years 2019 and 2030 from 7,7billion to up to 9,7 billion. Moreover, having such increase of the world populations mean mores devices they will want to access the internet. The idea of design a new system that can allow the online community to continue grow is more necessary than ever. Since we notice the problem the network community being working on different solution such as VLSM subnetting technics or from different organization like NAT-Network Address Translation. The main functions of NAT are to replace private IPv4 address into a public network to connect to the internet.

IPv6 structure

In the figure below we explain IPv6 structure:

X:	X:	X:	X:	X:	X:	X:	X:
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This the elected format for writing and IPv6 address. We have a column of 8 hexted separate by double colons with the total of $16+16+16+16+16+16+16+16 = 128$ -bit length and it provide a total of $2^{128} = 340$ undecillion devices available to connect to the network.

Hexadecimal			
2 ³	2 ²	2 ¹	2 ⁰
8	4	2	1

BINARY	HEXADECIMAL	
000	0	*This are the equivalent of binary to hexadecimal any time we have hexed like: 3BFF: = 0011 1011 1111 1111: *The range of available or combinations bits are 15 or from 0000 to FFFF *2001:2EB8:ADC1:54ED:1100:697A:3210:3331 HEX *0010 0000 0000 0001:0010 1110 1011 1000: BINARY 1010 1101 1100 0001:0101 0100 1110 1101: 0001 0001 0000 0000:0110 1001 0111 1010: 0001 0010 0001 0000:0011 0011 0011 0001
0001	1	
0010	2	
0011	3	
0100	4	
0101	5	
0110	6	
0111	7	
1000	8	
1001	9	
1010	A	
1011	B	
1100	C	
1101	D	
1110	E	
1111	F	

More characteristic regarding IPv6:

- ✓ In IPv4 the security feature is depend on the application whereas In IPv6 use IPSEC built in the protocol.
- ✓ The fragmentation process is performed only by the sender of the message.
- ✓ IPv6 is no using broadcasting only multicast and Anycast.
- ✓ In IPv6 we do not use the term hosts we use the term interfaces.

Type of IPv6

UNICAST	MULTICAST	ANYCAST
Is about one to one association between two interact. Any unicast address is for a unique receiver in a network.	Prefix: FF00::/8 Is the equivalent to broadcast address. It can not use as source address. One to many types of communication	Is the simplest one. Is a communication process of one to nearest device is used by nearest device like switch or router.
Link Local	Well-Know	
Global-Local	Solicited-Node	

VLSM

The requirements from the University is to design and planning an IPv4 network for all the entire University building. There are four main building in the campus so the organization need four network each one with different number of hosts per network also according to the requirement they will need two more networks for others possible use. Furthermore, they want to assign IPv6 addresses for six servers.

	Subnet	Department	Number of Host need
1	LAN	School of Applied Computing	441
2	LAN	School of Automotive Engineering	337
3	LAN	School of Architecture, Built and Natural Environment	285
4	LAN	School of Engineering, Manufacturing and Logistics	278
5	LAN	Test centre	240
6	LAN	Open Access lab	19
7	WAN-1	Serial Links	2
8	WAN-1	Serial Links	2
TOTAL			1604

The table above give me the first clear picture about the university requirement. As network engineering I found out that we have eight network each one with different host numbers needed and with a total number of host address needed for the entire University is one thousand and six hundred usable addresses. School of Applied Computing got the largest network with 441 IPv4 address needed, the next largest is School of Automotive Engineering with 337 host address and so on. Finally, because of the network topology design we will need few serial link networks with two host address each one.

In this context as network service provided, I will have to underline two point. First allocate a private address space for any host in the entire campus. Second, find out out how to design a network that can be able to divide each depart in term of having their own IP address space. As we all know IPv4 is divided by different types of address. For example, non-routable address and publics addresses, class A, B, C, D addresses also depending on the topology we will need broadcast. Let say the Ipv4 address allocated to the university campus is a class B private address 172.18.0.0 with custom subnet mask 255.255.224.0 or equivalent to network prefix format /21. In order to respond the second previous point, I will introduce the term subnet. The process of splitting a network into two or more networks is called subnetting, Therefore, if we want to divide each department I will use Variable Length Subnet Masks-VLSM is a subnetting technique that tends to be lest wasteful in terms of host address needed and allow more tighter control over the addressing scheme.

With this scenario it is time to introduce more deeper using mathematic and binary concepts. The table 2 sown that knowing the IP address and the subnet mask we can be able to determine more information regarding the University network such as:

Total No. of usable hosts per subnet = $2^{(\text{No. of host bits})} - 2 \rightarrow 2^{11} - 2 = 2048 - 2 = 2046$

Number of subnets = $2^{(\text{No. bits borrow})} = 2^5 = 32$ subnet

First network address = 172.18.0.0/21

Broadcast address/last address = 172.18.7.255/21

172.18.0.0/21 First address																													
172								18								0								0					
1	0	1	0	1	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

255.255.224.0-or prefix /21 Subnet mask																													
255								255								224								0					
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Network bits																							Host bits						

Last address																													
172								18								7								0					
1	0	1	0	1	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	1	1	1	1	1	1

So far, in table 2 say that range of IPv4 addresses is going from 172.18.0.0 through 172.18.7.255 for a total of 2048 host address. Knowing that the allocated address is enough to meet the university requirements, the next step is to come up with different IPv4 address ranges that will be used to allocate each campus. According to VLMS subnetting technique we have to start subnetting the largest subnet then going all the way down to the smallest. In table 1 shows that the biggest subnet is the School of Applied Computing with 441 host needed.

1. Subnetting School of Applied Computing

This first subnet is the beginning of VSLM subnetting in other word, School of Applied Computing IPv4 address scheme will start with the IPv4 address being allocate by the network provider 172.18.0.0. The question in VSLM is, 2^X raised to wat power is going to able to accommodate all 441 host? Knowing X will help the router to determine which network address a particular IP address belong to and also the subnet address range. Looking at table 22 $X=9$ so we got nine host bit that means, I going to use 9 host bits counting from the righthand side of my subnet mask bits and the rest 23 bits is for my network. Because we borrow two “1” the new prefix for this subnet is /23.

Last IP address																	
172	18	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1

Binary ANDing technique and then fill with “1” the host portions in order to get last address.

The second subnet School of Automotive Engineering will be allocated addresses from 172.18.2 through 172.18.3255 which always being a reserved address for the broadcast. The usable addresses are between the network address +1 and the broadcast -1.

subnet	Network	1 st usable	Last usable	broadcast	Total usable host	host needed
School of Automotive Engineering	172.18.2.0/23	172.18.2.1/23	172.18.3.254/23	172.18.3.255/23	510	337

3. Subnetting School of Architecture, Built and Natural Environment

Second subnet with 285 host needed its network will start from the previous department broadcast address plus one 172.18.4.0/23. As we see in figure 3, they going to have the same subnet mask /23, that is because after check 2^X raised to what power is going to be able to accommodate all 285 host? Looking at table 22 $X=9$ so we got nine host bit that means, I going to use 9 host bits counting from the righthand side of my subnet mask bits and the rest 23 bits is for my network.

First IP address																	
Third octet									Fourth octet								
172	18	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Subnet mask /23																	
255	255	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0
Network portion									Host portion								

Last IP address																	
172	18	0	0	0	0	0	1	0	1	1	1	1	1	1	1	1	1

Binary ANDing technique and then fill with “1” the host portions in order to get last address.

The third subnet network is allocating from 172.18.4.0/23 through 172.18.5.255 in this subnet we have 510 host available but only needed 285 host in this department then rest we will use it for future growth.

subnet	Network	1 st usable	Last usable	broadcast	Total usable host	host needed

School of Architecture, Built and Natural Environment	172.18.4.0/23	172.18.4.1/23	172.18.5.254/23	172.18.5.255/23	510	285
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4. Subnetting School of Engineering, Manufacturing and Logistics

First IP address																	
Third octet									Fourth octet								
172	18	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
Subnet mask /23																	
255	255	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0
Network portion									Host portion								

Last IP address																	
172	18	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1

Binary ANDing technique and then fill with "1" the host portions in order to get last address.

Figure 4 shown how we find out the next network IP address using the ANDing technique. The next thing is to figure out is 2^x raised to what power is going to be able to accommodate 278 host needed in this department. Looking at table 22 $X=9$ so we got nine host bit that means, I going to use 9 host bits counting from the righthand side of my subnet mask bits and the rest 23 bits is for my network.

Fourth subnetwork will begin where the previous left off at 172.18.7.0/23 and go up to 172.18.7.255/23 the range of usable host is 172.18.7.1/23 through 172.18.7.254/23.

subnet	Network	1 st usable	Last usable	broadcast	Total usable host	host needed
School of Engineering, Manufacturing and Logistics	172.18.7.0/23	172.18.7.1/23	172.18.7.254/23	172.18.7.255/23	510	278

5. Subnetting Open Access lab

In order to assign 245 host in the Open Lab subnetwork we asking again; 2^x raised to what power is going to be able to accommodate 245 hosts? Looking at table 22 $X=8$ in this case we borrow one bits we got eight host bit that means, I going to use 8 host bits counting from the righthand side of my subnet mask bits and the rest 24 bits is for my network.

Figure 5.a

First IP address																	
Third octet							Fourth octet										
172	18	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Subnet mask /24																	
255	255	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
Network portion										Host portion							

Last IP address																	
172	18	0	0	0	0	1	0	0	0	1	1	1	1	1	1	1	1

Binary ANDing technique and then fill with "1" the host portions in order to get last address.

As shown on both figure 5.a and 5.b Open Access Lab start at 172.18.8.0/24 where the previous subnet finish and go up to 172.18.8.0/24. Again, this last address is reserved for the broadcast. Subtracting the broadcast -1 and adding the network address +1 we have the range of usable address at 172.18.8.1/24 through 172.18.8.254/24. Also, for this subnetwork we have a new subnet mask 255.255.255.0.

Figure 5.b

subnet	Network	1 st usable	Last usable	broadcast	Total usable host	host needed
Open Access lab	172.18.8.0/24	172.18.8.1/24	172.18.8.254/24	172.18.8.0/24	254	245

6. Open Test centre

For the six department we ask again the question; 2^x raised to what power is going to be able to accommodate all 30 host? Knowing X will help the router to determine which network address a particular IP address belong to and also the subnet address range. Looking at table 22 $X=5$ so we got five host bit that means, I going to use 5 host bits counting from the righthand side of my subnet mask bits and the rest 27 bits is for my network. Because we borrow bit the new prefix for this subnet is /27.

First IP address																	
Third octet									Fourth octet								
172	18	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
Subnet mask /27																	
255	255	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Network portion												Host bits					

Last IP address																	
172	18	0	0	0	0	1	0	0	1	0	0	0	1	1	1	1	1

Binary ANDing technique and then fill with “1” the host portions in order to get last address.

In the Open Test center subnet will be allocated address from 172.18.9.0/27 through 172.18.9.31/27. With total number of 18 hosts needed the range of usable host are going from 172.18.9.1/27 through 172.18.9.30/27. The first network address and the broadcast address are shown above in table 6.b

Subnet	Network	1 st usable	Last usable	broadcast	Total usable host	host needed
Test centre	172.18.9.0/27	172.18.9.1/27	172.18.9.30/27	172.18.9.31/27	30	18

7. Serial Links

For serial links subnet we only need 2 usable address plus one for the network and one for the broadcast. In this case we borrow 2 bits having 3 bit for the host the rest is for the network therefore, the new subnet mask is the prefix /29

First IP address																	
Third octet						Fourth octet											
172	18	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0
Subnet mask /29																	
255	255	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
Network portion															Host P		

Last IP address																	
172	18	0	0	0	0	1	0	0	1	0	0	1	0	0	1	1	1

Binary ANDing technique and then fill with “1” the host portions in order to get last address.

subnet	Network	1 st usable	Last usable	broadcast	Total usable host	host needed
Serial Links	172.18.9.32/29	172.18.9.33/29	172.18.9.38/29	172.18.9.39/29	6	4

8. Serial Links

For the second serial link we need 4 IPv4 address as shown in figure 8.b the range of usable address is only two 172.18.9.41/29 and 172.18.9.40/29.

First IP address																	
Third octet									Fourth octet								
172	18	0	0	0	0	1	0	0	1	0	0	1	0	1	0	0	0

Subnet mask /29																	
255	255	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
Network portion															Host P		

Last IP address																	
172	18	0	0	0	0	1	0	0	1	0	0	1	0	1	1	1	1

Binary ANDing technique and then fill with "1" the host portions in order to get last address.

subnet	Network	1 st usable	Last usable	broadcast	Total usable host	host needed
Serial Links	172.18.9.40/29	172.18.9.41/29	172.18.9.40/29	172.18.9.47/29	6	4

9. Serial Links

The third serial link subnet start from where the previous serial link finishes its address. As shown in figures below at 172.18.48/29 through 172.18.54/29. The total usable host in this subnet is 6 however we need 4 address for our serial link connection. Again, /29 is used as prefix subnet mask because the host portion is only 3 bits available for host.

First IP address																	
Third octet									Fourth octet								
172	18	0	0	0	0	1	0	0	1	0	0	1	1	0	0	0	0

Subnet mask /29																	
255	255	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
Network portion															Host P.		

Last IP address																	
172	18	0	0	0	0	1	0	0	1	0	0	1	1	0	1	1	1

Binary ANDing technique and then fill with "1" the host portions in order to get last address.

In table 9.b below we add the rest of serial links needed in our network topology. Total of serial links needed are 8 all of them with same subnet mask prefix /29 each one will need host 4 host however in the subnet because of the host portion we have 6 host available. In any serial link subnet e must found y reserved network address and broadcast which always the highest address in the range.

9.b

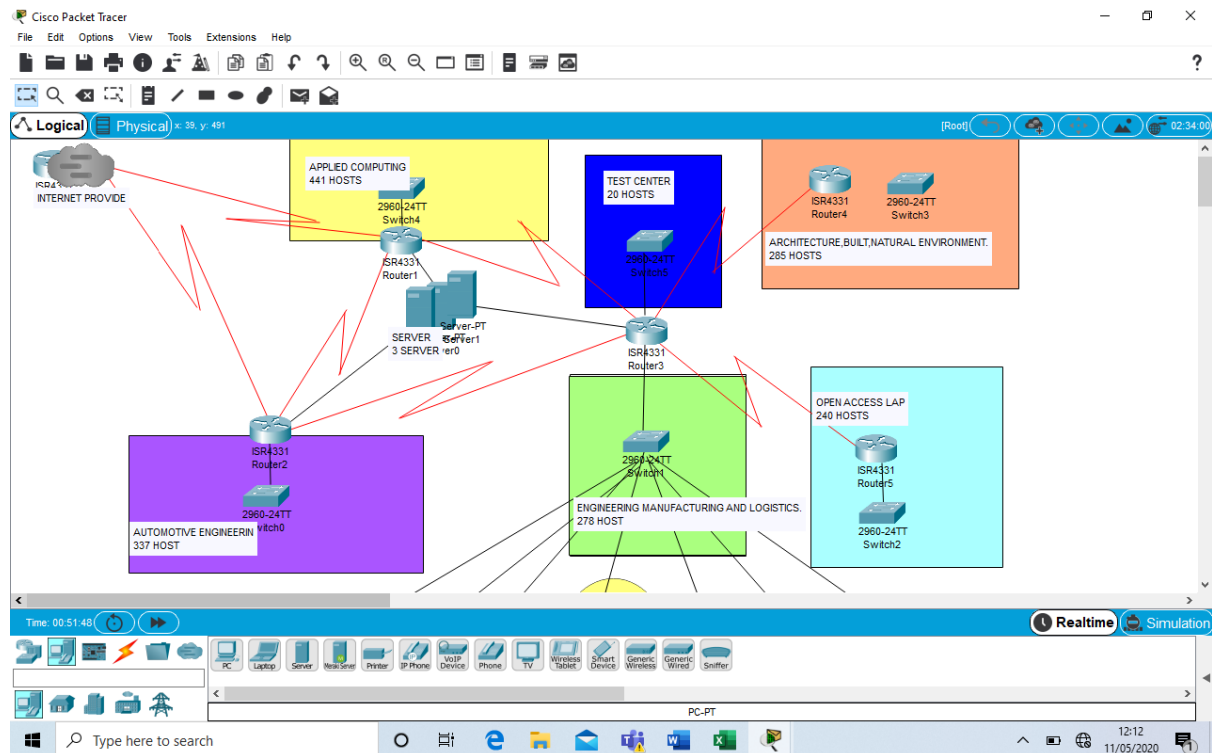
subnet	Network	1 st usable	Last usable	broadcast	Total usable host	host needed
Serial Links-9	172.18.9.48/29	172.18.9.49/29	172.18.9.53/29	172.18.9.54/29	6	4
Serial Links-11	172.18.9.55/29	172.18.9.56/29	172.18.9.60/29	172.18.9.61/29	6	4
Serial Links-12	172.18.9.62/29	172.18.9.63/29	172.18.9.67/29	172.18.9.68/29	6	4
Serial Links-13	172.18.9.69/29	172.18.9.70/29	172.18.9.74/29	172.18.9.75/29	6	4
Serial Links-14	172.18.9.76/29	172.18.9.77/29	172.18.9.81/29	172.18.9.82/29	6	4

10. Network topology

In this topology we have an internet provider connected through two serial links to the university. As we can see the topology design is secure because there is different way of traffic in case of failure of the system.

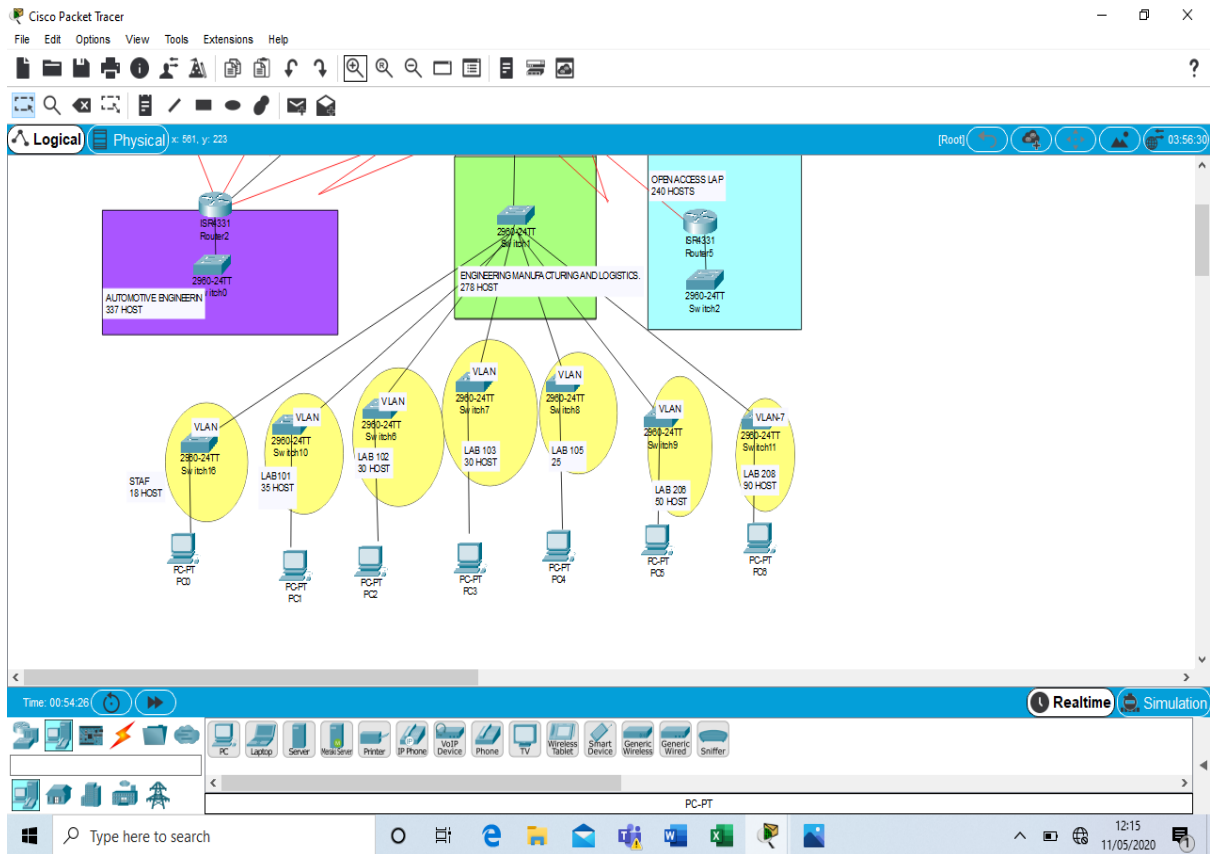
There is some import aspect regarding the way we allocate the server. As you can see the university server is only 2 or 3 physical machines because the rest is in cloud. All the university server is allocating in a virtual machine in the cloud. This give more security,

saving space and maintenance.



In the figure below we are zooming Engineering Manufacturing and Logistic subnet as an example of one of our particular topology designs. As you see in this subnet, we have WAN-wide Area Network and LAN Local Area Network. The WAN area environment is all relate to router connection. The router jobs are routing IP addresses, subnet mask also MAC, whenever came from different broadcast domain or different subnet mask you have to deal with router. In the other hand we have LAN connections and is all relate to Switch devices so, because we have to separate the local network addresses into different department, we have to use the concept of VLAN area. What happen in below figure 10.b is as required by the University we have separate a network host with identical broadcast domain into different department called LAB. For example, in school we have staff office with 18 hosts, LAB-101 with-35 hosts, LAB-102 with 30 hosts and so on. So, we create VLAN environment using only switch because in this network all the host share the same broadcast domain 172.18.7.255/23.

Figure 10.b



11. Conclusion

Can be able to assign IP for servers because lack of knowledge. Broadly speaking we able to fill all the organization requirement as show in all the section. As you can see in table 11.a will still have more address space for future grow.

Host	65536	3768	16384	8192	4096	2048	1024	512	256	128	64	32	16	8	4	2
Bits	128	64	32	16	8	4	2	1	128	64	32	16	8	4	2	1
Usable Hosts	65534	32766	16380	8190	4094	2046	1022	510	254	126	62	30	14	6	2	0
host bits "00000"	2 ¹⁶	2 ¹⁵	2 ¹⁴	2 ¹³	2 ¹²	2 ¹¹	2 ¹⁰	29	28	27	26	25	24	23	22	21
/ subnet mask "1111"	/16	/17	/18	/19	/20	/21	/22	/23	/24	/25	/26	/27	/28	/29	/30	/31

11.a

LAN	Network	first usable IP	last usable IP	Broadcast	No usable host in the subnet	No of host needed
SUBNT 441	172.18.0.0/23	172.18.0.1/23	172.18.1.254/23	172.18.1.255/23	510	441
SUBNT 337	172.18.2.0/23	172.18.2.1/23	172.18.3.254/23	172.18.3.255/23	510	337
SUBNT 285	172.18.4.0/23	172.18.4.1/23	172.18.5.254/23	172.18.5.255/23	510	285
SUBNT 278	172.18.7.0/23	172.18.7.1/23	172.18.7.254/23	172.18.7.255/23	510	278
SUBNT 245	178.18.8.0/24	178.18.8.1/24	172.18.8.254/24	172.18.8.255/24	254	245
SUBNT 18	178.18.9.0/27	178.18.9.1/27	172.18.9.30/27	172.18.9.31/27	30	18
SUBNT 4	172.18.6.32/29	172.18.9.33/29	172.18.9.34/29	172.18.9.35/29	6	4
SUBNT 4	172.18.9.36/29	172.18.9.37/29	172.18.9.38/29	172.18.9.39/29	6	4
					TOTAL 2330	TOTAL 1555

10.Reference

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