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رسالـــة الماجستير

تصميم شبكة معلومات داخلية لربط المراكز الإدارية في شعبية سرت

(المنهجيــــة و التطبيـــق)

إعداد: عبد السلام المزوغي عبد السلام مسعود

لجنة المناقشة

المشرف: أ.د. موسى محمد موسى — التوقيع ....

الممتحن الخارجي: أ.د. عبدالقادر الصادق عكي — التوقيع ....

الممتحن الداخلي: د. الهادي محمد الشاوش — التوقيع ....

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Dedication

With my highest personal regards

To

My parents, and

My family

Who encouraged me and whose help was invaluable to carry out this study

Acknowledgements

My gratitude goes to AL-Thadi University for providing me with the opportunity and the means to study here. I specially thank Prof. Dr. Mousa M. Mousa who without his supervision and guidance this project would not have been carried out. My deepest thanks and appreciation goes to all my tutors at AL-Tahadi University for their academic advice, help and support. I also wish to offer my sincere thanks to all who volunteered and helped me to complete this study, especially the technicians in the GPTC sirte branch. To all of my friends who have supported me through out my study. And finally gratitude and love goes to my family, without their inspiration and constant support I would not have managed to do this research.

Abstract:

Network technologies are classified into one of three categories depending on the size of the network; a Local Area Network , a Metropolitan Area Network, and a Wide Area Network.

One way to estimate the bandwidth requirements in a data communications network is to identify how the users are currently performing their work. Important details that should be collected for each and every group of users that will use a new WAN are; The type and transmission rate of each node, The number of connected users, number of connected hosts, Unsecured means of ingress, Routed protocols, The number of connected routers and the routing protocols, Internet addressing schemes.

The Factors to consider in selecting a WAN depend on establishing a criteria development of selecting the right WAN.

In this work position determination of all locations on geographical maps of sirte city requires using AUTOCAD program, where each node requires to have voice. text and video. type services, then to produce node grouping and final nodes. Next, analysis of all data in order to design an optimum network using MATLAB program. Final traffic of final nodes, is calculated. Erlangs to VOIP Bandwidth Calculator software, is also used as a Quick tool to find data traffic.

As. result of this research, we obtained an information network that connect all locations of the city to use most of GPTC paths, and to add some paths, by proposing proper transmissions media to give a sufficient reliability.

Finally to conclude this work; as this is a practical type WAN, the implemented methodology is recommended for other similar works.

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إشراف : أ. د. موسى محمد موسى

ملخص:

تصنف تقنية شبكات الاتصالات حسب حجم الشبكة إلى واحدة من الأصناف الثلاثة وهي ؛ شبكة محلية وشبكة منطقة حضرية و شبكة واسعة النطاق .

إحدى الطرق لتقدير سعة الإرسال في شبكة اتصال البيانات، يتم بتحديد العدد الحالي للمستعملين , وكذلك التفاصيل المهمة التي يجب أن تجمع مجموعة المستعملين الذين سيستعملون الشبكة واسعة النطاق الجديدة . وهي نوع وسعة الإرسال في كل عقدة ، وعدد المستعملين المرتبطين ، وعدد الحواسيب المرتبطة بالشبكة، ووسائل غير مضمونة الدخول ، ومسار البرتوكولات ، وعدد المسارات المرتبطة ، وبرتوكولات التوجيه ، ومخططات عناوين الانترنت .

وتعتمد الاعتبارات في اختيار الشبكة واسعة النطاق على تأسيس تطوير معايير أختيار الشبكة الصحيحة.

في هذا التصميم يتم تحديد كل المواقع على الخريطة الجغرافية لمدينة سرت بمساعدة برنامج أوتوكاد ، ثم تحدد نوع الخدمات في كل موقع أي هاتف وفاكس وفيديو , بالتالي يتم جمع كل المجموعات المتجاورة لاستخراج كل العقد النهائية ، بعد ذلك يتم تحليل كل البيانات لإيجاد تصميم شبكة مثالية بمساعدة برنامج MATLAB. ، وعلى هذا الأساس يتم حساب الحركة النهائية للعقد النهائية باستخدام برنامج حساب الحركة الرقمية مقابل السعة بالايرلنج .

وكنتيجة من البحث .. يتم الحصول على شبكة معلومات تربط كل الم‍ـ‍ـ‍ـع بالمدينة ، تستخدم معظم مسارات الشبكة العامة للبريد والاتصالات, باقتراح معدات إرسال مناسبة ، مع إضافة بعض المسارات لإعطاء موثوقية كافية.

أخيراً ... نستنتج من هذا البحث شبكة واسعة النطاق عملية وسهلة التطبيق ، ونوصي بتطبيقها في أعمال مشابهة.

Abbreviations

ADSL	Asymmetric Digital Subscriber Line
ADPCM	Adaptive Differential pulse code modulation
ATM	Asynchronous Transfer Mode
ASCII	American Standard Code for Information Interchange
AVVID	Architecture for Voice, Video, and Integrated Data
CCS	Centum Call Seconds
CIR	Committed Information Rate
cRTP	Compression Real-time Transport Protocol
DCE	Data Communication Equipment
DLCIs	Data Link Connection Identifiers
DSP	Digital Signal Processor
DPCM	Differential pulse code modulation
DTE	Data Terminal Equipment
E	Erlangs
EBCDIC	Extended Binary Coded Decimal Interchange Code
EIA/TIA-232	Electronic Industries Association / Telecommunications Industry Association
FDDI	Fiber Distributed Data interface
FNs	Final nodes
GOS	Grade Of Service
GPTC	General Post and Telecommunications Company
HDSL	High Digital Subscriber Line
JPEG	Joint photograph Experts
IGRP	Interior Gateway Routing Protocol
ISDN	Integrated Services Digital Network
ISO	International Organization Standardization
ISPs	Internet Service Providers
ITU-T	International Telecommunication Union Telecommunication
IP	Intelligent Peripheral
IPX	Internetwork Packet Exchange
LAN	Local area network
LAPB	Link Access Protocol Balanced
MAC	Medium access control
MAN	Metropolitan Area Network
MPEG	Moving Picture Experts
OSI	Open Systems Interconnection
OSPF	Open Shortest Path First
PABX	Private Automatic Branch Exchange
PBX	Private Branch Exchange

PCM	pulse code modulation
PSTN	Public Switched Telecommunications Network
PPP	Point-to-Point Protocol
PVCs	permanent virtual circuits
RIP	Routing Information Protocol
RTP	Real-time Transport Protocol
SNA	System Network Architecture
SDLC	Synchronous Data Link Control
SMDS	Switched Multimegabit Data Services
TCP	Transmission Control Protocol
UDP	User Datagram Protocol
VAD	Voice Activity Detection
VOATM	Voice over ATM
VOFR	Voice over Frame Relay
VOIP	Voice over IP
VPN	Virtual Private Network
WAN	Wide Area Network
WLAN	Wireless LAN

Table of contents

Pages

List of Figures

List of Tables

Title Pages

Chapter I

Introduction

1 Back ground

A network technology is classified into one of three categories, depending on the size of the network.[8] A Local Area Network (LAN) spans a single building or campus. A Metropolitan Area Network (MAN) spans a single city and A Wide Area Network (WAN) spans multiple cities, countries, or continents. The key issue that separates WAN technologies from LAN technologies is scalability - a WAN must be able to grow to connect sites that may be many thousands of kilometers apart. In addition, a WAN must provide sufficient capacity to allow computers to communicate simultaneously. A WAN is a data communications network that covers a relatively broad geographic area and often uses transmission facilities provided by common carriers, such as telephone companies.[8]

One way to estimate the bandwidth requirements in a data communications network is to identify how the users are currently performing their work; they should be monitored to determine the following for each site. Type of communications session (for example, bulk data transfer, online transaction processing, Web access, videoconferencing, and so on): Frequency of use with the monitored period, Peak utilization times; Peak utilization traffic volumes; average duration of each session, Average number of bytes transmitted per session, and frequently accessed destinations by each user group. The above will help in estimating traffic: its peak and can set required performance under load.

Important details that should be collected for each and every group of users that will use a new WAN [17] are; The type and transmission rate of each node. The number of connected users, number of connected hosts, Unsecured means of ingress, Routed protocols, The number of connected routers and the routing protocols, Internet addressing schemes.

The Factors to consider in selecting a WAN depend on establishing a Criteria Development OF Selecting the Right WAN. This criteria will guide selection of network technologies, determine the proper size of transmission facilities, and drive the topographical arrangement of the WAN. We can then consider the two primary aspects of wide area networking: ***technology*** and ***topology***.

Motive of WAN intra sirte city

Usually Intra –city network combines software: hardware of network infrastructure into an essential tool for network-city success. Resource *(Information, Hardware and software)* sharing, Information Accuracy, Reliable and low cost Telephony (VOIP).Procedural administration and technical information that are used to be written on paper can become part of the network. Communications that used to be verbal can be done through E-mail. This ensures information accuracy, and ease of E-mail use, that can be sent, and use to IP Telephony, that is VOIP which is a reliable, and inexpensive phone service.

Many networking researches use the dumbbell (single bottleneck) scenario to perform their simulations. Simulation may be the fastest way to implement these ideas because various conditions, such as link bandwidth, loss probability, and queuing delay (delay jitter) can be easily specified. However, simulations are often too simplified and ignore some details that may influence the results. Some well-known algorithms, such as TCP congestion control algorithms, has a lot of implementations, deployed at various operating systems, and has some different assumptions from the original versions, which is implemented in simulators. However we have no efficient way verifying their effectiveness against their original simulation results. After all, the purpose of networking researches is to deploy their ideas. We thus need to develop an efficient/cheap/realistic tool to make things easier. Some companies may also find using this tool useful for developing their products.

However the tasks of elements of the technology, elements of the topologies, and details of transmission requirement, their protocols, etc which need to be interacted and integrated form a case of non-linear problem when it comes to a real situation. This again makes the topic of intra city data network design case study a potential of the intended work to accomplish.

Now all administrations, university, hospital, airport and broadcasting station, etc. have and used the computer all today but all these locations doesn't have a network to inter-connect offices. The majority of locations that are connected with GPTC, have a number of telephones and faxes, and they use mailmen and cars to distribute letters and text information.

We can benefit from a WAN in sirte because in this network, sharing of resources can be done easily. Resources are applications programs(such as word processing packages), data, printers, modems, etc. In a LAN environment, instead of needing to install a word processing package on each and every location , we need only to install it once on a file server. This makes the package available to all. Similarly, instead of buying each computer a low-cost printer, we can buy a few high-speed, high-quality printers that are accessible to all. Networks also provide reliability with multiple computers beneficiary, if one goes down, we still have many others to fall back on. In the past, all data had to be accessed through a mainframe computer located in one data center. This created a phenomena called a " bottleneck," like water rushing through a neck of a bottle when being emptied. Similarly , the data center bottleneck also congested all the jobs that had to be processed through it. Today, processing can be distributed over a network. Jobs can run at several locations and do not depend on the performance of a single location. If one host is down. jobs can be redirected to others. Network today give local departments more, that is to say in specifying what is important and what is not. They know more about local issues than corporate headquarters which may be kilometers away.

3 Previous Work.

To connect computers or LANs spread over a large geographical area is now the order of the day. These wide area networks (WANs) may be private networks connecting corporate offices spread across the country or the globe, or they may be public networks offering data services to the public.

X.25 is used extensively in satellite-based wide area networks. The typical architecture of the network is shown in Figure 1.1. At the satellite hub, there will be a packet switch (DCE) to which an X.25 host is connected. [4]

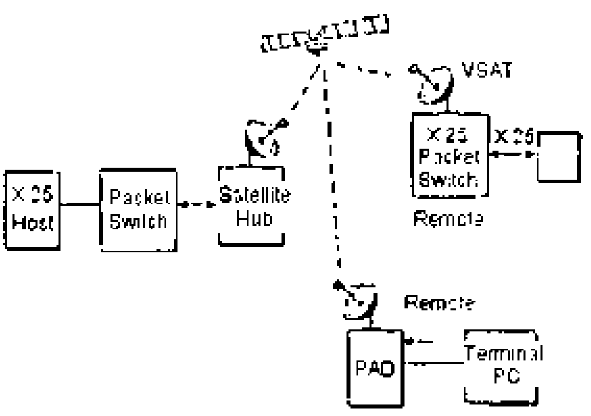


Figure 1.1: Satellite-based X.25 wide area network.

Designing Campus Networks[1]

A *campus* is a building or group of buildings all connected into one enterprise network that consists of many local area networks (LANs). A campus is generally a portion of a company (or the whole company) constrained to a fixed geographic area, as shown in Figure 1.2.

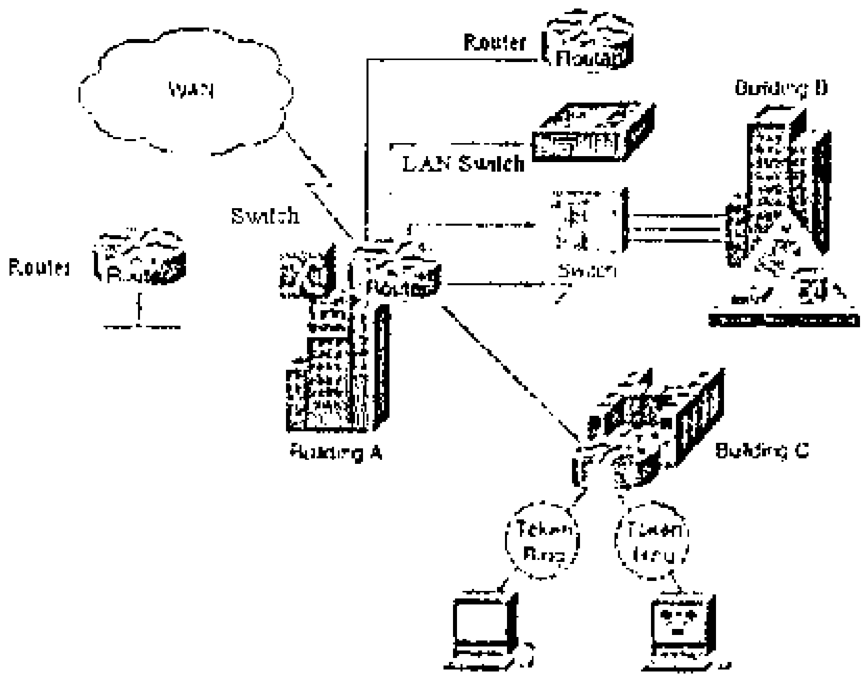


Figure 1.2: Example of a campus network.

The distinct characteristics of a campus environment is that the company that owns the campus network usually owns the physical wires deployed in the campus. The campus network topology is primarily LAN technology connecting all the end systems within the building. Campus networks generally use LAN technologies, such as Ethernet. Token Ring, Fiber Distributed Data Interface (FDDI), Fast Ethernet, Gigabit Ethernet, and Asynchronous Transfer Mode (ATM).

In the past, network designers had only a limited number of hardware options-routers or hubs---when purchasing a technology for their campus networks. Consequently, it was rare to make a hardware design mistake. Hubs for wiring closets and routers were for the data center or main telecommunications operations. Recently, local-area networking has been revolutionized by the exploding use of LAN switching at Layer 2 (the data link layer) to increase performance and to provide more bandwidth to meet new data networking applications. LAN switches provide this performance benefit by increasing bandwidth and throughput for workgroups and local servers. Network designers are deploying LAN switches out toward the network's edge in wiring closets. As Figure 1.3 shows, these switches are usually installed to replace shared concentrator hubs and give higher bandwidth connections to the end user.

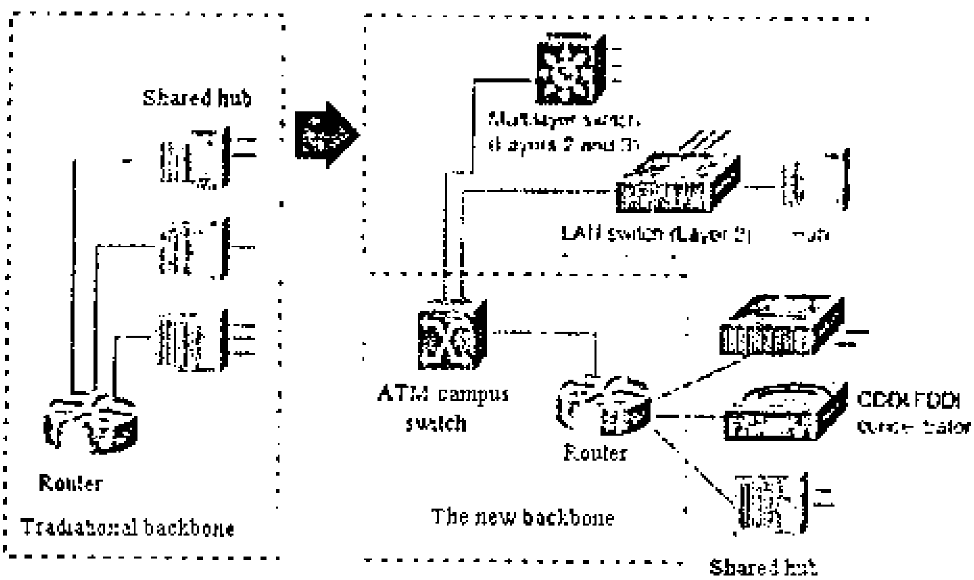


Figure 1.3: Example of trends in campus design.

Trends in WAN Design[1]

Traditionally, WAN communication has been characterized by relatively low throughput, high delay, and high error rates. WAN connections are mostly characterized by the cost of renting media (wire) from a service provider to connect two or more campuses together. Because the WAN infrastructure is often rented from a service provider, WAN network designs must optimize the cost of bandwidth and bandwidth efficiency. For example, all technologies and features used to connect campuses over a WAN are developed to meet the following design requirements: Optimize WAN bandwidth, Minimize the tariff cost and Maximize the effective service to the end users.

Recently, traditional shared-media networks are being overtaxed because of the following new network: Necessity to connect to remote sites. Growing need for users to have remote access to their networks. Explosive growth of the corporate intranets. Increased use of enterprise servers.

The trend in internetworking is to provide network designers greater flexibility in solving multiple internetworking problems without creating multiple networks or writing off existing data communication investments.

Leased Lines and WANs[5]

An enterprise consisting of multiple offices in an area usually needs continuous information access among sites. For this purpose a public network operator leases cable pairs or optical fibers for the connection between offices (see Figure 1.4). This is often the most economical way to interconnect LANs when the distance is of the order of a few kilometers. The line terminals shown in Figure 1.4 may be HDSL terminals for copper cable or optical terminals for optical fiber depending on the required data rate and distance. In the case of a long-distance connection. it is not economically feasible for each customer to build its own dedicated physical connection. This would require repeaters and separate cable pairs or fibers throughout the country. Instead the required end-to-end transmission capacity is leased from the core network of the long-distance network opera.`r. For long-distance connections the operator uses the same high-capacity optical transmission systems that are used for the interconnections of public exchanges in the network (see Figure 1.4).

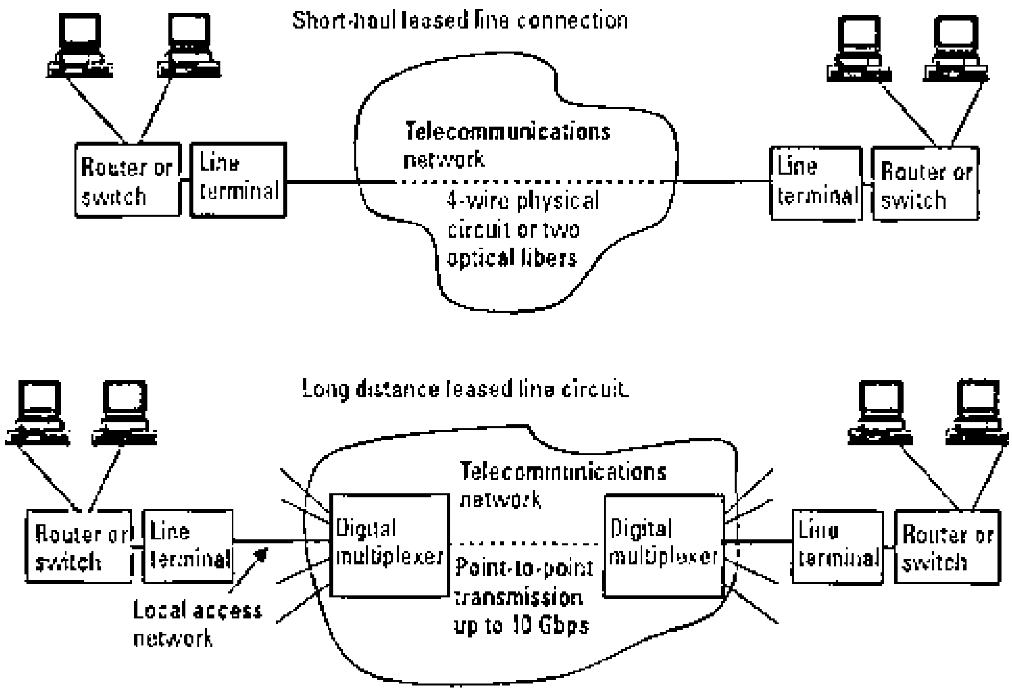


Figure 1.4 Regional and long-distance leased lines.

4 Objective of this work

To design a Wide Area Network to inter connect an intra city defined terminals through finding the optimum topology and suitable scalable configuration for the current nodes whose generated traffic depends on voice, data and video, and to introduce a network algorithm to select proper transmission media to transport this traffic by selecting a suitable routing mechanism.

5 Design approach

To meet and carry out the objective, of this work. As the area of concern exceeds the limit of one LAN, and definitely it will form a WAN. In addition there are various functions of concern of the different locations, and also variety of service are to be provided. So using known existing approaches will not implicate a proper solution to obtain. Therefore, the adopted approach takes into consideration the specific nature of the area, and is given in the following steps:-

a. To call the locations that are near and can form a LAN. This LAN is called a Final node.
b. The formed groups are to be inter connected , and for this task minimum distance is to be adopted.
c. The existing GPTC local telephone cable network is to be studied and the formed groups are to be checked in their connections against GPTC suitable lines.
d. The remaining uncovered group centers by GPTC lines are to be served by a suitable digital transmission media.
e. The capacity of each link whether existing or new will be studied through a detailed traffic calculation for both voice and data, and then to add video services as well.
f. The resulted WAN network will be a mix of GPTC lines and new links to be established; in addition the formed configuration has to guarantee the targeted reliability.

Scope of work

This research work is divided into 5-phases, as shown in figure 1.5

a. **Phase 0:** preparation, data collection and literature review.

To collect references that are related to the network from library and internet, and obtain Sirte maps that have each administration location in the city and GPTC maps that have paths that connect all sites with GPTC and define type of switches (analog switch, digital switch) and internet technique (dial up . ADSL).

b. **Phase 1:** Node design to calculate amount of data at each node.

To number all locations(nodes) in the network by giving each administration a reference number, and reduce the numbers by considering all positions that are near by and can form LAN: next is to give a new number of a final node, and to continue the process for all remaining locations, to obtain data by a questionnaire to employees of each administration and also GPTC technicians.

c. **Phase 2:** Network dimensioning and Optimum configuration.

To measure the distance between final nodes, to produce distance matrix, to divide all final nodes into groups and to connect them together depending on the relation in chapter 6; then to analyise the groups to produce optimum network.

d. **Phase 3:** Transmission media selection and possible optimization.

To utilize the GPTC media by using new technique, and if the path is not covered by GPTC network, we can propose a proper transmission media.

e. **Phase 4:** To put the work in its final form, and complete the writing of the thesis.

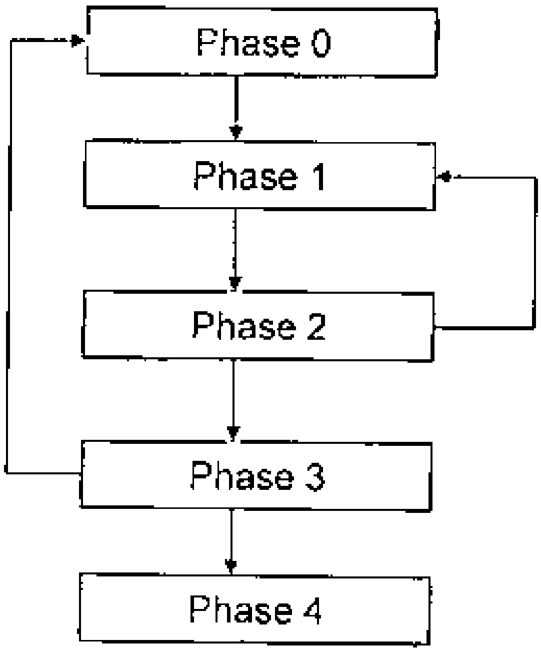


Figure 1.5 Flowchart of scope of work

Chapter's Description

In the Second chapter a study is performed on the Characteristics and Topologies of data Network that represent categories of Networks and Computer communication network architecture and the types of network and their hardware, to gether with , 'AN selection of technologies and topologies. In the Third chapter studying of Switching that represent point-to-point links, Circuit Switching and Packet Switching is presented. Introduction of Integration Technologies of Standards Technology of voice and data, Multiservice Access Technologies. Voice Over IP and Coding of Text. Voice. Image. and Video Signals are introduced. and studying the Transmission Media of Guided

Transmission Media and Wireless Transmission is studied. Chapter Four is a Study of the methods calculations of voice Traffic, data traffic and video traffic.

Input Data of Sirte Shabia is in the Fifth chapter and also gives some information for Sirte City, and collect all names of localities for the whole city and represented by nodes and manipulation in the nodes to produce the final nodes of sirte city.

In chapter Six: generation of Groups, and their analysis to produce optimum Configuration, and to collect data in each location for Traffic calculations in each path.

The Conclusion, and some Recommendations are given in the Seventh chapter.

Chapter II

Data Network Characteristics and Topologies

1 Data Network

2.1.1 What is network?

A computer communication network [10] is a collection of applications hosted on different machines and interconnected by an infrastructure that provides communications among the communicating entities. While the applications are generally understood to be computer programs, the generic model includes the human being as an application. In fact, one or all of the "applications" that are communicating may be human beings.

2.1.2 Types of Networks

We can divide telecommunications networks into categories in many different ways. If we consider the customers of networks and the availability of services, there are two broad categories: public networks and private or dedicated networks.

2.1.2.1 Public Networks

Public networks are owned and managed by telecommunications network operators These network operators have a license to provide telecommunications services and that is usually their core business. Any customer can be connected to the public telecommunications network if he has the correct equipment and an agreement with the network operator.

2.1.2.2 Telephone Network

The PSTN is the main public network in use. Sometimes we refer its service to as POTS if we want to distinguish ordinary fixed telephone service from other services provided by telecommunications networks today. In addition to voice communications between fixed telephones, data can be substituted for speech with the help of a voice-band modem. ISDN, introduced later, is considered the next evolutionary step after PSTN.

2.1.2.3 Mobile Telephone Networks

Mobile or cellular telephone systems provide radio communications over the local access part of the network. They are regional or national access networks and connected to the PSTN for long-distance and international connections.

2.1.2.4 Telex Network

This is a telegraph network that allows teleprinters to be connected by means of special dedicated switches. The bit rate of telex is very slow. 50 or 75 bps, which makes it robust. It was once widely used but its importance has been reduced as other messaging systems such as electronic mail and facsimile have reduced its market share.

2.1.2.5 Paging Networks

Paging networks are unidirectional only. Pagers are low-cost, lightweight wireless communication systems for contacting customers without the use of voice. Simple pagers just say "beep," but sophisticated pagers can receive large amounts of text and display the e-mail message on a screen. The importance of paging systems has been reduced in countries where penetration of cellular systems. providing text-messaging service, is high.

2.1.2.6 Private or Dedicated Networks

Private networks are built and designed to serve the needs of particular organizations. They usually own and maintain the networks themselves.

Services provided are a tailored mix of voice. data. and. for example. special control information.

2.1.2.6.1 Data Communication Networks

Data communication networks are dedicated networks especially designed for the transmission of data between the offices of an organization. They can incorporate LANs with mainframe computers feeding information to the branch offices. Banks, hotel chains, and travel agencies, for example, have their own separate data networks to update and distribute credit and reservation information.

2.1.2.6.2 Virtual Private Networks

It is very expensive for an organization to set up and maintain its own private network. Another choice is to lease resources, which are also shared with other users, from a public network operator. This *virtual private network* (VPN) provides a service similar to an ordinary private network, but the systems in the network are the property of the network operator.

In effect, a VPN provides a dedicated network for the customer with the help of public network equipment. As companies concentrate more and more on their core businesses, they are willing to outsource the provision, management, and maintenance of their telecommunications services to a public network operator that has skilled professionals dedicated to telecommunications.

The principle of VPN is used for voice services such as corporate PBX/PABX networks. In this case the network that interconnects the offices of a company uses (voice or 56/64 Kbps) channels from the public network that are leased from a public network operator.

An important application of VPN is intranet use. An intranet is a private data network that uses open Interne· echnology. Physically, an intranet may be made up of many LANs at different sites. To interconnect these LANs, a VPN is established to provide data transmission between sites through the public Internet network.

2.1.3 Computer Communication Network Architecture[4]

The reference model has seven layers, none of which can be bypassed conceptually. In general, a layer is defined by the types of services it provides to its users and the quality of those services. For each layer in the ISO/OSI architecture, the user of a layer is the next layer up in the hierarchy, except for the highest layer for which the user is an application. Clearly, when a layered architecture is implemented under this philosophy, then the quality of service obtained by the end user, the application, is a function of the quality of service provided by all of the layers. Figure 2.1 shows the basic structure of the OSI architecture and how this architecture is envisaged to provide for exchange of information between applications. As shown in the figure, there are seven layers: application, presentation, session, transport, network, data link, and physical.

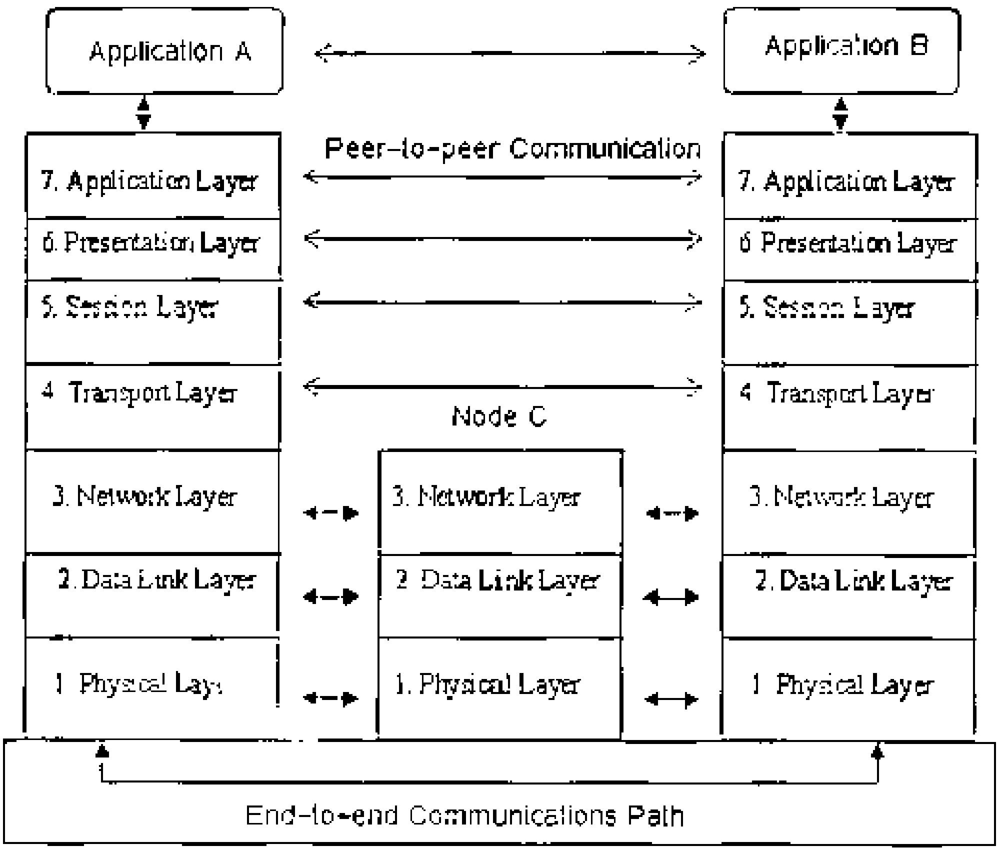


Figure 2.1 Layered architecture for ISO/OSI reference mode

2 Types of Networks and their Hardware

Broadly speaking, there are two types of transmission technology that are in widespread use. They are as follows:

- Broadcast links.
- Point-to-point links.

Broadcast networks have a single communication channel that is shared by all the machines on the network. Short messages, called packets in certain contexts, sent by any machine are received by all the others. An address field within the packet specifies the intended recipient.

Broadcast systems generally also allow the possibility of addressing a packet to all destinations by using a special code in the address field. When a packet with this code is transmitted, it is received and processed by every machine on the network. This mode of operation is called broadcasting.

In contrast, point-to-point networks consist of many connections between individual pairs of machines. To go from the source to the destination, a packet on this type of network may have to first visit one or more intermediate machines. Often multiple routes, of different lengths, are possible, so finding good ones is important in point-to-point networks. As a general rule (although there are many exceptions), smaller, geographically localized networks tend to use broadcasting, whereas larger networks usually are point-to-point. Point-to-point transmission with one sender and one receiver is sometimes called unicasting.

An alternative criterion for classifying networks is their scale. In Figure 2.2,we classify multiple processor systems by their physical size[2]. At the top are the personal area networks, networks that are meant for one person. For example, a wireless network connecting a computer with its mouse, keyboard, and printer is a personal area network. Also, a PDA that controls the user's hearing aid or pacemaker fits in this category. Beyond the personal area networks come longer-range networks. These can be divided into local, metropolitan, and wide area networks. Finally, the connection of two or more networks is called an internetwork.

Interprocessor distance	Processors located in same	Example
1 m	Square meter	Personal area network
10 m	Room	Local area network
100 m	Building	Local area network
1 km	Campus	Local area network
10 km	City	Metropolitan area network
100 km	Country	Wide area network
1000 km	Continent	Wide area network
10,000 km	Planet	The Internet

Figure 2.2 Classification of interconnected processors by scale.

.2.1 Local Area Networks [2, 7]

Local area networks, generally called LANs, are privately-owned networks within a single building or campus of up to a few kilometers in size. They are widely used to connect personal computers and workstations in company offices and factories to share resources (e.g., printers) and exchange information. LANs are distinguished from other kinds of networks by three characteristics: (1) their size, (2) their transmission technology, and (3) their topology.

LANs are restricted in size, which means that the worst-case transmission time is bounded and known in advance. Knowing this bound makes it possible to use certain kinds of designs that would not otherwise be possible. It also simplifies network management.

LANs may use a transmission technology consisting of a cable to which all the machines are attached, like the telephone company party lines once used in rural areas. Traditional LANs run at speeds of 10 Mbps to 100 Mbps, have low delay (microseconds or nanoseconds), and make very few errors. Newer LANs operate at up to 10 Gbps.

LAN topologies define the manner in which network devices are organized. Four common LAN topologies exist: bus, ring, star, and tree. These topologies are logical architectures, but the actual devices need not be physically organized in these configurations. Logical bus and ring topologies, for example, are commonly organized physically as a star[7].

A **bus topology** is a linear LAN architecture in which transmissions from network stations propagate the length of the medium and are received by all other stations. Of the three most widely used LAN implementations, Ethernet/IEEE 802.3 networks including 100BaseT implement a bus topology, which is illustrated in Figure 2.3.

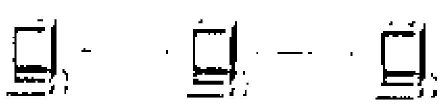


Figure 2.3 Local Bus Topology

A **ring topology** is a LAN architecture that consists of a series of devices connected to one another by unidirectional transmission links to form a single closed loop. Both Token Ring/IEEE 802.5 and FDDI networks implement a ring topology. Figure 2.4 a. depicts a logical ring topology.

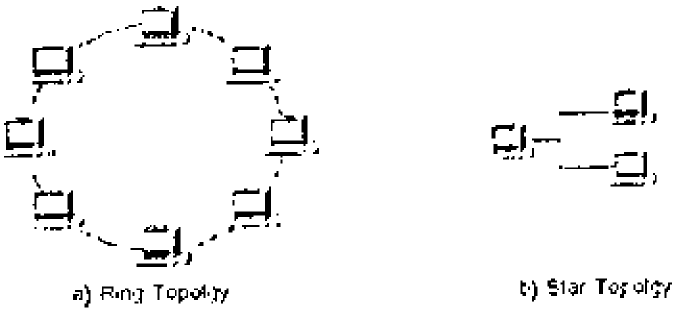


Figure 2.4a) Logical Ring Topology, b) star Topology

A **star topology** is a LAN architecture in which the endpoints on a network are connected to a common central hub, or switch, by dedicated links. Logical bus and ring topologies are often implemented physically in a star topology, which is illustrated in Figure 2.4 b.

A **tree topology** is a LAN architecture that is identical to the bus topology, except that branches with multiple nodes are possible in this case. Figure 2.5 illustrates a logical tree topology.

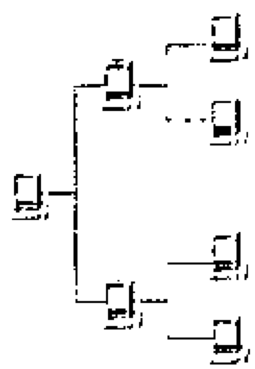


Figure 2.5 A Logical Tree Topology Can Contain Multiple Nodes

2.2.2 Metropolitan Area Networks

A metropolitan area network(MAN) covers a city. The best-known example of a MAN is the cable television network available in many cities. This system grew from earlier community antenna systems used in areas with poor over-the-air television reception. In these early systems, a large antenna was placed on top of a nearby hill and signal was then piped to the subscribers' houses.

To a first approximation, a MAN might look something like the system shown in Fig.2.6. In this figure we see both television signals and Internet being fed into the centralized head end for subsequent distribution to people's homes.

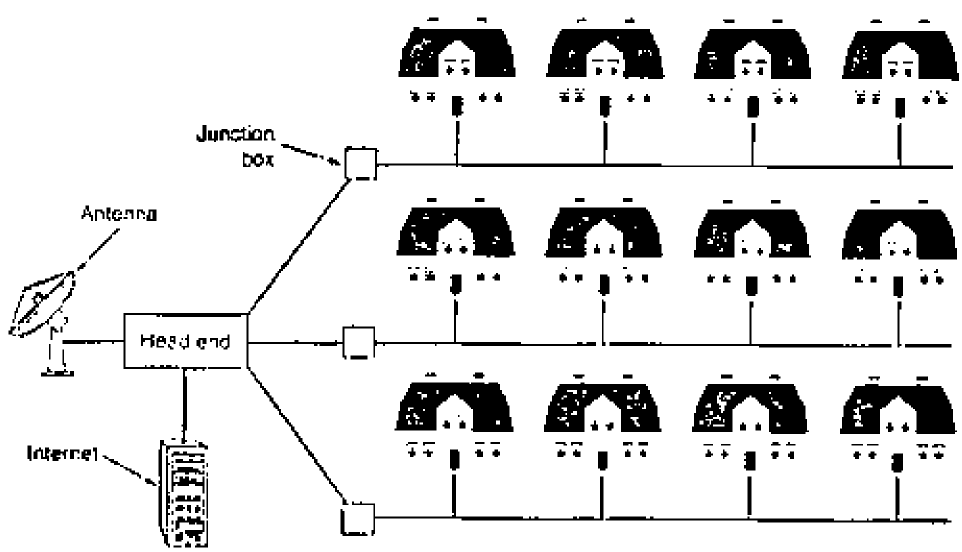


Figure 2.6 A metropolitan area network based on cable TV.

Cable television is not the only MAN. Recent developments in high-speed wireless Internet access resulted in another MAN, which has been standardized as IEEE 802.16.

2.2.3 Wide Area Networks

A wide area network, or WAN, spans a large geographical area, often a country or continent. It contains a collection of machines intended for running user (i.e., application) programs. We will follow traditional usage and call these machines hosts. The hosts are connected by a communication subnet, or just subnet for short. The hosts are owned by the customers (e.g., people's personal computers), whereas the communication subnet is typically owned and operated by a telephone company or Internet service provider. The job of the subnet is to carry messages from host to host, just as the telephone system carries words from speaker to listener. Separation of the pure communication aspects of the network (the subnet) from the application aspects (the hosts), greatly simplifies the complete network design. In this model, shown in Fig.2.7 each host is frequently connected to a LAN on which a router is present, although in some cases a host can be connected directly to a router. The collection of communication lines and routers (but not the hosts) form the subnet, which means the collection of routers and communication lines that move packets from the source host to the destination host.

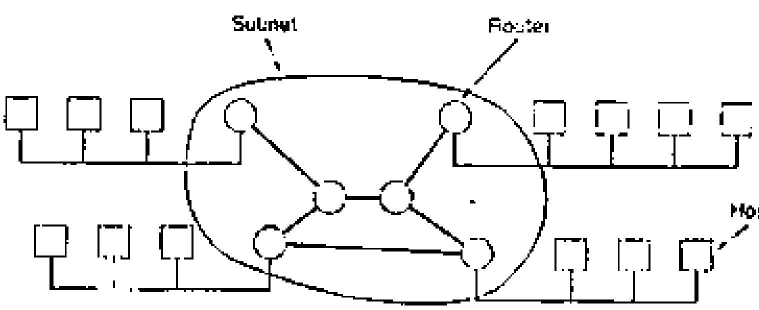


Figure 2.7 Relation between hosts on LANs and the subnet.

In most WANs, the network contains numerous transmission lines, each one connecting a pair of routers. If two routers that do not share a transmission line wish to communicate, they must do this indirectly, via other routers. When a packet is sent from one router to another via one or more intermediate routers, the packet is received at each intermediate router in its entirety, stored there until the required output line is free, and then forwarded. A subnet organized according to this principle is called a store-and-forward or packet-switched subnet. Nearly all wide area networks (except those using satellites) have store-and-forward subnets. When the packets are small and all the same size, they are often called cells. The packets are transported individually over the network and deposited at the receiving host, where they are reassembled into the original message and delivered to the receiving process. A stream of packets resulting from some initial message are illustrated in Figure 2.8.

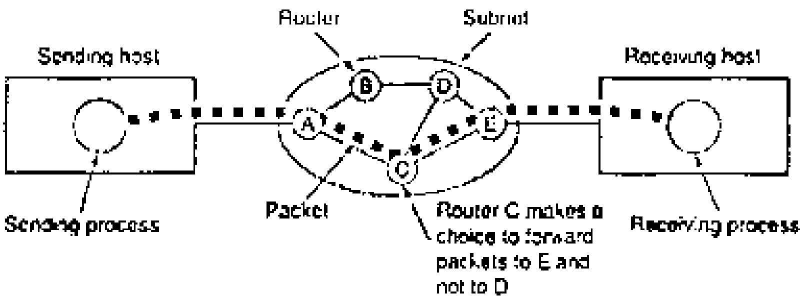


Figure 2.8 A stream of packets from sender to receiver.

In this figure, all the packets follow the route ACE, rather than ABDE or ACDE. In some networks all packets from a given message must follow the same route; in others each packet is routed separately. Of course, if ACE is the best route, all packets may be sent along it, even if each packet is individually routed.

Routing decisions are made locally. When a packet arrives at router A,it is up to A to decide if this packet sho ld be sent on the line to B or the line to C. How A makes that decision is called the routing algorithm.

WAN selection, technologies and topologies

2.3.1 WAN requirements

As a data communications network WAN covers a relatively broad geographic area, that often uses transmission facilities provided by common carriers. such as telephone companies. WAN technologies generally function at the lower three layers of the OSI reference model: the physical layer. the data link layer. and the network layer. Figure 2.9. illustrates the relationship between the common WAN technologies and the OSI model[8].

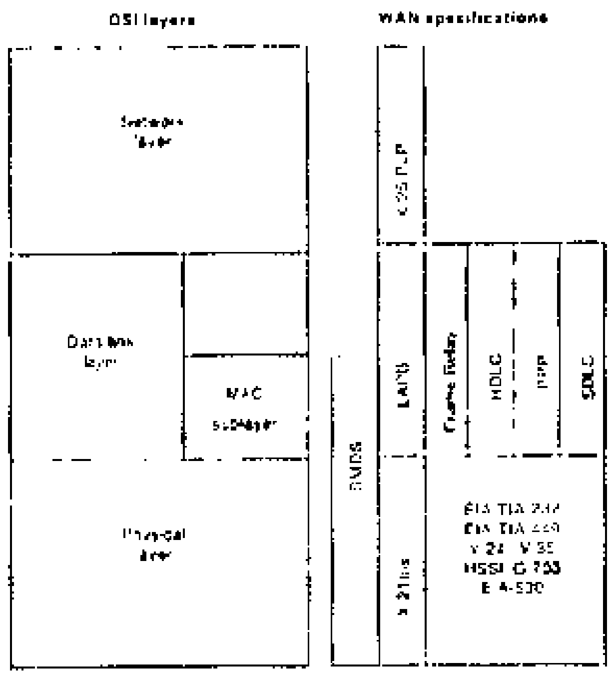


Figure 2.9 WAN Technologies Operate at the Lowest Levels of the OSI Model

WANs are frequently taken for granted. Most users, and even some LAN administrators. don't know what's on the other side of the router connecting them to the WAN. If the WAN was properly designed. implemented. and operated. it is extremely easy to take for granted. It is always there and it always works. Therefore, the very first step in selecting the right WAN must be to develop the right selection criteria. Properly chosen. these criteria will guide selection of network technologies.

determine the proper size of transmission facilities, and drive the topographical arrangement of the WAN.

2.3.2 Criteria Development

One way to estimate the bandwidth requirements is to identify how the users are currently performing their work. If there are existing networks being used, such as X.25, asynchronous networks, or even modems, they can be invaluable sources of information. They should be monitored to determine:

- Type of communications session (for example, bulk data transfer, online transaction processing, Web access, videoconferencing, and so on)
- Frequency of use
- Peak utilization times
- Peak utilization traffic volumes
- Average duration of each session
- Average number of bytes transmitted per session
- Each user groups' frequently accessed destinations

These are vital pieces of information that should form the core of your success criteria as the right WAN will be able to accommodate the projected traffic loads. In combination, these data reveal how much traffic will be put on the WAN and when it will be on the LAN. This is crucial to estimating the bandwidth required across every link of the network.

Other important data that should be determined during this data collection phase is the type of network performance needed. For example, will bulk data transfer constitute the majority of the traffic, or will interactive videoconferencing be the primary application? Is this situation likely to change in the near future? These two particular applications have opposite network performance requirements[6]. Bulk data transfer requires guaranteeing the integrity of the data delivered to its destination, regardless of the time it takes to get it there. Videoconferencing requires the network to deliver packets on time. Damaged packets are as worthless as late packets: They are both discarded. Therefore, it is essential that the performance requirements of the applications be factored into the WAN design. Another important piece of data that should be determined is the projected aggregate traffic flow. These selection criteria are neither perfect nor complete, but they are an excellent start. Unfortunately, collecting this data won't be quick or easy. In real life, "guesstimates" will likely be substituted for hard facts.

Additionally, if there are existing LANs in use, they must be carefully examined as they will need to be interconnected by the proposed WAN. Important details are:

- The type and transmission rate of each LAN
- The number of users connected to it
- The number of hosts connected to it
- Unsecured means of ingress
- Routed protocols (such as IP, IPX, and so on)
- The number of routers connected and the routing protocols used (such as : 'P, OSPF, IGRP, and so on)
- Internet addressing schemes

2.3.3 Technology

The WAN's technology base includes

- Transmission facilities
- Channel Service Units and Digital Service Units
- Premise edge vehicles, such as routers and switches
- Internet addressing
- Routing protocols

Each of these technologies must be examined for their performance capabilities relative to the expected WAN traffic load and performance requirements.

2.3.3.1 Transmission Facilities

Transmission facilities that will be used to construct the WAN present the richest array of options for the network planner. These facilities come in a variety of sizes and "flavors." For example, point-to-point private lines can range in size from 9.6 Kbps to 44.476 Mbps and beyond. These transmission facilities support a digital stream of data at a fixed and predetermined transmission rate. They can be implemented over a variety of physical media, for example, twisted pair or fiber-optic cabling, and can even support numerous framing formats.

These facilities also vary greatly in the manner that they provide connections. There are two primary types of facilities: **circuit switched and packet switched**. These two encompass all types of facilities, although technological innovation may be blurring their boundaries somewhat[6].

2.3.3.2 Internet Addressing

An aspect of the WAN that must be carefully considered is the Internet (that is, Layer 3 of the OSI Reference Model) addressing that will be used. These addresses are used to access and exchange data with hosts on other subnetworks within the WAN. As such, they are a critical component to consider as you select the right WAN for your users.

Theoretically, if your WAN will not be interconnected with the Internet, these addresses could be arbitrarily selected and function perfectly. This will reduce the workload required to manage the Internet addresses within the WAN, and will prevent duplicate addresses from being assigned[8].

These addresses will be determined by the routable protocol selected for use within the WAN. Some of the possibilities are: IPv4, IPv6, IPX, and AppleTalk. Each has its own unique addressing scheme. Thus, the choice of protocol determines the possible address hierarchies that can be implemented.

If your WAN requires the interconnection of networks with dissimilar routed protocols, you must have a *gateway* router at the border of the dissimilar regions. This router must be capable of calculating routes, forwarding route information, and forwarding packets in both protocols.

2.3.3.3 Routing Protocols

Dynamic routing protocols are used by routers to perform three basic functions:

- Discover , 'w routes
- Communicate the discovered route information to other routers
- Forward packets using those routes

There are three broad categories of dynamic routing protocols: distance-vector, link-state, and hybrids. Their primary differences lie in the way that they perform the first two of the three aforementioned functions. The only alternative to dynamic routing is static routing.

3.4 Topology

The topology describes the way the transmission facilities are arranged. Numerous topologies are possible, each one offering a slightly different mix of cost, performance, and scalability.

For example Hybridization of multiple topologies is useful in larger and more complex networks.

Multi-tiered WAN can be hybridized by fully meshing the backbone tier of routers, as shown in Figure 2.10 An effective hybrid topology may be developed in a multi-tiered WAN by using a fully meshed topology for the backbone nodes only. This affords a fault-tolerance to the network's backbone and can provide some of the hop-minimization of a full mesh network without experiencing all of its costs or incurring its limitations on scalability.

Fully meshing the backbone of a multi-tiered WAN is just one form of hybridized topology. Other hybrids, too, can be also highly effective. The key is to look for topologies, and sub-topologies, that can be used in combination to satisfy particular networking requirements.

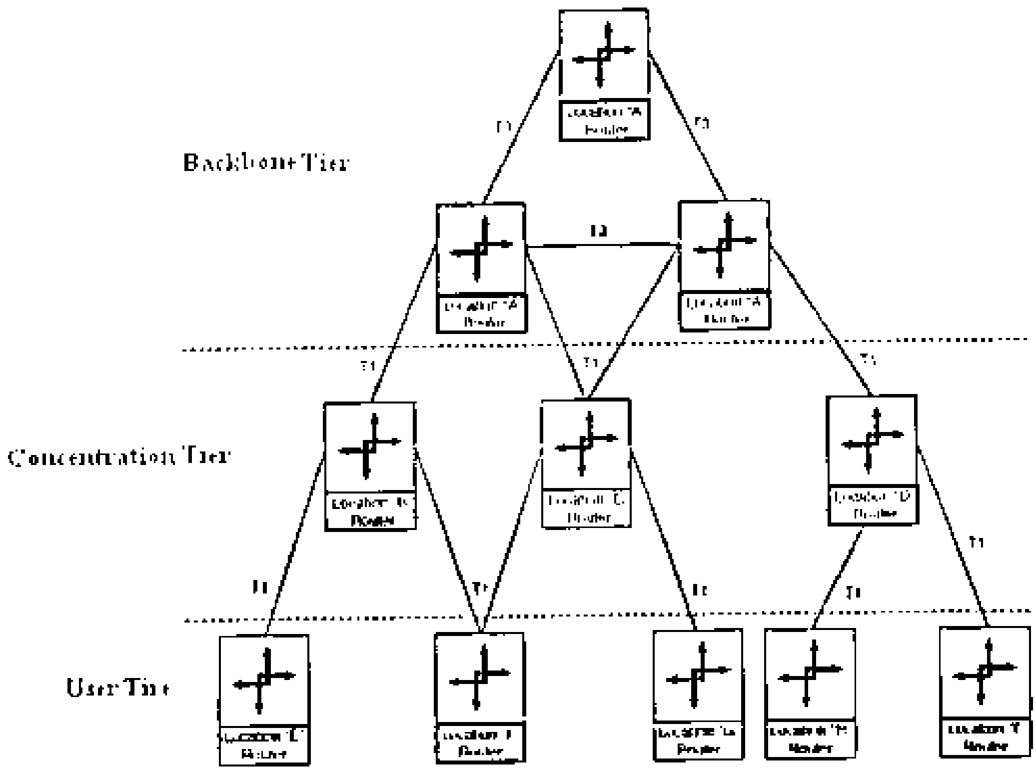


Figure 2.10- Multi-tiered hybrid WAN.

Chapter III

Communication System Technologies

3.1 Types of switching techniques

3.1.1 Introduction

We can divide data connections through a telecommunications network into different categories based on the principle of how the communications circuit is built between the communicating devices. Data communications through the telecommunications network may use three basic different types of circuits:

- Leased or dedicated: The cost of a leased line is fixed per month and depends on the capacity and length of the connection.
- Circuit switched or dial-up: The cost of switched service depends on the time the service is used, the data rate, and the distance.
- Packet switched: The cost is often fixed and depends on the interface data rate.

In some packet-switched networks, cost may depend on the amount of transferred data. Agreements with the service provider may specify other parameters that influence the cost, such as the maximum data rate or average data rate.

For corporate data networks, the leased-line solution is often attractive when the LANs of offices in a region need to be interconnected. The network operator provides a permanent circuit and the monthly cost is fixed and depends only on the agreed-on data rate. Over long distances, however, leased lines become expensive and switched service is often preferr.[3] In such a service, several corporate networks share transmission capacity and the cost of the backbone of the telecommunications network operator. Within the switched category there are two subcategories, circuit- and packet-switched networks as shown in Figure 3.1

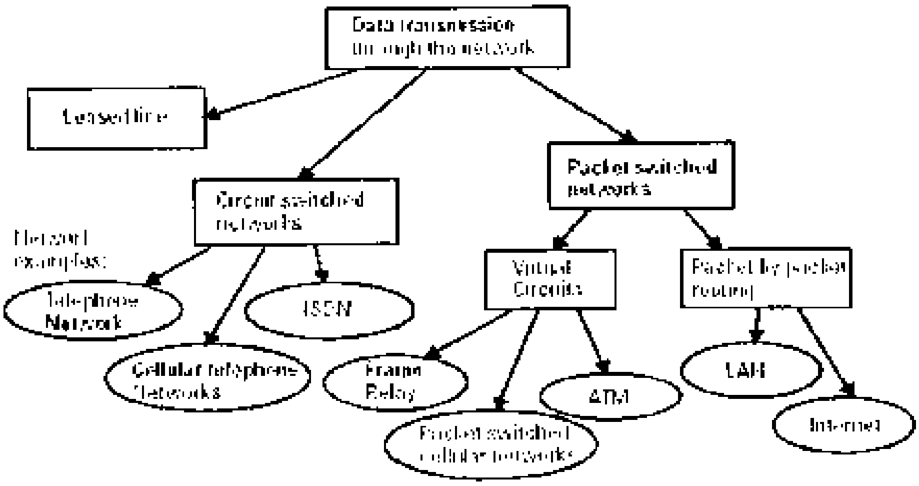


Figure 3.1 Leased lines and circuit- and packet-switched networks.

3.1.2 point-to-point links.

They provide a single, pre-established WAN communications path from the customer premises through a carrier network, such as a telephone company, to a remote network. Point-to-point lines are usually leased from a carrier and thus are often called leased lines. For a point-to-point line, the carrier allocates pairs of wire and facility hardware to your line only. These circuits are generally priced based on bandwidth required and distance between the two connected points. Point-to-point links are generally more expensive than shared services such as Frame Relay. Figure 3.2- illustrates a typical point-to-point link through a WAN.

Figure 3.2 A Typical Point-to-Point Link. through a WAN.

3.1.3 Circuit Switching.

The distinguishing property of a circuit-switched connection is the existence throughout the Communication phase of the call. of an unbroken physical and electrical path between origin and destination points. The path is established at call set-up and cleared after the call. The path may Offer either one direction (simplex) or two-direction (duplex) use. Telephone networks are circuit-switched networks.

Circuit switching is a WAN switching method in which a dedicated physical circuit is established. maintained. and terminated through a carrier network for each communication session. Circuit switching accommodates two types of transmissions: datagram transmissions and data-stream transmissions. Used extensively in telephone company networks. circuit switching operates much like a normal telephone call. *Integrated Services Digital Network* (ISDN) is an example of a circuit-switched WAN technology, and is illustrated in Figure 3.3.

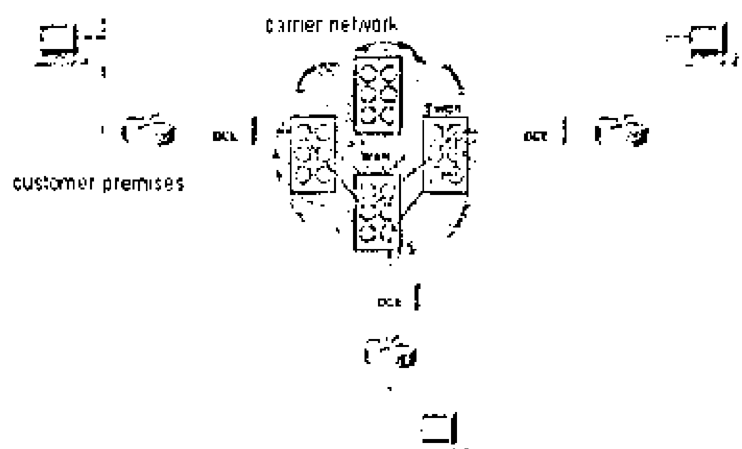


Figure 3.3 A circuit- switched WAN undergoes a process similar to that used for a telephone call.

.1.4 Packet Switching.

is a WAN technology in which users share common carrier resources. Because is allows the carrier to make more efficient use of its infrastructure. the cost to e customer is generally much better than with point-to-point lines. In a packet witching setup, networks have connections into the carrier's network, and many istomers share the carrier's network. The carrier can then create virtual circuits etween customers' sites by which packets of data are delivered from one to the ther through the network. The section of the carrier's network that is shared is ften referred to as a cloud.

Some examples of packet-switching networks include *Asynchronous Transfer Mode* (ATM), Frame Relay, *Switched Multimegabit Data Services* (SMDS), and X.25. Figure 3.4- shows an example of packet-switched circuit.

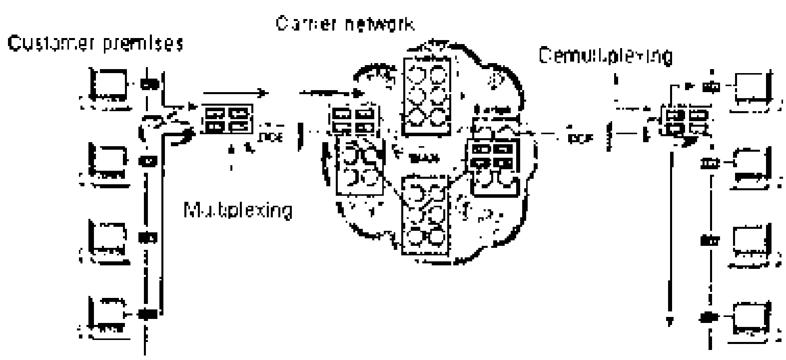


Figure 3.4 Packet Switching Transfers Packets Across a Carrier Network

Packet-switched networks a.. specially designed for data communication.
The source data are split into packets containing route or destination identifications. The packets are routed towards the destination by packet-switching nodes on the path hrough the network. The major drawback of the packet-switched technology is that it isually cannot provide a service for applications that require constant and low lelay[8].

There are two basic types of packet-switched networks

- virtual circuits
- datagram transmission

As illustrated in Figures 3.5 a,b:. In the case of virtual circuits, the virtual connection is established at the beginning of each conversation or it is permanently set up and every packet belonging to a certain connection is transmitted via the same established route. The main difference between circuit-switched physical circuits and virtual circuits is that many users share the capacity of the transmission lines and channels between network nodes if virtual instead of physical circuits are used. At a certain moment active users may use all the available capacity if other users are not transmitting anything. The complete address information is not needed in the packets when the connection is established. Only a short connection identifier is included in each packet to define the virtual circuit to which the packet belongs.

In true packet switched data communication with datagram, there is no dedicated connection between communicating devices. Each packet includes complete destination address and is sent and routed independently. One example is the Internet.

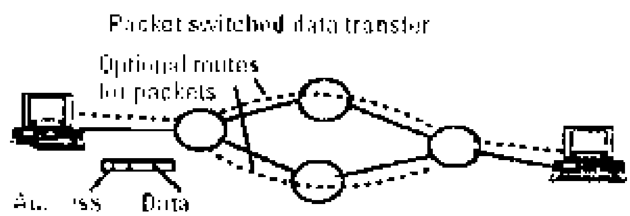


Figure 3.5a packet switched data transfer with datagram.

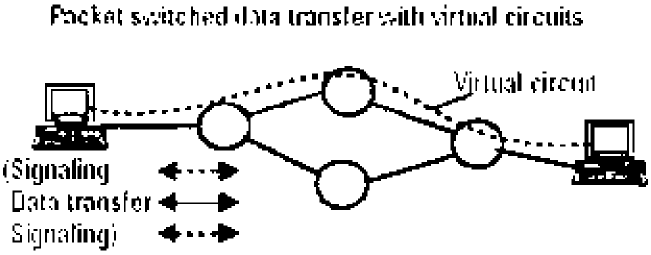


Figure 3.5b packet switched data transfer with virtual circuit.

Permanent virtual circuit exists (or virtual circuit is established for conversation). All data is transferred via the same path. (In the end the virtual circuit is released.) Each packet includes circuit identification. Capacity between nodes is shared by all users. For examples frame relay and ATM

2 Voice/Data Integration Technologies

3.2.1 Introduction

Voice/data integration is important to network designers of both service providers and enterprise. Service providers are attracted by the lower-cost model—the cost of packet voice is currently estimated to be only 20 to 50 percent of the cost of a traditional circuit-based voice network. Likewise, enterprise network designers are interested in direct cost savings associated with toll-bypass and tandem switching. Both are also interested in so-called "soft savings" associated with reduced maintenance costs and more efficient network control and management. Finally, packet-based voice systems offer access to newly enhanced services such as Unified Messaging and application control. These, in turn, promise to increase the productivity of users and differentiate services[11].

Integration of voice and data technologies has accelerated rapidly in recent years because of both supply- and demand-side interactions. On the demand side, customers are leveraging investment in network infrastructure to take advantage of integrated applications such as voice applications. On the supply side. vendors have been able to take advantage of breakthroughs in many areas, including standards, technology, and network performance.

3.2.1.1 Standards

Many standards for interoperability for voice signaling have finally been ratified and matured to the point of reasonable interoperability. This reduces the risk and costs faced by vendors offering components of a voice/data system. It also reduces the risk to consumers. Standards such as H.323 (approved by the ITU in June 1996), are now evolving through their third and fourth iterations.

3.2.1.2 Technology

Recent advances in technology have also enabled voice integration with data. For example, new *Digital Signal Processor* (DSP) technology has allowed analog signals to be processed in the digital domain. These powerful new chips offer tremendous processing speeds, allowing voice to be sampled, digitized, and compressed in real time. Further breakthroughs in the technology allow as many as four voice conversations to be managed at the same time on a single chip, with even greater performance in development.

3.2.1.3 Network Performance

Finally, data-networking technology has improved to the point that voice can be carried reliably. Over the last few years, growth in voice traffic has been relatively small, while data traffic has grown exponentially. The result is that data traffic is now greater than voice traffic in many networks[11]. In addition. the relative importance of data traffic has grown, as businesses and organizations come to base more business practices and policies on the ubiquity of data networks. This increase in importance of data networks has forced a fundamental change in the way data networks are engineered, built, and managed. Typical "best-effort" data modeling has given way to advanced policy-based networking with managed quality of service to support an even greater range of applications. Voice traffic, as an application on a data network, has benefited greatly from these technologies. For example, support of delay-sensitive SNA traffic over IP networks resulted in breakthroughs in latency management and queuing prioritization, which was then applied to voice traffic.

3.2.1.4 Economic Advantages

It has been estimated that packet voice networking costs only 20 to 30 percent of an equivalent circuit-based voice network. Logically, this implies that enterprise users can operate long-distance voice services between facilities at less cost than purchasing long-distance voice services from a carrier, and it's often true. For example, many enterprise users have deployed integrated voice/data technologies to transport voice over data wide-area networks (WANs) between traditional PBXs across different geographical locations.

However, savings associated with packet voice technologies don't stop with simple transport. It is also possible to switch voice calls in the data domain more economically than traditional circuit-based voice switches. For large, multisided enterprises, the savings result from using the data network to act as a "tandem switch" to route voice calls between PBXs on a call-by-call basis[11]. The resulting voice network structure is simpler to administer and uses a robust, no blocking switching fabric made up of data systems at its core.

3.2.2 Multiservice Access Technologies[12]

Multiservice networking is emerging as a strategically important issue for enterprise and public service provider infrastructures alike. The proposition of multiservice networking is the combination of all types of communications, all types of data, voice, and video over a single packet-cell-based infrastructure. The benefits of multiservice networking are reduced operational costs, higher performance, greater flexibility, integration and control, and faster new application and service deployment.

3.2.2.1 Packet Voice[12]

All packet voice systems follow a common model, as shown in Figure 3.6. The packet voice transport network, which may be IP based, Frame Relay, or ATM, forms the traditional "cloud." At the edges of this network are devices or components that can be called *voice agents*. It is the mission of these devices to change the voice information from its traditional telephony form to a form suitable for packet transmission. The network then forwards the packet data to a voice agent serving the destination or called party.

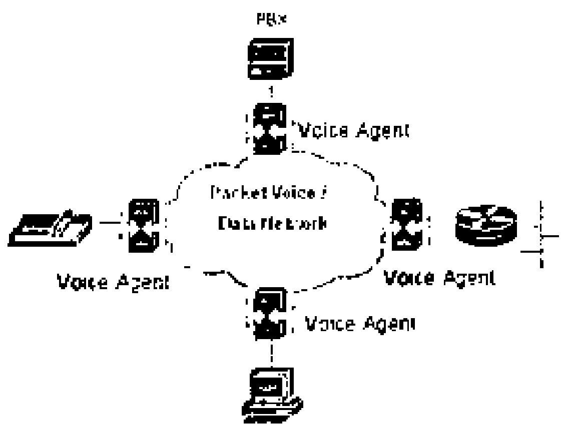


Figure 3.6 The packet voice model.

This voice agent connection model shows that there are two issues in packet voice networking that must be explored to ensure that packet voice services meet user needs. The first issue is voice coding—how voice information is transformed into packets, and how the packets are used to re-create the voice. Another issue is the signaling associated with identifying who the calling party is trying to call and where the called party is in the network.

3.2.2.2 Packet Voice Transport[11]

Integrating voice and data networks should include an evaluation of these three packet voice transport technologies:

- *Voice over ATM* (VoATM)
- *Voice over Frame Relay* (VoFR)
- *Voice over IP* (VoIP)

There are also mixed solutions, including voice over IP, over Frame Relay, and so on. These are illustrated in Figure 3.7 The figure shows that voice over ATM and voice over Frame Relay are primarily transport mechanisms between PBXs, while voice over IP can connect all the way to the desktop.

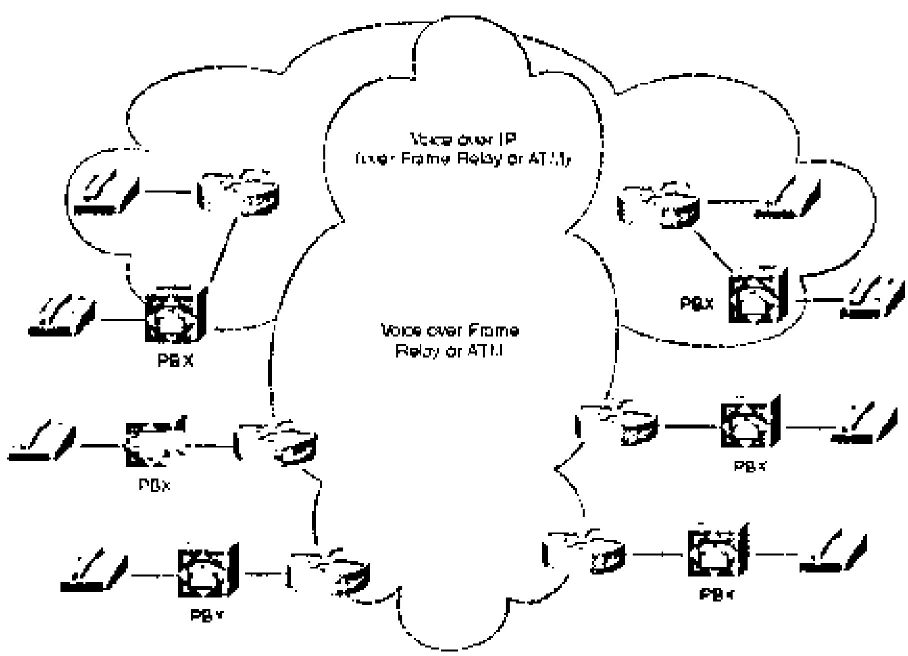


Figure 3.7 Mixed Solutions Including Voice over IP, Voice over Frame Relay, and so on.

3.2.3 Voice Over IP.

The vast majority of information exchanged over the public telecommunications networks has been voice. The present voice communications networks, public telephone and ISDN, use the circuit-switching principle. Circuit switching provides good quality service and it does not require a complicated encoding algorithm.

3.2.3.1 Voice Communications over Circuit- and Packet-Switched Networks

The characteristics of data transmission are different from waveform-coded speech, and the data networks that were developed to provide data services utilize packet-switched technology. These technologies include LANs, Internet, frame relay, and ATM. Packet-switched networks utilize network resources more efficiently than circuit-switched networks because the capacity in the network is dynamically shared among all users. If there are no data to be transmitted between two users, their share of the data capacity is available for other users. This difference in the operating principle makes a packet-switched network superior to a circuit-switched network when the data rate per user is not constant[5].

3.2.3.2 Applications for VoIP.

The implementation of VoIP service is attractive for subscribers because it reduces the cost of international and long-distance calls and it is also attractive to ISPs because it would increase the usage of Internet services. The technology for VoIP does not yet provide voice quality that is as good as a circuit-switched telephone network, but a lot of activity is being aimed at developing protocols for the implementation of high-quality voice service. Figure 3.8. shows three possible ways to make telephone call over the Internet. In the first application example, a telephone subscriber dials the telephone number of the local gateway for an IP telephone service provider. The call travels over the PSTN to the nearest gateway that acts as an access point to the Internet. The service providers have their own telephone number prefix that connects a customer to the right gateway. Then the caller enters the destination telephone number and the gateway in the local office establishes a connection over the Internet to the gateway in his remote office closest to the destination. Then the gateway in the remote office calls the destination subscriber via the local PSTN. Internet routing and speech processing is performed by the gateways and ordinary telephones can be used for the call. Now the Internet, instead of PSTN, carries a long-distance section of the call.

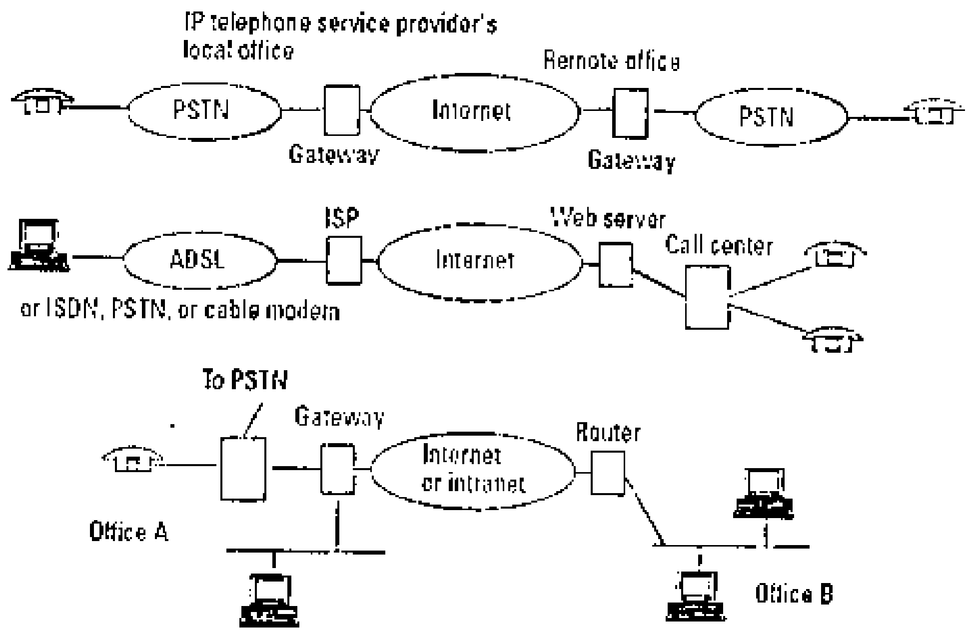


Figure 3.8 Voice over Internet applications.

3.2.4 Coding of Text, Voice, Image, and Video Signals.

The information that has to be exchanged between two entities (persons or machines) in a communication system can be in one of the following formats:

- Text
- Voice
- Image
- Video

In an electrical communication system, the information is first converted into an electrical signal. For instance, a microphone is the transducer that converts the human voice into an analog signal. Similarly, the video camera converts the real-life scenery into an analog signal. In a digital communication system, the first step is to convert the analog signal into digital format using analog-to-digital conversion techniques.

3.2.4.1 Text messages:

They are generally represented in *American Standard Code for Information Interchange* (ASCII), in which a 7-bit code is used to represent each character. Another code form called *Extended Binary Coded Decimal Interchange Code* (EBCDIC) is also used. To transmit text messages, first the text is converted into one of these formats, and then the bit stream is converted into an electrical signal. Using ASCII, the number of characters that can be represented is limited to 128 because only 7-bit code is used. The ASCII code is used for representing many European languages as well. ASCII is the mo… widely used coding scheme for representation of text in computers. Unicode has been developed to represent all the world languages. Unicode uses 16 bits to represent each character and can be used to encode the characters of any recognized language in the world. Modern programming languages such as Java and markup languages such as XML support Unicode. It is important to note that the ASCII/Unicode coding mechanism is not the best way, according to Shannon. If we consider the frequency of occurrence of the letters of a language and use small code words for frequently occurring letters, the coding will be more efficient. However, more processing will be required, and more delay will result. The best coding mechanism for text messages was developed by Morse[4].

3.2.4.2 VOICE

To transmit voice from one place to another, the speech (acoustic signal) is first converted into an electrical signal using a transducer, the microphone. This electrical signal is an analog signal. The voice signal corresponding to the speech "how are you" is shown in Figure 3.9. The important characteristics of the voice signal are given here:

- The voice signal occupies a bandwidth of 4kHz. Though higher frequency components are present, they are not significant, so a filter is used to remove all the high-frequency components above 4kHz. In telephone networks, the bandwidth is limited to only 3.4kHz.

- The pitch varies from person to person. Pitch is the fundamental frequency in the voice signal. In a male voice, the pitch is in the range of 50–250 Hz. In a female voice, the pitch is in the range of 200-400 Hz.
- The speech sounds can be classified broadly as voiced sounds and unvoiced soun. Signals corresponding to voiced sounds (such as the vowels a, e, i, o, u) will be periodic signals and will have high amplitude. Signals corresponding to unvoiced sounds (such as th, s, z, etc.) will look like noise signals and will have low amplitude.

- Voice signal is considered a nonstationary signal, i.e., the characteristics of the signal (such as pitch and energy) vary. However, if we take small portions of the voice signals of about 20msec duration, the signal can be considered stationary. In other words, during this small duration, the characteristics of the signal do not change much. Therefore, the pitch value can be calculated using the voice signal of 20msec. However, if we take the next 20msec, the pitch may be different.

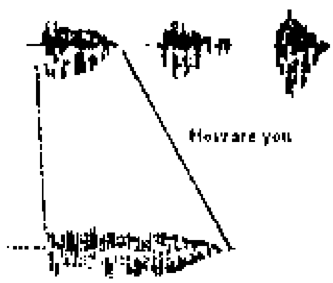


Figure 3.9 Speech waveform.

Analog-to-digital conversion of voice signals can be done using one of two techniques: waveform coding and vocoding.

3.2.4.2.1 Waveform Coding.

Waveform coding is done in such a way that the analog electrical signal can be reproduced at the receiving end with minimum distortion. Hundreds of waveform coding techniques have been proposed by many researchers[4]. We will study two important waveform coding techniques: *pulse code modulation* (PCM) and *adaptive differential pulse code modulation* (ADPCM).

a. Pulse Code Modulation (PCM)

PCM is the first and the most widely used waveform coding technique. The ITU-T Recommendation G.711 specifies the algorithm for coding speech in PCM format.

The sample values are still analog values, and we can "quantize" these values into a fixed number of levels. As shown in Figure3.10. if the number of quantization levels is 256, we can represent each sample by 8 bits. So. 1 second of voice signal can be represented by 8000 × 8 bits, 64kbits. Hence, for transmitting voice using PCM, we require 64 kbps data rate. However, note that since we are approximating the sample values through quantization. there will be a distortion in the reconstructed signal: this distortion is known as quantization noise.

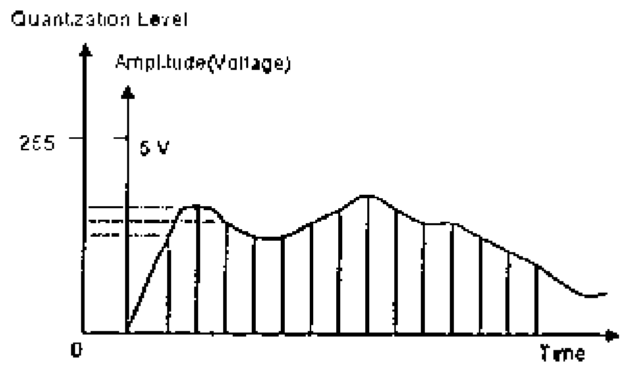


Figure 3.10: Pulse Code Modulation.

b. Adaptive Differential Pulse Code Modulation(ADPCM)

One simple modification that can be mode to PCM is that we can code the difference between two successive samples rather than coding the samples directly. This technique is known as (DPCM).

Another characteristic of the voice signal that can be used is that a sample value can be predicted from past sample values. At the transmitting side, we predict the sample value and find the difference between the predicted value and the actual value and then send the difference value. This technique is known as ADPCM. Using ADPCM. voice signals can be coded at 32kbps without any degradation of quality as compared to PCM.ITU-T Recommendation G.721 specifies the coding algorithm. Generally, the ADPCM coder takes the PCM coded speech data and converts it to ADPCM data.

3.2.4.2.2 vocoding.

A radically different method of coding speech signals was proposed by H. Dudley in 1939. He named his coder vocoder, a term derived from VOice CODER. In a vocoder, the electrical model for speech production seen in Figure 3.11 is used. This model is called the source–filter model because the speech production mechanism is considered as two distinct entities—a filter to model the vocal tract and an excitation source. The excitation source consists of a pulse generator and a noise generator. The filter is excited by the pulse generator to produce voiced sounds (vowels) and by the noise generator to produce unvoiced sounds (consonants). The vocal tract filter is a time-varying filter—the filter coefficients vary with time. As the characteristics of the voice signal vary slowly with time, for time periods on the order of 20msec, the filter coefficients can be assumed to be constant.

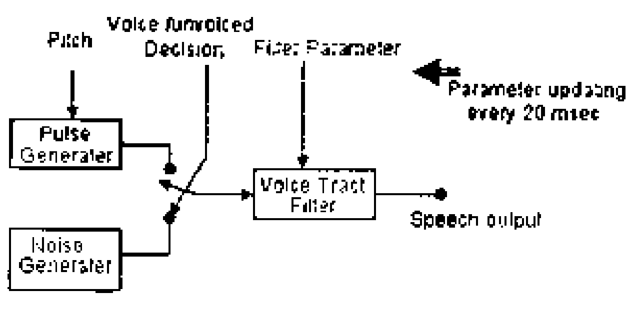


Figure 3.11: Electrical model of speech production.

In vocoding techniques, at the transmitter, the speech signal is divided into frames of 20msec in duration. Each frame contains 160 samples. Each frame is analyzed to check whether it is a voiced frame or unvoiced frame by using parameters such as energy, amplitude levels, etc. For voiced frames, the pitch is determined.

For each frame, the filter coefficients are also determined. These parameters voiced/unvoiced classification, filter coefficients, and pitch for voiced frames—are transmitted to the receiver. At the receiving end, the speech signal is reconstructed using the electrical model of speech production. Using this approach, the data rate can be reduced as low as 1.2kbps. However, compared to voice coding techniques, the quality of speech will not be very good. A number of techniques are used for calculating the filter coefficients. Linear prediction is the most widely used of these techniques.

3.2.4.3 IMAGE

To transmit an image, the image is divided into grids called pixels (or picture elements). The higher the number of grids, the higher the resolution. Grid sizes such as 768 × 1024 and 400 × 600 are generally used in computer graphics. For black-and-white pictures, each pixel is given a certain gray scale value. If there are 256 gray scale levels, each pixel is represented by 8 bits. So, to represent a picture with a grid size of 400 × 600 pixels with each pixel of 8 bits, 240kbytes of storage is required. To represent color, the levels of the three fundamental colors—red, blue, and green—are combined together. The shades of the colors will be higher if more levels of each color are used.

For example, if an image is coded with a resolution of 352 × 240 pixels, and each pixel is represented by 24 bits, the size of the image is 352 × 240 × 24/8 = 247.5 kilobytes.

To store the images as well as to send them through a communication medium, the image needs to be compressed. A compressed image occupies less storage space if stored on a medium such as hard disk or CD-ROM. If the image is sent through a communication medium, the compressed image can be transmitted faster.

One of the most widely used image coding formats is JPEG format. *Joint Photograph Experts Group* (JPEG) proposed this standard for coding of images. The block diagram of JPEG image compression is shown in Figure 3.12.

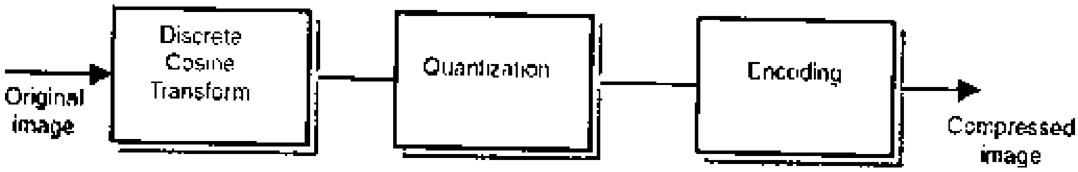


Figure 3.12: JPEG compression.

Compression ratios of 30:1 can be achieved using JPEG compression. In other words, a 300kB image can be reduced to about 10kB.

3.2.4.4 VIDEO

A video signal occupies a bandwidth of 5MHz. Using the Nyquist sampling theorem, we need to sample the video signal at 10 samples/msec. If we use 8-bit PCM, video signal requires a bandwidth of 80Mbps. This is a very high data rate, and this coding technique is not suitable for digital transmission of video. A number of video coding techniques have been proposed to reduce the data rate. For video coding, the video is considered as a series of frames. At least 16 frames per second are required to get the perception of moving video. Each frame is compressed using the image compression techniques and transmitted. Using this technique, video can be compressed to 64kbps, though the quality will not be very good.

Video encoding is an extension of image encoding. As shown in Figure3.13, a series of images or frames, typically 16 to 30 frames, are transmitted per second. Due to the persistence of the eye, these discrete images appear as though it is a moving video. Accordingly, the data rate for transmission of video will be the number of frames multiplied by the data rate for one frame. The data rate is reduced to about 64kbps in desktop video conferencing systems where the resolution of the image and the number of frames are reduced considerably[4]. The resulting video is generally acceptable for conducting business meetings over the Internet or corporate intranets, but not for transmission of, say, dance programs, because the video will have many jerks.

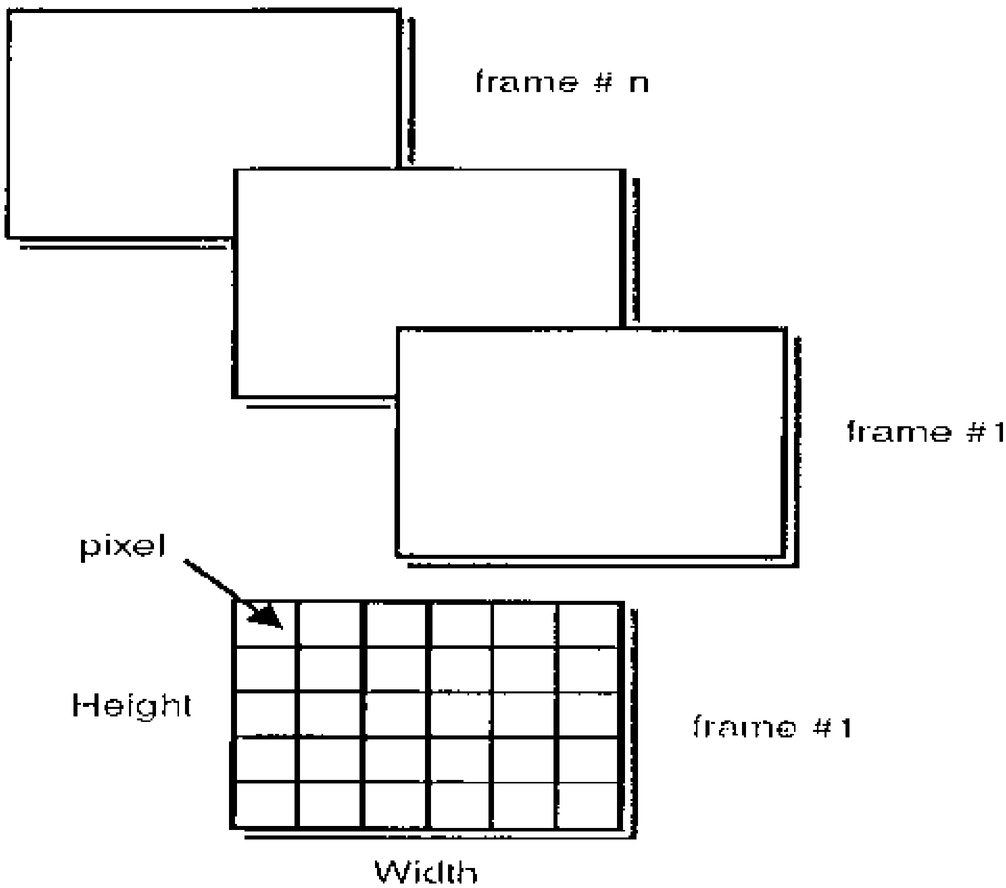


Figure 3.13: Video coding through frames and pixels.

Moving Picture Experts Group (MPEG) released a number of standards for video coding. The following standards are used presently:

MPEG-2: This standard is for digital video broadcasting. The data rates are 3 and 7.5Mbps. The picture quality will be much better than analog TV. This standard is used in broadcasting through direct broadcast satellites.

PEG-4: This standard is used extensively for coding, creation, and tribution of audio-visual content for many applications because it supports a wide ge of data rates. The MPEG-4 standard addresses the following aspects:

- Representing audio-visual content, called media objects.
- Describing the composition of these objects to create compound media objects.
- Multiplexing and synchronizing the data.

e primitive objects can be still images, audio, text, graphics, video, or synthesized eech. Video coding between 5kbps and 10Mbps, speech coding from 1.2kbps to kbps, audio (music) coding at 128kbps, etc. are possible. MP3 (MPEG Layer-3) is standard for distribution of music at 128kbps data rate, which is a part of the PEG-4 standards.

r video conferencing, 384kbps and 2.048Mbps data rates are very commonly used obtain better quality as compared to 64kbps. Video conferencing equipment that pports these data rates is commercially available. MPEG-4 is used in mobile mmunication systems for supporting video conferencing while on the move. It is ed also in video conferencing over the Internet.

ransmission Media

.3.1 Guided Transmission Media

he purpose of the physical layer is to transport a raw bit stream from one machine to other. Various physical media can be used for the actual transmission. Each one has own niche in terms of bandwidth, delay, cost, and ease of installation and aintenance. Media are roughly grouped into guided media, such as copper wire, axial cable and fiber optics.

n optical transmission system has three key components: the light source, the ansmission medium, and the detector, and have advantages include High transmission capacity; Low cost; Tolerance against external interference; Small size and low weight; Unlimited material resource and Low attenuation.

A fiber optics can be used for LANs as well as for long-haul transmission, although tapping into it is more complex than connecting to an Ethernet. One way around the problem is to realize that a ring network is really just a collection of point-to-point links, as shown in Figure 3.14.

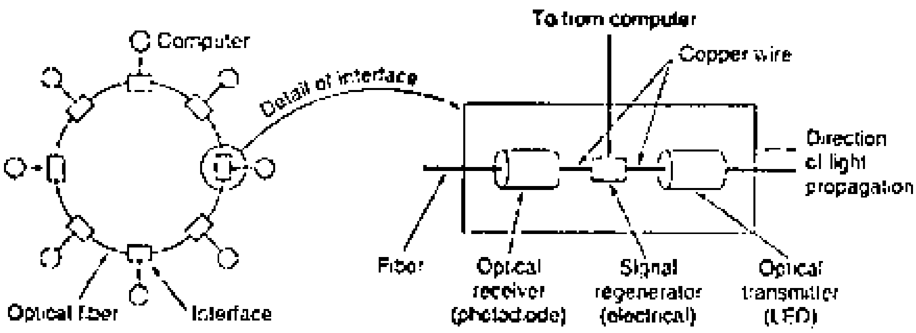


Figure 3.14 A fiber optic ring with active repeaters.

3.3.2 Wireless Transmission

Mobile users need to be on-line all the time. For these mobile users, twisted pair, coax, and fiber optics are of no use. They need to get their hits of data for their laptop, notebook, shirt pocket, palmtop, or wristwatch computers without being tethered to the terrestrial communication infrastructure. For these users, wireless communication is the answer. Some people believe that the future holds only two kinds of communication: fiber and wireless. All fixed (i.e., nonmobile) computers, telephones, faxes, and so on will use fiber, and all mobile ones will use wireless. Unguided media indude radio, lightwave, satellites and mobile communications.

Chapter IV

Basics of Traffic

Introduction to Teletraffic Theory[3]

Telecommunication networks, like roads, are said to carry traffic.

consisting not of vehicles but of telephone calls or data messages. The more traffic there is, the more circuits and exchanges must be provided. On a road network the more cars and lorries, the more roads and roundabouts are needed. In any kind of network, if traffic exceeds the design capacity then there will be pockets of congestion. On the road this means traffic jams; on the telephone the frustrated caller receives frequent 'busy tones'; in a data network unacceptably long ' response times' are experienced. Short of providing an infinite number of lines, it is impossible to know in advance precisely how much equipment to build into a telecommunications network to meet demand without congestion. However, there is a tool for 'dimensioning' network links and exchanges.

It is the rather complex statistical science of 'teletraffic theory' (sometimes called ' teletraffic engineering').

4.1.1 Telecommunications Traffic

Traffic is the term to describe the amount of telephone calls or data messages conveyed over a telecommunications network, but this

Could cover any number of different scientific definitions. Possible definitions of traffic include

- The total number of calls or messages.
- The total conversation time (i.e. the number of calls multiplied by

The conversation time on each)

- The total circuit holding time. This is the number of calls multiplied by the holding time on each; the holding time includes the time periodod during which the parties are in conversation and also the time prior to conversation when the call is being set-up; holding time is the total time for which the network is in use.

- The total number of data characters conveyed.

4.1.2 Traffic Intensity (Circuit-Switched Networks)

The traffic intensity of a circuit-switched network is defined to be the average number of calls simultaneously in progress during a particular period of time. It is measured in units of Erlangs.

Thus an average of one call in progress during a particular Period would represent a traffic intensity of one Erlang. The traffic intensity on any route between two exchanges can also be quoted in Erlangs. It is measured by first summing the total holding time of all the circuits Within the route and then dividing this by the time period T. over Which the measurement was made. In some countries, including The United States, traffic intensity is measured not in Erlangs but in units called CCS (hundred call seconds). CCS is a measure of the total call. Holding time during the network or route busy hour. The two units. CCS and Erlang are very simply related because one Erlang = 3600 call seconds = 36 CCS

The definition of traffic intensity is not restricted to traffic between exchanges, cross exchange traffic (that passing across an exchange from incoming ports to outgoing ports) can also be measured and quoted in Erlangs.

4.1.3 The Traffic intensity Formula

Our next step is to develop the formula for traffic intensity, as a Basis for subsequent discussion of the Erlang method of network dimensioning. Recapping in mathematical terms, the traffic intensity is given by the expression.

Traffic intensity(carried traffic) = $\frac{\text{the sum of circit holing times}}{\text{the duration of the monitoring period}}$

Now let

A =the traffic Intensity in Erlangs.

T = the duration of the monitoring period.

h_i = the holding time of the ith individual call.

c = the total number of calls in the period of mathematical summation.

Then, from above

$$A = \frac{\sum_{1}^{c} h_i}{T} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4.1)$$

Now, because the sum of the holding times is equal to the number of calls multiplied by the average holding time, then

$$\sum_{1}^{c} h_i = ch \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4.2)$$

where

h =average call holding time, and therefore

$$A = \frac{ch}{T} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4.3)$$

It is interesting to calculate the call arrival rate, in particular the number of calls expected to arrive during the average holding time.

Let N be this number of calls, then

N = no. of call arrivals during a period equal to the average holding time

N = h x call arrival rate per unit of time

N =h x c/T

N= ch/T = A

In other words. the number of calls expected to be generated during the average holding time of a call is equal to the traffic intensity (A).

This is perhaps a surprising result, but one which sometimes proves extremely valuable[3].

4.1.4 Dimensioning Circuit-Switched Networks

The future circuit requirements for each route of a circuit-switched network (i.e. telephone, telex, circuit switched data) may be determined.

This can be carried by using Erlang loss for made given by:

$$B(M\ ,A) = \frac{E^{M}/M!}{\sum_{k=0}^{M} A^{k}/k!} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4.4)$$

where,

$B(M\ ,A)$ = Proportion of lost calls, and probability of blocking

M = available number or circuits

A = offered traffic intensity

From equation (4.4). We do so by substituting the predicted offered traffic intensity A. and using trial-and-error values of M

To determine the value which gives a slightly better performance than the target blocking or grade of service B. A commonly used grade of service for interchange traffic routes is 0.01 or 1% blocking. It is not an easy task by direct calculation to determine the value of M (circuits required). and for this reason it is usual to use either a suitably programmed computer or a set of traffic tables.

In recent years. numerous authors and organizations have produced modified versions of the Erlang method. more advanced and complicated techniques intended to predict accurately the traffic-carrying capacity of various sized circuit groups for different grades of service. All have their place but in practice it comes down to finding the most appropriate method by trying several for the best fit for given circumstances. Table 4.1 illustrates a typical traffic table.

In the middle of the table. the values represent the maximum offered Erlang capacity corresponding to the route size and grade of service chosen. Thus a route of four circuits, working to a design grade of service of 0.01, has a maximum offered traffic capacity of 0.9 Erlangs. We can also use Table 4.1 to determine how many circuits are required to provide a 0.01 grade of service, given an offered traffic of 1 Erlang. In this case the answer is five circuits. The maximum carrying capacity of five circuits at 1% grade of service Is 1.4Erlangs, slightly greater than needed. but the capacity of four circuits is only 0.9 Erlangs.

The problem with traffic routes of only a few circuits is that only a small increase in traffic is needed to cause congestion. It is good practice therefore to ensure that a minimum number of circuits (say five) are provided on every route.

Table 4.1 A simple Erlang traffic table

Number of circuits M	Grade of service (B(M, A))			
	0.020	0.010	0.005	0.001
1	0.020	0.010	0.005	0.001
2	0.22	0.15	0.105	0.046
3	0.60	0.45	0.35	0.19
4	1.1	0.9	0.7	0.44
5	1.7	1.4	1.1	0.8
6	2.3	1.9	1.6	1.1
7	2.9	2.5	2.2	1.6
8	3.6	3.2	2.7	2.1
9	4.3	3.8	3.3	2.6
10	5.1	4.5	4.0	3.1
11	5.8	5.2	4.6	3.6
12	6.6	5.9	5.3	4.2

The information in Table 4.1 is sometimes presented graphically, and Figure 4.1 illustrates this. The traffic offered in Erlangs is usually plotted along the horizontal axis, and the circuit numbers up the vertical axis. A number of different curves then correspond to different grades of service. To determine how many circuits are required for a given offered traffic, the offered Erlang value is read along the horizontal axis, then a vertical line is drawn upwards to the curve corresponding to the required grade of service, and a horizontal line is drawn from this point to the vertical axis, where the circuit requirement can be read.

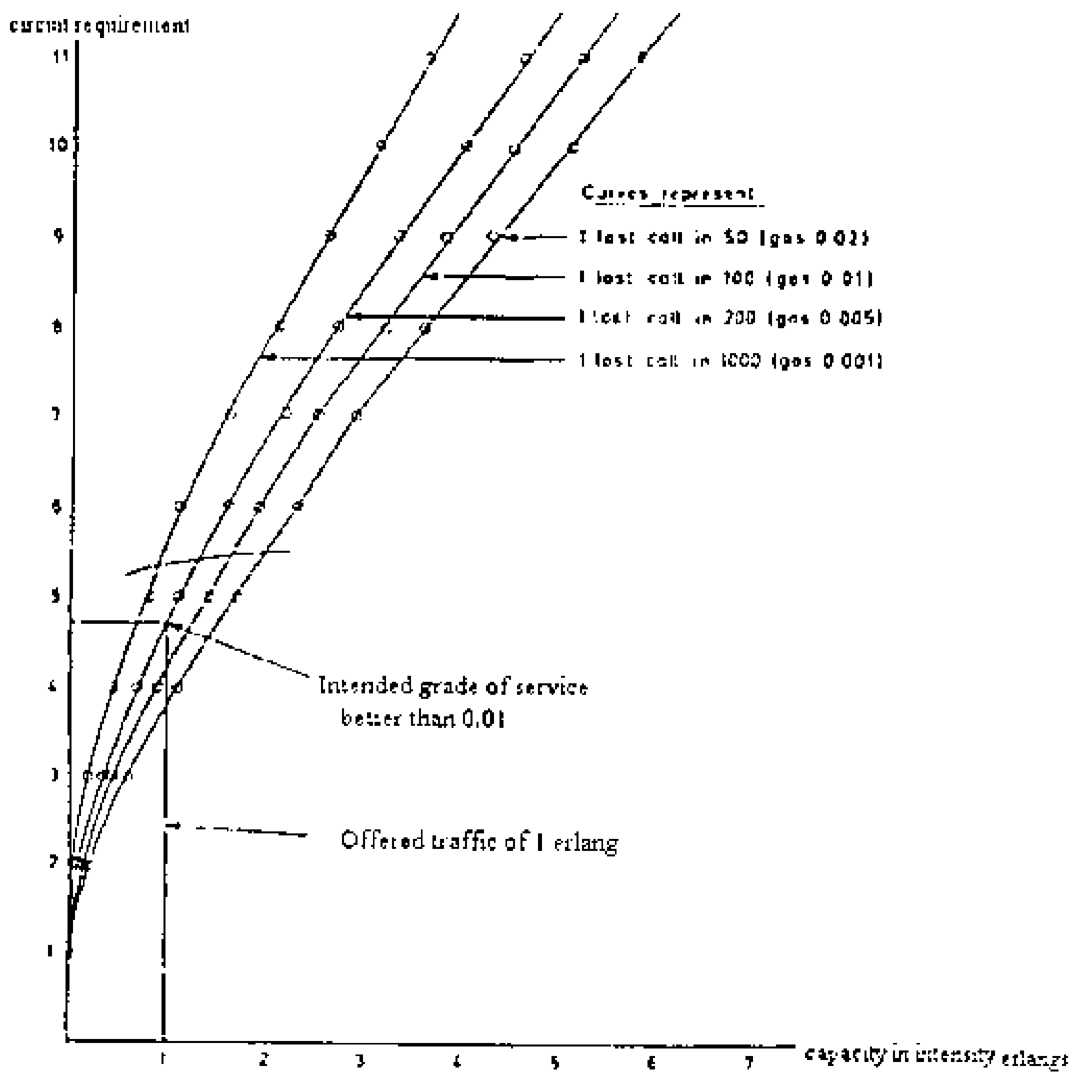


Figure 4.1 Graphical representation of the Erlang formula

Traffic Analysis Overview[15]

Networks, whether voice or data, are designed around many different variables. Two of the most important factors that you need to consider in network design are service and cost. Service is essential for maintaining customer satisfaction. Cost is always a factor in maintaining profitability. One way that you can factor in some of the service and cost elements in network design is to optimize circuit utilization.

Network designers need a way to properly size network capacity, especially as networks grow. Traffic theory enables network designers to make assumptions about their networks based on past experience.

Traffic is defined as either the amount of data or the number of messages over a circuit during a given period of time. Traffic also includes the relationship between call attempts on traffic-sensitive equipment and the speed with which the calls are completed.

Traffic analysis enables you to determine the amount of bandwidth you need in your circuits for data and for voice calls. Traffic engineering addresses service issues by enabling you to define a grade of service or blocking factor. A properly engineered network has low blocking and high circuit utilization, which means that service is increased and your costs are reduced.

There are many different factors that you need to take into account when analyzing traffic. The most important factors are described in the following sections[15]:

- Traffic Load Measurement
- Grade of Service
- Traffic Types
- Sampling Methods

Of course, other factors might affect the results of traffic analysis calculations, but these are the main ones. You can make assumptions about the other factors.

Applying Traffic Analysis to VoIP Networks[15]

Because VoIP traffic uses *Real-time Transport Protocol* (RTP) to transport voice traffic, you can use the same principles to define the bandwidth on your WAN links. There are some challenges in defining the bandwidth. The considerations discussed will affect the bandwidth of voice networks:

- Voice Codecs
- Samples
- Voice Activity Detection
- RTP Header Compression

4.3.1 Voice Codecs

Many voice codecs are used in IP telephony. These codecs all have different bit rates and complexities to them. Some of the standard voice codecs are G.711, G.729, G.726, G.723.1, and G.728. Available voice-enabled routers and access servers support some or all of these codecs.

Codecs impact bandwidth because they determine the payload size of the packets transferred over the IP leg of a call. In voice gateways, you can configure the payload size to control bandwidth. By increasing payload size, you reduce the total number of packets sent, thus decreasing the bandwidth needed by reducing the number of headers required for the call.

4.3.2 Samples

The number of samples per packet is another factor in determining the bandwidth of a voice call. The codec defines the size of the sample but the total number of samples placed in a packet affects how many packets are sent per second. So, the number of samples included in a packet affects the overall bandwidth of a call.

For example, a G.711 10-ms sample is 80 bytes per sample. A call with only one sample per packet would yield the following:

80 bytes + 20 bytes IP + 12 UDP + 8 RTP = 120 bytes per packet

120 bytes per packet * 100 pps = (12000 * 8 bits)/1000 = 96 kbps per call.

The same call using two 10 ms samples per packet would yield the following:

(80 bytes * 2 samples) + 20 bytes IP + 12 UDP + 8 RTP = 200 bytes per packet

(200 bytes per packet) * (50 pps) = (10000 * 8 bits)/1000 = 80 kbps per call

The results show that there is a 16 kbps difference between the two calls. By changing the number of samples per packet, you definitely can change the amount of bandwidth a call uses, but there is a trade-off. When you increase the number of samples per packet, you also increase the amount of delay on each call. DSP resources, which handle each call, must buffer the samples for a longer period of time. You should keep this in mind when you design a voice network.

4.3.3 Voice Activity Detection

Typical voice conversations can contain up to 35 to 50 percent silence. With traditional, circuit-based voice networks, all voice calls use a fixed bandwidth of 64 kbps regardless of how much of the conversation is speech and how much is silence. With VoIP networks, all conversation and silence is packetized. *Voice Activity Detection* (VAD) sends RTP packets only when voice is detected. For VoIP bandwidth planning, assume that VAD reduces bandwidth by 35 percent[15]. Although this value might be less than the actual reduction, it provides a conservative estimate that takes into consideration different dialects and language patterns.

4.3.4 RTP Header Compression

All VoIP packets have two components: voice samples and IP/UDP/RTP headers. Although the voice samples are compressed by the *digital signal processor* (DSP) and vary in size depending on the codec used, the headers are always a constant 40 bytes. When compared to the 20 bytes of voice samples in a default G.729 call, these headers take up a considerable amount of overhead. By using RTP Header *Compression* (cRTP), which is used on a link by link basis, these headers can be compressed to 2 or 4 bytes. This compression can offer substantial VoIP bandwidth savings. For example, a default G.729 VoIP call consumes 24 kbps without cRTP, but only 12 kbps with cRTP enabled[15].

Technical Considerations for Converging Data, Voice, and Video Networks[17]

In networking today, corporations are looking for strategies to integrate disparate networking technologies over a single common network infrastructure. This trend started many years ago in the internetworking area when corporate networks began the migration of delay-sensitive, mission-critical Systems Network Architecture data traffic across an IP infrastructure. Now, people are examining their existing and often separate data, voice, and video network infrastructures and determining the most efficient ways of bringing these together.

In today's environment, most corporations have voice networks anchored around *private branch exchange* (PBX) systems, while most data networks are IP-based and anchored around switches and routers. Figure 4.2, illustrates this concept, where traditional telephony in fixed 64-kbps bandwidth increments is carried across a circuit-switched PBX infrastructure while other dynamic data applications are consolidated over an intelligent IP-based backbone[17].

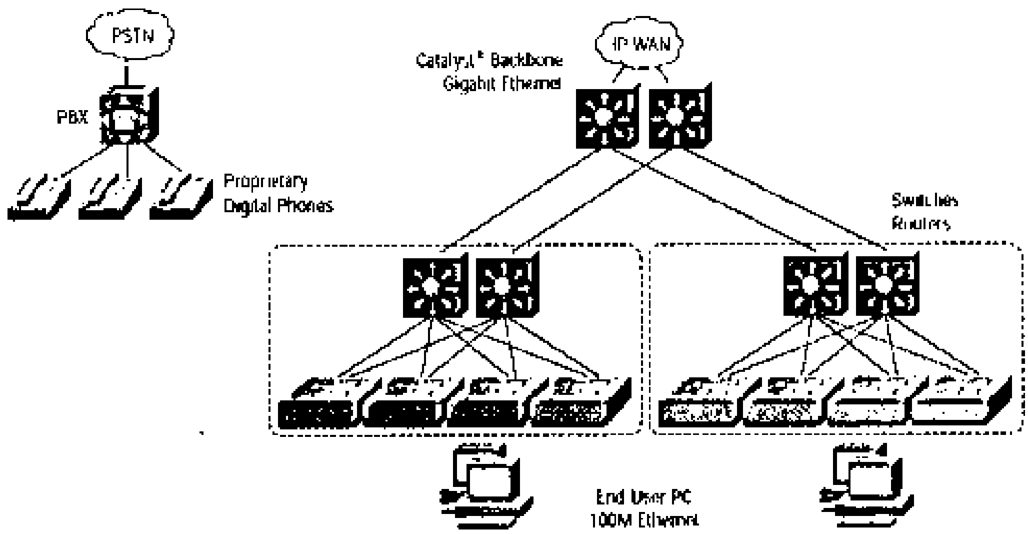


Figure 4.2 Typical Network Infrastructures

With today's separate infrastructures, two strategic directions toward the convergence of data, voice, and video are possible. These approaches are illustrated in Figure 4.3.

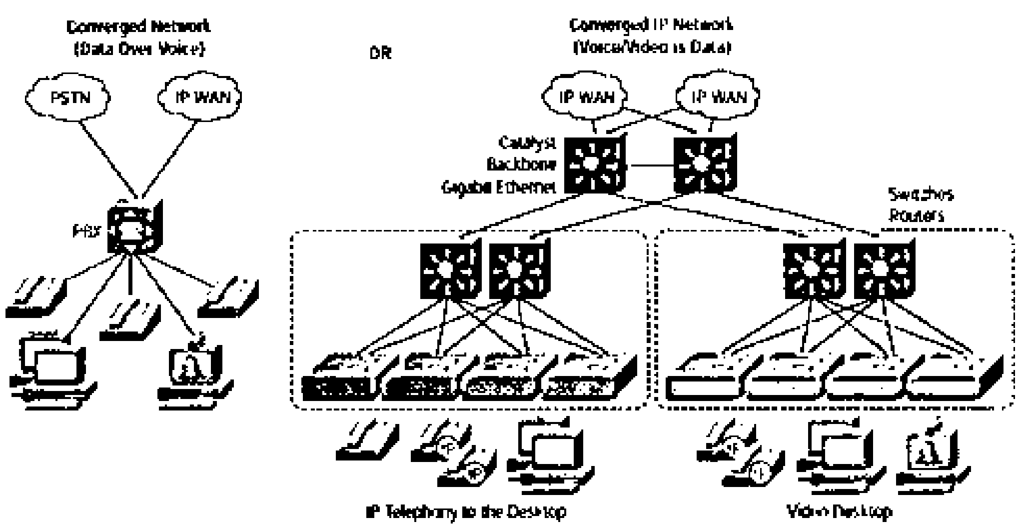


Figure 4.3 Strategies for Convergence

In the video world, it is common to have H.320 based videoconferencing systems, each with their own PSTN network connections.

LAN-based H.323 video systems also are commonly deployed in many companies, which utilizes H.323 for videoconferencing and shared collaboration.

Again, other company is have solution which provides several different ways to preserve investment in legacy systems while investing in converged network solutions. Two different scenarios are shown in Figure 4.4

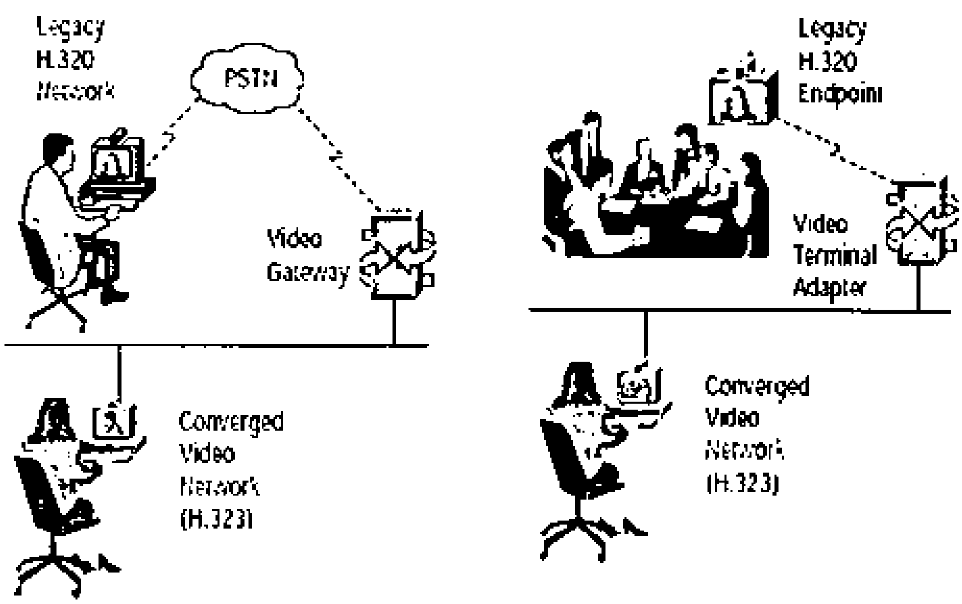


Figure 4.4 Migration from Legacy Video Networks

Chapter V

Input Data of Sirte City

5.1 Introduction.

Sirte is a Libyan City along the Mediterranean sea. It is located in the middle of the Libyan coast between Tripoli and Benghazi, of latitude 31:12:19 N. and of longitude 16:35:18 E. and is about 450 km East of the capital city, Tripoli. Its weather is mixed between mild and desert weather. Historically was one of the main stations between Africa and Europe. Its population is about 156.389, and has an area of approximately 77660 km^2.

The city of Sirte accommodates the Government Administrative Buildings, which has many Administrative branches around the city itself, and also there is a university, an airport , a radio and TV stations, etc. . The aim of this project is to link all these small branches and the central administrative Building with each other for data services and also Internet connections.

5.2 Representation of nodes

- Location Name
- Location Number

The First Step is to Collect data that include all names, localities for Sirte city, and each location is called a node as in (Appendix A). Table A.1 contains 58 nodes that are within the city center, and 21 nodes are out of the city center.

All nodes in (Table. A.1) are shown in the satellite map of Sirte given in figure 5.1a, b.

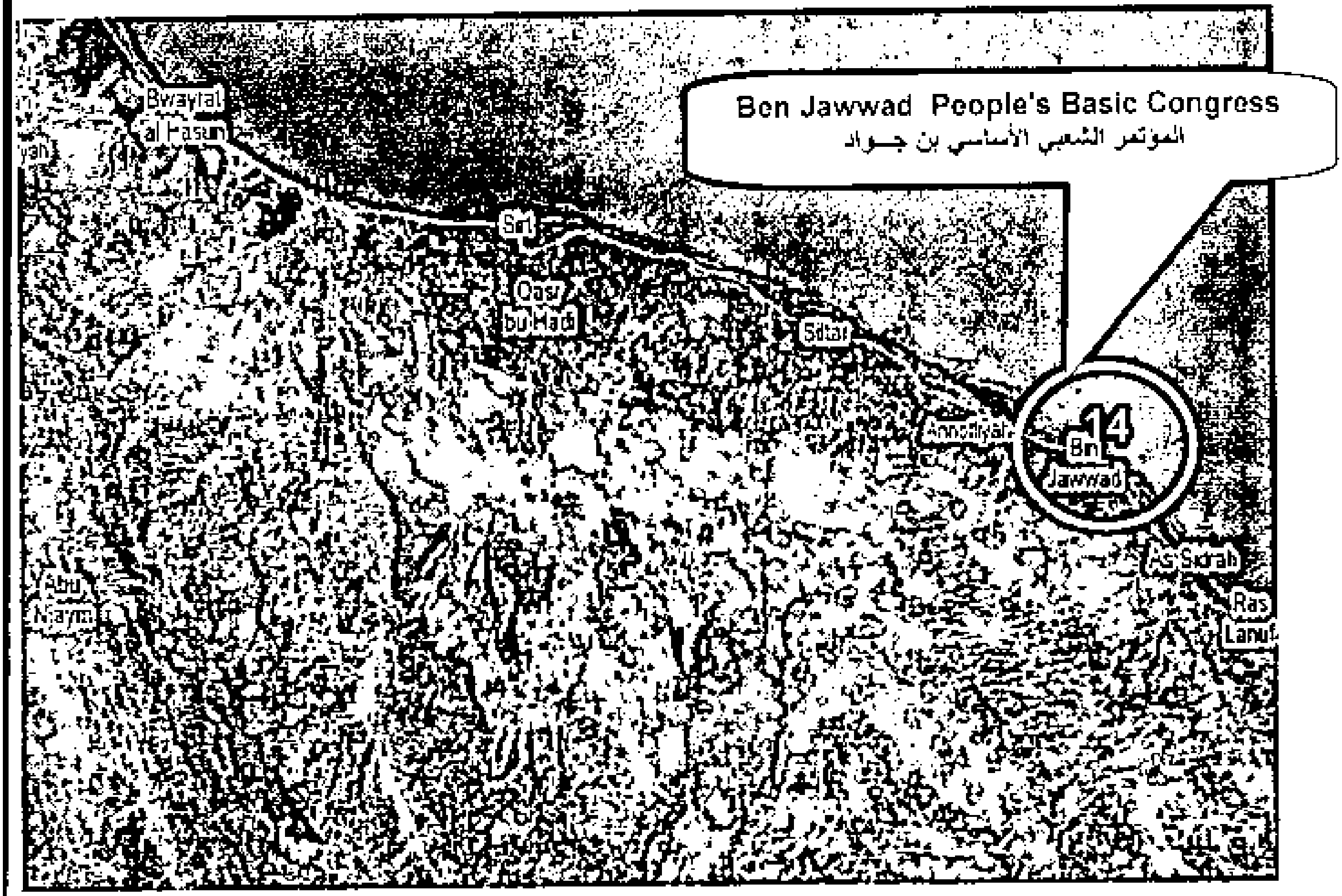


Figure 5.1a Satellite map of Sirte Shabia

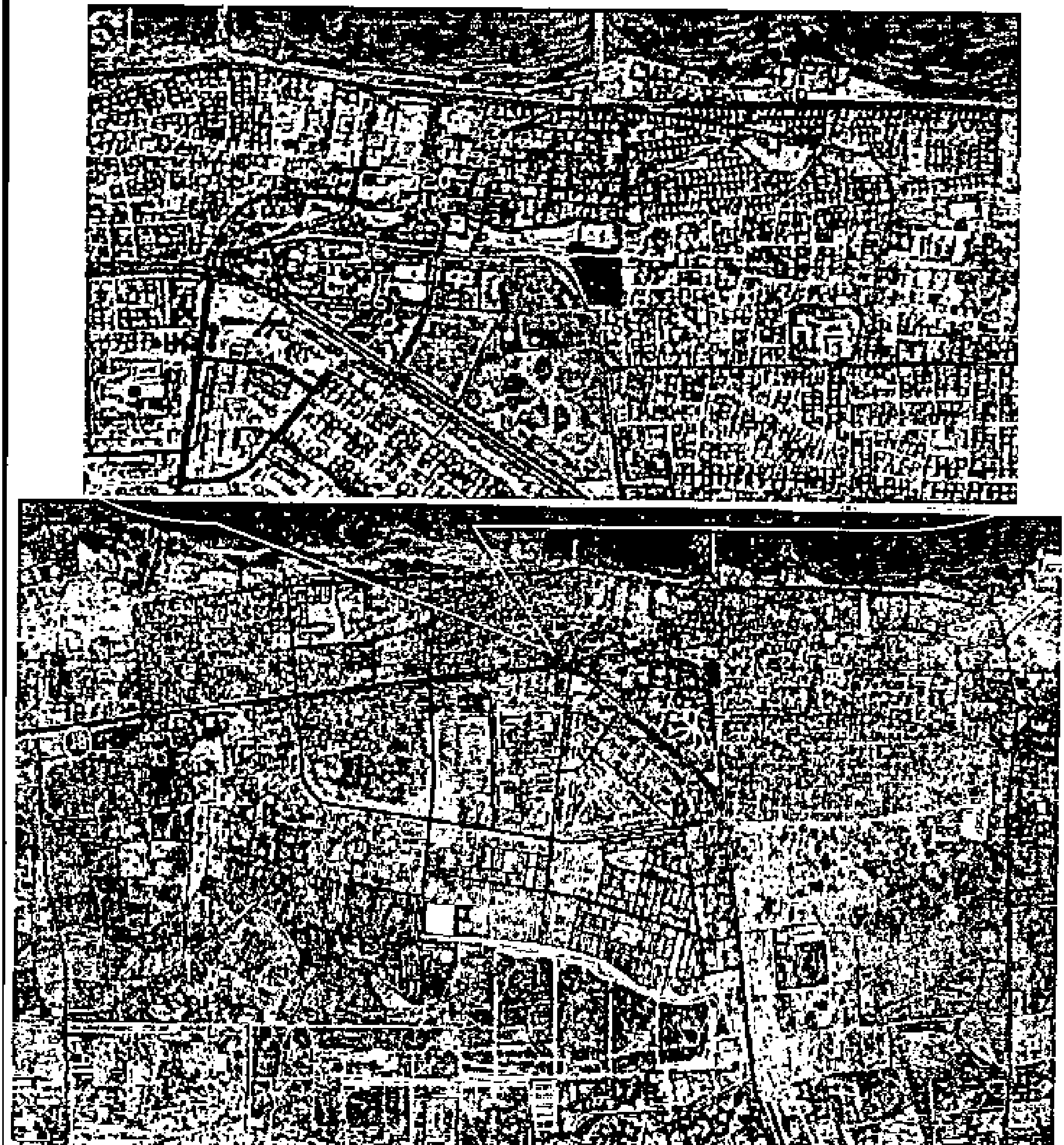


Figure 5.1.b Satellite map of Sirte City

5.3 Manipulation of nodes

- Reduction of nodes
- Produce Final nodes

The number of nodes are reduced from 58 nodes to 26 nodes by collecting all nodes that can form a LAN. and change old nodes into new nodes, as shown in figure 5.2a.b that depicts creation of LANs of the sirte city.

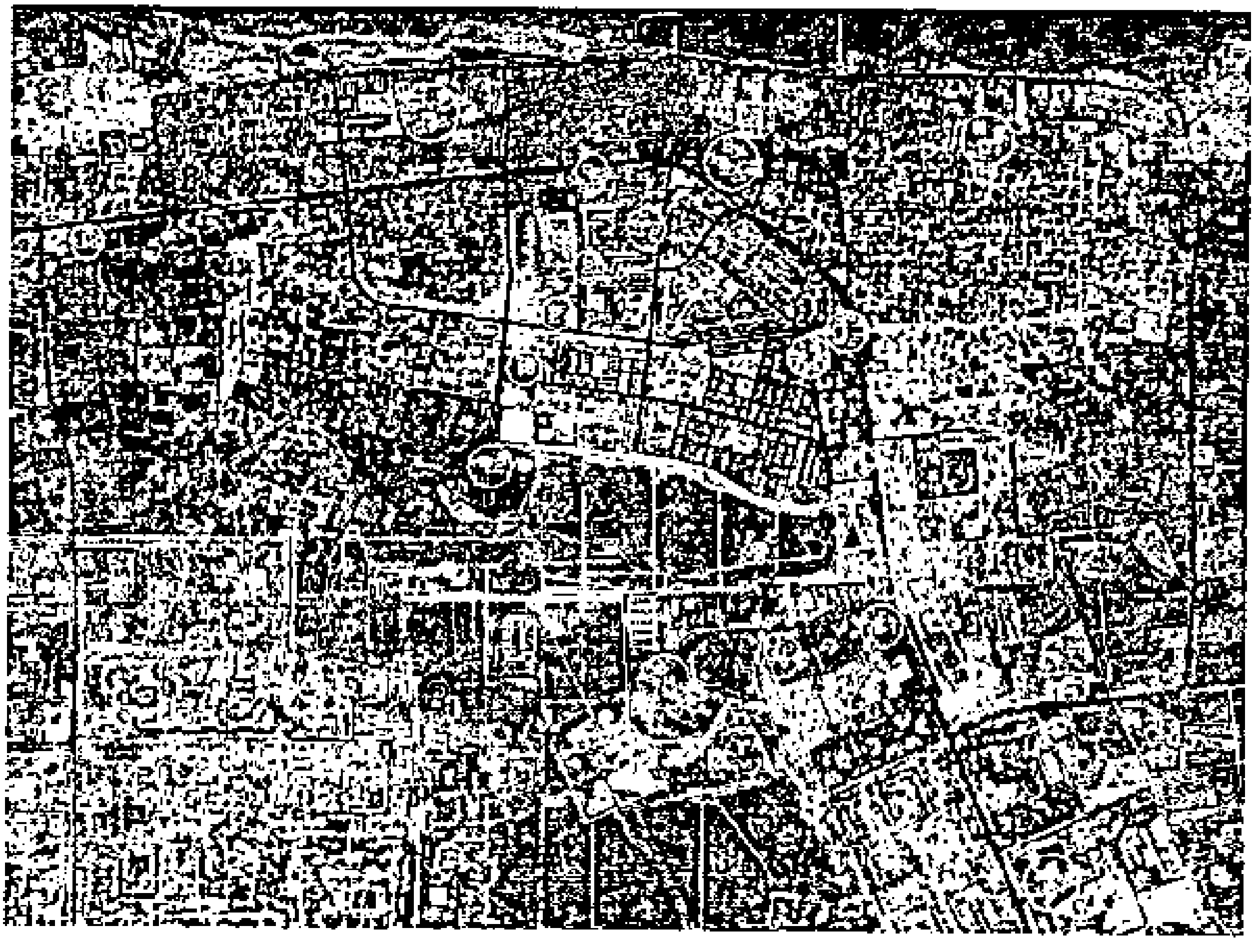


Figure 5.2a. Potential of nodes to form LANs in sirte city

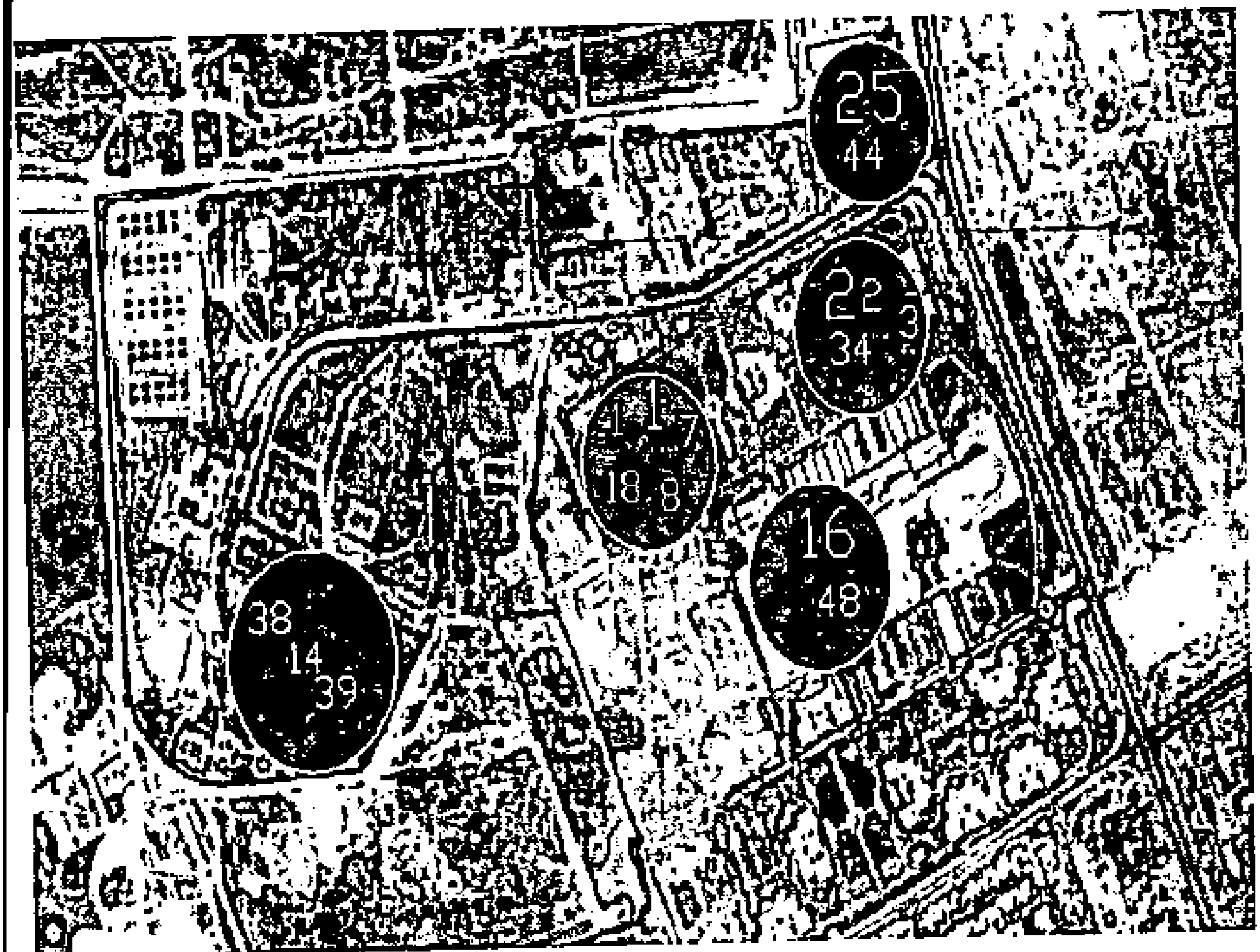


Figure5.2b, Illustration of new node(1,2,14,16,25), and old node(1,2,3,7,8,18,38,34,39,44,48)

5.4 Final Nodes Numbering for Sirte city

The FN *(Final nodes)* of Sirte city are produced from all LANs. Table 5.1 contains final nodes, that are also shown in figures 5.3

Table 5.1-Final Nodes Numbering, and the included nodes.

Final node	Possible LAN with numbering as they are in Table A.1	Final node	Possible LAN with numbering as they are in Table A.1
1	1 - 7 – 8 - 18	14	38 – 39
2	2 - 3 – 34	15	40
3	4 – 6 – 10 – 11 – 15 – 23 – 36 – 41	16	48
4	5- 29 – 33 – 55	17	47
5	12	18	52
6	13	19	22 – 25 – 53 – 54
7	14 – 20 – 24 – 27 – 45 – 58	20	57
8	16 – 17 – 26 – 50 – 51	21	21
9	42 – 43 – 56	22	49
10	28 – 46	23	19
11	30 – 31	24	9
12	35	25	44
13	37	26	32

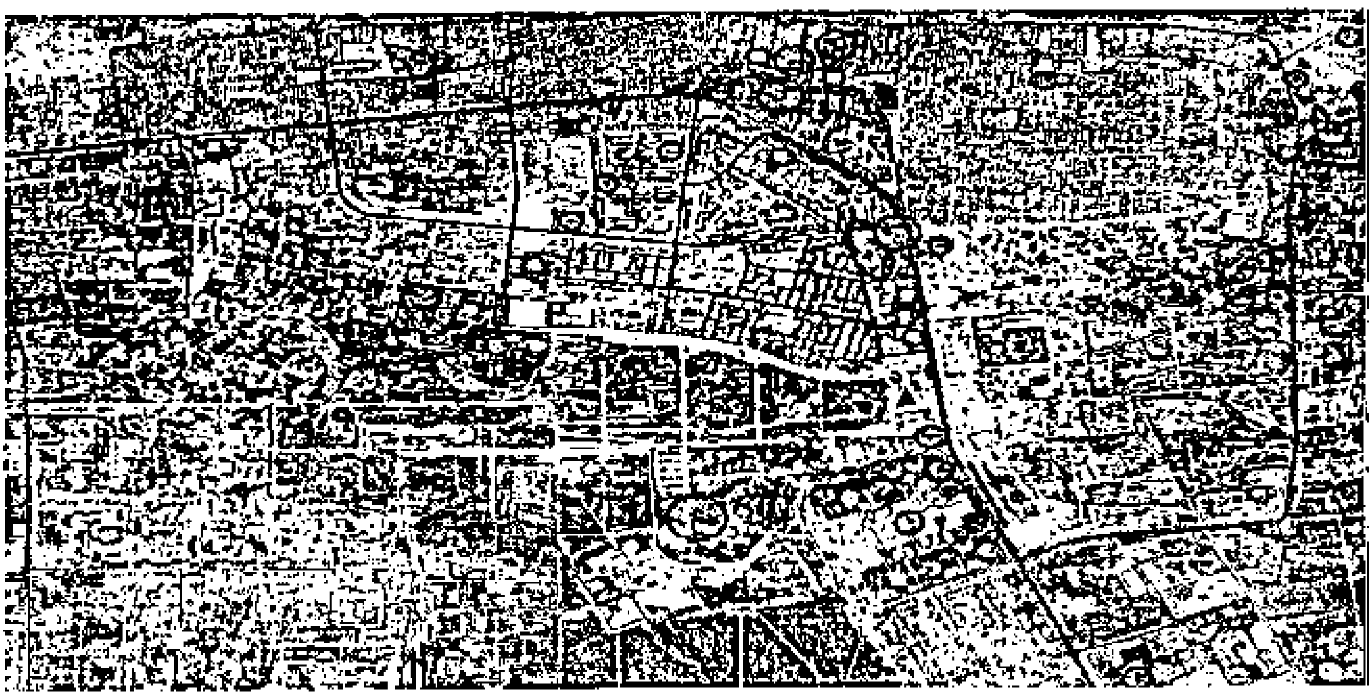


Figure 5.3 Indication of FNs

5.5 Graph of GPTC Paths[20].

The GPTC branch in sirte connects all administration locations by twisted pair cable with a central digital switch, but there are some locations that use optical fiber cable. e.g. Al-Wafa Hall. The GPTC local network paths are pointed on sirte map. and also FNs are positioned on their map ,as shown in figure 5.4.

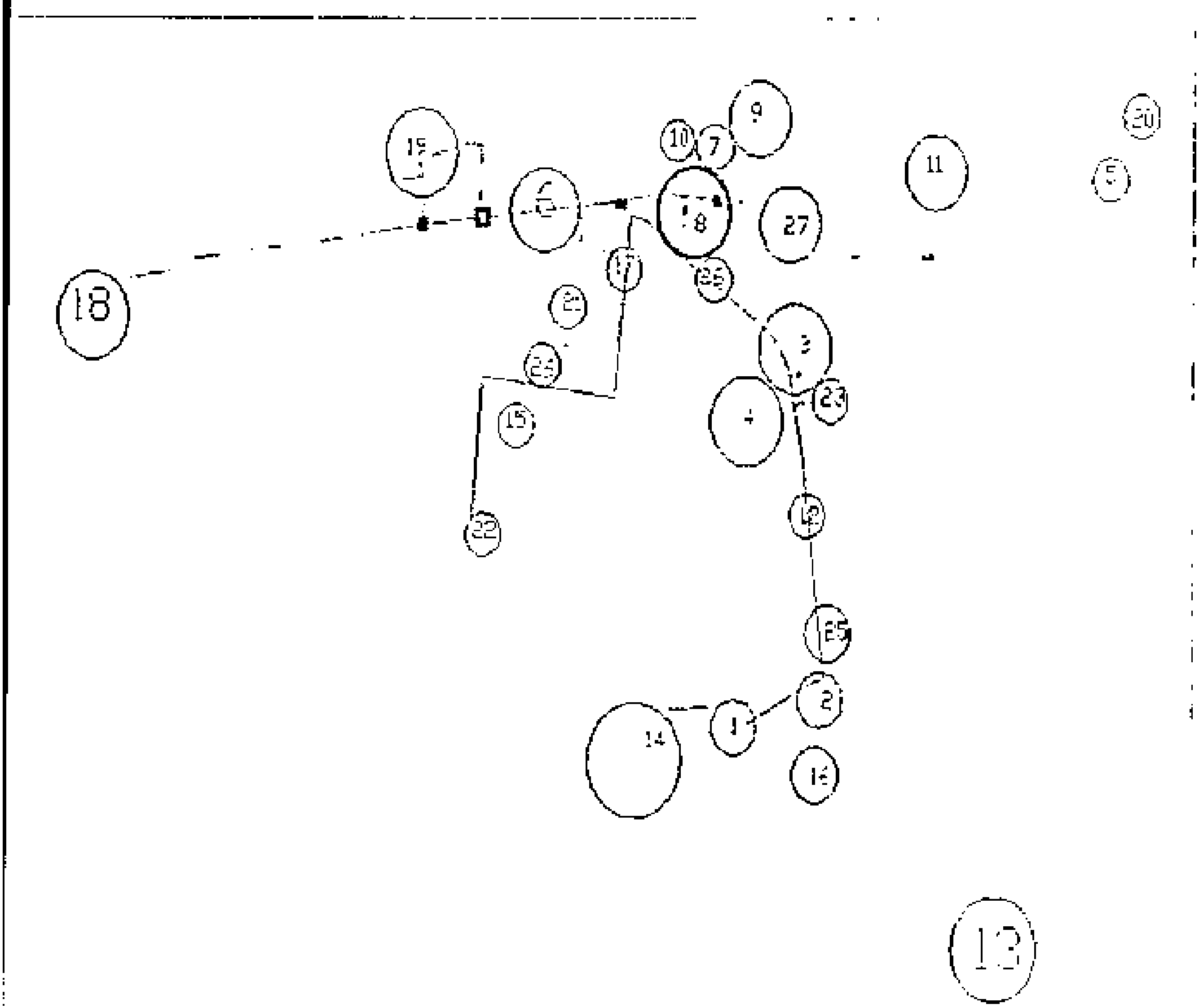


Figure 5.4 GPTC local network paths. location numbers indicate FNs.

Chapter VI

Analysis of input Data and Traffic calculations

6.1 Introduction

In this chapter we will find a method to determine an optimum topology based on minimum distance and same function. use of this topology on GPTC network of the city, and calculate all trfafic values in the final network.

6.2 Generation of Groups

A Group represents the relation between a part of some nodes that are included in some *Final nodes* (FNs), according to the given below parameters. These FNs are constructed based on location of the initial nodes given by the entities of the Shabia as given in section 5.3 of chapter 5. The parameters that control formation of a group are:

- Nature of node function
- Administrative relations
- Same type of functioning employees
- Same type of services

For Example in table 6.1 the Group 2 that contains (3,7 and 8 FNs), after application of the above parameters, and shown in figures 6.1, also given in Appendix (B).

Table 6.1 Group 2 which contain (3.7 and 8 FNs)

Initial Node	Node Name	FNs
14	People' Committee for Housing Proprieties	7
23	Civil service record	3
24	House Planning Unit	7
26	Properties Registration Unit	8

Note from table 6.1, nodes 14.24 exist in FN7

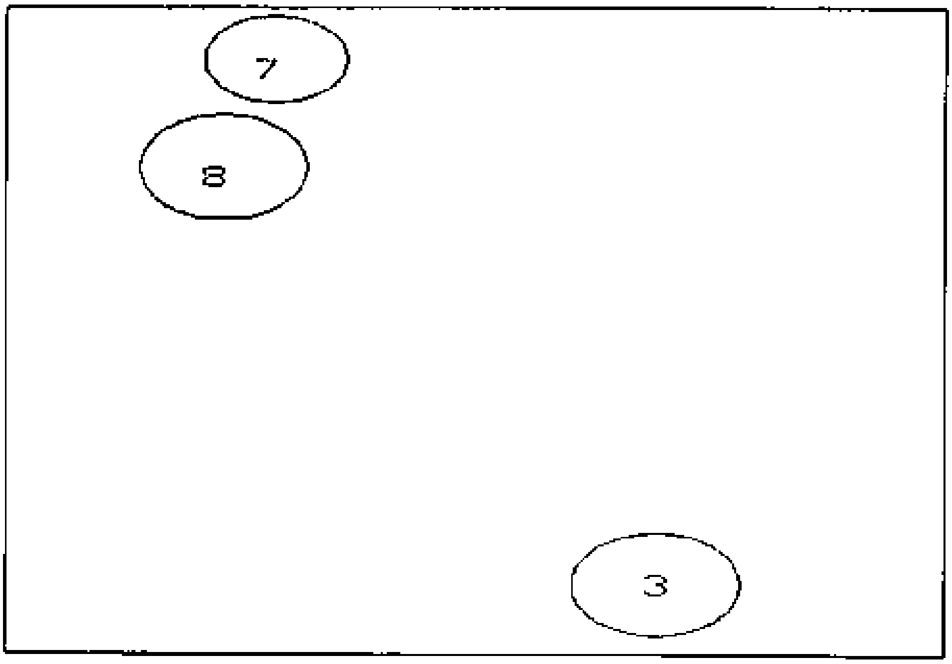


Figure 6.1 Represents Group 2 FNs. number in the figure Indicate FNs as given in chapter 5.

Table 6.2 gives a summary of all formed groups, where it's assumed that a FN may exist in more than one group. as shown Appendix (B).

Table 6.2 Summary of all groups

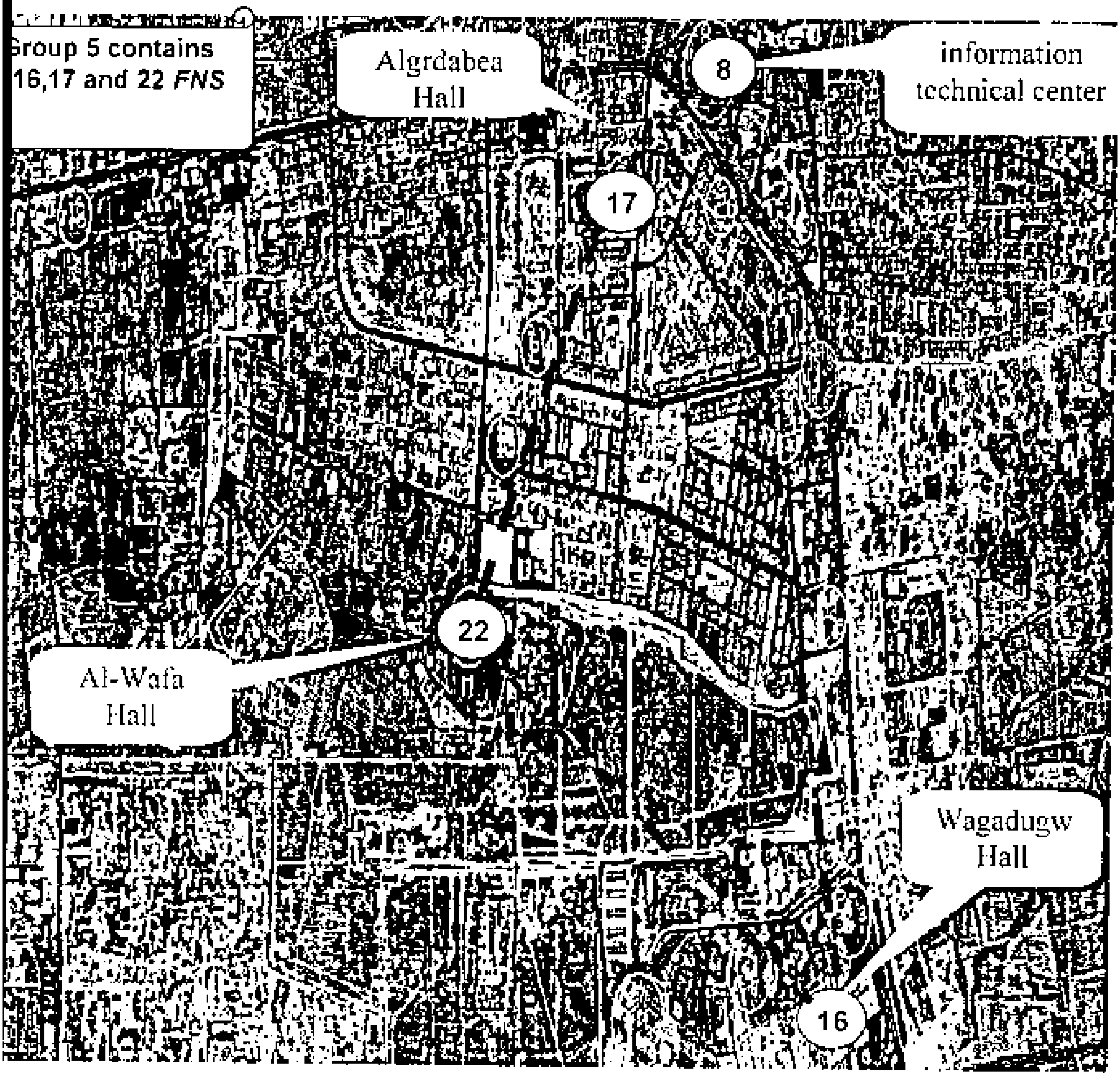
Group no.	FNs forming a group
1	1-2-3-4-5-6-7-8-19-21-23-24
2	3-8-7
3	6-14-15
4	7-9-10-25
5	16-17-22
6	7-8-19- 24
7	5-20
8	3-12
9	8-18
10	3- 26
11	13-14-19
12	8-11

6.3 Group Topology

The adopted topology is ring topology as this topology allows each (FN) within a group to be connected in cascade with both preceding nodes and successive nodes. and must connect each group with information technical center (FN8) as shown in table 6.3. In the following sub sections we will show in figure 6.2. group 5 which contains the FNs 8,16,17 and 22 and the resulted network that collects all. groups in figure 6.3.

Table 6.3 shows each group when FN8 is added to each one.

Group no.	FNs forming a group including FN8
1	1-2-3-4-5-6-7-8-19-21-23-24
2	3-8-7
3	6-8-14-15
4	7-8-9-10-25
5	8-16-17-22
6	7-8-19- 24
7	5-8-20
8	3-8-12
9	8-18
10	3-8- 26
11	8-13-14-19
12	8-11



igure 6.2 Group 5 that contains 8,16,17 and 22 FNs.

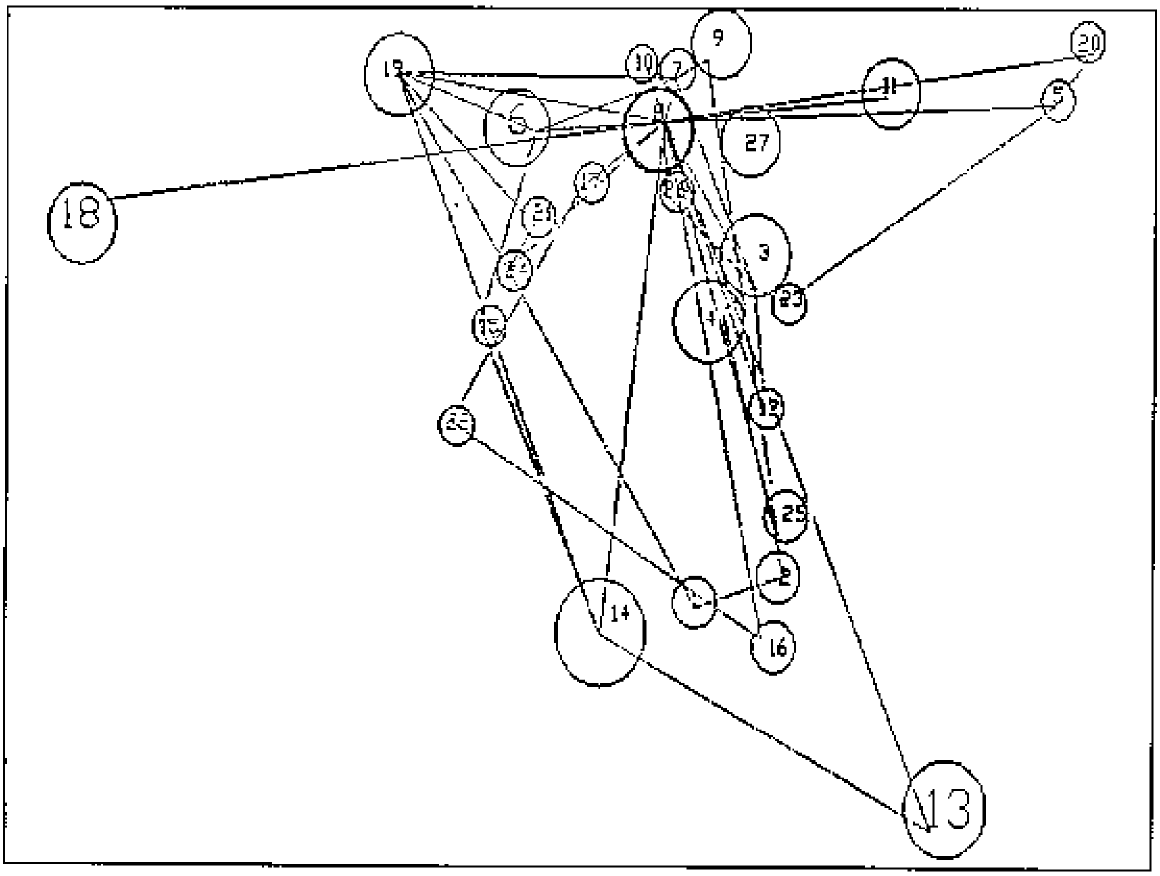


Figure 6.3 All groups and FNs as given in table 6.3

From figure 6.3 it can be seen clearly that there are some repeated, common links which need to be reduced in order to reduce the no. of connected links.

6.4 Analysis of graph

6.4.1 Path division

Here we will divide each long path into two or more smaller paths, and considering geographical locations which also depends on whether the node is a long the way of the path or near to it , in order to utilize an existing path or add new paths for the network to become highly reliable, modified paths are given in table 6.4

Table 6.4 Modified paths

Direct path according to figure 6.3	Modified path		
	Existing path	Add one path	Add two paths
8 – 12	8 – 3 – 12	--------	--------
6 – 7	6 – 8- 7	--------	--------
7 – 3	7 – 8 – 3	--------	--------
10 - 8	10 - 7 – 8	--------	--------
8 – 5	8 - 11 - 5	--------	--------
8 – 20	8 -11 - 20	--------	--------
19 – 8	19 – 6 – 8	--------	--------
19 – 21	19 -24 - 21	--------	--------
19 – 24	19 – 6	6- 24	-------
8 - 13	8 - 3	3 -13	-------
8 - 25	8 -3	3 -25	--------
8 – 16	8 -3	3 -16	-------
4 – 2	4 – 3	3 - 2	-------
8 – 18	8 – 6	6 -18	-------
7 – 19	7 – 10	10-19	-------
1 - 24	1 - 14	14- 24	-------
16 –22	16 –14	14 -22	-------
15 – 14	15 –22	22 -14	-------
9 – 25	-------	-------	9 - 3 - 25
3 -13	--------	-------	3 - 25 -13
5 - 23	-------	--------	5 - 3 - 23
17 –22	-------	-------	17- 24- 22
15 – 6	--------	-------	15 - 24 - 6

------- not Required / not Existing

is noticed that a simple design and more reliable by modifying some new path :ecause FNs(3,12,25) are in the same path and there fore is a need to create a new node. This is called node 27.which is located between FNs(3.8.9.11).Therefore, we can produce new path as given in table 6.5. and to add the new path (18-19) for the design in order to be more reliable.

Table 6.5 A new path to be simplest path and used by transit node(FN27)

Direct path according of figure 6.3	Add two paths
9-3	9 - 27- 3
8-11	8 - 27- 11
22 - 24	22 -15-24
25 - 16	25 - 2 - 16
3 - 16	3 - 25- 16

Then we can produce the final Configuration after completing analysis of all Groups, as shown figures 6.4a,b.

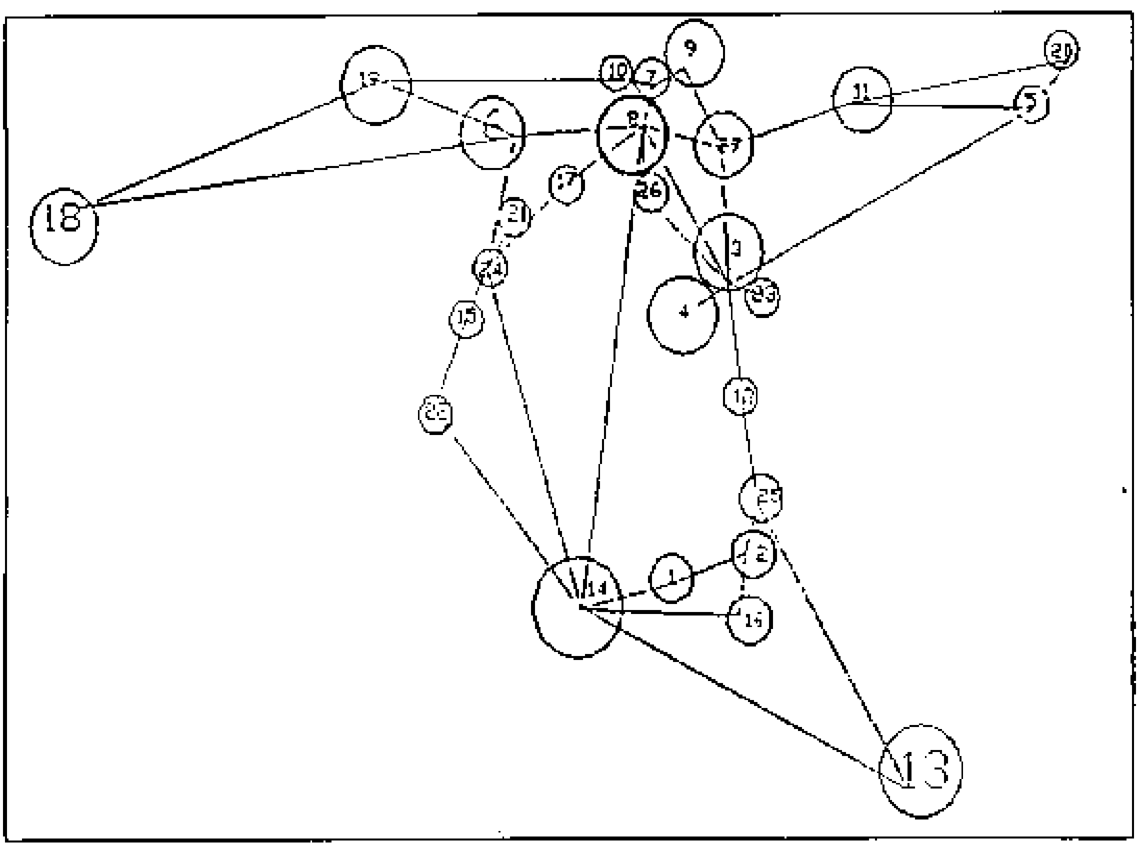


Figure 6.4a Final network Configuration

Figure 6.4b Final network Configuration on Sirte City map

6.4.2 Path length calculations

To calculate the length of all paths that connect FNs together in meters *using AUTOCAD 2004 software* is given in table 6.6, and table 6.7 shows the distance matrix of the Final network topologies.

Table 6.6 final path. and their lengths in meters(m).

No.	Final Path	Path lengths in (m)	No.	Final Path	Path lengths in (m)
1	7-10	159.5	21	3-26	676.9
2	3-4	193.8	22	6-24	684.2
3	7-9	200	23	3-27	698.4
4	3-23	204.6	24	6-8	738
5	7-8	213.3	25	11-27	756.7
6	2-25	259.8	26	19-6	838.3
7	24-21	264.6	27	14-16	922.3
8	24-15	299	28	3-8	953.4
9	16-2	321.6	29	11-5	1051.6
10	5-20	324.3	30	20-11	1278.8
11	26-8	352.7	31	22-14	1342.3
12	27-9	457.9	32	10-19	1430.3
13	27-8	469.8	33	13-25	1657.6
14	15-22	491	34	24-14	1802.2
15	1-2	514.3	35	18-19	1805
16	1-14	569.2	36	3-5	1902.6
17	8-17	580.2	37	13-14	2105.8
18	17-24	583.9	38	6-18	2496
19	12-3	592.5	39	8-14	2499.6
20	12-25	598.4			

Table 6.7 The final distance matrix (lengths in m.)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
1	0	514.3	:	:	:	:	:	:	:	:	:	:	:	569.2	:	:	:	:	:	:	:	:	:	:	:	:	:
2	514.3	0	:	:	:	:	:	:	:	:	:	:	:	:	:	321.6	:	:	:	:	:	:	:	:	259.8	:	:
3	:	:	0	193.8	1902.6	:	:	953.4	:	:	:	592.5	:	:	:	:	:	:	:	:	:	:	204.6	:	:	676.9	698.4
4	:	:	193.8	0	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
5	:	:	1902.6	:	0	:	:	:	:	:	1051.6	:	:	:	:	:	:	:	:	324.3	:	:	:	:	:	:	:
6	:	:	:	:	:	0	:	738	:	:	:	:	:	:	:	:	:	2469	838.3	:	:	:	:	684.2	:	:	:
7	:	:	:	:	:	:	0	213.3	200	159.5	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
8	:	:	953.4	:	:	738	213.3	0	:	:	:	:	:	2499.6	:	:	580.2	:	:	:	:	:	:	:	:	352.7	469.8
9	:	:	:	:	:	:	200	:	0	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	457.9
10	:	:	:	:	:	:	159.5	:	:	0	:	:	:	:	:	:	:	:	1430.3	:	:	:	:	:	:	:	:
11	:	:	:	:	1051.6	:	:	:	:	:	0	:	:	:	:	:	:	:	:	1278.8	:	:	:	:	:	:	756.7
12	:	:	592.5	:	:	:	:	:	:	:	:	0	:	:	:	:	:	:	:	:	:	:	:	:	598.4	:	:
13	:	:	:	:	:	:	:	:	:	:	:	:	0	2105.8	:	:	:	:	:	:	:	:	:	:	1657.6	:	:
14	569.2	:	:	:	:	:	:	2499.6	:	:	:	:	2105.8	0	:	922.3	:	:	:	:	:	1342.3	:	1802.2	:	:	:
15	:	:	:	:	:	:	:	:	:	:	:	:	:	:	0	:	:	:	:	:	:	491	:	299	:	:	:
16	:	321.6	:	:	:	:	:	:	:	:	:	:	:	922.3	:	0	:	:	:	:	:	:	:	:	:	:	:
17	:	:	:	:	:	:	:	580.2	:	:	:	:	:	:	:	:	0	:	:	:	:	:	:	583.9	:	:	:
18	:	:	:	:	:	2469	:	:	:	:	:	:	:	:	:	:	:	0	1805	:	:	:	:	:	:	:	:
19	:	:	:	:	:	838.3	:	:	:	1430.3	:	:	:	:	:	:	:	1805	0	:	:	:	:	:	:	:	:
20	:	:	:	:	324.3	:	:	:	:	:	1278.8	:	:	:	:	:	:	:	:	0	:	:	:	:	:	:	:
21	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	0	:	:	264.6	:	:	:
22	:	:	:	:	:	:	:	:	:	:	:	:	:	1342.3	491	:	:	:	:	:	:	0	:	:	:	:	:
23	:	:	204.6	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	0	:	:	:	:
24	:	:	:	:	:	684.2	:	:	:	:	:	:	:	1802.2	299	:	583.9	:	:	:	264.6	:	:	0	:	:	:
25	:	259.8	:	:	:	:	:	:	:	:	:	598.4	1657.6	:	:	:	:	:	:	:	:	:	:	:	0	:	:
26	:	:	676.9	:	:	:	:	352.7	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	0	:
27	:	:	698.4	:	:	:	:	469.8	457.9	:	756.7	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	0

: indicates NO path Exist

6.4.3 Comparison of developed paths with GPTC paths.

Table (6.8) gives the required comparison as shown in figures 5.4 and 6.4.

Table 6.8 Comparison of our network paths and GPTC network paths.

Path	Our Network	GPTC	Path	Our Network	GPTC
7-10	√	√	6-8	√	√
3 -4	√	√	11-27	√	√
7-9	√	√	19-6	√	√
3-23	√	√	14-16	√	X
7-8	√	√	3-8	√	X
2-25	√	X	11-5	√	X
24-21	√	√	20-11	√	X
24-15	√	√	22-14	√	X
16-2	√	√	10-19	√	X
5-20	√	X	13-25	√	√
26-8	√	√	24-14	√	X
27-9	√	X	19-18	√	X
27-8	√	√	3-5	√	X
15-22	√	X	13-14	√	X
1-2	√	√	6-18	√	√
1-14	√	X	8-14	√	X
8-17	√	√	14-25	X	√
17-24	√	√	1-16	X	√
12-3	√	√	1-25	X	√
12-25	√	√	17-21	X	√
3-26	√	√	8-22	X	√
6-24	√	X	1-8	X	√
3-27	√	√	2-16	X	√

where (√) indicate an Existing path
(X) indicate No path Exist.

6.4.4 Path between information technical center (FN8) with all FNs.

A study of final configuration (figure 6.4) is carried in table 6.9 by calculating the distance from /to FN8 based on our Final configuration.

Table 6.9 Distance calculation from /to FN8

From FN 8 to all FN	Path according to final configuration	Path length in meters **
1	8 3 12 25 2 1	2918.4
2	8 3 12 25 2	2404.1
3	8 3	953.4
4	8 3 4	1147.2
5	8 27 11 5	2278.1
6	8 6	738
7	8 7	213.3
8	0	0
9	8 7 9	413.3
10	8 7 10	372.8
11	8 27 11	1226.5
12	8 3 12	1545.9
13	8 3 12 25 13	3801.9
14	8 14	2499.6
15	8 17 24 15	1463.1
16	8 3 12 25 2 16	2725.7
17	8 17	580.2
18	8 6 18	3207
19	8 6 19	1576.3
20	8 27 11 20	2505.3
21	8 17 24 21	1428.7
22	8 17 24 15 22	1954.1
23	8 3 23	1158
24	8 17 24	1164.1
25	8 3 12 25	2144.3
26	8 26	352.7
27	8 27	469.8

** MATLAB 7.0 software to calculate distance[14]

It's observed from table 6.8 that majority of existing GPTC paths are used in the final configuration, and adds some paths to the network of the city. This gives a more reliable network and an easy solution to implement.

6.5 Traffic Design

We collect data services in each node(voice, text, and video), by a questionnaire, as given in Appendix D.2.

6.5.1 Voice Traffic

The Voice Traffic is calculated by equation(4.1) which is:

$$A = \frac{\sum_{i}^{c} h_i}{T} \quad \text{in Erlangs.}$$

Therefore we can calculate voice traffic in FN1 which contains nodes(1,7,8,18) that have 100,80,50,180 daily calls, with duration of each call as: 5,3,3,5 minutes respectively as a daily traffic with 7 hours work time. Appendix C.2 gives traffic calculation of all other Nodes.

Voice Traffic FN1= *(180*5+100*5+80*3+50*3)/ (7*60) =4.2619* E

To find the bandwidth of each FN in bps, with some of the standard voice codec G.711, G.729, G.726, G.723.1, and G.728 are used. Voice-enabled routers and access servers support some or all of these codec.

In the worst case we can use codec (G.711). A G.711 10-ms sample is 80 bytes per sample. A call with only one sample per packet would yield the following:

80 bytes + 20 bytes IP + 12 UDP + 8 RTP = 120 bytes per packet

120 bytes per packet * 100 pps = (12000 * 8 bits)/1000 = 96 kbps per call.

'o decrease the size of bandwidth we can use G.729 coding with 10-ms sample as shown in table 6.10, and to use Erlangs to VOIP Bandwidth Calculator software[13] o convert voice traffic from E to bps.

Table 6.10 Final voice traffic of FNs.

FNs	Generated traffic (E)	No. of Paths for GOS 0.01 *	Bandwidth (kBps) *	
			G.711	G.729
1	4.2619	10	960	400
2	1.809524	6	576	240
3	8.154762	16	1536	640
4	5.142857	11	1056	440
5	1.333333	5	480	200
6	4.761905	11	1056	640
7	4.97619	11	1056	640
8	5.5	12	1152	480
9	3.904762	10	960	400
10	1.761905	6	576	240
11	1.333333	5	480	200
12	5	11	1056	440
13	0.928571	5	480	200
14	0.928571	5	480	200
15	0.666667	4	384	160
16	1.333333	5	480	200
17	1.071429	5	480	200
18	4.761905	11	1056	440
19	3.952381	10	960	400
20	2.142857	7	672	280
21	1.047619	5	480	200
22	0.857143	4	348	160
23	0.952381	5	480	200
24	2.380952	7	672	280
25	1.047619	5	480	200
26	0.666667	4	348	160

* :Use Erlangs to VOIP Bandwidth Calculator software[13]

6.5.2 Data Traffic

The parameters that control this type of traffic.depend on Size of paper which also depends on:

- number of lines in each paper
- number of words in each line
- number of characters in each word

Take four papers as a sample of web page that have text, tables, pictures and table with picture, where these papers have sizes; 60kB, 54KB, 24KB,49kB, then we can use one paper size equal 60KB, as in table 6.11. We can find total size of each FN by multiplying paper size and the number of papers per day. We can generate size of traffic in FN1 in bps.

Data traffic = (190+55+25+155)* 60*1024*8/(3600*7) =406300 bps

Appendix C.3 gives data traffic calculation of all Nodes.

Table 6.11 Final data traffic of FNs.

FN	Traffic in bps		FN	Traffic in bps
1	406300		14	382400
2	420640		15	133840
3	1065940		16	219880
4	611840		17	19120
5	124280		18	219880
6	57360		19	669200
7	850840		20	219880
8	1013360		21	114720
9	382400		22	57360
10	325040		23	86040
11	391960		24	181640
12	286800		25	219880
13	191200		26	76480

6.5.3 Total traffic

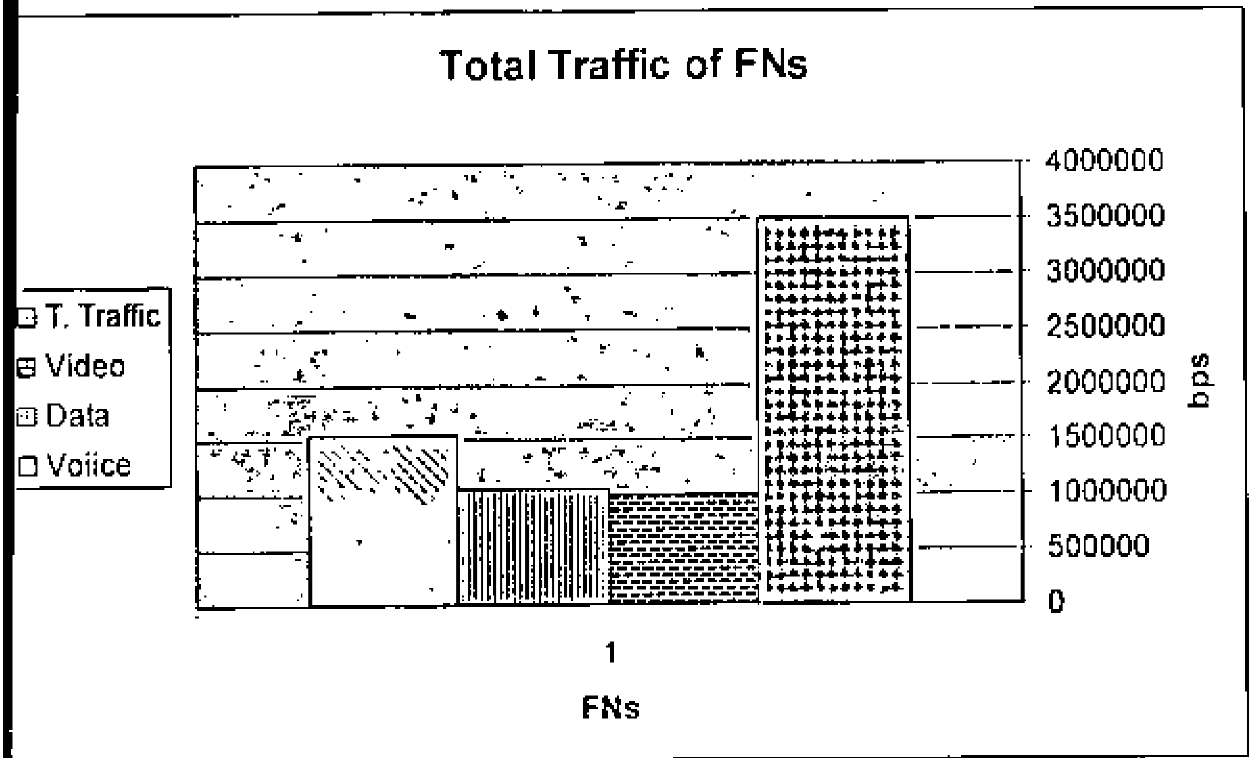
6.5.3.1 Total traffic of each FN

From tables 6.10 and 6.11 we can produce the total traffic of voice, data and video which is based on a questionnaire result, as shown in table 6.12, Figure 6.5 gives the maximum value of voice, data ,and video traffic.

Table 6.12 Final traffic of FNs. as BW in bps.

FNs	voice	data	video *	Total bandwidth bps
1	960000	406300	1000000	2366300
2	576000	420640	0	996640
3	1536000	1065940	1000000	3601940
4	1056000	611840	0	1667840
5	480000	124280	0	604280
6	1056000	57360	0	1113360
7	1056000	850840	0	1906840
8	1152000	1013360	1000000	3165360
9	960000	382400	0	1342400
10	576000	325040	0	901040
11	480000	391960	0	871960
12	1056000	286800	1000000	2342800
13	480000	191200	1000000	1671200
14	480000	382400	1000000	1862400
15	384000	133840	0	517840
16	480000	219880	1000000	1699880
17	480000	19120	1000000	1499120
18	1056000	219880	1000000	2275880
19	960000	669200	0	1629200
20	672000	219880	0	891880
21	480000	114720	0	594720
22	348000	57360	1000000	1405360
23	480000	86040	0	566040
24	672000	181640	0	853640
25	480000	219880	0	699880
26	348000	76480	0	424480

* Assumed based on Questionnaire Result



igure 6.5 Maximum values of Traffic

.5.3.2 Total traffic between FNs

'o measure the traffic between FNs. The relation between each FN with its adjacent FNs connected to other FNs in the same group is given in Appendix B.2. then the veight of the traffic on FNs in each path is to take one of the 5 point scale as follows:

Weight =5 high relation(*Exist in same Group and connected with adjacent FNs*)

Weight =3 medium relation(*Exist in same Group and not connected with adjacent FNs*)

Weight =1 low relation(does not exist in same Group and connected with adjacent FNs)

Weight =0 no relation(does not exist in same Group and not connected with adjacent FNs)

Where the weight relation in the same group, is as shown in Appendix D.1 divided by weight of FNs.

In the figure 6.6 gives relation between FNs 1,2,3,8,12, and 25 with all FNs.

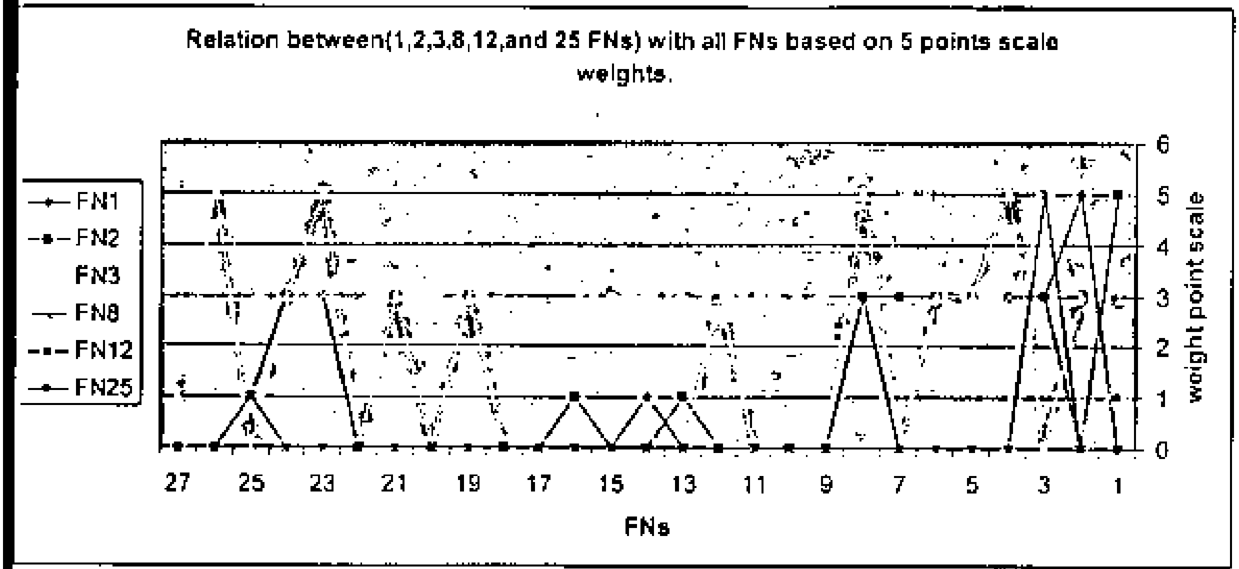


Figure 6.6 Weight according to 5 points scale

As an example for FN1 the method to calculate relation traffic is:

SUM of relations =5+3+3+3+3+3+3+1+1+3+3+3+3=37

Value of high relation 5/37*2366300 = 319770.26 bps

Value of medium relation 3/37*2366300 = 191862.16 bps

Value of low relation 1/37*2366300 = 63954.05 bps

The value of total traffic between FNs is obtained as shown above according to 5 points scale, and the result is given in table 6.13. Figure 6.7 shows total traffic of each FN in bps, and it is disturbed according 5 points scale weights.

Table 6.13 Total traffic of each FN in bps, and distortion.

FN	SUM of points	Value of generated traffic (bps)	Value of a point in bps		
			1	3	5
1	37	2366300	63954.05	191862.16	319770.26
2	38	996640	26227.36	78682.1	131136.8
3	45	3601940	80043.11	240129.3	400215.55
4	35	1667840	47652.57	142957.71	238262.8
5	41	604280	14738.536	44215.6	73692.68
6	46	1113360	24203.47	72610.43	121017.39
7	48	1906840	39725.833	119177.49	198629.15
8	86	3165360	36806.511	110419.53	184032.55
9	15	1342400	89493.33	268479.9	447466.65
10	15	901040	60069.33	180207.99	300346.65
11	6	871960	145326.66	435979.98	726633.3
12	9	2342800	260311.11	780933.3	1301555.5
13	12	1671200	139266.66	417799.98	696333.3
14	23	1862400	80973.913	242921.73	404869.55
15	11	517840	47076.363	141229.08	235381.8
16	11	1699880	154534.54	463603.63	772672.7
17	12	1499120	124926.66	374779.98	624633.3
18	5	2275880	455176	1365528	2275880
19	43	1629200	37888.37	113665.11	189441.85
20	9	891880	99091.77	297293.3	495488.88
21	35	594720	16992	50976	84960
22	11	1405360	127760	383280	638800
23	35	566040	16172.57	48517.71	80862.855
24	40	853640	21341	64023	106705
25	15	699880	46658.66	139975.99	233293.3
26	10	424480	42448	127344	212240
27	20	0	0	0	0

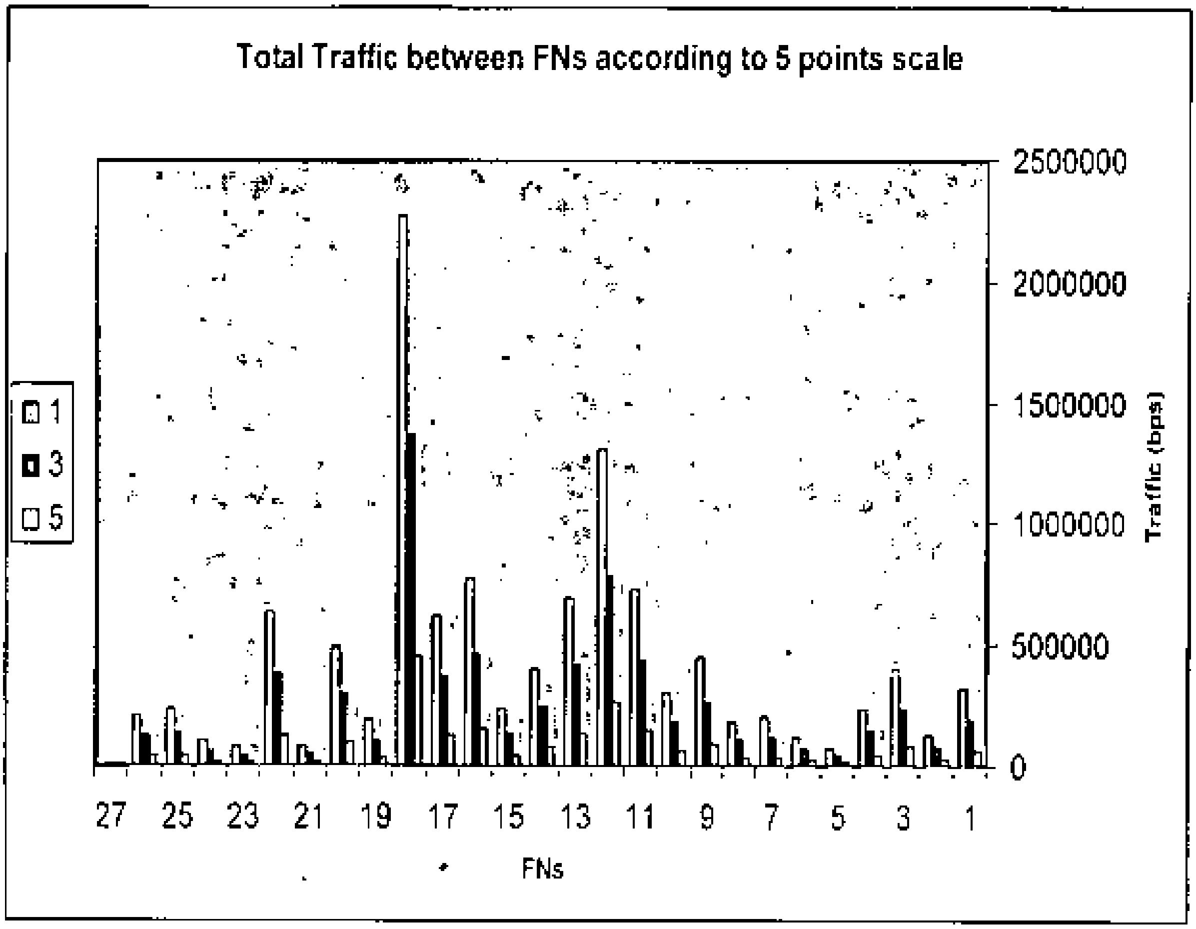


Figure 6.7 Total traffic of FNs in bps, and disturbing according 5 points scale weights.

Generated final traffic in bps from /to information technical center (FN8) with all FNs by adding weight of each link between FN8 and other FNs, as shown in Table 6.14 we can find total traffic carried by each link.

Table 6.14 Total Traffic between FN8 and other FNs.

FN8 / FNs	Path	Weight of link *	Generated traffic (bps)	Total traffic (bps)
1	8 3 12 25 2 1	3+3+1+1+5	110419.53+240129.3+260311.11+46658.66+131136.8	788655.4
2	8 3 12 25 2	3+3+1+1	110419.53+240129.3+260311.11+46658.66	657518.6
3	8 3	3	110419.53	110419.53
4	8 3 4	3+5	110419.53+400215.55	510635.1
5	8 27 11 5	1+5+1	36806.51+0+145326.66	182133.2
6	8 6	5	184032.55	184032.55
7	8 7	5	184032.55	184032.55
8	0	0	0	0
9	8 7 9	5+5	184032.55+198629.15	382661.7
10	8 7 10	5+5	184032.55+198629.15	382661.7
11	8 27 11	1+5	36806.51+0	36806.51
12	8 3 12	3+3	110419.53+240129.3	350548.8
13	8 3 12 25 13	3+3+1+1	110419.53+240129.3+260311.11+46658.66	657518.6
14	8 14	3	110419.53	110419.53
15	8 17 24 15	5+1+1	184032.55+124926.6+21341	330300.2
16	8 3 12 25 2 16	3+3+1+1+1	110419.53+240129.3+260311.11+46658.66+26227.36	683746
17	8 17	5	184032.55	184032.55
18	8 6 18	5+1	184032.55+24203.47	208236
19	8 6 19	5+5	184032.55+121017.39	305049.9
20	8 27 11 20	1+5+1	36806.51+0+145326.66	182133.2
21	8 17 24 21	5+1+5	184032.5+124926.6+106705	415664.1
22	8 17 24 15 22	5+1+1+1	184032.5+124926.6+21341+47076.363	377376.5
23	8 3 23	3+5	110419.53+400215.55	510635.1
24	8 17 24	5+1	36806.51+124926.66	161733.2
25	8 3 12 25	3+3+1	110419.53+240129.3+260311.1	610859.9
26	8 26	5	184032.5	184032.5
27	8 27	1	36806.51	36806.511

* As shown in Appendix D (Table D.1 Relation between FNs based on 5 points scale weights)

To produce the overall final bandwidth, traffic must be increased between FNs that may use some services e.g. internet, etc. This comes by adding some Mbps of total traffic that is produced in table 6.14, between all FNs as shown the table 6.15. Figure 6.8 shows Final traffic from FN8/FNs in bps.

Table 6.15 Overall Final traffic (0.5=512kbps. 0.25 =256kbps)

FN8 / FNs	Total traffic	Service by Mbps	Final traffic (bps)
1	788655.4	0.5	1288655
2	657518.6	0.25	907518.6
3	110419.53	0.5	610419.5
4	510635.1	0.5	1010635
5	182133.2	0.25	432133.2
6	184032.55	0.25	434032.6
7	184032.55	0.5	684032.6
8	0	0	0
9	382661.7	0.25	632661.7
10	382661.7	0.25	632661.7
11	36806.51	0.25	286806.5
12	350548.8	0.25	600548.8
13	657518.6	0.25	907518.6
14	110419.53	0.5	610419.5
15	330300.2	0.25	580300.2
16	683746	0.25	933746
17	184032.55	0.25	434032.6
18	208236	0.25	458236
19	305049.9	0.25	555049.9
20	182133.2	0.25	432133.2
21	415664.1	0.25	665664.1
22	377376.5	0.25	627376.5
23	510635.1	0.25	760635.1
24	161733.2	0.25	411733.2
25	610859.9	0.25	860859.9
26	184032.5	0.25	434032.5
27	36806.511	0.25	286806.5

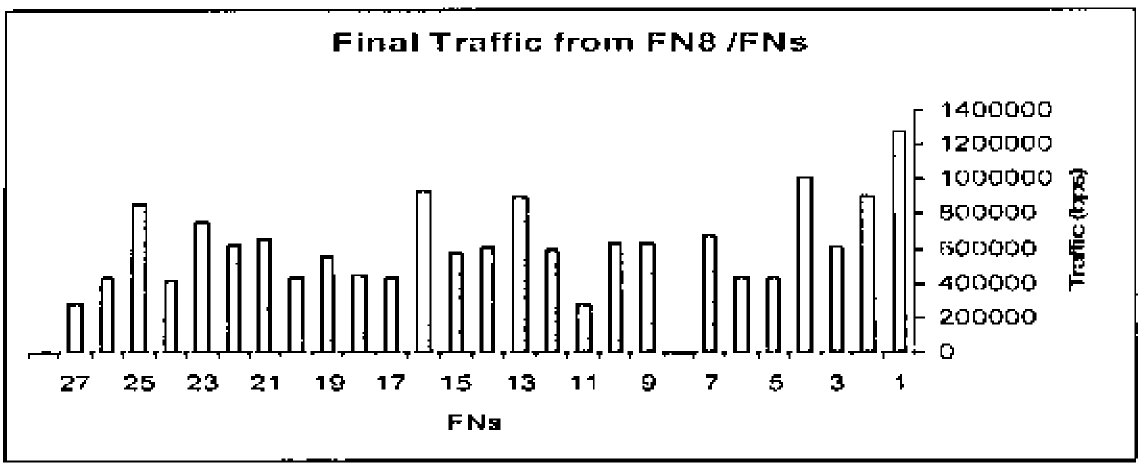


Figure 6.8 Final Traffic from FN8/ FNs in bps.

Chapter VII

Summary of Results, Conclusion and Recommendations

.1 Final results

able 7.1 identifies all final nodes and the names of nodes contained in each final ode in sirte city, and in figures 7.1,7.2 locations of all these nodes are shown on the ity map.

able 7.1 Defined Final nodes and nodes they contain

Final node	Node number	Names of nodes in sirte city
1	1	People's Congress Trustee For Shabiayete
	7	People's Committee For Tourism
	8	People's Committee For Planning
	18	People's Committee Of Transport
2	2	People's Congress Governorate For Shabiayete
	3	Council Of Planning
	34	Union Of Experts
3	4	The People's Committee For Industry, Energy And Metals
	6	People Committee For Information And Culture
	10	General People Committee For Agriculture
	11	General People Committee For Zoology
	15	People' Committee Of Economy And Commerce
	23	Civil Service Record
	36	Algrdabea News
	41	Man Power Unit
4	5	People Committee For Finance
	29	People's Court
	33	Alaogaf Unit
	55	GECOL sirte Branc
5	12	People Committee For Nautical Sea

6	13	General People Committee For Health
7	14 20 24 27 45 58	People' Committee For Housing Proprieties Sirte Al-Markaz People's Basic Congress House Planning Unit Environment Service Unity Bank Police Station
8	16 17 26 50 51	People' Committee Of Youth And Sport People' Committee Of Justice Properties Registration Unit Sirte GPTC Technical Centre For Information
9	42 43 56	Central Bank Real Estate Bank Libyan Airline Company
10	28 46	Cooperation For Environment, Social And Popular leadership Agriculture Bank
11	30 31	Social And Soldierly Fund Social And Security Fund
12	35	Sirte Radio Station
13	37	Al-Tahaddi University
14	38 39	Faculty Of Medicine Ibn-Sina Hospital
15	40	Central Clinics Comple
16	48	Wagadugw Hall
17	47	Algrdabea Hall
18	52	Satellite Station For Communication
19	22 25 53 54	Al-Fateh People's Basic Congress Meteorology Service Evaluation Of Tuition Passport Section
20	57	Sirte Port
21	21	Eople's Basic Congress Al- Rebate Al- Amami
22	49	Al-Wafa Hall
23	19	Kaleej Sirte People's Basic Congress
24	9	People' Committee Of General Security
25	44	Trading Bank
26	32	Agriculture And Industrial And Commercial Unit

Figure 7.1 All nodes on city map.

Figure 7.2 Node's in final node 3 and 4

Next, dividing all final node into groups to produce a final configuration. as shown in table 7.2, also given before in chapter 6.

Table 7.2 Final groups

Group no.	Final node	Group no.	Final node
1	1-2-3-4-5-6-7-8-19-21-23-24	7	5-8-20
2	3-8-7	8	3-8-12
3	6-8-14-15	9	8-18
4	7-8-9-10-25	10	3-8- 26
5	8-16-17-22	11	8-13-14-19
6	7-8-19- 24	12	8-11

After analysis of groups topology, we can produce a final design that have paths as shown in table 7.3, and connect FNs by paths as in figure 7.3.

Table 7.3 Paths of sirte city

No.	Final Path	Path lengths in (m)	No.	Final Path	Path lengths in (m)
1	7-10	159.5	21	3-26	676.9
2	3-4	193.8	22	6-24	684.2
3	7-9	200	23	3-27	698.4
4	3-23	204.6	24	6-8	738
5	7-8	213.3	25	11-27	756.7
6	2-25	259.8	26	19-6	838.3
7	24-21	264.6	27	14-16	922.3
8	24-15	299	28	3-8	953.4
9	16-2	321.6	29	11-5	1051.6
10	5-20	324.3	30	20-11	1278.8
11	26-8	352.7	31	22-14	1342.3
12	27-9	457.9	32	10-19	1430.3
13	27-8	469.8	33	13-25	1657.6
14	15-22	491	34	24-14	1802.2
15	1-2	514.3	35	18-19	1805
16	1-14	569.2	36	3-5	1902.6
17	8-17	580.2	37	13-14	2105.8
18	17-24	583.9	38	6-18	2496
19	12-3	592.5	39	8-14	2499.6
20	12-25	598.4			

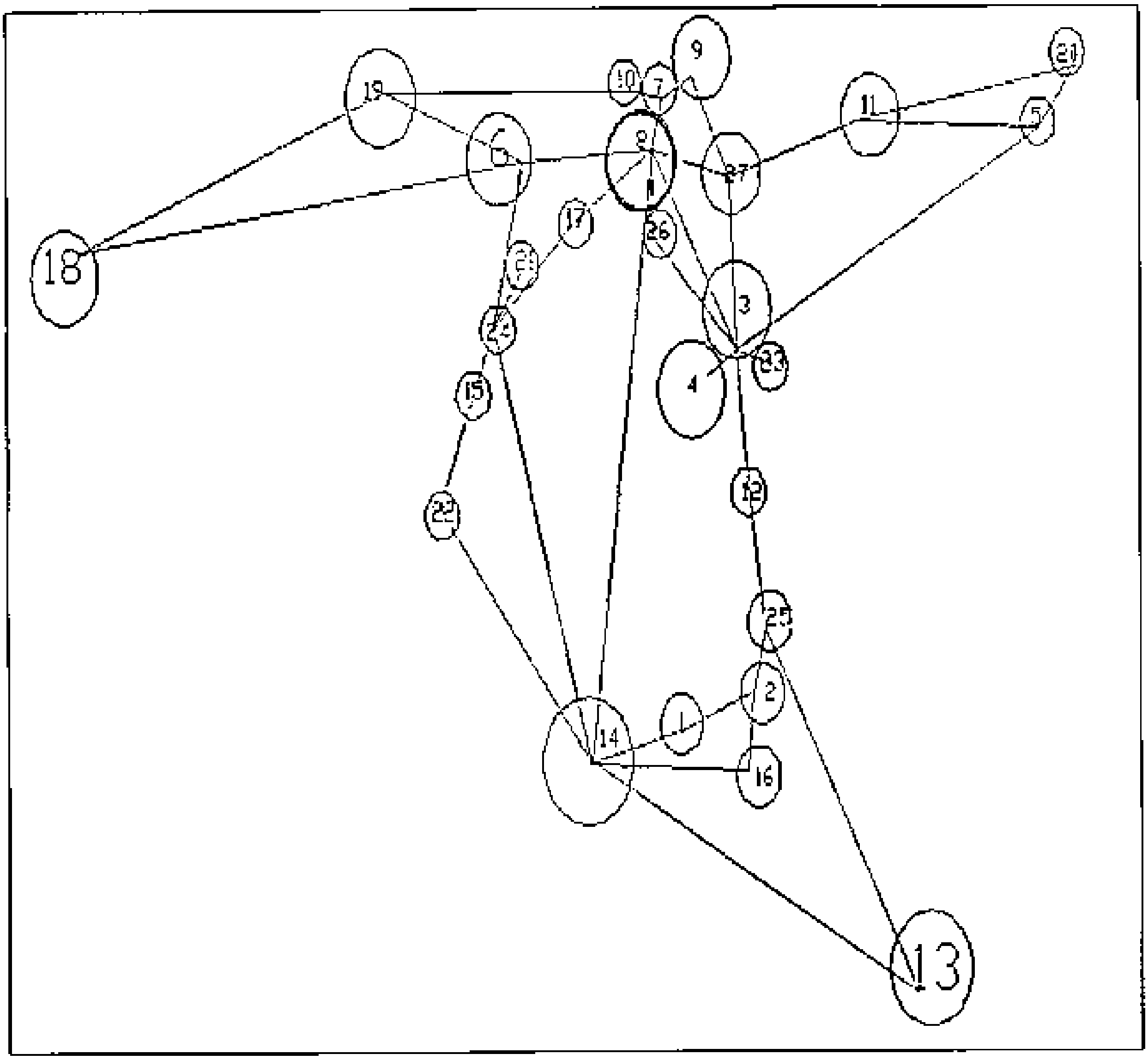


Figure 7.3 WAN of srite city

7.2 Selected transmission media

After producing Final network Configuration, we can calculate the carried traffic in each path by dividing weight of the traffic on FNs, as given in table 6.13 (Total Traffic), and also given in Appendix D.1(Relation between FNs based on 5 points scale weights). In Figure 7.4 Traffic in bps of each path is also given.

We can use the existing GPTC paths with a new termination technology(e.g. ADSL) for paths of small distances that is from 1.5km or less which are already use GPTC twisted pairs but for the remaining paths it is suggested to use Optical Fiber (OP) as their technology of transmission media has proved to be the most suitable one for digital traffic. These can be seen clearly in most of the implemented recent projects in GPTC [4]. As shown in table 7.4.

Table 7.4 Selected proper transmission media with carried Traffic each path

No.	Path	Traffic (bps)		Availability	Type of transmissions media
		Up	Down		
1	7-10	198629.15	300346.65	√	TP
2	3-4	238262.8	400215.55	√	TP
3	7-9	198629.15	447466.65	√	TP
4	3-23	80862.855	400215.55	√	TP
5	7-8	920162.8	993145.8	√	TP
6	2-25	78682.08	139976	X	OP
7	24-21	84960	106705	√	TP
8	24-15	42682	94152.73	√	TP
9	16-2	26227.36	154534.54	√	TP
10	5-20	14738.536	99091.77	X	OP
11	26-8	184032.55	212240	√	TP
12	27-9	447466.65	447466.65	X	OP
13	27-8	147226	147226	√	TP
14	15-22	47076.363	127760	X	OP
15	1-2	131136.8	319770.26	√	TP
16	1-14	63954.05	80973.913	X	OP
17	8-17	920162.8	3123167	√	TP

Table 7.4 **Continued.**

No.	Path	Traffic (bps)		Availability	Type of transmissions media
		Up	Down		
18	17-24	85364	499706.6	√	TP
19	12-3	1200647	3904667	√	TP
20	12-25	233293.3	1301556	√	TP
21	3-26	42448	80043.11	√	TP
22	6-24	24203.47	42448	X	OP
23	3-27	80043.11	80043.11	√	TP
24	6-8	363052.2	552097.7	√	TP
25	11-27	2179900	2179900	√	TP
26	19-6	37888.37	47652.57	√	TP
27	14-16	80973.913	154534.54	X	OP
28	3-8	883356	1921034	X	OP
29	11-5	73692.68	726633.3	X	OP
30	20-11	99091.77	145326.66	X	OP
31	22-14	80973.913	127760	X	OP
32	10-19	37888.37	60069.33	X	OP
33	13-25	46658.66	139266.66	√	OP
34	24-14	21341	80973.913	X	OP
35	19-18	37888.37	455176	X	OP
36	3-5	14738.536	80043.11	X	OP
37	13-14	80973.913	139266.66	X	OP
38	6-18	24203.47	455176	√	OP
39	8-14	110419.53	242921.73	X	OP

where (√) indicate an Existing path
(X) indicate No physical path Exist.
TP: Twisted pair , OP: Optical fiber

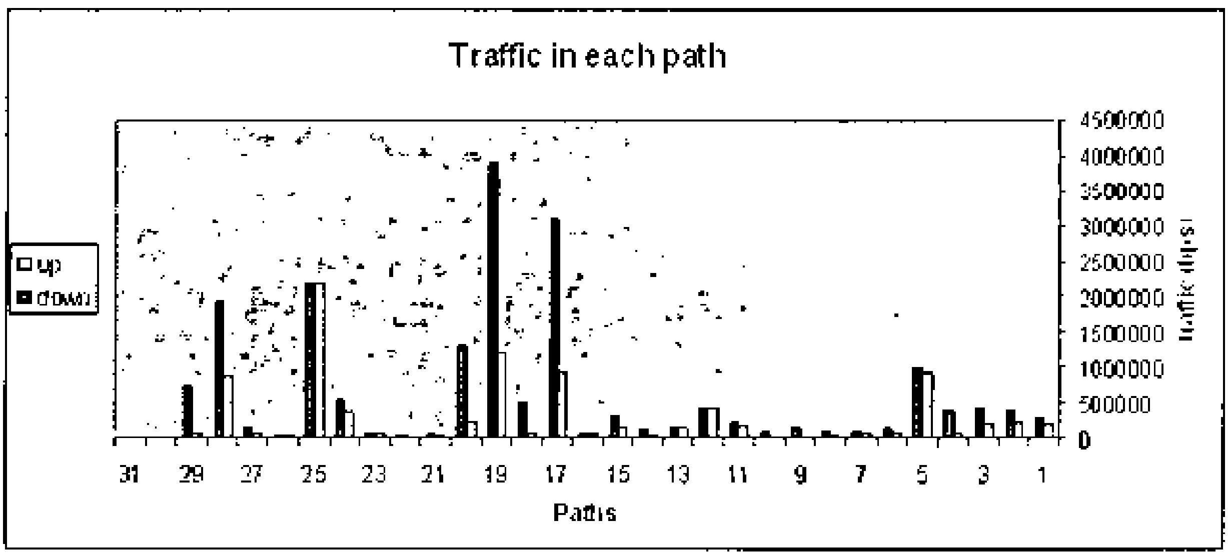


Figure 7.4 Traffic in bps in each path.

7.3 Conclusion

- All government locations of the city are represented into nodes, these nodes are used to generate the final nodes. The final nodes consist of some adjacent nodes, which are investigated against services of voice, data and video in each location, then to divide final nodes into groups according to the relations as given in chapter 6.
- All final nodes that are connected to form groups. There are some groups that have same FNs, as in appendices B1, B2. then analysing all groups to produce the optimum configuration.
- All locations in sirte city do not have an intranet LANs. Hence calculations of real traffic is based on Questionnaire result and add to it some percentage as reserve.
- To find the traffic in each FN it took us a long time. As there are problems of changing positions of some of the administrative locations, this problem implies the re-arrangement content of old and new FNs, all groups, and also to repeat the traffic calculations of old and new FNs.
- We can implement this design using the GPTC available ground network by introducing advanced technology such as ADSL, and by the addition of some extra links where GPTC does not exist.

7.4 Recommendations.

- To connect the remaining administrative locations that are out of the city with the designed network.
- To connect Final nodes using optical fiber, as a new transmission media.
- To use LANs in all locations to measure real traffic by advanced software program.

References

1. **Network Design and Case Studies** Copyright 1989-2000 © Cisco Systems Inc.

2. **Computer Networks, Fourth Edition** By Andrew S. Tanenbaum Publisher : Prentice Hall, Pub Date: March 17, 2003

3. **Networks and Telecommunications** Copyright 0 1991. 1997 by John Wiley & Sons Ltd Baffins Lane

4. **Principles of Digital Communication Systems and Computer** Networks by Dr. K.V. Prasad, ISBN:1584503297, Charles River Media © 2003

5. **Introduction to telecommunications network engineering**—2nd ed. by Tarmo Anttalainen. ISBN 1-58053-500-3 , © 2003 ARTECH HOUSE, INC.

6. **High-Performance Networking Unleashed.** *by Arthur Cooper.* ©2005, Macmillan Computer Publishing. All rights reserved.

7. **Introduction to LAN Protocols.** All contents are Copyright © 1992--2005 Cisco Systems, Inc. All rights reserved. Posted: Mon Mar 7 17:08:30 PST 2005.

8. **Introduction to WAN Technologies.** All contents are Copyright © 1992--2002 Cisco Systems, Inc. All rights reserved. Posted: Wed Feb 20 21:37:52 PST 2002.

9. **Introduction to Internet.** All contents are Copyright © 1992--2002 Cisco Systems, Inc. All rights reserved. Posted: Wed Feb 20 21:16:23 PST 2002

10. **The Electrical Engineering Handbook.** Chan, Shu-Park "Section I – Circuits" Ed. Richard C. Dorf ,Boca Raton: CRC Press LLC, 2000

11. **Voice-Data Integration Technologies.** All contents are Copyright © 1992--2005 Cisco Systems, Inc. Posted: Tue Feb 15 22:40:35 PST 2005

12. **Multiservice Access Technologies.** All contents are Copyright © 1992--2002 Cisco Systems, Inc. Posted: Wed Feb 20 21:15:07 PST 2002

13. **VOIP Bandwidth Calculator** by West bay engineers limited the word's first online Erlang traffic calculators. Copyright © 2005. Last Modified 19 September 2005

14. **Data And Computer communications.** By William stallings (Seven Edition). ©2004 by pearson Education, Inc. ISBN 0-13-183311-1

15. **Traffic Analysis**. All contents are Copyright © 1992--2002 Cisco Systems, Inc. Posted: Thu Sep 12 13:08:38 PDT 2002.

16. **Third-Generation Standards**. www.itu.int/imt2000/

17. **Technical Considerations for Converging Data, Voice, and Video.** Copyright © 2000 Cisco Systems, Inc.

18. **WAN Technology Computer Networks and Internets with Internet Applications** *(fourth edition)*, Prentice Hall, Upper Saddle River, NJ, 2004, ISBN 0-13-143351-2, Last modified: Mon 04 Oct 2004 13:05:57 BST, http://netbook.cs.purdue.edu/ .

مراجع باللغة العربية

19. خريطة مدينة سرت. تم التقاط هذه الصورة بواسطة القمر الصناعي كويك بيرد بتاريخ 17-5-2003 ف وبدقة تمييز 60 سم بمركز البيروني للاستشعار عن بعد.

20. خرائط ورسومات شبكة البريد. من الشركة العامة للبريد والاتصالات فرع سرت بتاريخ 25-2- 2006ف

21. بيانات أسماء المواقع بالشعبية. عن طريق المركز الفني للمعلومات بشعبية سرت 2005 ف

Appendices

Appendix A.

Table A.1 Names, Locations of Sirte City

Number	Names of node in sirte city	
1	People's Congress Trustee For Shabia	اللجنة الشعبية لشعبية سرت
2	People's Congress Governorate For Shabia	أمانة المؤتمر الشعبي للشعبية
3	Council Of Planning	مجلس التخطيط
4	The People's Committee For Industry, Energy And Metals	اللجنة الشعبية للصناعة والمعادن والطاقة
5	People Committee For Finance	اللجنة الشعبية للمالية
6	People Committee For Information And Culture	اللجنة الشعبية لإعلام والثقافة
7	People Committee For Tourism	اللجنة الشعبية للسياحة
8	People Committee For Planning	اللجنة الشعبية للتخطيط
9	People' Committee Of General Security	اللجنة الشعبية للأمن العسكر
10	General People Committee For Agriculture	اللجنة الشعبية للزراعة
11	General People Committee For Zoology	اللجنة الشعبية للثروة الحيوانية
12	People Committee For Nautical Sea	اللجنة الشعبية للثروة البحرية
13	General People Committee For Health	اللجنة الشعبية للصحة
14	People' Committee For Housing Proprieties	اللجنة الشعبية لإسكان والمرافق
15	People' Committee Of Economy And Commerce	اللجنة الشعبية للاقتصاد والتجارة
16	People' Committee Of Youth And Sport	اللجنة الشعبية للشباب والرياضة
17	People' Committee Of Justice	اللجنة الشعبية للعدل
18	People' Committee Of Transport	اللجنة الشعبية للمواصلات والنقل
19	Kaleej Sirte People's Basic Congress	المؤتمر الشعبي الأساسي خليج سرت
20	Sirte Al-Markaz People's Basic Congress	المؤتمر الشعبي الأساسي سرت المركز
21	Eople's Basic Congress Al- Rebate Al- Amami	المؤتمر الشعبي الأساسي الرباط الأمامي
22	Al-Fateh People's Basic Congress	المؤتمر الشعبي الأساسي الفاتح

23	Civil Service Record	مصلحة السجل المدني
24	House Planning Unit	مصلحة التخطيط العمراني
25	Meteorology Service	مصلحة الأرصاد الجوية
26	Properties Registration Unit	مصلحة السجل العقاري
27	Environment Service	الهيئة العامة للبيئة
28	Cooperation For Environment, Social And Popular leadership	القيادات الشعبية الاجتماعية
29	People's Court	محكمة الشعب
30	Social And Soldierly Fund	صندوق التضامن الاجتماعي
31	Social And Security Fund	صندوق الضمان الاجتماعي
32	Agriculture And Industrial And Commercial Unit	الغرفة التجارية و الصناعية والزراعية
33	Alaogaf Unit	الهيئة العامة للأوقاف فرع سرت
34	Union Of Experts	رابطة الخبراء
35	Sirte Radio Station	إذاعة سرت المحلية
36	Algrdabea News	صحيفة القرضابية
37	Al-Tahaddi University	جامعة التحدي
38	Faculty Of Medicine	كلية الطب
39	Ibn-Sina Hospital	مستشفى ابن سينا
40	Central Clinics Comple	مجمع العيادات المركزي
41	Man Power Unit	القوى العاملة
42	Central Bank	المصرف المركزي
43	Real Estate Bank	المصرف العقاري
44	Trading Bank	المصرف التجاري
45	Unity Bank	مصرف الوحدة
46	Agriculture Bank	المصرف الزراعي
47	Algrdabea Hall	قاعة القرضابية
48	Wagadugw Hall	قاعة واقادوقو
49	Al-Wafa Hall	قاعة الوفاء
50	Sirte Post Office	البريد المركزي بسرت
51	Technical Centre For Information	المركز الفني للمعلومات
52	Satellite Station For Communication	المحطة الأرضية عبر الأقمار الصناعية
53	Education office of Evaluation and standards	التقويم والقياس
54	Passport Section	إدارة الجوازات
55	Electricity Company	شركة الكهرباء
56	Libyan Airline Company	شركة الخطوط الجوية
57	Sirte Port	الميناء البحري
58	Police Station	مركز الشرطة
59	Sirte Airport	مطار سرت الدولي

	The nodes and their names that are out of the city	
1	Al-Garbiat People's Basic Congress	المؤتمر الشعبي الأساسي الغريبات
2	Al-Jaref People's Basic Congressm	المؤتمر الشعبي الأساسي جارف
3	Al-Abo Hadi People's Basic Congress	المؤتمر الشعبي الأساسي أبو هادي
4	Al-Zamzam People's Basic Congress	المؤتمر الشعبي الأساسي زمزم
5	Al-Washka People's Basic Congress	المؤتمر الشعبي الأساسي الوشكة
6	Al-Hish Al-Jadeda People's Basic Congress	المؤتمر الشعبي الأساسي الهيشة الجديدة
7	Al-Hnewa People's Basic Congress	المؤتمر الشعبي الأساسي الهنيوة
8	Al-Nufalia People's Basic Congress	المؤتمر الشعبي الأساسي النوفلية
9	Abo –Zahia People's Basic Congress	المؤتمر الشعبي الأساسي أبوزاهية
10	Al-Gurdhabia People's Basic Congress	المؤتمر الشعبي الأساسي القرضابية
11	Al-Amera People's Basic Congress	المؤتمر الشعبي الأساسي العامرة
12	Ehrawa People's Basic Congress	المؤتمر الشعبي الأساسي إهراوة
13	Al-Wadi Al-Ahmer People's Basic Congress	المؤتمر الشعبي الأساسي الوادي الأحمر
14	Ben Jawad People's Basic Congress	المؤتمر الشعبي الأساسي بن جواد
15	Ras-Lanwaf People's Basic Congress	المؤتمر الشعبي الأساسي راس لانوف
16	Abo- Njeem People's Basic Congress	المؤتمر الشعبي الأساسي أبونجيم
17	Al-Wasat People's Basic Congress	المؤتمر الشعبي الأساسي الوسط
18	Abo- Seada People's Basic Congress	المؤتمر الشعبي الأساسي أبوسعدة
19	Al- Zafaran People's	المؤتمر الشعبي الأساسي الزعفران
20	Sultan People's Basic Congress	المؤتمر الشعبي الأساسي سلطان
21	Al-Gbiba People's Basic Congress	المؤتمر الشعبي الأساسي القبيبة

Table A.2 Nodes and their adjacent nodes that may form a LAN

Number as in table A.1	Adjacent nodes that may form (LAN)
1	18 – 8 – 7
2	34 – 3
3	34– 2
4	41 – 36 – 23 – 15 - 11 – 10 – 6
5	55 – 33 – 29
6	41 – 36 – 23 – 15 - 11 – 10 –4
7	18 – 8– 1
8	18– 7 – 1
9	0
10	41 – 36 – 23 – 15 - 11– 6 – 4
11	41 – 36 – 23 – 15– 10 – 6 – 4
12	0
13	0
14	58 –27 – 24 –45 – 20
15	41 – 36 – 23 –11 – 10 – 6 – 4
16	51 – 50 – 26 – 17
17	51 – 50 – 26 –16
18	8 – 7 – 1
19	0
20	45- 58–27 – 24 – 14
21	0
22	54 – 53– 22
23	41 – 36 –15 - 11 – 10 – 6 – 4
24	45 – 20- 58 –27– 14
25	54 – 53– 22
26	51 – 50 –17 – 16
27	45 – 20- 58 –24 – 14
28	28
29	55 – 33 –5
30	30
31	30
32	0
33	55– 29 – 5
34	3 – 2
35	0
36	41 –23 – 15 - 11 – 10 – 6 – 4
37	0
38	39
39	38
40	0
41	36 – 23 – 15 - 11 – 10 – 6 – 4
42	56 – 43

43	56 –42
44	0
45	20- 58 –27 – 24 – 14
46	28
47	0
48	0
49	0
50	51 –26 – 17 – 16
51	50 – 26 – 17 – 16
52	0
53	54– 25 – 22
54	53 – 25 – 22
55	33 – 29 – 5
56	43 – 42
57	0
58	0
59	45 – 20- 27 – 24 – 14

0 --- No adjacent node

Table A.2 The result of FNs contents..

Final node	LAN(nos. of original nodes)	Final node	LAN(nos. of original nodes)
1	18 – 8 – 7 – 1	14	39 – 38
2	34 – 3 – 2	15	40
3	– 23 – 15 - 11 – 10 – 6 – 4 41 – 36	16	48
4	55 – 33 – 29 – 5	17	47
5	12	18	52
6	13	19	54 – 53 – 25 – 22
7	58 – 45 – 27 – 24 –20 -14	20	57
8	51 – 50 – 26 – 17 – 16	21	21
9	56 – 43 – 42	22	49
10	46 – 28	23	19
11	31 – 30	24	9
12	35	25	44
13	37	26	32

Appendix B

Appendix B.1 Represents the production of Groups

Table B.1.1 Group1 consist of FNs 1,2,3,4,5,6,7,8,19,21,23,24

Initial Node no.	Node Name(Function)	Final node no.
1	People's Congress Trustee for Shabia	1
2	People's Congress governorate for shabia	2
3	Council of Planning	2
4	The General People's Committee for Industry, Energy and Metals	3
5	General People Committee for Finance	4
6	General People Committee for Information and Culture	3
7	General People Committee for tourism	1
8	General People Committee for Planning	1
9	People' Committee of General Security	24
10	General People Committee for Agriculture	3
11	General People Committee for zoology	3
12	General People Committee for nautical sea	5
13	General People Committee for Health	6
14	People' Committee for Housing Proprieties	7
15	People' Committee of Economy and Commerce	3
16	People' Committee of Youth and Sport	8
17	People' Committee of Justice	8
18	People' Committee of transport	1
19	kaleej sirte people's basic congress	23
20	sirte Al-markaz people's basic congress	7
21	eople's basic congress AL- Rebate AL- Amami	21
22	al-Fateh people's basic congress	19

Table B.1.2 Group2 consist of FNs 3, 7, 8

Initial Node no.	Node Name(Function)	Final node no.
14	People' Committee for Housing Proprieties	7
23	Civil service record	3
24	House Planning Unit	7
26	Properties Registration Unit	8

Table B.1.3 Group3 consist of FNs 6, 14, 15

Initial Node no.	Node Name(Function)	Final node no.
13	General People Committee for Health	6
38	Faculty of Medicine	14
39	Ibn-Sina Hospital	14
40	Central Clinics Complexx	15

Table B.1.4 Group4 consist of FNs 7, 9, 10, 25

Initial Node no.	Node Name(Function)	Final node no.
42	Central Bank	9
43	Real estate Bank	9
44	Trading Bank	25
45	Unily Bank	7
46	Agriculture Bank	10

Table B.1.5 Group5 consist of FNs 16, 17, 22

Initial Node no.	Node Name(Function)	Final node no.
47	Algrdabea Hall	17
48	Wagadugw Hall	16
49	Al-Wafa Hall	22

Table B.1.6 Group 6 consist of FNs 7, 8, 19, 24

Initial Node no.	Node Name(Function)	Final node no.
9	People' Committee of General Security	24
58	Police Station	7
54	Passport Section	19
17	People' Committee of Justice	8

Table B.1.7 Group7 consist of FNs 5, 20

Initial Node no.	Node Name(Function)	Final node no.
12	General People Committee for nautical sea	5
57	Sirte Port	20

Table B.1.8 Group8 consist of FNs 3, 12

Initial Node no.	Node Name(Function)	Final node no.
6	General People Committee for Information and Culture	3
35	Sirte Radio Station	12
36	Algrdabea news	3

Table B.1.9 Group9 consist of FNs 8, 18

Initial Node no.	Node Name(Function)	Final node no.
50	Sirte Post office	8
52	Satellite Station for Communication	18

Table B.1.10 Group10 consist of FNs 3, 26

Initial Node no.	Node Name(Function)	Final node no.
32	Agriculture and Industrial and Commercial Unit	26
4	The General People's Committee for Industry, Energy and Metals	3
10	General People Committee for Agriculture	3

Table B.1.11-Group11 consist of FNs 13, 14, 19

Initial Node no.	Node Name(Function)	Final node no.
37	Al-Tahaddi University	13
38	Faculty of Medicine	14
53	Evaluation of Tuition	19

Table B.1.12 Group12 consist of FNs 8, 11

Initial Node no.	Node Name(Function)	Final node no.
50	Sirte Post office	8
31	Social and Security Fund	11
32	Agriculture and Industrial and Commercial Unit	11

Appendix B.2

Table B.2 Relation of a FN with an adjacent connected other FNs

FNs Exist in same Group	Connected with adjacent FN	Value of a point		
		5	3	1
24-23-21-19-8-7-6-5-4-3-2	2-14-16	2	-23-21-19-8-7-6-5-4-3 24	16-14
24-23-21-19-8-7-6-5-4-3 -1	1-13-16-25	1	-23-21-19-8-7-6-5-4-3 24	13-16-25
8-7-6-5-4-2 -1-12--23-21-19- 24-26	4-8-23-26-27	4-8-23- 26-	1-2-5-6-7-12-21-19-24	27
24-23-21-19-8-7-6-5-3-2 -1	3	3	-23-21-19-8-7-6-5-2 -1 24	0
24-23-21-20-19-8-7-6-4-3-2 -1	3-11-20	3-20	-23-21-19-8-7-6-4-2 -1 24	11
-23-21-19-15-14-8-7-5-4-3-2 -1 24	8-18-19-24	8-19-24	-21-15-14-7-5-4-3-2 -1 23	18
-23-21-19-10-9-8-6-5-4-3-2 -1 2425-	8-9-10	8-9-10	-23-21-19-6-5-4-3-2 -1 2425-	0
-13-12-11-10-9-7-6-5-4-3-2 -1 -22-21-20-19-18-17-16-15-14 26-25-24-23	3-6-7-17-26-27	3-6-7- 17-26	-12-11-10-9-5-4-2 -1 -20-19-18-16-15-14-13 25-24-23-22-21	27
8-7-10-25	7-27	7	8-10-25	27
8-7-25- 9	7-19	7	8-25- 9	19
8	5-20-27	0	8	5-20-27
3-8	3-25	3	8	25
19-14-8	14-25	14	8-19	25
19-15-13-8-6	1-8-13-16-22-24	8-13	6-15-19	1-16-22- 24
8 - 14- 6	22-24	0	6-8-14	22-24
17-22-8	2-14	0	8-17-22	2-14
16-22-8	8-24	8	16-22	24
8	6-19	0	8	6-19
-23-21-14-13-8-7-6-5-4-3-2 -1 24	6-10-18	6	-14-13-8-7-5-4-3-2 -1 24-23-21	10-18
5- 8	5-11	5	8	11
24-23-19-8-7-6-5-4-3-2 -1	24	24	23-19-8-7-6-5-4-3-2 -1	0
16-17-8	14-15	0	8-16-17	14-15
24-21-19-8-7-6-5-4-3-2 -1	3	3	-21-19-8-7-6-5-4-2 -1 24	0
23-21-19-8-7-6-5-4-3-2 -1	6-14-15-17-21	6-21	23-19-8-7-5-4-3-2 -1	14-15-17
8-7-10- 9	2-12-13	0	8-7-10- 9	2-12-13
3- 8	3-8	3-8	0	0
3-8-9-11	3-8-9-11	3-8-9- 11	0	0

Appendix C

AppendixC.1

Table C.1 Each node and all compendia FNs and Basic traffic data(voice, data, video)

FNs	Nodes included	No. of call x duration of a call(voice)	Number of papers for Data	Video by Mbps
1	1	100*5	190	1
	7	80*3	55	
	8	180*5	25	
	18	50*3	155	
2	2	110*2	190	0
	3	110*3	130	
	34	70*3	120	
3	6	130*10	75	1
	41	90*5	150	
	4	40*5	80	
	10	45*5	50	
	11	50*5	200	
	15	80*5	120	
	23	100*3	220	
	36	60*5	220	
4	5	120*4	190	0
	29	100*3	160	
	33	70*4	80	
	55	220*5	210	
5	12	140*4	130	0
6	13	200*10	60	0
7	14	130*4	160	0
	20	100*3	80	
	24	70*3	200	
	45	90*3	110	
	58	170*3	190	
	27	70*4	150	
8	16	90*4	90	1
	17	130*3	210	
	26	70*3	230	
	50	250*3	200	
	51	200*3	330	
9	56	130*3	50	0
	43	120*5	100	
	42	130*5	250	
10	28	110*4	150	0
	46	100*3	190	
11	30	80*4	230	0
	31	80*3	180	
12	35	300*7	300	1
13	37	130*3	200	1
14	38	100*4	190	1
	39	200*3	210	

15	40	70*4	140	0
16	48	140*4	230	1
17	47	150*3	20	1
18	52	500*4	230	1
19	22	80*3	80	0
	25	110*4	140	
	53	100*5	280	
	54	120*4	200	
20	57	180*5	230	0
21	21	110*4	120	0
22	49	90*4	60	1
23	19	100*4	90	0
24	9	200*5	190	0
25	44	110*4	230	0
26	32	70*4	80	0

Appendix c.2

Calculation of voice traffic of all nodes, using the equation: FN traffic =(no. of calls x duration of call)/(work day *hour)

Table c.2 Total Voice traffic

FNs	SUM of call in each time	Generated traffic (E)	No. of links at GOS 0.01	Bandwidth Bps
1	1790	4.2619	10	960
2	760	1.809524	6	576
3	3425	8.154762	16	1536
4	2160	5.142857	11	1056
5	560	1.333333	5	480
6	2000	4.761905	11	1056
7	2090	4.97619	11	1056
8	2310	5.5	12	1152
9	1640	3.904762	10	960
10	740	1.761905	6	576
11	560	1.333333	5	480
12	2100	5	11	1056
13	390	0.928571	5	480
14	1000	0.928571	5	480
15	280	0.666667	4	384
16	560	1.333333	5	480
17	450	1.071429	5	480
18	2000	4.761905	11	1056
19	1660	3.952381	10	960
20	900	2.142857	7	672
21	440	1.047619	5	480
22	360	0.857143	4	348
23	400	0.952381	5	480
24	1000	2.380952	7	672
25	440	1.047619	5	480
26	280	0.666667	4	348

Appendix c.3

Data traffic = number of pages per working day x bits per page/ (no. of hours per day x 3600).

for example for FN1

Data Traffic =(190+55+25+155)* 60*1024*8/3600*7=406300 bps

Total c.3 Data traffic

FN	No.node	Number of papers for Data	Sum of pages	Total Data traffic (bps)
1	1	190		
	7	55		
	8	25		
	18	155	425	406300
2	2	190		
	3	130		
	34	120	440	420640
3	6	75		
	41	150		
	4	80		
	10	50		
	11	200		
	15	120		
	23	220		
	36	220	1115	1065940
4	5	190		
	29	160		
	33	80		
	55	210	640	611840
5	12	130	130	124280
6	13	60	60	57360
7	14	160		
	20	80		
	24	200		
	45	110		
	58	190		
	27	150	890	850840
8	16	90		
	17	210		
	26	230		
	50	200		
	51	330	1060	1013360
9	56	50		
	43	100		
	42	250	400	382400
10	28	150		
	46	190	340	325040
11	30	230		
	31	180	410	391960
12	35	300	300	286800
13	37	200	200	191200
14	38	190		
	39	210	400	382400

con.

FN	No.node	Number of papers for Data	Sum of pages	Total Data traffic (bps)
15	40	140	140	133840
16	48	230	230	219880
17	47	20	20	19120
18	52	230	230	219880
19	22	80		
	25	140		
	53	280	.	
	54	200	700	669200
20	57	230	230	219880
21	21	120	120	114720
22	49	60	60	57360
23	19	90	90	86040
24	9	190	190	181640
25	44	230	230	219880
26	32	80	80	76480

Appendix D

Table **D.1** Relation between FNs based on 5 points scale weights.

FN/FN	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	sum
1	x	5	3	3	3	3	3	3	0	0	0	0	0	1	0	1	0	0	3	0	3	0	3	3	0	0	0	37
2	5	x	3	3	3	3	3	3	0	0	0	0	1	0	0	1	0	0	3	0	3	0	3	3	1	0	0	38
3	3	3	x	5	3	3	0	5	0	0	0	3	0	0	0	0	0	0	3	0	3	0	5	3	0	5	1	45
4	3	3	5	x	3	3	3	3	0	0	0	0	0	0	0	0	0	0	3	0	3	0	3	3	0	0	0	35
5	3	3	5	3	x	3	3	3	0	0	1	0	0	0	0	0	0	0	3	5	3	0	3	3	0	0	0	41
6	3	3	3	3	3	x	3	5	0	0	0	0	0	3	3	0	0	1	5	0	3	0	3	5	0	0	0	46
7	3	3	3	3	3	3	x	5	5	5	0	0	0	0	0	0	0	0	3	0	3	0	3	3	3	0	0	48
8	3	3	5	3	3	5	5	x	3	3	3	3	3	3	3	3	5	3	3	3	3	3	3	3	3	5	1	86
9	0	0	0	0	0	0	5	3	x	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	1	15
10	0	0	0	0	0	0	5	3	3	x	0	0	0	0	0	0	0	0	1	0	0	0	0	0	3	0	0	15
11	0	0	0	0	1	0	0	3	0	0	x	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	6
12	0	0	5	0	0	0	0	3	0	0	0	x	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	9
13	0	0	0	0	0	0	0	3	0	0	0	0	x	5	0	0	0	0	3	0	0	0	0	0	1	0	0	12
14	1	0	0	0	0	3	0	5	0	0	0	0	5	x	3	1	0	0	3	0	0	1	0	1	0	0	0	23
15	0	0	0	0	0	3	0	3	0	0	0	0	0	3	x	0	0	0	0	0	0	1	0	1	0	0	0	11
16	0	1	0	0	0	0	0	3	0	0	0	0	0	1	0	x	3	0	0	0	0	3	0	0	0	0	0	11
17	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	3	x	0	0	0	0	3	0	1	0	0	0	12
18	0	0	0	0	0	1	0	3	0	0	0	0	0	0	0	0	0	x	1	0	0	0	0	0	0	0	0	5
19	3	3	3	3	3	5	3	3	0	1	0	0	3	3	0	0	0	1	x	0	3	0	3	3	0	0	0	43
20	0	0	0	0	5	0	0	3	0	0	1	0	0	0	0	0	0	0	0	x	0	0	0	0	0	0	0	9
21	3	3	3	3	3	3	3	3	0	0	0	0	0	0	0	0	0	0	3	0	x	0	3	5	0	0	0	35
22	0	0	0	0	0	0	0	3	0	0	0	0	0	1	1	3	3	0	0	0	0	x	0	0	0	0	0	11
23	3	3	5	3	3	3	3	3	0	0	0	0	0	0	0	0	0	0	3	0	3	0	x	3	0	0	0	35
24	3	3	3	3	3	5	3	3	0	0	0	0	0	1	1	0	1	0	3	0	5	0	3	X	0	0	0	40
25	0	1	0	0	0	0	3	3	3	3	0	1	1	0	0	0	0	0	0	0	0	0	0	0	x	0	0	15
26	0	0	5	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	x	0	10
27	0	0	5	0	0	0	0	5	5	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	x	20

Table D.2 questionnaire Form

الجماهيرية العربية الليبية الشعبية الاشتراكية العظمى | المعرفة حق طبيعي لكل إنسان

اللجنة الشعبية للشعبية سرت | التاريخ / / و.ر

المركز الفني للمعلومات | الموافق 26/02/2006

استبيانا عن احتياجات موقع لتبادل البيانات

اسم الموقع اللجنة الشعبية للسياحة بالجهة التابع لها الشعبية..node.. 7 .. final node.....!..

س1 – الخدمات القائمة

هاتف ✓ فاكس ✓ صور ✓ فيديو X نقل الملفات X نقل رسائل ✓ إنترنت X

نوع الخدمة	العدد	معدل الاستخدام —1 n	المرسلة —1n	المستقبلة —1n	زمن الاستخدام —1 n	ملاحظات
هاتف	3	80	30	50	3 دقائق	
فاكس	1	20	10	10		
صور		15	5	10		
فيديو	1					
نقل المرفقات						
نقل رسائل		20	5	15		
إنترنت						

س2 - الخدمات المطلوبة (الجديدة)
هاتف ✓ فاكس ✓ صور ✓ فيديو ✓ نقل الملفات ✓ نقل رسائل ✓ إنترنت ✓

س3 - الخدمات المقترح توفيرها

1 -.....دورات في مجال الحاسب...

2-..................................

3-..................................

4-..................................

محطة مصدر المعلومات
مدير مكتب الشؤون الإدارية