A Computer Network for Small and Medium Enterprises (Production Sector)

by

Mr. Teanjuob Mahantassanapong

A Final Report of the Three - Credit Course
CE 6998 Project

Submitted in Partial Fulfillment
of the Requirements for the Degree of
Master of Science
in Computer and Engineering Management
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Academic Year	March 2000

The Graduate School of Assumption University has approved this final report of the three-credit course, CE 6998 PROJECT, submitted in partial fulfillment of the requirements for the degree of Master of Science in Computer and Engineering Management.

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ABSTRACT

This project is to develop a Small and Medium Enterprises (SMEs) computer network. The competitiveness of the SMEs is obstructed by the disorder of computer network system. The network system was designed to suit the production base of SMEs. The study procedure includes SMEs characteristics, network topology, network capacity planning and network layout.

The new network system will improve SMEs competitiveness by better information management, better security, shared access to information, the saving of money on hardware and overcoming the problem of distance.

The scope of this project includes the layout of the network system to suit the characteristic of production SMEs. In the future, the successful network system will replace all paper work and manual filing systems.

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1.1 Introduction

Small and Medium Enterprises (SME) in Thailand are contributing to general economic growth, promoting entrepreneurship, producing goods for export and boosting foreign exchange earning particularly through exports of manufactured products. However, during the economic crisis, SMEs need to develop their organization to compete with foreign investors, Thai joint ventures and other SMEs. The ways to be competitive include cost reduction, high productivity, good quality, and consistency. All of this comes from good management and control. For this, sophisticated tools are needed.

The computer network is an effective way of communicating common information among all employees in an organization and is the solution for a SME to control and manage their information.

A computer network will increase SME efficiency, save paper, time and money by making information available to all employees all the time. Therefore, we try to find A suitable type of computer network for SMEs. We provide the idea of computer a network that is suitable for SMEs including the way to design and calculate the link between users and their required information.

1.2 Objective

The objective of this project is to designed an appropriate computer network system to SMEs which includes:

(a) reviewing and determining the SMEs characteristic

(b) showing the benefit of computer network to SMEs

(c) finding the suitable network topology for Productions Sector SMEs

(d) optimizing the use of additional equipment for the new network

1.3 Scope

The scope of this project includes:

(a) developing the suitable computer network for production sector SMEs

(b) computing the network diagram and physical link for production sector SMEs

(c) finding the suitable hardware for computer network

(d) calculating the cost for additional hardware

II. SMALL AND MEDIUM ENTERPRISES

2.1 Definition of Small and Medium Enterprises (SMEs)

An Overview of the Development of Small and Medium Enterprises in Thailand. Before 1970, Thailand's economy was heavily dependent on agriculture and had a very low level of industrial and commercial activity. Although there were very few SMEs, existing firms taking advantage of abundant labor and low wages, with the hard-working characteristics of Thai people, were able to successfully establish labor-intensive industries with a relatively low level of technological reliance. More than twenty years later, Thai people live in an affluent society and enjoy university education and brisk economic growth. Commodity prices are stable, industrialization is proceeding rapidly, unemployment is low and income is high. Among many "Made in Thailand" products that enjoy a good reputation and are widely sold overseas are fasteners, ceramics, bicycles, golf clubs, molds, personal computers and printed circuit boards, cloth, wood furniture.

SME is a business of small or medium size that was driven from an unique skill product using a local raw material that is flexible and feasible to the local people way of life and the world market demand. The product or service must not rely on the large manufacturers or business to supply the resources but provide a high international standard which will generate income from outside Thailand with minimal initial investment. The mentioned businesses cover many sector mentioned above. Thus, the business will generate income to its natives and bring the modernization to the region which will be a shock absorber to the fluctuation of the future economy. In general SMEs should have characteristic as follows:

SMEs produce more and offer a more diversified range of products with less investment.

SMEs create employment with lower investment costs.

SMEs are less affected by economic fluctuations, due to their structure.

SMEs are more flexible in adapting to changes in and diversification of demand.

SMEs are more prepared to adopt technological innovation.SMEs contribute to inter-regional development.

SMEs mitigate effects of a skewed income distribution pattern.

SMEs encourage, channel and mobilize individual savings.

SMEs are an indispensable support of large industrial enterprises.

SMEs are an element of balance and stability political and social systems.

SMEs are one of the main guarantors of democratic society and liberal economy.

2.2 Role of SMEs in Support of the Economy

There were 124,771 Small and Medium Enterprises registered in Thailand, equivalent to 97.9 percent of total industries. Their employment totaled 1.6 million or 50.4 percent of aggregate employment. Investment funds amounted to 1,218.90 billion Bahts or about half of total investment funds.

This sector is very important for Thailand's economy so the Thai government has a policy to support Small and Medium enterprise.

There are two sets of policies which affect SMEs, and each has its own set of goals and objectives. The first set is the industrial development policy. The goals of the Thai government concerning industrial development are to:

(a) promote and support industry as a whole

(b) revamp the system of taxes and privileges

(c) speed up infrastructure services

(d) provide training the level of labor skills

(e) enhance technological capability to increase productivity and competitiveness

(f) encourage use of the Industrial Product Standard System

(g) develop the target industry, agro-industry, textile, metal working, electronic, petrochemical and iron and steel

The second set is the export promotion policies. The goals are to:

(a) promote international trade

(b) enhance Thailand's capability to expand and protect its trade interest

(c) expand and maintain Thailand's share of existing market

(d) develop a trade data system

(e) develop Thailand into a trade center

There are a number of government agencies with policies and programs designed to support export and foreign investment in general, as well as with some emphasis on SMEs.

In the future, the SMEs will play and important role in export earning because of the government policy to decentralize by encouraging growth of industries in regions outside of Bangkok. Also the export-oriented small and medium enterprises has a good future prospect by way of government policy.

2.3 Examples of SMEs

In the EU

There are 18 million small and medium-sized enterprises (SMEs) in the EU. They employ 66% of the workforce and are responsible for 55% of turnover. They represent 99.8% of all enterprises excluding those in the agricultural and non-market sectors.

Statistical Office of the European Communities in Luxembourg:

"The objective is to support and facilitate the establishment of new enterprises as well as to simplify and improve the environment of existing enterprises. Considering that every year two million new enterprises are created in the **EU**, their potential part in creating new jobs is impressive. With this in mind, our objective is not only to support the new enterprises but also assist them in surviving and growing after their establishment." See Figure 2.1.

Table 2.1. SMEs in the European Union,1995, Break Down by Sector of Activity.

Type	Enterprise		Employment		Turnover		Employment share of SMEs
	Thousands	%	Millions	%	ECU billions	%	%
Industry and Energy	2043	11.3	33.24	29.7	4454	26.0	52.6
Construction	2408	13.3	10.14	9.1	905	5.3	87.7
Trade and Horace	6804	37.7	29.82	26.7	4787	28.0	78.8
Transport and Communication	930	5.2	8.16	7.3	715	4.2	46.6
Financial Intermediation	326	1.8	4.70	4.2	4347	25.4	28.3
Other Business Activities	2062	11.4	10.25	9.2	795	4.6	68.9
Other Services	3477	19.3	15.46	13.8	1107	6.5	73.2
Total	18050	100.0	111.76	100.0	17109	100.0	65.7

In Taiwan

The Current Status of Development of Small and Medium Enterprises Statistics for 1997 concerning SMEs including number of firms, number of employees, sales, geographical distribution, value of exports, R&D, and financial backing showed that SMEs played an extremely important role in the country's economic development.

(a) The 1,020,435 SMEs constituted 97.81% of all firms. This number represents an increase of 17,110 firms, or 1.71%, over 1996.

(b) A total of 7,197 thousand people were employed in SMEs. This figure represents 79.43% of the working population owners. The self-employed, and unpaid family members represent approximately 40% of the total, the remainder being paid employees.

(c) SMEs had sales of NT$6.9 trillion, or 32.11% of all company sales. Of this total, manufacturing firms accounted for 34.77%, commercial firms for 42.95%, construction firms for 11.53%, and service firms for 10.12%.

(d) As for the geographical distribution of SMEs, the greatest number was located in Taipei city, which had 188,077 firms (18.43%), followed by Taipei county with 14.85%, Kaohsiung city, 7.64%, Taichung county, 6.78%, Taoyuan county, 6.09%, Taichung city, 5.72%, and Changhua county, 5.38%.

(e) As for exports, the total value of exports generated by SMEs was approximately US$ 59.5 billion. This was an increase of US$ 1.8 billion, or 3.23%, over 1996, representing 48.77% of total exports.

(f) Research & Development, among those firms that engaged in R&D, average R&D expenditure per firm was NT$4.15 million (1995). The R&D expenditures of firms that engaged in R&D amounted to 2.22% of their operating income (1995). Operating income: average operating income per unit of labor among 5,613 SMEs engaging in R&D was NT$2.47 million per employee (1995). Value Added: added value per unit of labor among SMEs engaging in R&D was NT$890 thousand per employee (1995).

(g) Life span of firm: 13.11% of SMEs had been in business for 20 years or more, 24.80%, 10 to 20 years, 21.62%, 5 to 10 years, 8.91% 1 to 2 years, and 10.19%, less than one year.

In Hong Kong

Statistics of SMEs

In March 1999, there were more than 280,000 SMEs in Hong Kong. They accounted for over 98% of the total establishments and provided job opportunities to over 1,330,000 persons, about 60% of the workforce.

Amongst the business sectors, the majority of SMEs was engaged in import and export sector, followed by the wholesale, retail, restaurants and hotels sector. These two sectors constituted over 60% of the SMEs in Hong Kong, employing more than half of the workforce engaging in SMEs.

The breakdown of industry sector is as follows:

	No. of Establishments	No. of employees
Manufacturing	23,251	161,907
Mining & Quarrying, Electrical, Gas & Water, Construction	634	10,571

excluding the agriculture & fishing sector.

Establishments in construction sector refers to number of construction sites. Employee refer to manual worker only.

In Thailand

In December 1996, there were more than 800,000 SMEs in Thailand. They accounted for over 98% of the total companies in Thailand. Table 2.2 shows the distribution of SMEs in different areas of Thailand. The employment rate in each section is shown in Table 2.3.

2.4 Characteristics of SMEs

Different countries have different definitions of SMEs. Table 2.4 shows the detail for each country.

Table 2.2. Distribution of SMEs in Different Area of Thailand.

	Bangkok area		Central area		Northern		North-East		Southern		Total	
	No. of SME	%	No. of SME	%	No. of SME	%	No. of SME	%	No. of SME	%	No. of SME	%
Productions	57,243	20.69	22,158	16.26	30,522	22.04	33,258	18.00	14,182	12.02	157,363	18.43
Wholesale	16,002	5.78	2,811	2.06	2,194	1.58	2,941	1.59	3,168	2.69	27,116	3.17
Retail	87,972	31.80	48,282	35.44	40,103	28.96	48,688	26.36	34,265	29.04	259,310	30.36
Service Sector	58,337	21.09	22,811	16.74	21,240	15.34	21,950	11.88	17,653	14.96	141,991	16.63
Hotel, Restaurant	27,548	9.96	14,678	10.77	12,687	9.16	13,687	7.41	13,709	11.62	82,300	9.64
Construction	3,337	1.21	893	0.66	1,531	1.11	1,802	0.98	1,520	1.29	9,083	1.06
Others	26,179	9.46	24,600	18.06	30,212	21.82	62,410	33.78	33,491	28.39	176,892	20.71
Total	276,618	100	136,233	100	138,489	100	184,736	100	117,988	100	854,055	100

Table 2.3. Small and Medium Enterprises Break Down by Sector of Activity, Investment % and Employment Rate.

Type of Business	Investment < 10 Million Bahts			Investment 10-100 Million Bahts		
	No. of factory %	Investment %	Employment %	No. of factory %	Investment %	Employment %
Food and Beverage	45.55	16.22	18.35	13.12	14.77	11.35
Textile and leather	3.72	9.21	18.06	11.20	11.40	22.75
Wood, Paper and Printed	9.21	13.03	13.27	10.01	9.06	9.42
Rubber and Plastic	4.21	9.65	6.36	12.94	13.71	12.02
Metal	11.73	18.25	11.61	17.38	16.46	11.12
Machine and Transportation	15.69	15.28	16.78	15.12	15.62	13.60
Other	9.90	18.35	15.30	20.23	18.99	19.73
Total	100.00	100.00	100.00	100.00	100.00	100.00

Table 2.4. Characteristic of SMEs in Other Countries.

Country	Type of Business	Characterized By	Amount	Maximum Employees
Japan	# Production # Wholesale # Retail # Service	Investment	30 Million Bahts 15 Million Bahts 9 Million Bahts 15 Million Bahts	300 100 50 50
Taiwan	# Production # Service, Wholesale # Retail	Investment	54 Million Bahts -	200 50
South Korea	# Production # Service, Wholesale # Retail	Employment	- -	300 20
Singapore	# Production # Service	Fix asset	330 Million Bahts 330 Million Bahts	- 200
Philippine	# Production # Wholesale, Retail # Service	Fix asset	54 Million Bahts	200
Malaysia	# Production	Sale Volume	238 Million Bahts	150
USA	# Production # Wholesale, Retail # Service	Sale Volume	185 Million Bahts	500
Hong Kong	# Production # Service, Wholesale # Retail	- -	- -	100 50

In Thailand the followings are the characteristics that distinguish SMEs companies from other companies:

(a) business are able to perform well in Baht and Dollar currency.

(b) the product must be a design item which meets world wide demand and standards.

(c) business must be a joint effort with other nations to share risks which will participate in managing and transferring technical know-how to the company.

(d) Small and Medium Enterprises are defined by 100-1000 employees.

(e) product line of the business must be able to change according to the market.

(f) business must keep fixed cost low and will look for foreign investment.

(g) fixed assets include land are specified for each sector.

	Medium Business	Small Business
Production Sector	Less than 200 MB	Less than 50 MB
Service Sector	Less than 200 MB	Less than 50 MB
Trading Sector Wholesale	Less than 100 MB	Less than 50 MB
Trading Sector Retail	Less than 60 MB	Less than 30 MB

2.5 Characteristic of Potential SMEs

Export Products

The business should generate an income in foreign currency such as US dollar, Yen or German mark. Not only will this help the country economy, it also automatically controls the quality of the exported products base on a global standard.

Independence

The business must be self-sufficient in producing diversified product. Providing a raw material to a large factory creates much dependency on the product distribution.

Flexibility

The business should consist of a small number of employee which will provide more flexibility to change its product line and production process depending on market demand.

Low Investment

The business should require a minimal initial investment.

Use of Local Material

The merchandise should be produced using locally obtained material or it should be from a local or nearby resident. The usage of imported material should be minimal and it must be an important part that enhances the value of the product tremendously. The profit margin should be quite high.

Global Standard

The product should be of a high quality standard and be accepted globally in its design and material used.

Information Technology Transfer

The business should established information technology to support decision making and efficient management.

The businesses using information technology to support their organizations will gain a competitive advantage by

Increasing productivity (due to less manual work and a higher level of data-sharing capabilities);

Improving computing capabilities (better automation of data tracking, analyzing, and reporting processes);

A more complete integration of enterprise technologies (easier management and maximum utilization of corporate data and existing infrastructure).

2.6 Problems of SMEs Being Competitive

In general, small and medium enterprises throughout Thailand are single proprietorships, while medium and large-scale firms are registered as limited partnerships or companies. This indicates that companies take more formalized form as the firm size increase. Small enterprises usually have internal sources of funds for a large share of their start up cost and working capital. They tend to use rudimentary technology. The production, employment, marketing and growth of the SMEs are usually by mean of the availability of local raw material, skilled labor and market requirment.

IFCT research showed that Thai SMEs have problems on:

Marketing

90 % of SME products serve the local market; few SMEs know the export market. In the near future a free trade market will begin so they will have to be competitive with foreign companies.

Most SMEs lack marketing skills, they don't know how to promote their product or distribute their product to the market.

Labor

SMEs have a high rate of labor turnover; most laborers lack skill, have low experience, and low education. Because of the growth of the economy, the workers come from up country.

Due to the high rate of turn over, SMEs cannot train their workers to become skilled workers. From this reason, most of the SMEs are unable to employ skilled worker to ensure quality production of goods and services.

Information System

SMEs lack technology on information system because this technology are new to Thailand.

The Thai government cannot support information system technology for SMEs.

Most of the SMEs cannot access the valuable information on the Internet so they are unable to adapt this information for their business and their information system.

Management Problem

SMEs are lack of management skill and systematic thinking. Most of the SME owners are fromer employees or are freelance or come from family business. They don't have enough training in management, marketing and accounting skills.

Most of SMEs use a traditional management style so their accounting systems are unclear and inefficient.

The Problem of Accessing Government Policy

There is a lack of detailed information on certain areas of SMEs development policy.

Different definitions are used by different agencies to categorize SMEs at the operational level.

There are too many agencies and institutions dealing with SMEs development without an effective coordinating mechanism. This causes duplication of effort and lack of transparency for the target groups.

Financial Problem

The recent financial turmoil caused SMEs to face a worsening financial problem.

They lack capital investment. Most of SMEs use loans from a Bank and these loans have a high interest rate.

Most of equity in SMEs is derived from owner savings or from the family and active partners.

SMEs find it difficult to meet bank and security requirements for a loan.

SMEs are not well informed of all the finance options available to them and are not sufficiently skilled to present appropriate finance applications.

2.7 Improvement of SMEs Competitiveness

These is no doubt about the significance and importance of SMEs in terms of job creation and suppliers. However, under the era of market liberalization and globalization, SMEs in Thailand have to face a new level of competition from foreign suppliers in terms of better quality, low prices, and advantages of economy of scale. As local content requirement have been relaxed, competitive pressure increasingly mounts on Thai SMEs at all stages in the chain of production and distribution

In general, to develop SMEs effectively and efficiently, three majors area should be considered:

(a) Entrepreneur (owner/manager); his/her technical, managerial and human relation skill as well as ability to open to foreign market should be developed.

(b) Enterprise; it includes its productive capacity and technical capacity, the level of modernization, and its proximity to suppliers and market.

(c) Product and services; the focus should be on overall quality and standard (ISO standard), their suitability to foreign markets, and their compatibility with the demand trend.

Development of these three major areas for SMEs requires government involvement to create an environment favorable to business. This does not mean that the government should decide what SMEs should or should not do. Creating favorable environment includes reducing regulatory burdens, establishing an appropriate tax incentive, and encouraging more innovation and growth of new firms. By doing so, the government should promote entrepreneurship and ensure that SMEs have easy access to information, new technology and innovations, as well as required resources and incentives to improve management performance and skill formation. Financial assistance from the government is only the vehicle for achieving the SMEs development.

As mention above, it is the responsibility of government to create a favorable environment for SMEs. The practical ways to assist SMEs are:

Financial assistance: access credits is often listed as a serious problem of SMEs. High transaction cost, high risk, and lack of collateral are hindrances to low-interest rate credit. The government can create easy access to credit for SMEs through Government financial channels such as Small Industry Financial Corporation (SIFC), Export-Import Bank of Thailand, and the state own commercial bank. In addition, the government may set up a special fund for SMEs.

Advisory services: the government should provide advisory service to SMEs in area including marketing and quality improvement.

Information: the government should provide basic information on the market, technology and regulations through various sources such as business centers, consultants and self-help associations.

Training: to develop human capital and encourage private sector to provide such training are key factors for SMEs development. The government may assist private sector to formulate training programs within enterprises, trade association, chambers of commerce, and training institutions.

For future competition SMEs should develop information systems for their enterprise, the information system will provide a big impact on the organization competitiveness.

2.8 The Benefit of Computer Networking for SMEs

This will show the benefit of computer network for SME to change the SMEs attitude, and the network will improve their organization to become competitive.

Businesses connect their computers because people benefit when their computers can communicate. In a small business where efficiency is crucial and profits are measured very closely, the benefits which can make the difference between success and failure include:

Fast Access to Information

Networks speed access to information by letting one computer share its files with other computers and their users.

For example, you might find that you need information from a document located on one of the five other computers in your office. If the computers are not networked, you need to search each one (or interrupt other people to have them search their disks for you). If the document is small enough, you move it to your computer on a floppy disk (also known as a 'sneaker net'); if it is not you may have to transfer it in pieces or by hard copy. If it is on a branch office computer in another city, you may have to do all this by mail or an overnight service such as Federal Express.

If the computers were networked, you could search each of them without leaving your desk or interrupting other workers. When you found the document you could copy it to your machine, or even open the document without copying it. In either case copying information over a network is much faster than copying it to and from floppy disks. Also, you don't need to worry about the document's size or the distance between your computer and the one where the document resides.

Easier Information Management

File sharing has a side benefit: it makes it easier for you to manage your information.

For instance, everyone can agree to store the same kind of information in a particular directory on a file server. A fileserver is a computer that shares its resources, such as files or printers, with other computers on the network. Computers that access resources shared by other computers are called clients.

You can put all of your marketing documents in one directory on a file server, all of the customer satisfaction surveys in another directory, all the accounting data in a third, and so on. In addition to making information easy to find, the network also makes it easy to access. If the person in charge of satisfaction surveys is not around, you can always go to the fileserver and get the latest copy yourself.

Also, your documents are usually worth protecting, but it is hard to get 20 office workers with stand-alone computers to back up their files to floppy disks once a week. With a network, you can purchase one tape backup unit and one person can use it to back up important shared directories from a file server, or even files from desktop client computers.

Security

None of us can afford to have our critical business information fall into the wrong hands. These hands can even belong to employees within our organization. Utilizing network operating system software such as Windows NT, we take the utmost care to prevent unauthorized access to our data files. With Windows NT, we can create an entry in a log for those unauthorized users who are trying to access our critical business information. Taking this one step further, we can instruct the operating system to page or e-mail us when this breach occurs.

Shared Access to Information

Networks let two or more people access the same information at the same time. Inevitably this improves efficiency, and sometimes it is the only way to solve a problem. The computer industry refers to this as 'collaboration'. Sophisticated word processors such as Microsoft Word will actually track changes made to a document, and by whom. You have the ability to mark up your document using different screen colors for these changes. The dates of change will accompany this information as well.

For example, suppose one person takes customers orders by phone and enters it into a database. That database lets you track specific orders, monitor inventory, and analyze customers' purchasing habits. If your business grows and you need a second person to help take phone orders, both people will need access to the same database at the same time. They can't both sit at the same computer, so you need to let their computers communicate. A network makes this possible, economical, efficient and highly effective.

Save Money on Hardware

A network lets people share resources such as hardware, (including printers, fax machines, and modems), so that you get the most benefit from each purchase.

For example, most people in an office need to print, but few print often enough to justify the cost of a dedicated printer. You can connect a few printers with several computers using a switch box if all of the hardware is in the same room. Mechanical switch boxes make you leave your desk to switch to a different printer, and digital switch boxes are not always compatible with your software, and in either case you often wait in line to use the most popular printer.

With a network you can save money on printers and avoid switch boxes by connecting printers to various computers and letting computers print to other computer's printers. You can also attach a printer directly to the network, which lets you locate the printer in a common area instead of on someone's desk, and that common area can be anywhere that your network reaches. Finally, clients can send print jobs to a print server computer and then continue working, while the print server feeds the jobs to the printer.

Overcome the Problems of Distance

Networks use communication technology to span distance. This distance can be feet, miles, or thousands of miles.

One example is dial-up networking, which lets a computer dial into another computer (or into an entire network) using a standard telephone line.

Without this feature, sales people on the road with laptop computers are isolated; their laptops must contain all of the information they think they might need, even though that information cannot be more current than the last time they were in the office. When you are in the office you cannot exchange information with people from other companies, such as contractors, or other branches of your company, without sending floppy disks through the mail. If you remember an unfinished task during dinner you can't take care of it without returning to the office.

With dial-up networking the office is only as far away as the nearest phone jack is. A sales person can get up-to-the-minute information while at a customer's site. You can exchange information easily with a contractor located across town, or on the other side of the world. You can stay connected to your business while staying at home with a sick child.

Enhance Communication between People

Networks let people communicate more easily using electronic mail and group scheduling software.

Electronic mail (often-abbreviated e-mail or email) lets people use their computers to exchange messages that can contain text, as well as data such as graphics and audio or video clips.

Unlike postal mail, e-mail need not be sent from or received at a fixed street address; a person with a laptop can use dial-up networking to send and receive e-mail messages anywhere. Additionally, e-mail is faster than postal mail. A message can travel between countries in seconds. E-mail costs fractions of what it costs to print it out and ship the pages. You can send e-mail to multiple people as easily as to one person. You can store messages, search for them, and forward them to other people. And since e-mail is easy to store, you can easily keep a "paper trail" that includes names, dates and messages but does not require tracking or filing loose slips of paper.

Electronic mail enhances communication, especially with people at a remote location. You can ask a question of anyone in your company instead of just the people sitting near you. Information from field sales staff can travel quickly to your main office, and those field sales people can let each other know what sales strategies worked best. People can avoid duplicating effort by telling each other what they're doing.

Group scheduling lets people on a network keep track of their schedules, and more importantly, it lets them coordinate schedules. For example, scheduling software can search several people's schedules to find currently available meeting times, then send meeting requests to each person and automatically book the meeting for those who say they can attend.

Improve Efficiency

Many of the network features discussed above improve people's efficiency. Networking can also improve your computers' efficiency through client/server computing. This problem-solving approach improves efficiency by dividing a task into different parts and distributing the parts to several computers.

For instance, an inexpensive desktop computer is well-suited to entering information into a database and displaying information that a person requests, but it does not have the processing power to search for information efficiently. With a client/server database application, a user at a desktop PC can enter information and compose requests, but a powerful database application server computer does the hard work of finding the requested information and sending it back to the user (or client computer).

Adding a powerful application server gives you a larger performance boost than you could have obtained by upgrading ten or twenty desktop computers, and does so at a much lower price.

Access a Huge Pool of Information

"Information Superhighway" is almost as vague as "small business," but people usually mean a nationwide or worldwide set of connection services, such as the Internet and numerous commercial networks.

The Internet is a worldwide collection of millions of computers and users. Information on nearly every topic is distributed on the Internet, most of it for free. Companies provide access to the Internet for a fee, just as telephone company sells you access to the phone lines, usually a monthly charge, plus additional fees for special services. Commercial networks such as CompuServe, America Online, and the Microsoft Network [also known as content providers] also link many people together, and also sell access to information. They tend to be easier to use, and they were designed with pricing structures in mind so they can provide information not distributed for free on the Internet.

In either case, it is hard to grasp the volume of information that these networks provide. You can browse through stored information on virtually any topic, and you can participate in discussions on virtually any subject. Although it is hard to grasp the volume of information, it is easy to see its advantages. Print media are convenient because you can choose which topics to view, and when, but the information is never fresh; the news in your morning newspaper is at least a few hours old. Broadcast media are fast, and may even let you witness events as they occur, but you can't choose which topics a news broadcast will cover, or in what order, and when you've seen and heard enough of one topic you can't skip to another one.

Online information has the best qualities of both media; it can carry live broadcasts of text, sound, and video, and you can skip from one topic to the next at will. In addition, much of it is archived so that you can view it (or hear it) later if you wish. It is like a newspaper except that the text updates as you watch, the photographs are live video feeds, the comics are animated, and you can flip to any of hundreds of related stories just by touching the page.

Reach New Customers

Online services and the Internet give you more than just a huge pool of information; they put you in touch with millions of other people, some of whom are prospective customers, some of whom are competition, some of whom know things you might find interesting and profitable. You can monitor a topical forum and speak up when someone asks about a product or service that you offer. Electronic advertisements can be interactive, so customers can tell you about themselves and tell you what they want, and such ads are often easy to change on short notice.

Many vendors offer software that runs on a Microsoft operating system and adds networking functionality, but Microsoft products are designed to work together: if one can share a file, the others can access it; if one can share a printer, the others can send it their print jobs.

This distinction is important because a computer's role affects network administration, and that can be important to a small business. In server-based networks one person (the network administrator) can oversee the entire network, which is good because it frees the other people from this task, but it requires that someone at your business (or a contractor or consultant) be technically knowledgeable about networks in general and specifically about yours. Peer-to-peer networking implies that each person's computer can share files and printers with little or no centralized control. Sharing resources on a peer server is simple, but it requires that everyone who shares resources learn a little bit about networks. A future article in this series discusses this topic in more detail.

III. LANS INTRODUCTIONS AND NETWORK TOPOLOGY

In the last 15 years, LANs have gone from being an experimental technology to becoming a key business tool used by companies worldwide. A LAN is a high-speed communications system designed to link computers and other data processing devices together within a small geographic area such as a workgroup, department, or a single floor of a multistory building. Several LANs can also be interconnected within a building or campus of buildings to extend connectivity.

Some Background on LANs

LANs have become popular because they allow users to share vital computing resources electronically, including expensive hardware such as printers and CD-ROM drives, application programs, and, most importantly, the information the users need to do their jobs. Prior to the development of LAN technology, individual computers were isolated from each other and limited in their range of applications. By linking these individual computers over LANs, their usefulness and productivity have been increased enormously. But a LAN by its very nature is a local network, confined to a fairly small area such as a building or even a single floor of a building. To realize the full benefit of computer networking, it is critical to link the individual LANs into an enterprise-wide backbone network that connects all of the company's employees and computing resources, no matter how geographically dispersed they may be.

Today's LANs and LAN internetworks are powerful, flexible, and easy to use, but they incorporate many sophisticated technologies that must work together flawlessly. For a LAN to really benefit an organization it must be designed to meet the organization's changing communications requirements. Building a LAN is a process of choosing different pieces and matching them together. This chapter is designed to help first-time LAN equipment buyers and users understand the fundamentals of how LANs operate, what the different technology choices are for building a LAN, and the ramifications of choosing one option over another. Also discussed is the concept of internetworking or connecting disparate and geographically dispersed LANs together to form an enterprise system, the different technologies and products available to do so, and the benefits and limitations of each.

The Basics of Local Area Networking

Today local area networking is a shared access technology. This means that all of the devices attached to the LAN share a single communications medium, usually a coaxial, twisted pair, or fiber optic cable. Figure3.1 illustrates this concept: several computers are connected to a single cable that serves as the communications medium for all of them. The physical connection to the network is made by putting a network interface card (NIC) inside the computer and connecting it to the network cable. Once the physical connection is in place, it is up to the network software to manage communications between stations on the network.

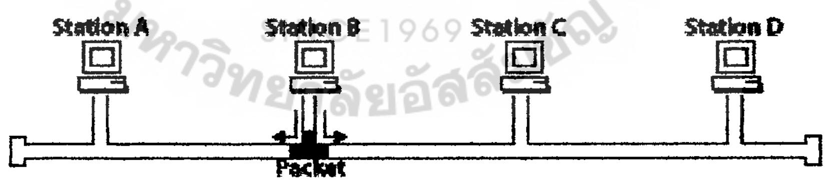

Figure 3.1. A Basic LAN Bus Network.

When Station B sends a packet to another station on the LAN, it passes by all of the stations connected to that LAN. On the bus network illustrated here, the electrical signal representing the packet travels away from the sending station in both directions on the shared cable. All stations will see the packet, but only the station it is addressed to will pay attention to it.

In a shared media network, when one station wishes to send a message to another station it uses the software in the workstation to put the message in an "envelope". This envelope, called a packet, consists of message data surrounded by a header and trailer that carry special information used by the network software to the destination station. One of the pieces of information placed in the packet header is the address of the destination station.

The NIC then transmits the packet onto the LAN. The packet is transmitted as a stream of data bits represented by changes in electrical signals. As it travels along the shared cable, all of the stations attached to it see the packet. As it goes by the NIC in each station, the NIC checks the destination address in the packet header to determine if the packet is addressed to it. When the packet passes the station it is addressed to, the NIC at that station copies the packet and then takes the data out of the envelope and gives it to the computer.

Figure 3.1 shows one source station sending a single message packet to one destination station. If the message the source station wants to send is too big to fit into one packet, it will send the message in a series of packets. On a shared access LAN, however, many stations all share the same cable. Since each individual packet is small, it takes very little time to travel to the ends of the cable where the electrical signal dissipates. So after a packet carrying a message between one pair of stations passes along the cable, another station can transmit a packet to whatever station it needs to send a message. In this way, many devices can share the same LAN medium.

3.1 Ethernet

The most widely used LAN technology in use today is Ethernet. It strikes a good balance between speed, price, ease of installation, and supportability. Approximately 80 percent of all LAN connections installed use Ethernet.

The Ethernet standard is defined by the Institute of Electrical and Electronics Engineers (IEEE) in a specification commonly known as IEEE 802.3. The 802.3 specification covers rules for configuring Ethernet LANs, the types of media that can be used, and how the elements of the network should interact. The Ethernet protocol provides the services called for in the Physical and Data Link Layers of the OSI reference model.

One element of the 802.3 specification states that Ethernet networks run at a data rate of 10 million bits per second (10 Mbps) or 100 million bits per second (100 Mbps) in the case of Fast Ethernet. This means that when a station transmits a packet onto the Ethernet medium it travels along that medium at 10 Mbps.

Another important element defined by the 802.3 specification is the access method to be used by stations connected to an Ethernet LAN, called carrier sense multiple access with collision detection (CSMA/CD). In this method, each station contends for access to the shared medium. It is possible for two stations to try sending packets at the same time, which results in a collision on the LAN. In Ethernet networks, collisions are considered normal events and the CSMA/CD access method is designed to quickly restore the network to normal activity after a collision occurs.

Ethernet Media and Topologies are important part of designing and installing a LAN is selecting the appropriate medium and topology for the environment. Ethernet networks can be configured in either a star or bus topology and installed using any of three different media.

Coaxial cable was the original LAN medium and it is used in what is called a bus topology. see Figure 3.1 for a typical bus topology. In this configuration, the coaxial cable forms a single bus to which all stations are attached. This topology is rarely used in new LAN installations today because it is relatively difficult to accommodate adding new users or moving existing users from one location to another. It is also difficult to troubleshoot problems on a bus LAN unless it is very small.

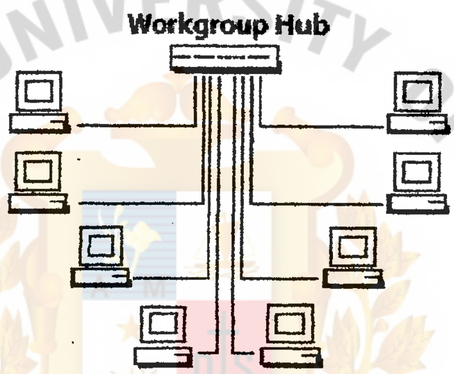

Figure 3.2. Basic Star Topography LAN.

In a star topology all stations are wired to a central wiring concentrator called a hub. Similar to a bus topology, packets sent from one station to another are repeated to all ports on the hub. This allows all stations to see each packet sent on the network, but only the station a packet is addressed to pays attention to it.

Figure 3.2 illustrates a star topology LAN -- which is a more robust topology. In a star topology, each station is connected to a central wiring concentrator, or hub, by an individual length of twisted pair cable. The cable is connected to the station's NIC at one end and to a port on the hub at the other. The hubs are placed in wiring closets centrally located in a building.

Ethernet networks can be built using three different types of media: shielded and unshielded twisted pair, coaxial, and fiber optic cables. By far the most common is twisted pair because it is associated with the more popular star topology. It is inexpensive, and very easy to install, troubleshoot, and repair. Twisted pair cable comes both unshielded and shielded. Unshielded twisted pair (UTP) cable used for LANs is similar to telephone cable but has somewhat more stringent specifications regarding its susceptibility to outside electromagnetic interference (EMI) than common telephone wire. Shielded twisted pair (STP), as its name implies, comes with a shielding around the cable to provide more protection against EMI.

Of the two types of twisted pair cable, UTP is by far the most commonly used. The specification for running Ethernet on UTP is called 10BASE-T. This stands for 10 Mbps, baseband signaling (the signaling method used by Ethernet networks), over twisted pair cable. Other Ethernet specifications include 10BASE5, which uses a thick coaxial cable, and 10BASE2, which uses a thin coaxial cable media. Today, 10BASE5 is seldom installed in new Ethernet networks, and 10BASE2 is used only in very small office networks. An additional standard allows 10BASE-F Ethernet to run on fiber optic cable.

Fast Ethernet

An extension of the popular 10BASE-T Ethernet standard, Fast Ethernet transports data at 100 Mbps. With rules defined by the IEEE 802.3u standard, Fast Ethernet leverages the familiar Ethernet technology and retains the CSMA/CD protocol of 10 Mbps Ethernet. Two types of Fast Ethernet are available: 100BASE-TX, which runs over Category 5 UTP; and 100BASE-FX, which operates over multimode fiber optic cabling.

3.2 Token Ring

Another major LAN technology in use today is Token Ring. Token Ring rules are defined in the IEEE 802.5 specification. Like Ethernet, the Token Ring protocol provides services at the Physical and Data Link Layers of the OSI model. Token Ring networks can be run at two different data rates, 4 Mbps or 16 Mbps.

The access method used on Token Ring networks is called token passing. Token passing is a deterministic access method in which collisions are prevented by assuring that only one station can transmit at any given time. This is accomplished by passing a special packet called a token from one station to another around a ring. A station can only send a packet when it gets the free token. When a station gets a free token and transmits a packet, it travels in one direction around the ring, passing all of the other stations along the way. As with Ethernet, the packet is usually addressed to a single station, and when it passes by that station the packet is copied. The packet continues to travel around the ring until it returns to the sending station, which removes it and sends a free token to the next station around the ring.

Token Ring Topology and Media Token Ring networks use what is called a ring topology. However, it is actually implemented in what can best be described as a collapsed ring that looks like a physical star topology. See Figure 3.3.

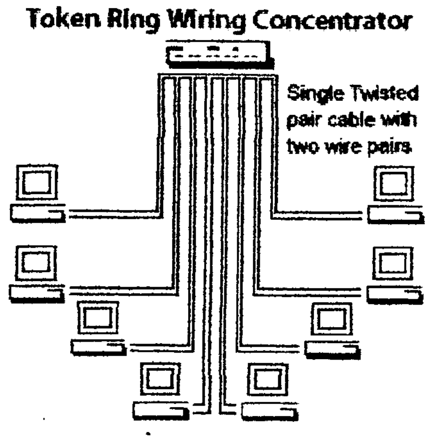

Figure 3.3. Basic Ring Topography LAN.

The ring topology used in Token Ring networks is a collapsed ring that looks like a physical star. Each station is connected to a Token Ring wiring connector by a single twisted pair cable with two wire pairs. One pair serves as the "inbound" portion of the ring (also known as the receive pair) and the other pair serves as the "outbound" or transmit pair.

In Token Ring LANs, each station is connected to a Token Ring wiring concentrator, called a multistation access unit (MAU), using an individual run of twisted pair cable. Like Ethernet hubs, MAUs are located in wiring closets.

3.3 FDDI

Fiber Distributed Data Interface, commonly known as FDDI, provides data transport at 100 Mbps, a much higher data rate than Ethernet or Token Ring. Originally, FDDI networks required fiber optic cable, but today they can be run on UTP as well. Fiber is still preferred in many FDDI networks because it can be used over much greater distances than UTP cable. Like Token Ring, FDDI uses a token passing media access method. It is also usually configured in a collapsed ring, or physical star, topology. FDDI is used primarily as a backbone, a segment of network that links several individual workgroup or department LANs together in a single building. It is also used to link several building LANs together in a campus environment.

Structured Wiring Both the Ethernet star topology and the "collapsed ring" topology used in Token Ring LANs are supported by what is called a structured wiring architecture. With structured wiring, all of the network stations are physically star wired to intelligent hubs. Intelligent hubs are hubs that can be monitored and managed by network operators. This combination of a star topology and intelligent hubs make troubleshooting and fault isolation easier and faster because each endstation is attached to the network on its own individual port, which means it can be monitored easily and, if necessary, can be easily turned off. In addition, structured wiring makes adding users to the network, moving them, or making other physical changes on the network very simple. Since both Ethernet and Token Ring networks can use twisted pair cable and can be configured in a physical star topology, a structured wiring architecture will support either network technology.

3.4 Hubs

The hub is one of the most important elements of a LAN. It is a central connection point for wiring the network, see Figure 3.4, and all stations on the LAN are linked to each other through the hub.

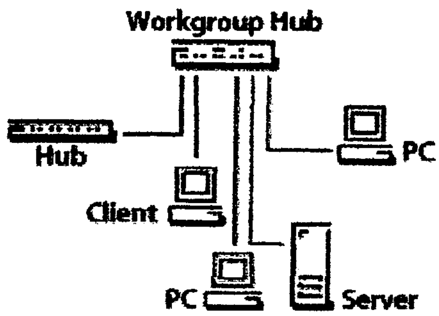

Figure 3.4. Basic LAN with the Hub as the Central Connection Point.

The cornerstone of the network is the intelligent hub, or concentrator, which serves as the control point for systems activity, management, and growth. By integrating any combination of connectivity, internetworking, and management capabilities into intelligent hubs, network managers can create the perfect physical network infrastructure for their environment.

The term hub is generally associated with 10BASE-T Ethernet networks, while the term multistation access unit (MAU) is used to refer to the Token Ring wiring concentrator. Just as these two LAN technologies use different media access methods, hubs and MAUs perform different media access functions internally, but at one level they perform the same function: They are both network wiring concentrators.

A typical hub has multiple user ports to which computers and peripheral devices such as servers are attached. Each port supports a single 10BASE-T twisted pair connection from a network station. When an Ethernet packet is transmitted to the hub by one station, it is repeated, or copied, over onto all of the other ports of the hub. In this way, all of the stations "see" every packet just as they do on a bus network, so even though each station is connected to the hub with its own dedicated twisted pair cable, a hub-based network is still a shared media LAN -- picture it as a LAN in a box.

Manageable Hubs Intelligent hubs have been defined as manageable hubs, meaning that each of the ports on the hub can be configured, monitored, enabled, or disabled by a network operator from a hub management console. Hub management can also include gathering information on a variety of network parameters, such as the numbers of packets that pass through the hub and each of its ports, what types of packets they are, whether the packets contain errors, and how many collisions have occurred. Each hub vendor has some type of management package it sells with its products. These applications vary in how much information they can gather, what commands can be issued, and how the information is presented to the network operator.

Standalone Hubs Both hubs and MAUs come in three configurations: standalone hubs, stackable hubs, and modular hubs. Some products are combinations of the best configurations. Standalone hubs are -- as the term implies -- single box-level products with a number of ports. Standalone hubs usually include some method of linking them to other standalone hubs -- either by connecting them together with a length of 10BASE5 coaxial cable or cascading them using twisted pair between individual ports on each hub. See Figure 3.5. Standalone hubs are usually the least expensive type of hub and are often not managed. They are best suited for small, independent workgroups, departments, or offices typically with fewer than 12 users per LAN.

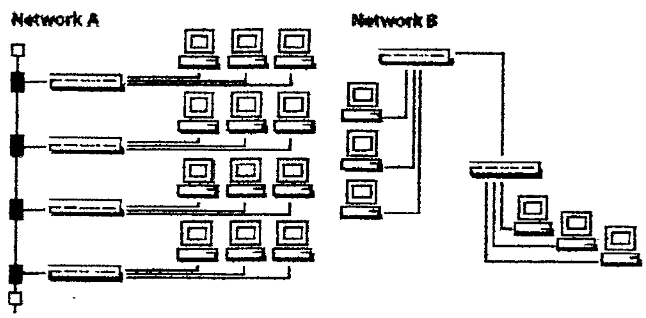

Figure 3.5. Summary of Network Architectures.

Network A illustrates four 10BASE-T hubs connected together by a single cable. This cable could be a coaxial or an optical fiber cable. All of the hubs are part of a single LAN. Network B illustrates two 10BASE-T hubs cascaded. Here the cable connecting the two ports is unshielded twisted pair wire. All of the hubs that are cascaded in this fashion are part of a single LAN.

Stackable Hubs

A third type of hub is the stackable hub. Stackable hubs look and act like standalone hubs except that several of them can be stacked or connected together, usually by short lengths of cable. When they are linked together, they act like a modular hub in that they can be managed as a single unit. One manageable hub, used within a stack, can typically provide the management for all other hubs in the stack. These hubs are ideal when an organization wants to start with a minimal investment but knows that its LAN will grow. By utilizing stackable hubs, an organization doesn't need to invest in a large chassis, which may only have one or two cards in it for a considerable length of time until more are needed.

Linking Hubs

Each hub usually represents a single LAN. In most organizations it is desirable to interconnect all of the LANs, which means linking hubs in some way. One way to link hubs is to use an interrepeater linkor cascaded segment. This type of connection simply repeats all of the packets from one hub to the other hub it is linked to, so that in effect the two hubs are part of the same LAN.

Modular Hubs

Modular hubs are popular in networks because they are easily expanded and always have a management option. A modular hub starts with a chassis, or card cage, with multiple card slots, each of which accepts a communications card, or module. Each module acts like a standalone hub; when the communications modules are placed in the card slots in the chassis, they connect to a communications backplane that links them together so that a station connected to a port on one module can easily communicate with a station on another module.

Modular hubs provide a central point where multiple concentrators located in different wiring closets can be united into a LAN or WAN. The modular hub can be equipped with a wide variety of connectivity and network management modules designed to provide a customized solution for the creation of enterprise-wide LANs and WANs.

Modular hubs typically range in size from four to 14 slots, so the network can be easily expanded. Typically, several slots in a modular hub will be filled with 10BASE-T Ethernet modules. For instance, with 10 modules, each supporting 12 users, a single hub could support 120 users over 10BASE-T. The modules are linked by the high-speed backplane, which can also be used to connect the communications modules to a management module that manages all of the cards in the chassis. In addition to using one management module for a large number of ports, all of the modules share a common power supply. Another advantage of some modular hubs is that Ethernet, Token Ring, and even FDDI communications modules can be placed in the same chassis, using the same common power supplies.

IV. SMALL AND MEDIUM ENTERPRISE NETWORK

4.1 Network Planning

We are interested to use the top down model to summarize the factors influencing the required functionality of enterprise networks.

Organization

(1) Dawn of the virtual corporation

(2) Matrix management, center of excellence

(3) Extending the enterprise to include customers and vender

Number of Users

(1) Number of users of each department

(2) Dynamic work team, virtual workgroups

External Access

(1) Remote access require full access to corporate information resource

(2) Remote user required data and files to be automatically synchronized each time they log in

Access Time

(1) Database access time for local user and remote user

Traffic

(1) Number of transactions in local workgroup per minute

(2) Collaborative application software has high bandwidth demands and time-sensitive delivery constraints

(3) Distributed database replication imposes high bandwidth demands on the network

(4) Amount of transactions between virtual workgroup

For SME in the industrial sector, their organization is simply defined as Figure 4.1.

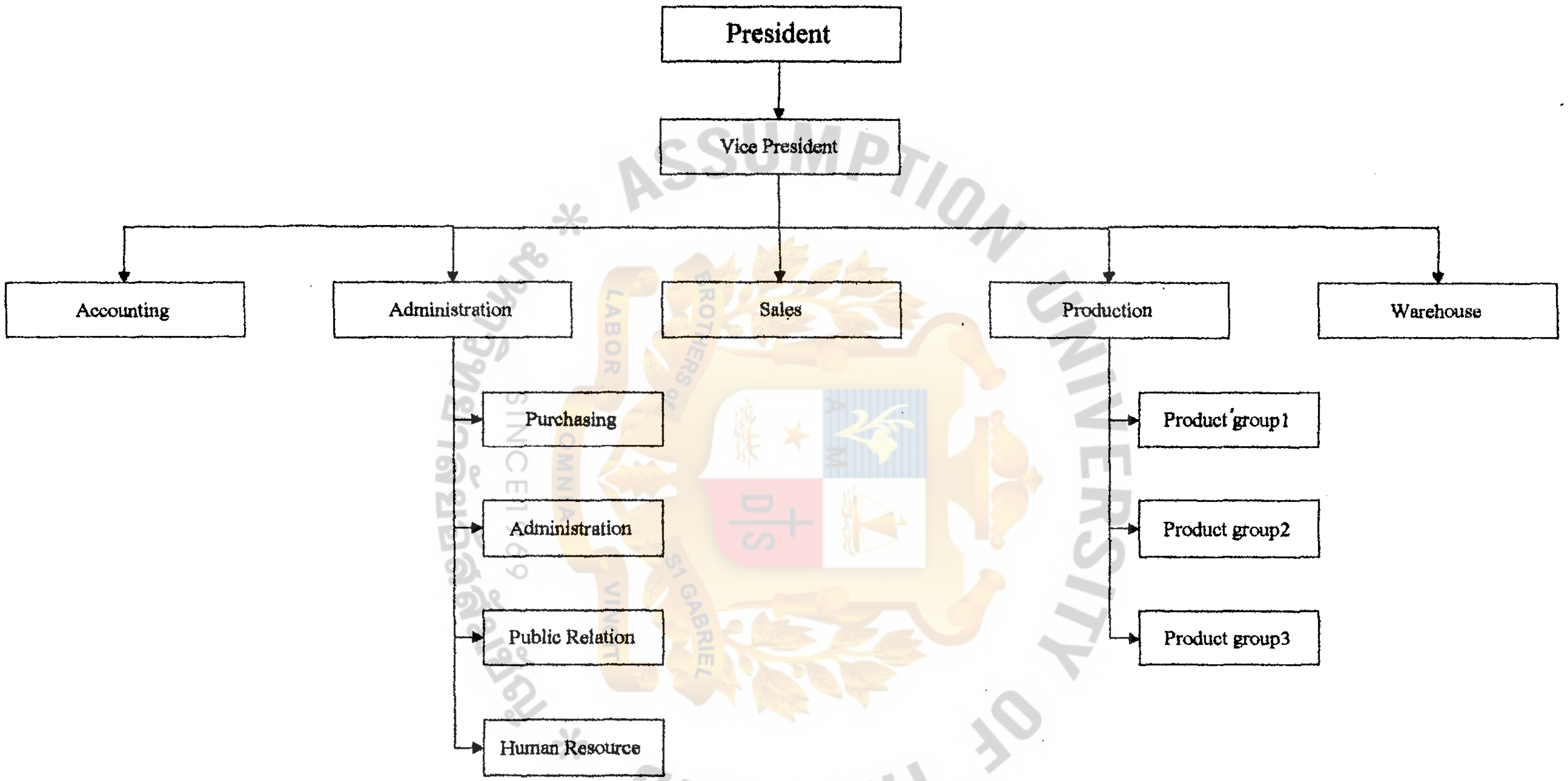

Figure 4.1. Small and Medium Enterprise Organization Chart.

4.2 Main Purpose for Each Department

Sales department

(1) Share customer name, order and past record.

(2) Use database to forecast sales.

(3) Transfer sales forecast to Production department.

(4) Transfer day–to–day sale transaction to Accounting and warehouse.

Production department

(1) Production planing

(2) Raw material planing

(3) Transfer material requirements to Administration department

(4) Transfer production data to Accounting department

Administration department

(1) Purchasing planing

(2) Personal planing

(3) Monthly payment for worker and employee salary

(4) Transfer purchasing to Accounting department

Accounting department

(1) Cost calculations

(2) Accounting transactions

(3) Financial monitoring

(4) Transfer product cost to sales department

(5) Store product and raw material data

Warehouse department

(1) Monitoring raw material incoming

(2) Product delivery to customer

(3) Inventory reports to Accounting, Production and Administration department.

4.3 Calculating Network Load

Most important aspect of planning a network the understanding of loading. Loading is defined as the utilization, as a percentage of capacity, placed on the backbone, server, user stations, and other network resources. Capacity is rated per resource. To avoid resource overloading and network bottlenecks, resources should be implemented to maintain consistent capacities or at least capacities equivalent to the resources demand. Loading can be classified into normal (75%), peak (20%), and extreme (5%). The percentages indicated reflect time. Therefore, normal loading would be the average load level sustained 75% of the time.

Typically, networks that are intended to support distributed processing should be designed to maintain normal loading at less than 30% capacity. Networks designed for network centric architectures should be designed to maintain normal loading at up to 50% capacity.

Peak usage can be defined as heavy demands on network resources on a recurring, predictable schedule. The peak usage range should be between 30% to 60% capacities for less than 20% of the time. Peak usage may include periods such as early morning when users first load their applications, end of month when accounting is reconciling, and end of year inventory calculations.

Extreme network demands may include events such as reindexing database files, extensive file transfers, or using your backbone as an alternate route for outside traffic. It is necessary to be aware of extreme network loading potential during the network-planning phase. However, it probably would not be practical to design the network to meet these demands with 100% efficiency. Depending on the criticality of the extreme demands, it would be more typical to plan to accommodate normal and peak usage loads.

To help determine loading, begin by first dividing users into two primary groups:

Users who work with static or structured information (information that receives little or no manipulation from the user), such as order entry, bookkeeping, and word-processing. These typically perform better with network centric solutions such as NCs. Users who work with information in a more informal and unstructured manner such as multistation CAD and 3D rendering. These typically perform better with dedicated processing resources such as a PC.

With respect to network applications, network loading is much different for NCs in a network centric environment than for PCs in a distributed processing environment. PCs simply transfer programs and data from network servers into local memory and process them locally. Performance is heavily dependent on network loading as well as the processing power of the PC. A network server acts as nothing more than a remote disk drive for the PC station. NCs, on the other hand, initiate sessions on remote hosts leaving all data and applications on the server. Execution of the application occurs on the server; therefore, NCs rely heavily on server performance and very little on network loading.

Much of the same network modeling is required for both network centric computing and distributed processing solutions, however the network load is distributed much differently. Distributed processing characteristically consumes vast amounts of network resources, resulting in detrimental effects to other nodes. It is best to place them on separate LAN segments if you have more than a handful of PCs/workstations. Network segmentation can be as easy as adding an additional network interface card to a server and establishing a static route. This segmentation will allow nodes with similar network characteristics to play together, allowing more predictable network load planning.

4.4 Distributed Processing Architecture

Running a network database application in a distributed processing environment can cause heavy network loading simply through normal transaction processing. The client in this case would be a PC or workstation.

A networked database application requires data files to be stored on the server and client files, such as the actual application or user parameters, to be executed locally. The client files can be stored on the client's local disk or on the network server. When the client portion is stored locally, the application is loaded directly from the local hard drive into local memory and execution begins without requiring network access. If the client portion of the application resides on the network server, it must be downloaded over the network into local memory. This could be several megabytes and should be considered in network loading calculations.

The user is required to authenticate over the network to the database host that will verify the user id and password and return acknowledgment of the user. Network traffic is typically insignificant for authentication.

Remote database files are then opened. It is surprising how much traffic this generates between the client and the database host(s). The client in this case is treating the remote host as a disk drive only. All of the same processing is required by the client as would be required if the files were accessed from its hard disk. Instead of opening, reading, writing, and closing files on a local disk, the same actions are performed on a remote disk using the network in place of the client's internal bus. Client environments must be configured to handle the appropriate number of FILE

HANDLES, BUFFERS, and FCBs, and also must have enough free local hard drive space for temporary files and indices.

When the user queries the database, again, all processing is performed on the local client. This means that all data necessary to complete the query (typically index information) needs to be transmitted to the client in order for the seek request to be completed. Once the record number(s) for the queries are determined, the client then fetches the record(s) from the host and reads it into local memory.

When the user wishes to update a record, all actions as stated in step above are performed. In addition, a record lock is written to the database file. The record is modified on the client and then uploaded (written) to the database file on the host. Following the update, the record needs to be unlocked on the host.

The most significant revelation here is the high level of network activity required supporting the application. Equally as significant is the fact that no serious load is placed on the host. The most work performed by the host is fulfilling disk I/O requests. If you monitor CPU utilization of the server while clients are running the database application, utilization percentage remains extremely low with most of the activity resulting from disk access.

Also note that applications which have distributed client code implies that each copy of the program which resides on the client must be updated whenever updates to the application are made. It is difficult enough to distribute software to networked clients reliably - they all must be turned on and working correctly, and logged in. The addition of a few laptops and telecommuters makes the task next to impossible.

The speed of the application is dependent on the client hardware configuration, and each client must be configured to meet minimal hardware and operating system requirements of the application. As the application grows, it is likely that the client requirements will increase making it necessary to update the hardware or obsolete the entire client.

4.5 Network Centric Architecture

Accessing a database application in a network centric environment is much less demanding on network resources than distributed processing solutions. The client in this case would be a NC.

Compared to traditional PCs, NCs divide the users interactive activities such as control of the keyboard, the mouse and the visual display from the other operations that make up the computer program.

When a database application is launched from a NC, no significant network traffic is generated. Server resources are allocated, and the application is hosted 100% on the server. All database transactions occur between the application server and the database server which may, or may not, reside on the same host. If they are not hosted on the same server, the network design will need to accommodate for resource loading between the application and database servers. The client machines used by the querier need only package and send a few strings of text and deal with relatively small parcels of returned data.

The most significant revelation here is that only a relatively thin client is necessary to run the database application. No substantial network traffic is generated y the client during database transaction processing. By centralizing the applications, all program updates take place on the server. There is no issue with updating the application on distributed clients.

Speed of the application does not depend on the type of computer on the desktop or on network loading conditions; rather, application processing is server centric and dependent on the computing resources of the server. Server CPU utilization is higher in a centralized processing environment. Planing for server sizing, positioning and clustering will prevent server resource contention from becoming a problem. As the application grows and processing demands increase, only the server needs to be updated, not the clients. There is no client obsolescence in this case.

Direct dial-in access delivers the same application performance as clients attached directly to the LAN.

4.6 Network Capacity Planning

The efficiency at which data flows through a network has a direct impact on application performance. This, in turn, affects end user perception of computing performance as well as transaction processing between hosts. Network traffic tends to be bursty in nature, with general traffic occurring at very low levels of utilization. To help understand network traffic flow characteristics through an Ethernet network, a brief explanation of the protocol and associated limitations is in order.

Ethernet is based on a contention access protocol. This means that only one frame can be transmitted at a time, and each node is in contention for access to the media. Access is controlled by a transceiver connected to each NIC. The transceiver enables frames to be sent when the cable is free. When other communications are detected, the transceiver does not enable the Network Interface Card (NIC) to send data. If any other bits are detected on the cable during the first portion of the transmission, a collision is detected. Under these conditions the transceiver aborts the frame transmission, waits a random amount of time (to avoid a subsequent collision) and attempts to resend data when the cable is clear. One concern about Ethernet is that busy nodes can dominate a LAN to the detriment of other nodes. In an attempt to control LAN domination, the transceiver implements jabber control. After each frame

(150ms), the transceiver interrupts any transmission coming from its NIC, allowing other nodes to take control of the medium.

A 10Mb/s Ethernet network reaches saturation at 30% - 40% utilization. At this level, an event known as data storming occurs. This is where collisions and retransmissions occur with such frequency that the network becomes inoperable. So even though the backbone is running at 10Mb/s, the theoretical capacity is 3 - 4 Mb/s (assuming that the backbone cabling is perfect). For the following calculations a capacity of 3 Mb/s (1,350 MB/hr) is used.

In a distributed processing environment where the client must pull applications and data over the network to be executed locally, LAN domination is a common occurrence. There are several ways to demonstrate this. Since basically every operation in a distributed processing environment requires the transfer of data into local memory, using a PC, attach to a network drive on the server and copy a file from one directory on the server to a different directory on the same server. A simple transaction like copying a file from one directory to another on the same server requires the file to be transferred over the network into the PC's memory to complete the file read process and transferred back over the network to the server again to complete the write process. The file is transferred twice over the network to complete this task. During the copying process, the server and the client consumed as much of the network bandwidth as they could contend for. For this example, using a PCI based PC with a high performance NIC copying to server which also has high performance network I/O, sustained throughput may reach 750Kb/s. Four simultaneous file transfers would saturate a LAN segment.

LAN domination is typically not a problem with NCs since network traffic volume is minimal compared to the distributed processing counterparts. Also important to note is that a NC rarely contends for the maximum available bandwidth, since it is not necessary to transfer data into local memory. In the above scenario, the transaction would occur entirely on the server and the only network traffic would be the transfer of updates to the screen image.

The volume of network bandwidth demand per network node is the deciding factor for how many nodes should be on a LAN segment. You should plan on normal network load, that is the average load level 75% of the time, not to exceed 1.5Mb/s and peak load (20% of the time) should not exceed 2.5Mb/s.

4.7 Network Traffic Analysis

The following analysis identifies five user categories with different applications and work patterns. The Traffic Study measured user traffic over a 5-day period. Categories had test samples of at least five people running similar levels and types of applications. Samples of total network traffic (packet counting) were taken for one-hour blocks three times daily. Communication used the X11 protocol to the Windows application. Screen resolutions were 1280 x 1024 or 1024 x 768 with 8bit color. Test groups using the ICA protocol showed about 30% less traffic at the higher screen resolution and color depth. The average is the total traffic measured for each category divided by the number of users.

4.8 User Category and Application Sampling

Process worker - 90% terminal emulation (text based) and 10% Windows applications.

Production knowledge worker - 60% terminal emulation (text based), 35% Windows applications, and 5% Internet browsing.

Technical knowledge worker - 25% terminal emulation (text based), 60% Windows applications, and 15% Internet browsing.

Management worker - 70% terminal emulation (text based), 25% Windows applications, and 5% Internet browsing.

Table 4.1. Average Traffic per User.

Job Category	Traffic Range (MB/hr)	Average Traffic/user
1. Process worker	1.5 - 2 MB/hr.	1.6 MB/hr.
2. Production Knowledge worker	1 - 3.5 MB/hr.	2.7 MB/hr.
3. Technical Knowledge worker	0.05 - 7 MB/hr.	1.4 MB/hr.
4. Management worker	8 - 24 MB/hr.	11 MB/hr.

From the above information each department will have different characteristic of network. We can design a network for each department then combine them together by company backbone network.

Sales Department

Number of users are 5-10 user composed of

4 sale people (Technical Knowledge worker).

1 sale manager (Management worker).

2 sale coordinator (Process worker).

Require remote access to all sales department resource.

Network traffic can be calculated from Table 4.1.

4 sale people Average traffic/user 1.4 MB/hr. Total 5.6 MB/hr.

1 sale manager Average traffic/user 11 MB/hr. Total 11 MB/hr.

2 sale coordinator Average traffic/user 1.6 MB/hr. Total 3.2 MB/hr.

Sales department access time 19.8 MB/hr is approximate 44 Kb/s.

Production Department

Number of users is 10-20 users composed of

12 Production supervisor (Production Knowledge worker).

2 Product designer (Technical Knowledge worker).

3 Assistance production manager (Management worker).

1 Production manager (Management worker).

4 Production secretary (Process worker).

Not require remote access to all department resource.

Network traffic can becalculated from Table 4.1.

12 Production supervisor Average traffic/user 2.7 MB/hr Total 32.4 MB/hr.

2 Product designer Average traffic/user 1.4 MB/hr Total 2.8 MB/hr.

3 Assistance production manager Average traffic/user 11 MB/hr Total 33 MB/hr.

1 Production manager Average traffic/user 11 MB/hr Total 11 MB/hr.

4 Production secretary Average traffic/user 1.6 MB/hr Total 6.4 Mb/hr.

But product designers require more data on CAD approximate 1500 MB/hr.

Production department access time 1585.6 MB/hr is approximate 3.52Kb/s

Administration Department

Number of users is 10-20 users composed of

10 Administrator (Process worker).

4 Assistance manager (Management worker).

1 Administration manager (Management worker).

Not require remote access to all department resource.

Network traffic can be calculated from Table 4.1.

10 Administrator	Average traffic/user 1.6 MB/hr.	Total 16 MB/hr.
4 Assistance manager	Average traffic/user 11 MB/hr.	Total 44 MB/hr.
1 Administration manage	Average traffic/user 11 MB/hr.	Total 11MB/hr.

Administration department access time 71 MB/hr is approximate 155.8 Kb/hr.

Accounting Department

Number of users are 5-10 users composed of

4 Accountant (Process worker)

2 Assistance manager (Management worker)

1 Accounting manager (Management worker)

Not require remote access to all department resource.

Network traffic can be calculated from Table 4.1.

4 Accountant	Average traffic/user 1.6 MB/hr.	Total 6.4 MB/hr.
2 Assistance manager	Average traffic/user 11 MB/hr.	Total 22 MB/hr.
1 Accounting manager	Average traffic/user 11 MB/hr.	Total 11 MB/hr.

Accounting department require data at 2000 MB/hr once a month for monthly closing process.

Accounting department access time 39.4 MB/hr. is approximate 87.56 Kb/s. and require extra access time for month-ended 2000 MB/hr. is approximate 4.4 Mb/hr.

Warehouse Department

Number of users 5-10 users are composed of

2 Warehouse secretary (Process worker)

2 Warehouse Supervisor (Production Knowledge worker)

1 Warehouse manager (Management worker)

Require remote access to department resource by sale.

Network traffic can be calculated from Table 4.1.

2 Warehouse secretary	Average traffic/user 1.6 MB/hr.	Total 3.2 MB/hr.
2 Warehouse supervisor	Average traffic/user 2.7 MB/hr.	Total 5.2 MB/hr.
1 Warehouse manager	Average traffic/user 11 MB/hr.	Total 11 MB/hr.

Warehouse department access time 19.4 MB/hr. is approximate 43.1 Kb/hr.

From the above information, we can design a network for all departments.

Network for each department shows on Figures 4.2-4.7.

For a large department, we have to divide the network into logical networks. The Production department will have 3 logical networks for each product group. The Administration department will have 4 logical networks for different task.

Human resource

Public relation

Purchasing

Administration

4.9 Network Segmentation

For purposes of calculating network loading, the 3 Mb level is taken as the network traffic limit (3 Mb/sec. is equivalent to 375 KB/sec. or 1,350 MB/hr.). The proposed network design uses 50% of its saturation limit or 675 MB/hr. for normal operation. Other factors influencing this analysis include the frequency of large file transfers, alternate routing paths for this segment, the criticality of applications and data and the required level of speed for user productivity.

4.10 Network Loading Factor

Using the data accumulated above, each job category was weighted for its share of the network capacity (675 MB/hr. divided by traffic/user). These numbers give the number of users per network segment or a loading factor that can be multiplied by the number of users in each category and summed to 100% for total usage requirements.

Table 4.2. Network Load Factor.

Job Category	# Users on Net	Network Load Factor (%)
1. Process worker	422	0.236 %/user
2. Production knowledge worker	250	0.40 %/user
3. Technical knowledge worker	482	0.207 %/user
4. Management worker	61	1.6 %/user

The table calculates the maximum number of each category of user per 10 BaseT line. This data shows that we can connect all department to an enterprise database server with 10 BaseT line. Nevertheless, the Production department requires a huge stream of data for CAD design and the Accounting department requires quick response for month end data closing. Therefore, we link both departments with 100baseT to back bone database server.

From the above data we can design a network for a SME as show on Figures 4.2-4.7.

4.11 Cost Calculation for Additional Equipment

Since we designed the network base on Distributed Process System, we can make use of an existing computer to be the client computer of the new network. We need to estimate the cost of physical lining and addition equipment as below:

1 Labor and material cost for

UTP cable 10 base-5 (10 Mbps line) is 1,500 Bahts per point.

UTP cable 10 base-TX (100 Mbps line) is 2,000 Bahts per point.

2 Hup 10 Mbps.

12 Port is 15,000 Bahts. (Includes installation and configuration)

24 Port is 24,000 Bahts. (Includes installation and configuration)

3 Hup 10/100 Mbps.

12 Port is 32,000 Bahts. (Includes installation and configuration)

24 Port is 36,000 Bahts. (Includes installation and configuration)

4 Fast Ethernet Switch 10/100 Mbps.

12 Port is 52,000 Bahts. (Includes installation and configuration)

5 File Server estimated 120,000 Bahts.

6 Modem 56 Kbps estimated 12,000 Bahts.

There are additional physical link and Equipment on each department as follows

Production Department

19 connecting point of UTP 10 base-5 are 19x1,500 = 28,500 Bahts.

2 connecting point of UTP 10 base-TX are 2x2,000 = 4,000 Bahts.

1 Hup 10/100 Mbps, 24 Port is 36,000 Bahts.

Total cost 68,500 Bahts.

Administration Department

17 connecting point of UTP 10 base-5 are 17x1,500 = 25,500 Bahts.

1 Hup 10 Mbps, 24 Port is 24,000 Bahts.

Total cost 49,500 Bahts.

Accounting Department

4 connecting point of UTP 10 base-5 are 4x1,500 = 6,000 Bahts.

3 connecting point of UTP 10 base-TX are 3x2,000 = 6,000 Bahts.

1 Hup 10/100 Mbps, 12 Port is 32000 Bahts.

Total cost 44,000 Bahts.

Sales Department

7 connecting point of UTP 10 base-5 are 7x1,500 = 10,500 Bahts.

1 Hup 10 Mbps, 12 Port is 15,000 Bahts.

Total cost 25,500 Bahts.

Warehouse Department

6 connecting point of UTP 10 base-5 are 6x1,500 = 9,000 Bahts.

1 Hup 10 Mbps, 12 Port is 15,000 Bahts.

Total cost 24,000 Bahts.

Organization Network

3 connecting point of UTP 10 base-TX are 4x2,000 =8,000 Bahts.

4 File Servers are 4x120,000 =480,000 Bahts.

1 Fast Ethernet switch is 52,000 Bahts.

1 Modem 56 Kbps is 12,000 Bahts.

Total cost 552,000 Bahts.

Cost of Additional Equipment

Production Department is 68,500 Bahts.

Administration Department is 49,500 Bahts.

Accounting Department is 44,000 Bahts.

Sales Department is 25,500 Bahts.

Warehouse Department is 24,000 Bahts.

Organization network is 552,000 Bahts.

Total cost is 763,500 Bahts for physical link and additional equipment.

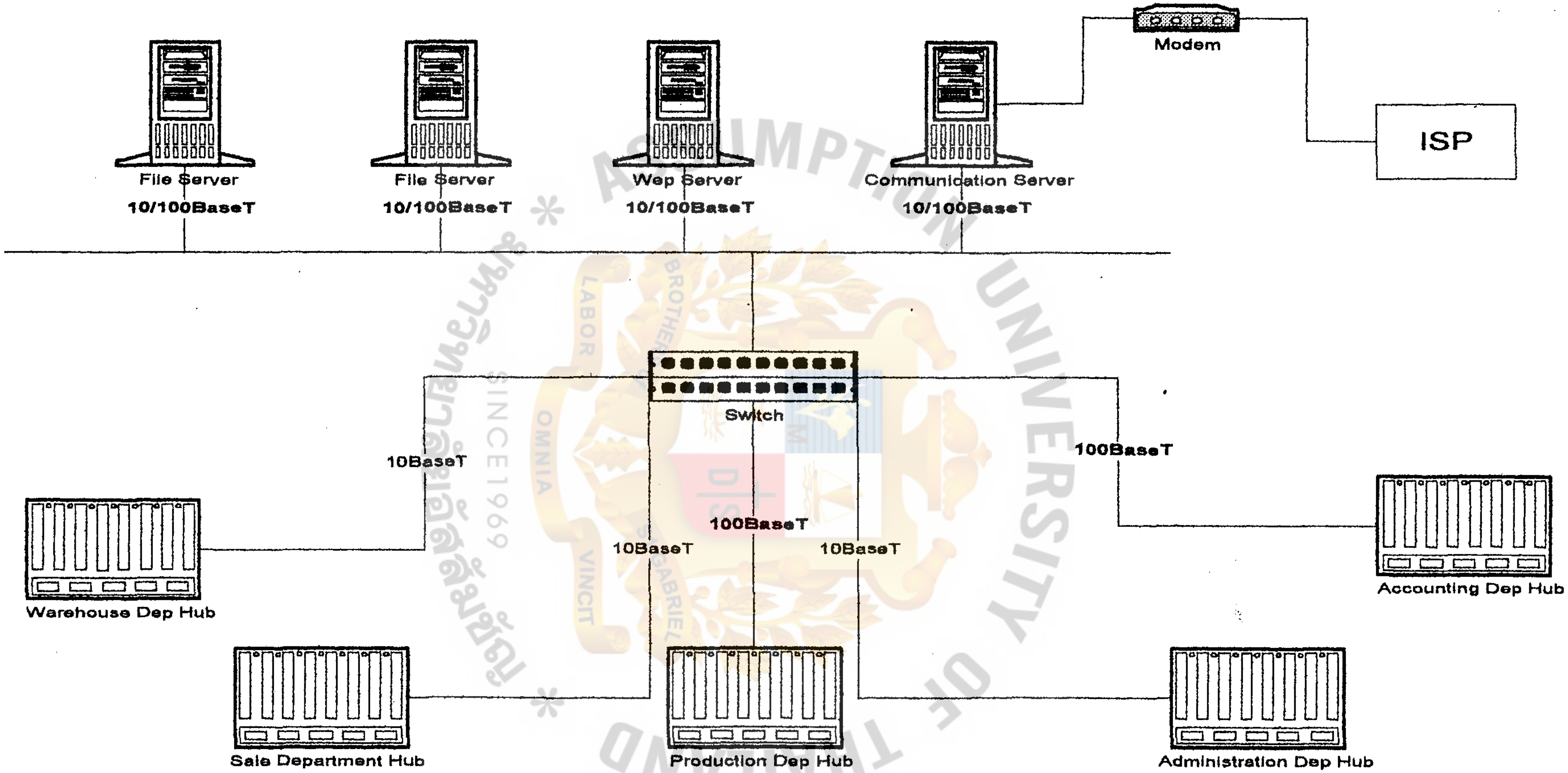

Figure 4.2. Enterprise Network.

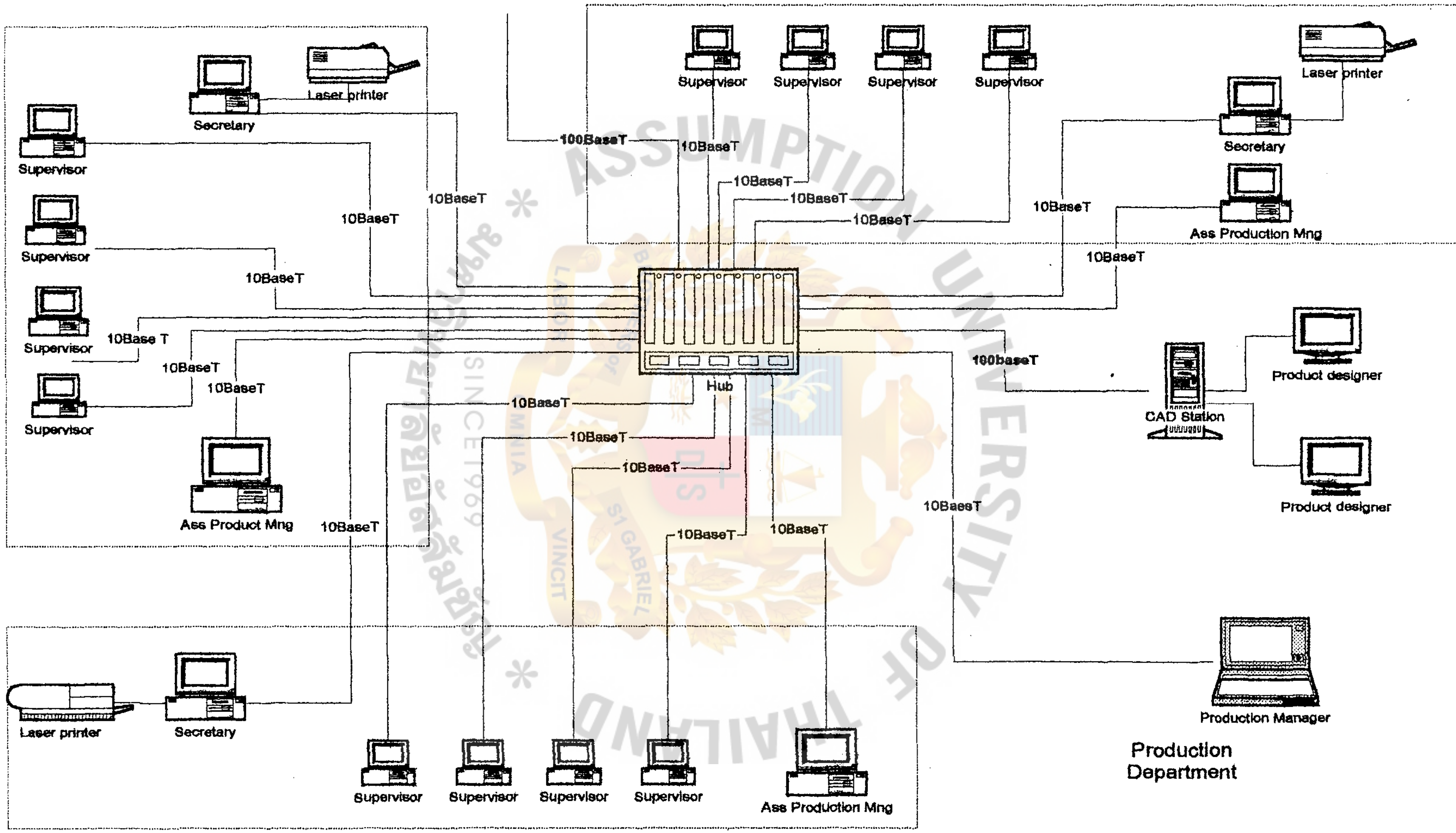

Figure 4.3. Production Department.

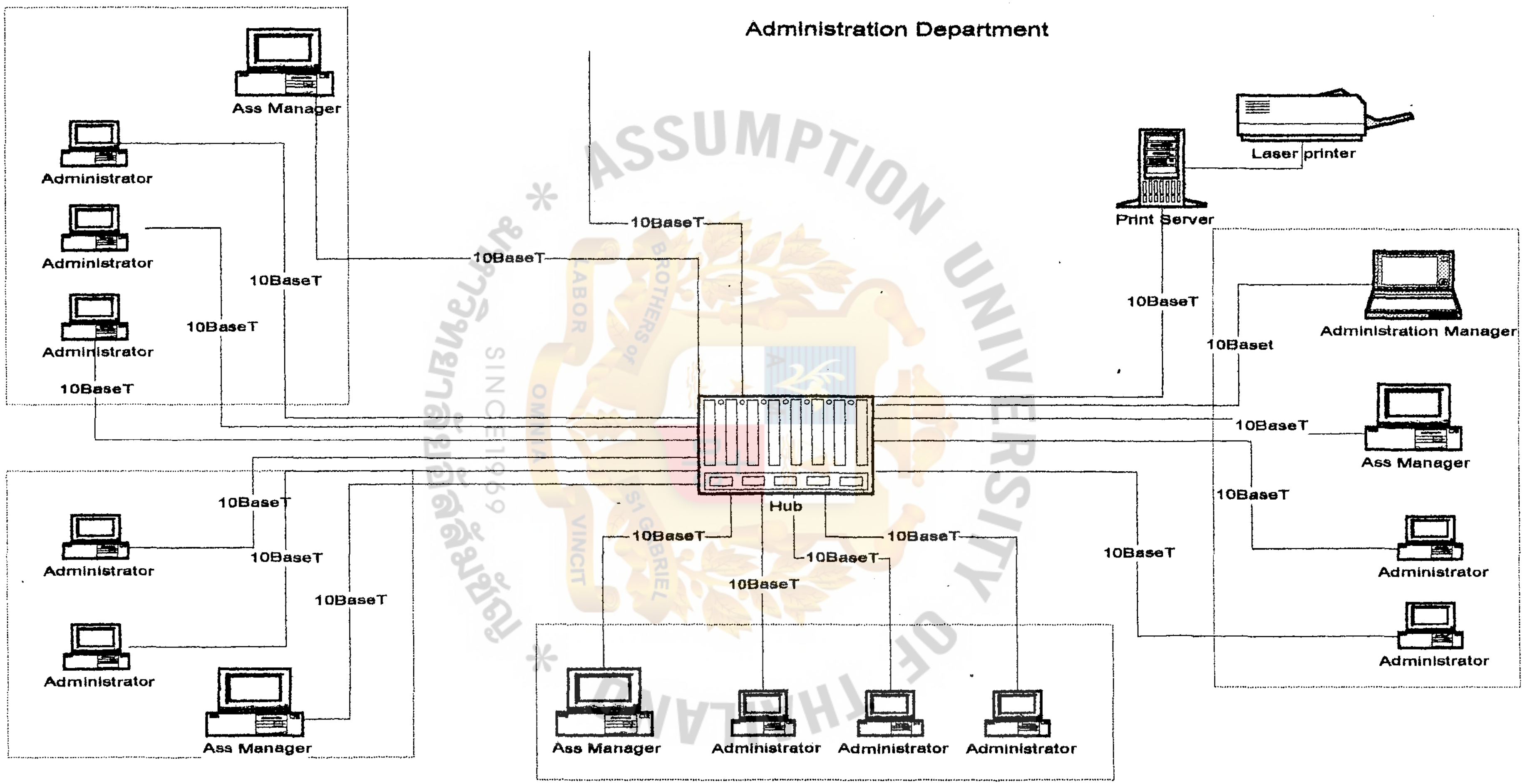

Figure 4.4. Administration Department.

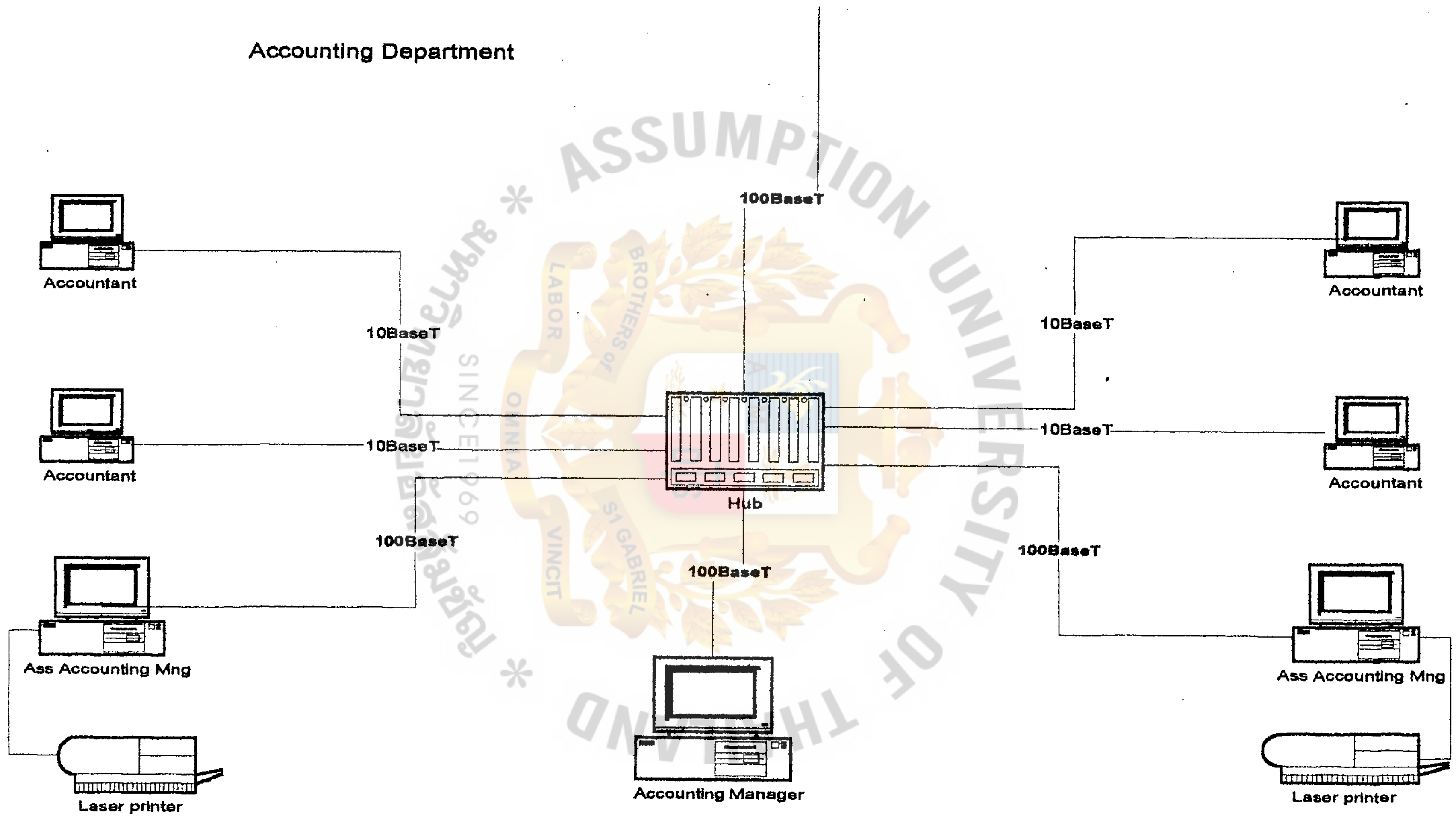

Figure 4.5. Accounting Department.

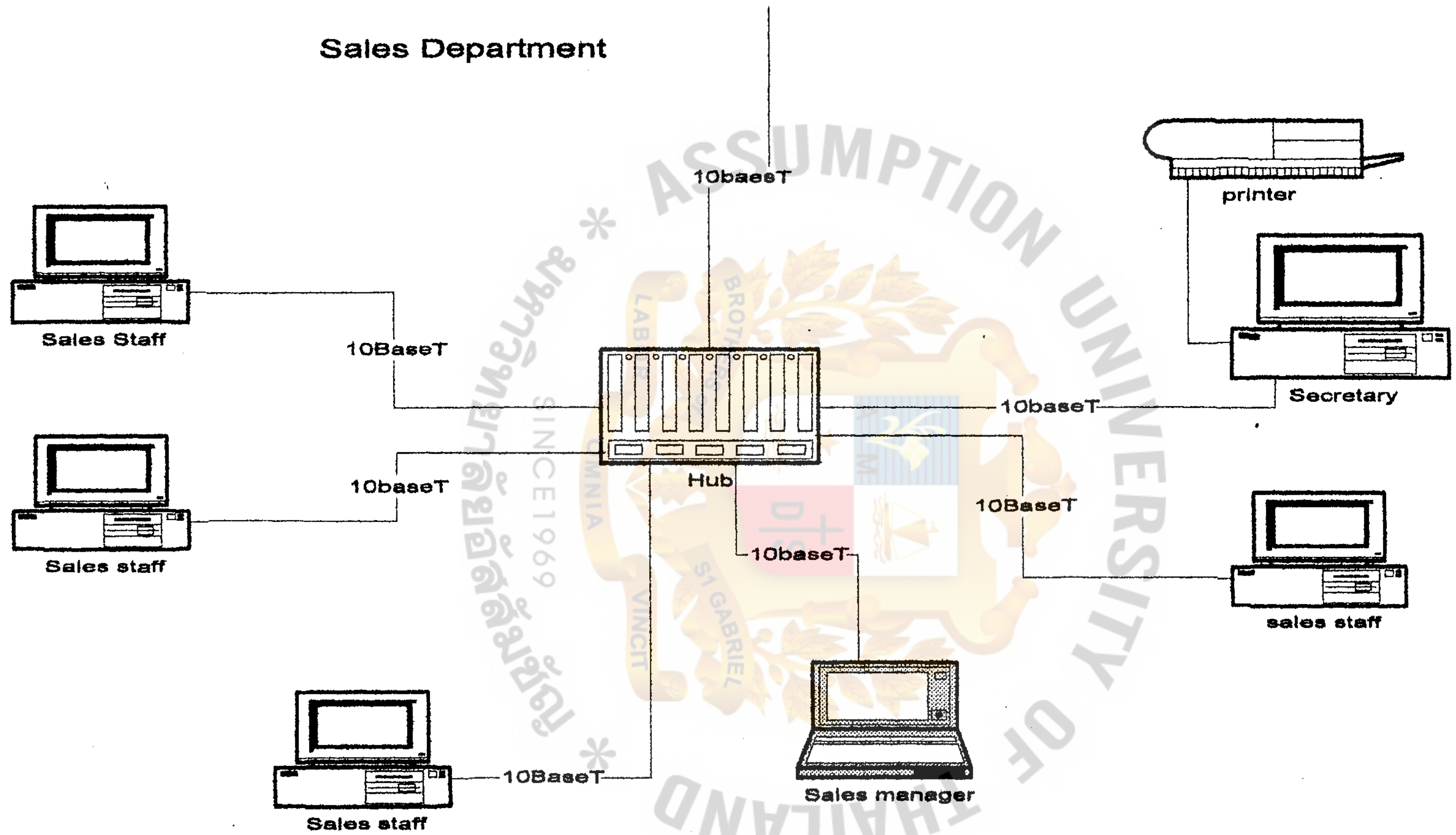

Figure 4.6. Sales Department.

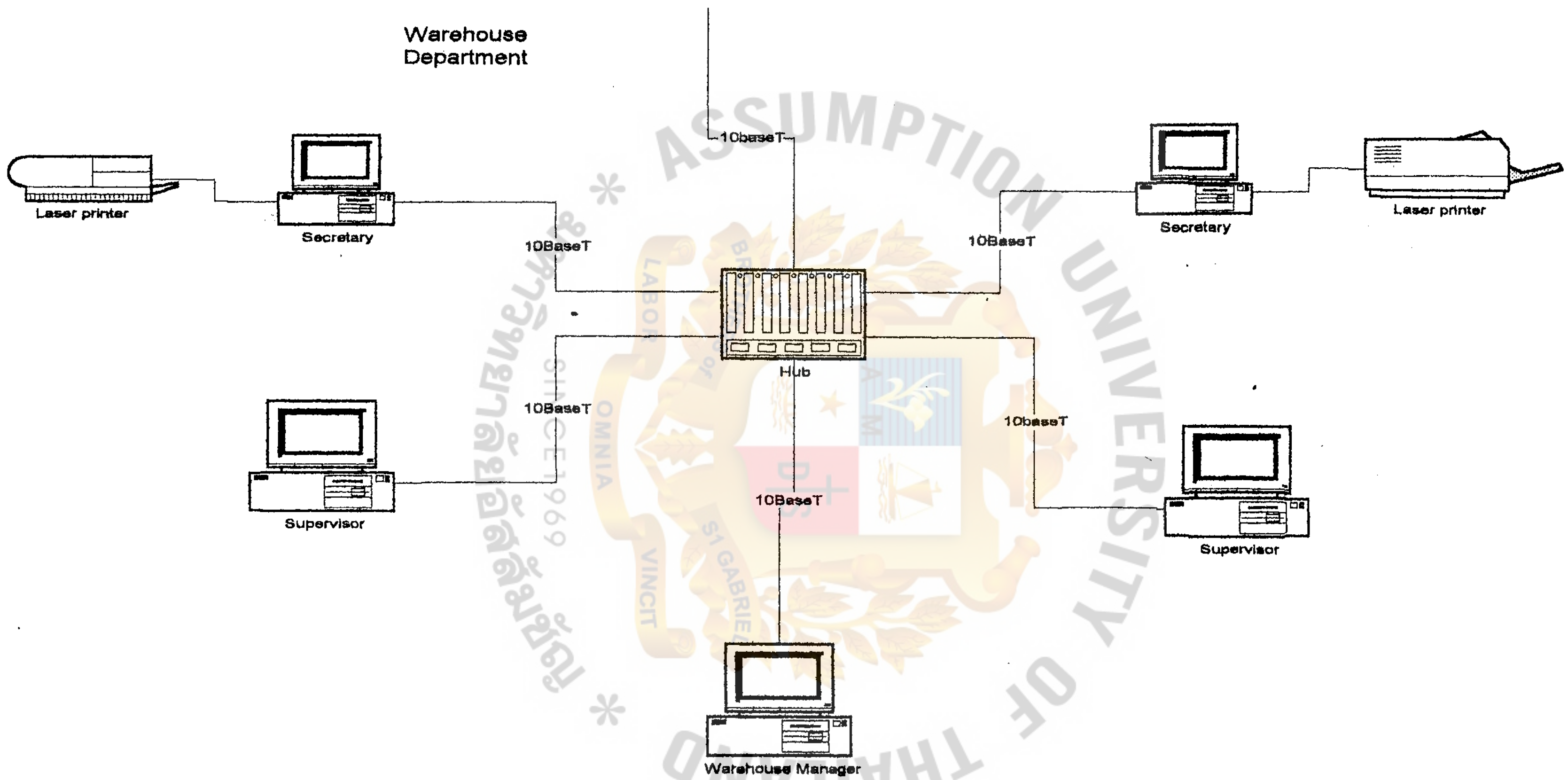

Figure 4.7. Warehouse Department.

V. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Small and Medium Enterprises (SMEs) are very important to Thailand economy. They play an important role in Thailand economic recovery. According to a survey of Thai Supporting Industrial Agency, there were 124,771 registered SMEs in Thailand. This number is equivalent to 97.90 percent of total industry. SMEs employ 1.6 million employees, which is 50.40 percent of aggregate employment.

Small and Medium Enterprises need to compete with the world market in the near future. They need to change their management style in marketing management and financial management. They must also make use of their information system, which is the most important part.

There are many benefits of computer networking to SMEs. It will help SMEs to cope with their problems. Computer networking will help SMEs to:

(1) Be able to access enterprise information system

(2) Be able to handle system security

(3) Share access to information

(4) Save money on hardware

(5) Overcome the problem of distance

(6) Enhance communication between people

(7) Improve efficiency

(8) Access a huge pool of information in the Internet

(9) Reach new customers

The most suitable network topology for SMEs is the Star network because it is robust, is easy to expand, is easy to troubleshoot and has inexpensive hardware.

In the planning stage of SMEs computer network, there are two major types of network designed: Distributed Processing Architecture, Network Centric Architecture. This project designed a network by using Distributed Processing Architecture because it can link the existing computer to the company network, requires less additional hardware and has open technology.

The computer network for Industrial SMEs is designed based on categorizing users into 4 group, which are process workers, production knowledge workers, technical knowledge workers and management workers.

After the average traffic of each group of users is computed, the computer network is designed as in Figures 4.2-4.7.

5.2 Recommendations

There are many ways to design the computer network for SMEs. This project focuses on capacity planning. However, in the organizations that have an existing computer network, a baselining stage is needed. It will help to survey the existing network and information flow before going to the capacity planning stage.

The goal of baselining is to produce an accurate understanding of the network as it currently exists. Baselining is the process of documenting the current network in order to understand what is available and how it is typically being used. This includes an accurate rendering (topology map) and characterization of the network infrastructure, as well as many snapshots of network activity or traffic flow.

In the case that each department is located far away from the others, the long distance connection with UTP cable, the data transferring is interfered by the other's magnetic field. The other end will receive a weak signal or no signal, so it will take a lot of time to collect the data.

We can solve this problem by installing a repeater or modem between the lines depending on the connecting distance.

If the distance is between 30-50 meters, we have to use a repeater between the line. See Figure 5.1.

Figure 5.1. Connecting Network with Repeater.

If the distance is over 100 meters, we should use a modem with TOT line. The speed of data transfer will drop to modem capacity. See Figure 5.2.

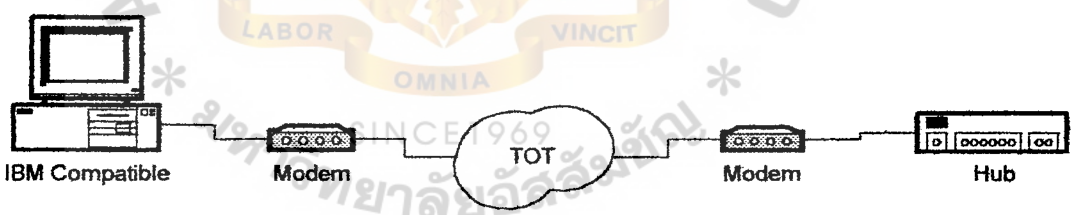

Figure 5.2. Connecting Network with Modem.

In the case that one department located over 100 meters from the others, but we require high speed for data transfer, we have to connect it with a leased line. The leased line can serve a higher speed of data transfer than the normal TOT line. It also requires a higher cost. See Figure 5.3.

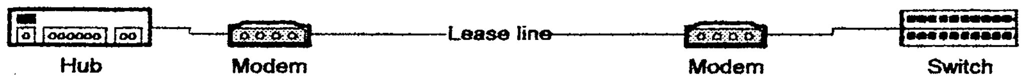

Figure 5.3. Connecting Network with Leased Line.

In the future, the network is expanded to serve the organization. The data transfers rate is high. The existing backbone cannot serve the organization. We need to make use of an alternative backbone to connect all departments together. This backbone can be FDDI or Fiber Optic using line modem. The configuration can look like below Figure 5.4.

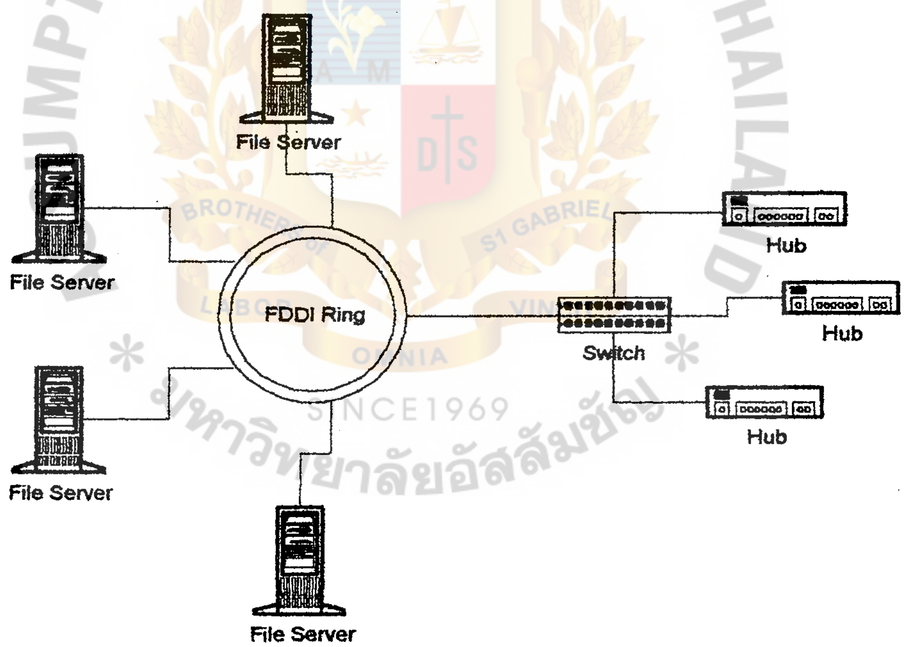

Figure 5.4. FDDI Backbone Network.

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