

Faculty of Computing, Engineering and Technology



Module Name: Networks and Protocols

Module Number : CE00997-3

Title of Assignment : The International manufacturing Corporation

Module Learning Outcomes for This Assignment

1.	
2.	
3.	
3. DESIGN, IMPLEMENT AND INVESTIGATE NETWORKS USING APPROPRIATE SIMULATION SOFTWARE, INTERNETWORKING TOOLS AND TECHNOLOGY IN MULTI-PROTOCOL ENVIRONMENTS.	

Hand in deadline : Friday 27th November 2009, 15:30hrs

Assignment description

Please see attached.

Assessment criteria

The project purpose is to restructure the network for a large commercial enterprise that employs approximately 2500 employees.

Currently, this commercial enterprise has 3 sites in different countries. The head quarter is in Geneva in Switzerland, the distribution site is in Birmingham in United Kingdom, and the manufacturing site is in Annecy in France.

I must to improve the current network installation, to increase the bandwidth, the efficiency and overall quality of communications of the network. I will perform a business plan in a suitable for the Chief Executive Officer that explains the technology, and provides comment on the Return on Investment.

We will start by explaining the implementation of the local area network. Then I will show and justify the choice that we made for the inter building and inter site connectivity. Finally, we will justify this new implementation by a return on Investment and with a simulation on Opnet.

LAN Architecture

Within each site, we have a local area network (LAN). This communication network interconnects a variety of data communicating devices in a small geographic area. It is useful to share hardware and software resources (file serving, print serving). We have secure transfers at high speeds with low error rates. Moreover, we can connect a LAN to other LANs or WANs.

The creation of a local network needs to make the choice between Ethernet and Token-Ring.

The first is the most common and cheaper, while the second is the reverse. Therefore, we will choose the first one.

Regarding topology, the most practical is the Star-Wired Bus Topology. All cabling systems are based on this principle.

Regarding the bandwidth, we have different variants of the Ethernet standard: 10Mbit/s (standard 10bT), 100Mbit/s (standard 100bT), and 1Gbit/s (standard 1000bT). Gigabit Ethernet is expensive. Gigabit Ethernet is expensive and is reserved for links between the concentration of facilities and servers. So we choose 10/100 Mbit/s for PC and 100/1000 Mbit/s for servers.

Currently, each site cabled using cat3 UTP and base around hub technology.

A hub is a simple repeater. It only amplifies the signal for broadcast on all ports. It is used in Ethernet base 10 (10 Mb/s over a maximum distance of 100 meters) and base 100 (100 Mb/s over a maximum distance of 100 meters). The real problem with a hub is exactly the reference data to all equipment. Once the number of computers increases, the collision rate increases proportionately, reducing the actual speed of the network. It is an Half Duplex (no transmission / reception at the same time).

It shares bandwidth, so available bandwidth is $\frac{\text{Total bandwidth}}{\text{Number of users}}$

A switch however uses a process called micro segmentation to create dedication full bandwidth links between the ports. Data sent from one device to another are only received by the recipient. If another device sends data to the printer, they are completely separated, the two communications can occur simultaneously.

For a hub, the bandwidth is limited to his speed. A hub 100 base-T offers 100 Mbps of bandwidth shared between all devices connected.

For a switch, the bandwidth is determined by the number of ports. For example, a 100 Mbps Switch 8 ports can handle up to 800 Mbps half duplex, and the double in full duplex.

So we choose to replace the hubs by the switches. We will improve our bandwidth for each computer and we will avoid that every computer can listen data which are not to him.

Two families of twisted pair cables are used: the shielded cables (STP: Shielded Twisted Pair) surrounded by aluminium foil as electrostatic shield and, more often used, UTP (Unshielded Twisted Pair) which do not use aluminium foil.

Moreover there are different categories in cables:

cable type	Speed supported	Topology
Category 1	Telephony	Telephone
Category 2	1 Mbps	Token-ring et telephone
Category 3	16 Mbps	Token-Ring and 10 base T
Category 4	20 Mbps en full duplex	10 Base T
Category 5	100 Mbps	10BaseT and 100 Base TX
Category 5e	1 Gbps	Giga Ethernet

Currently, all site cabled with cable of category 3. The bandwidth with a cable of category 3 is not sufficient. We must have at least Category 5 cables to facilitate the transfer of DATA between PCs

WIRELESS ACCESS POINT:

We have nomadic users and some visitors will need internet access.

We have two different types of users who must have different permissions on the network. Visitors just need an internet connection, while nomadic users must also have access to the whole local network.

For this, we must establish an identification system.

According to the identity, the user will have a different access.

For the security of our network, we will encrypt data with WPA2 using AES encryption. We also need a MAC address filtering to block access to unauthorized material.

LAN SITES

In each site, we have in each floor one switch where PCs are connected. And each switch in a building are connected together. Therefore if we have a problem with a switch, it is not the whole network that is penalized

For example, in the head quarter of Geneva, there are three floors, so three switches.

PCs, access point and server are connected on switches. Servers are positioned in the main building in each site (HQ – Geneva, Regional Sales in Birmingham and Manufacturing in Annecy). It is also the main building of each site which has a router with an internet connection. Each router is connected to all switches.

Phones are now connected to a PBX.

PBXs make connections among the internal telephones of a private organization.

the primary advantage of PBXs was cost savings on internal phone calls: handling the circuit switching locally reduced charges for local phone service.

However some buildings as the test chamber in Annecy have not a router. We cannot establish PBX. Therefore we replaced phones by ip phones.

We use UTP (Unshielded Twisted Pair) cables because it is cheapest than STP (Shielded Twisted Pair) cables. However the test chamber in Annecy is EMI shielded. In this case I must to use STP cables.

To connect switches, server and router between them, I use a 1000bt cable, because I need a very low latency.

To connect IP phone, PCs and access point on switches, I just need 100btx cables. You can see all connections on topology diagram in attached documents.

Inter building connectivity:

BIRMINGHAM

The distribution centre in Birmingham has two buildings. The regional sales building is considered as the main building and the distribution building is considered as the second. To connect LANs between them we will put a wireless bridge.

Why a wireless bridge?

These two buildings are separated by a two lane road.

If you want to connect the two buildings by a line, we would need a permit to bury a line under the road. This one would be hard to obtain. Moreover this solution is not the cheapest.

The second solution will be to connect the second building to a WAN with an xDSL technology. But we need to pay per month so the cost is too expensive.

To enable a wireless bridge, we have two solutions: Laser technology or WiFi technology.

The Advantages of laser technology is the speed (up to 100Mbps) and the security.

However, it is an expensive technology. And the WiFi technology is cheaper but the bandwidth is up to 54Mbps in optimal condition and the security is not the best.

It is two lane roads which separate the buildings, so we have not obstructions might obscure a visual link. The Line of Sight is good. We can expect a bandwidth about 54Mbps. The best solution in this situation is to use WiFi technology.

To establish the connection between these two building, we need for each building a WiFi bridge. So we use The Cisco Aironet 1310. We need also directional antenna to have a better signal between two bridges. A directional antenna as opposed to an omni-directional antenna sends the signal in one direction. We use coaxial cables to connect the bridges to antennas. For the security we will used WPA2

ANNECY

In Annecy, the main building is separated from the environmental test chamber of 35 meters. We choose to use the same solution as in Birmingham. Because this solution is the easiest to implement and it does not cost too expensive.

GENEVA

In Geneva the main headquarters is located 3.5 km away the server farm. At this distance wireless technology is not the best solution. If we choose this solution, we will need a Wifi bridge and an antenna with a higher gain to have less chance of receiving interference. But there are too many obstacles and the connection will be not stable. Moreover we need internet access which is located in the data server/farm building. In this case it would be interesting to use a leased line. A leased line is a symmetric telecommunications line connecting two locations.

Inter site connectivity

For long distance, the router is the only device which connects sites between them. Internet consists of routers with specialized connections, ATM and Frame Relay. Router allows connecting LAN of site to a WAN. For us, the WAN is represented by Internet. So we need to use an Internet service provider to interconnect our sites.

Like DSL, ISDN brings voice, video and data packets.

An ISDN BRI connection supports two 64 kbps B-channels and one 16 kbps D-channel over a standard phone line

However, ISDN is slower than DSL. We need to increase the bandwidth, so we will use DSL and leave ISDN.

The two basic types of DSL technologies are asymmetric (ADSL) and symmetric (SDSL).

Asymmetric service provides higher download or downstream bandwidth to the user than upload bandwidth.

Symmetric service provides the same capacity in both directions.

The simultaneous use of the Internet connection with a phone call is impossible.

Therefore a separate line is required for the SDSL service.

It is better for us, to use SDSL because it provides constant flow of traffic in the network. The same speed for downstream and upstream allows a trade thinned and more specifically those in private networks such as IP or VPN for teleworkers.

We need to have a high availability and a backup between lines. Therefore, we put two entrances on two different networks. If we have a problem with the first line, the second take over the failed link.

The “Celeste” Company offers an attractive offer. (<http://www.celeste.fr/sdsl-duo>).

The offer SDSL Duo is composed by a line SDSL and ADSL line coupled. We have also a dedicated line for SDSL and fixed IP. I could choose an offer with 2 SDSL line, but the price is excessive. We chose the offer which answers to our need.

For the router, we must to have dual WAN ports which support two broadband connections. Our router must to have a firewall to block unauthorized access while permitting authorized communications.

We need also a virtual private network (VPN) to create a private scope of computer communications. It provides a secure extension of a private network into an insecure network such as the Internet. We will use a VPN IPsec, because it is almost the ideal VPN solution. It supports strong authentication and encryption and emerging security standard.

To satisfy these conditions, I will use the Netgear router FVX538. It is a ProSafe Dual WAN VPN Firewall with 8 port 10/100 Switch. For the VPN, it uses IPsec.

DATA BACKUP SITES

The main backup server is located in Geneva. All sites have needs to save their work. Therefore, they need access to the main server in Geneva. However, unless all our site is connected to the main server through a leased line, we cannot exchange data with e server all day. The solution of the leased line is not profitable, it is much too expensive for long distances.

We need an access to the servers all day; the best way is to have on each site its own server. The evening at midnight, once the company is closed, the servers at each site backup and synchronize their data with the central server of Geneva.

Simulation on Opnet

The objective of this simulation is to examine the change in throughput in a local area network when upgrading from a hub to a switch and from a 10bt cable to a 100bt cable.

So we three scenarios:

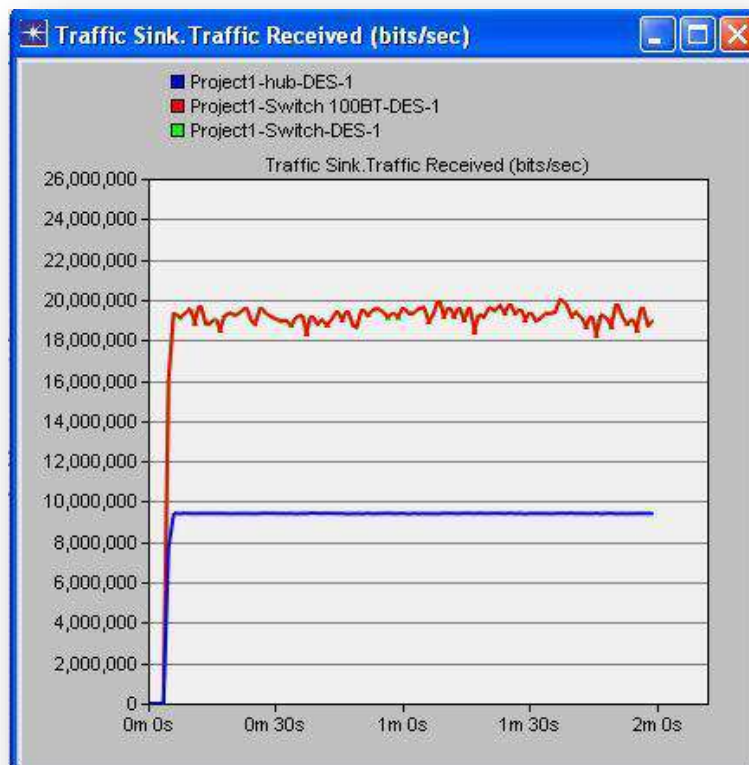
- A LAN with a hub and 10bt cables
- A LAN with a switch and 10bt cables
- A LAN with a switch and 100bt cables

In this simulation, we have 12 PCs connected on the switch.

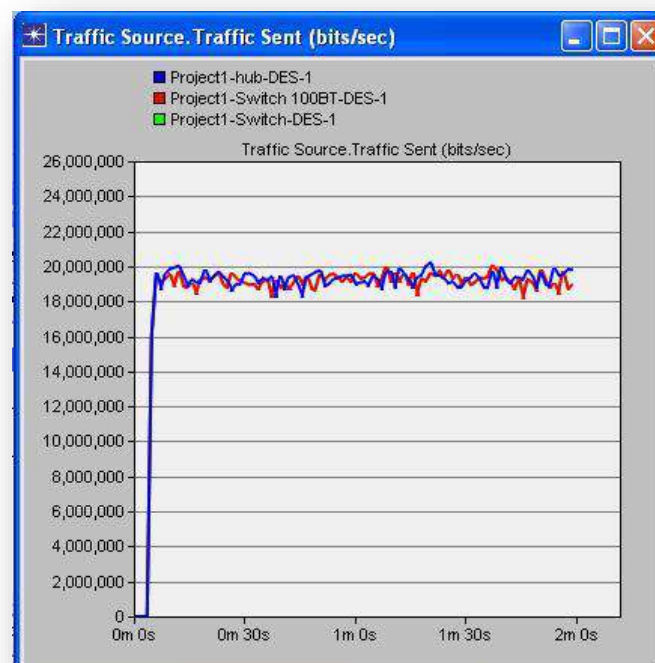
Stations are always sending and each station will generate traffic at an average rate of one 1000 byte packet every 5 milliseconds.

The average traffic generates by each node from the interarrival time and the packet size is: $1000 \text{ bytes/packet} * 8 \text{ bits/packet} * 1 \text{ packet}/0,005 \text{ sec} = 1,6 \text{ Mbps}$

So with 12 nodes in the system that comes to $12 \times 1,6\text{Mbps} = 19,2\text{Mbps}$ of offered load. The hub is operating at only 10Mbps.

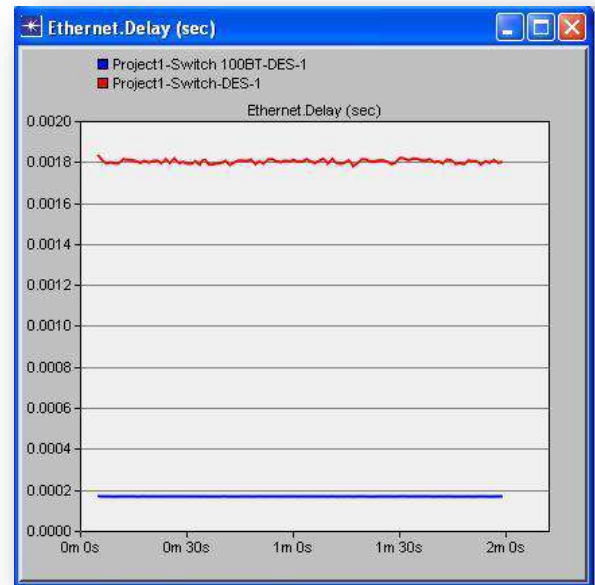
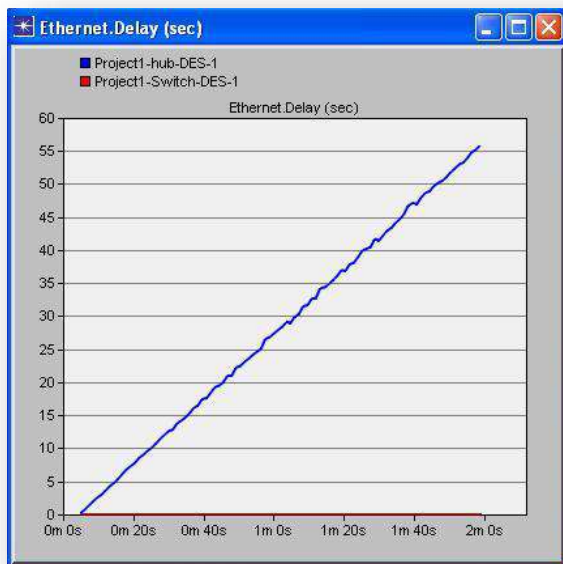


We can see that the traffic received in the hub case tops out near 10Mbps, the rated speed of the hub. The switch, on the other hand can easily deliver nearly twice that much traffic.



The traffic sent(bit/sec) shows the sum of total of traffic sent by all stations in LAN. We can see that the same amount of traffic was generated in both scenarios. The switch, however can actually carry this much traffic.

With the collision count statistic, we can see that hub close to 2000 collisions per second occurred. This is due to the heavy overloading of the hub.



With the hub, the delay increases with the time and stay stable with a switch. It is with the delay that we can see that 100bt cables are better than 10 bt cables. The delay is better with 100bt cables

Return on Investment

Equipement	Product name	Price
Switch	PROSAFE® 24-PORT GIGABIT STACKABLE SMART SWITCH	312,79 €
Router	PROSAFE® DUAL WAN VPN FIREWALL WITH 8-PORT 10/100 SWITCH FVX538	267,70 €
PBX	Panasonic pbx KX TDA100NE	907,50 €
IP Phone	Linksys - SPA921	66,16 €
100 btx	Cable RJ45 Cat 5 - 50m	11,80 €
1000 bt	Cable RJ45 Cat 5e - 50m	19,90 €
Access Point	PROSAFE® WIRELESS ACCESS POINT 802.11G WG302	156,13 €
Server	IBM System Storage DS3200 Express	4 390,00 €
Bridge	Cisco Aironet 1310 Outdoor Access Point/Bridge	655,96 €

Site 3 : Regional Sales (Birmingham)			Number of PC = 22	
Equipment	to intall	Replacement	Price for 1	Total price
Switch	2	1	312,79 €	938,37 €
Router	1	1	267,70 €	535,40 €
PBX	1	0	907,50 €	907,50 €
IP Phone	0	0	66,16 €	0,00 €
100 btx	22	4	11,80 €	306,80 €
1000 bt	7	2	19,90 €	179,10 €
Access Point	1	0	156,13 €	156,13 €
Server	1	0	4 390,00 €	4 390,00 €
Bridge	1	0	655,96 €	655,96 €
			Total	8 069,26 €

Site 3 : Distribution U.K (Birmingham)			Number of PC = 26	
Equipment	to intall	Replacement	Price for 1	Total price
Switch	3	1	312,79 €	1 251,16 €
Router	0	0	267,70 €	0,00 €
PBX	0	0	907,50 €	0,00 €
IP Phone	26	3	66,16 €	1 918,64 €
100 btx	54	6	11,80 €	708,00 €
1000 bt	3	1	19,90 €	79,60 €
Access Point	1	0	156,13 €	156,13 €
Server	0	0	4 390,00 €	0,00 €
Bridge	1	0	655,96 €	655,96 €
			Total	4 769,49 €

Site 1 : HQ - Geneva			Number of PC = 41	
Equipment	to intall	Replacement	Price for 1	Total price
Switch	3	1	312,79 €	1 251,16 €
Router	1	1	267,70 €	535,40 €
PBX	1	0	907,50 €	907,50 €
IP Phone	0	0	66,16 €	0,00 €
100 btx	42	4	11,80 €	542,80 €
1000 bt	9	3	19,90 €	238,80 €
Access Point	1	0	156,13 €	156,13 €
Server	1	0	4 390,00 €	4 390,00 €
Bridge	0	0	655,96 €	0,00 €
			Total	8 021,79 €

Site 1 : HQ – Server/data farm			Number of PC = 1	
Equipment	to intall	Replacement	Price for 1	Total price
Switch	1	0	312,79 €	312,79 €
Router	1	1	267,70 €	535,40 €
PBX	0	0	907,50 €	0,00 €
IP Phone	8	0	66,16 €	529,28 €
100 btx	3	1	11,80 €	47,20 €
1000 bt	19	3	19,90 €	437,80 €
Access Point	1	0	156,13 €	156,13 €
Server	0	0	4 390,00 €	0,00 €
Bridge	0	0	655,96 €	0,00 €
			Total	2 018,60 €

Site 2 : Manufacturing Annecy			Number of PC = 26	
Equipment	to intall	Replacement	Price for 1	Total price
Switch	3	1	312,79 €	1 251,16 €
Router	1	1	267,70 €	535,40 €
PBX	1	0	907,50 €	907,50 €
IP Phone	0	0	66,16 €	0,00 €
100 btx	27	4	11,80 €	365,80 €
1000 bt	11	4	19,90 €	298,50 €
Access Point	1	0	156,13 €	156,13 €
Server	1	0	4 390,00 €	4 390,00 €
Bridge	1	0	655,96 €	655,96 €
			Total	8 560,45 €

Site 2 : Test Chamber			Number of PC = 6	
Equipment	to intall	Replacement	Price for 1	Total price
Switch	1	0	312,79 €	312,79 €
Router	0	0	267,70 €	0,00 €
PBX	0	0	907,50 €	0,00 €
IP Phone	1	0	66,16 €	66,16 €
100 btx	16	5	11,80 €	247,80 €
1000 bt	0	3	19,90 €	59,70 €
Access Point	1	0	156,13 €	156,13 €
Server	0	0	4 390,00 €	0,00 €
Bridge	1	0	655,96 €	655,96 €
			Total	1 498,54 €

total facility and equipment replacement	32 938,13 €
--	-------------

Return on Investment VoIP	
number of days worked per year	240
price of international communications(/min)	0,02 €
number of employees	2500
call time per employee (/min)	15
Percentage of inter-site call	30,00%
Total price for 1 year	216 000,00 €
Total price for 1 year for inter-site call	64 800,00 €
Total price for 5 years	1 080 000,00 €
Total price for 5 years for inter-site call	324 000,00 €
Price installation VoIP	5 736,58 €
Return on investment for 5 years	318 263,42 €

Price of installation per month	
3x SDSL DUO by Celeste (SDSL 2Mbps / ADLS 20Mbps)	1074
Leased Line (2Mbps)	250

For the VoIP for 5 years, we have a return on investment of 318 263,42 €
 The new facility will increase productivity and ease trade.

Attached documents

