LAN'S SOLUTIONS FOR THE COLLEGE OF ENGINEERING KING SAUD UNIVERSITY

Mohammed Alhaider and Mohammad Al-Zahrani

This paper evaluates possible LAN solutions for enabling every terminal or a PC in the College of Engineering, King Saud University, to access the various computing facilities within the College of Engineering, the mainframes of the University Computer Center, and other computing facilities in other colleges of the university.

1. INTRODUCTION

The computing facilities at King Saud University are of high international standard. These facilities include: Personal Computers (PCs), minis, and mainframes, located in various colleges and departments of the university. The College of Engineering of the University has a number of personal computers, and two VAX 785 in addition to a CAD/CAM Laboratory that has two VAX 780, graphic stations and plotters. In addition, the college is also connected to the mainframes of the main computer center of the university. To utilize these facilities efficiently, easy access to all of them from distributed single points is needed. Such single points may be PCs or terminals in staff offices or labs. An obvious solution to this problem is to build a Local Area Network (LAN) that interconnects these points, together with the minis of the College of Engineering and the mainframes of the Computer Center and may be with other computing facilities in the other colleges of the university. However, various LAN solutions are available, and therefore a practical evaluation of these solutions is needed.

This paper is concerned with the valuation of three LAN solutions for the College of Engineering, King Saud University.

The solutions are practically feasible, but they belong to different techniques and are expected to provide different service levels, and to be of different cost. The first solution is to use an existing Private Automatic Branching Exchange (PABX). The second is concerned with using a convention coaxial cable Ethernet for interconnecting the points and the computing facilities within the college and an optical fiber ring LAN (FDDI: Fiber Distributed Data Interface) for connecting the college to the main computer center and other colleges. The solutions are described and evaluated against three main factors: operation, service, and cost.

2. THE PABX SOLUTION

With regards to the PABX solution, King Saud University has the Erisccon MD 110 digital PABX, with around 3000 digital lines and 5000 analog lines. Each digital line is capable of acting as a data communication link, without interrupting the normal telephone use of the line. A digital line with the appropriate interfacing can connect a terminal or a PC to the MD 110, and another digital line can provide the single user with an access to the VAX, the mainframe or any other machine. The providion of such access is based on the automatic circuit switching technique.

The data communications facility in MD 110 embraces data transmission between terminals connected with interfaces. The data transmission can be asynchronous or synchronous and have full duplex or half duplex transmission mode.

Terminals are connected to the PABX with the aid of terminal adapters.

There are five types of extensions designated "data extensions":

(1) DCE-S (2) DCE-T (3) DBA 703 (4) TAU-PC (a) TAU-T
(b) TAU-S (5) Leased Modem connection.

Data extensions are connected to digital extension lines.

From the user aspect, digital extension lines have two independent channels:

*) 64 - K bit channel.
*) 16 - K bit channel.

The two channels are used in different manners, depending on the type of the extension connected to the digital extension line.

2.1 DCE-S: "Data Circuit Terminating Equipment - Stand alone"

It is a terminal adapter used to connect a computer port or terminal that does not have a digital system telephone affiliated to it.

The 64-K bit channel is used for transmission of data for this type of DCE. The highest speed that can be transmitted is 48 k bit/second.

2.2 DCE-T: "Data Circuit Terminating Equipment - Telephone"

It is a terminal adapter that is affiliated to a digital system telephone. Thus unit is attached to the rear of digital system telephone and uses the buttons on the digital system telephone.

For this type of DCE only the 16-k bit channel of the digital extension line is used for transmission of data. The highest speed that can be transmitted is 12 k bit/sound.

2.3 DBA 703:

DBA 703 is a simpler digital system telephone with built-T applies to DBA 703.

2.4 TAU-PC: "Terminal Adapter Unit - Personal Computer"

It is a terminal adapter which fits PCs compatible with IBM. A digital extension line and a digital telephone are connected to it.

(a) Terminal Adapter Unit - Telephone: (TAU-T)

The TAU-T is a plug-in terminal adapter that is easily attached by a screw driver to the rear of a DIAVOX courier 701 or 702 digital system telephone installed in most of the offices.

Any data terminal using a **V.24/V.28 (RS-232-C)** interface can be connected to the TAU-T. That is done via a normal V.24 cable. The user can then take full advantage of the MD 110 Data switching system and user facilities without affecting voice traffic. The data terminal communicates through the TAU-T and the digital system telephone over the two-wire extension line without affecting voice traffic. Fully independent and simultaneous voice and data traffic are provided.

Data transmission parameters for the TAU-T can easily be reprogrammed by the user from the DIAVOX courier 701 or 702 digital system telephone.

(b) Terminal Adapter Unit - Stand alone: (TAU-S)

The TAU-S is one of the terminal adapters for use with ERICSSON's MD 110 digital PABX. The TAU-S is a stand alone terminal adapter designed to be most suitable for connection of passive data equipment such as printers, computer, ports, ... etc.

Any data device using a V.24/V.28 (RS-232-C) interface can be connected to the TAU-S unit in order to take full advantage of the MD 110 data switching system and user facilities.

No additional hardware except for the TAU-S is required to connect a data terminal to the MD 110 system. The data terminal communicates through the TAU-S over the digital two-wire extension line.

2.5 Cabling:

The data terminal is connected to the TAU-S via a normal straight-wired V.24 terminal cable.

The TAU-S is connected to the exchange via normal telephone two-wire cabling.

2.6 Cost:

	Unit Price
(1) Supply and installation of Terminal Adapter Unit Stand alone (TAU-S)	2996 SR
(b) Supply and installation of Terminal Adapter Unit TAU-T	2420 SR

2.7 Conclusions:

The PABX MD 110 solution has the following advantages:

(1) The MD 110 network already exists in the King Saud University used for digital telephone.

(2) We need only the cost of Terminal Adapter Units (TAU-T OR TAU-S), as the initial cost of MD 110 PABX is already paid.

(3) The maintenance of new data communication system should be part of the digital telephone network, and the responsible company (Ericsson) is already available in the university.

(4) Simplicity and fast installation to get the required data communication system.

But this system has the disadvantage of operating on limited data rates (not exceeding 64 kbps). Although such rates are acceptable for Terminal-computer applications, they are not enough for computer-computer applications.

3. THE ETHERNET SOLUTION

Ethernet is a local network jointly developed by Xeros Corporation, Digital Equipment Corporation and Intel Corporations.

It is a bus network that employs baseband coaxial cable to transfer data between systems attached to it. One channel is shared by all attached systems, and data is transferred among the system. The coaxial cable is referred to as Ether.

Equipments are connected to the Ether through a transceiver and a controller. The transceiver inserts and extracts bits of information as messages are sent along the Ether. The controller is a large-scale integrated circuit chip that enables all sorts of communications devices to connect to the Ether regardness of the manufacturer. The communications device transceiver, and controller together are referred to as a station.

Many different types of office equipment can be attached to the Ether: electronic printers/copiers, information storage devices, electronic type writers, and personal computers.

Since the Ether is passive, the failure of one piece of equipment has no effect on others.

Multiple Ethernet networks can be interconnected through special transceivers called gateways. Gateways enable connection of the local network to telephone lines, satellite links, or microwaves links for long-distance transmissions.

3.1 Description of Ethernet LAN:

In the few following pages, we will present a general description for each piece of equipment that is needed to build (Ethernet) Local Area Network.

3.1.1 PVC Baseband 802.3/Ethernet Cable

Standard baseband 802.3/Ethernet cable is the main transmission medium of a baseband network. The cable is available in four lengths, which can be joined using barrel connectors to create segments up to 500 meters long.

Local area networks can be extended beyond 500 meters by adding repeaters. A maximum of 100 transceivers can be used on a standard 802.3/Ethernet cable segment. A single cable segment can be up to 500 meters long. Multiple cable segments can be linked together with barrel connectors.

3.1.2 Terminators

Terminators are used to electrically complete the ends of the standard baseband cable. A terminator must be installed at each end of a standard cable segment that is not connected to another standard cable segment.

3.1.3 Local Repeater

The standard baseband Ethernet repeater (DEREP) is a table top, stand alone device that connects two segments of standard baseband Ethernet cables, thus extending an ethernet LAN beyond the 500 meter single-cable segment. Each repeater can connect two segments of standard

Ethernet cable, each up to 500 m long with as many as 99 additional Ethernet transceivers installed. (The DEREP uses one transceiver space).

The repeater retimes, amplifies, and repeats all signals it receives from one cable segment and passes the signal to the next segment, creating one logical segment.

The DEREP repeater is offered in two versions, local and fiber optic. The local DEREP repeater connects two standard baseband Ethernet segments via transceiver cables and H 4000 transceiver separated by no more than 100 meters.

3.1.4 PVC Transceiver Cable

A transceiver cable connects an 802.3/Ethernet transceiver or a local network interconnects to an 802.3/Ethernet communications controller. The cable is compatible with Ethernet and IEEE 802.3 networking products and consists of four twisted-pair wires enclosed in a shield and jacket of either plenum-rated or PVC (polyvinyl chloride).

The transceiver drop cable is available in standard and office types, both of which support Ethernet or IEEE 802.3 hardware. Office cable is thinner than standard cable and is easier to run in an office environment. Because office cables have a high signal loss, they are limited to a maximum distance of 12.5 meters, whereas standard cable can run up to 50 m.

3.1.5 802.3 Ethernet Transceiver (H 4005)

The H 4005 is a non-intrusive tapping transceiver that provides a physical and electrical connection to a physical and electrical connection to a standard 802.3/Ethernet cable. The H 4005 connects to the standard baseband cable via a removable tap assembly.

This product complies with the IEEE 802.3 specification and can interface to both 802.3 and ethernet station controllers.

The H 4005 contains the necessary electronics to send and receive signal at 10 Mb/s, detect the occurrence of collisions, and provide electrical inolation between the cable and the station.

3.1.6 Compatibility

The H 4005 is compatible with all products except the DEREP, which requires the H 4000 transceiver to connect to the standard 802.3/Ethernet cable.

3.1.7 DELUA: UNIBUS-ETHERNET Communication Controller

The 802.3/Ethernet-to-UNIBUS high-performance synchronous communications controller (DELUA) connects UNIBUS systems (VAX and PDP) to both Ethernet V 2.0 and IEEE 802.3 Local Area Networks.

It is M 68000 microprocessor-based chip, and operates at 10 Mb/s, and has 4 Mb/s throughput capability.

It provides network maintainability feautres such as remote look-back of data from other stations, resident microdiagnostics, system identification, and loading and remote booting on UNIBUS PDP-11 systems from other stations on the network.

The DELUA physically and electrically connects to the standard baseband cable via transceiver cable and either a baseband transceiver or local network interconnect (DELNI). The DELUA also connects to Thin Wire cable in Thin Wire networks.

3.1.8 DEC Server 200

The DEC server 200 is a network terminal switch for 802.3/Ethernet LAN. It supports the simultaneous operation of up to eight terminals at speeds up to 19.2 kb/s full duplex. Two versions of the DEC server 200 are available: DEC server 200/MC and DEC server 200/DL.

3.2 Cost:

It has been estimated that based on the Ethernet solution, 500 terminals or PCs can be connected within the College of Engineering to the computing facilities of the college for 500 SR per terminal or a PC. In addition, each terminal or a PC would need an interface to the network with a cost of around 1500 SR. The total would be 2000 SR per terminal or a PC or around 1,000,000 SR for 500 terminals and PCs.

3.3 Conclusions:

From the previous discussion, we note that the Ethernet solution provides higher data rate than the PABX solution. However, the Ethernet solution is limited to computing facilities within the College of Engineering. An extension to this solution is needed to provide connections to the computing facilities of the main Computer Center of the University, and to the computing facilities of other colleges. This can be done by connecting the Ethernet LAN of the College of Engineering to the University FDDI.

4. THE FIBER OPTICS SOLUTION

The increasing number of users coupled with the large capacity of present computers make it necessary to think of communication links that meet these requirements. Optical fibers have got many good properties among which are the extremely high bandwidth, low losses and light weight that make them very attractive for present and future applications. They will be used as a backbone running along the spines of the University and connecting all CPU's of the University with a bandwidth of 100 Mb/s. Other local area networks, such as the College of Engineering Ethernet LAN, will branch off this backbone.

4.1 Definition & Characteristics of Fiber Optics:

Optical fibers are waveguides, widely used in communications. They are made of transparent dielectrics to guide light from one end to another end over long distances with low losses.

Optical fibers may be classified in terms of the refractive index of the core. So there are three kinds of fibers: (1) Step index fiber, SI (Multimode fiber), (2) Graded index fiber, GI (Multimode fiber), and (3) Single mode fiber, SM.

We can summarize the applications and characteristics of the three kinds of optical fibers in the following table:

	Single Mode Fiber	Graded-index Multimode Fiber	Step-index Multimode Fiber
Source	LASER	LASER or LED	LASER or LED
Bandwidth	Very very large more than 3 GHz	very large 200 MHz - 3 GHz	large less than 200 MHz
Connection & splicing	small core very difficult	difficult but it is possible	difficult but it is possible
Application	Submarine cable system	Telephone trunk between central offices	DATA communication
Cost	less expensive	most expensive	least expensive

Upon investigating the availability of fiber optics LAN's we found that Fiber Distributed Data Interface (FDDI) can provide a throughput of 100 Mbits/sec. FDDI is a fiber optic based counterrotating token-ring architecture. Although the present cost of FDDI is four times that of Ethernet. The bandwidth obtained is ten times that of Ethernet. FDDI will be used as a backbone that connects the mainframes at the computer center and the CAD/CAM and VAX computer centers. Other LAN's can be connected to the FDDI to avail computing facilities to other colleges of the university.

4.2 Attenuation in Fiber Optics:

Attenuation is defined as the difference between transmitted and received light power due to loss through equipment, lines (like fibers) or other transmission devices.

It is an important consideration in the design of an optical communication system, and it is important to determine the maximum distance between transmitter and receiver. Attenuation is normally measured in.dB/km.

The basic attenuation mechanisms in a fiber are scattering and absorption:

(*) The scattering may be caused by:

(1) Irregularities in core diameter.
(2) Variations in material density during fiber manufacture.
(3) Rayleigh scattering follows a characteristic dependence, it decreases dramatically with increasing wavelength.
(4) Flaws in the optical fibers.

(*) The absorption may be caused by the following:

(1) Extrinsic absorption by impurity atoms in the glass material.
(2) Absorption by atomic defects in glass composition.
(3) Infra-red absorption.
(4) Damage from pulling and sharp bending.
(5) Ultra-violet absorption.
(6) Intrinsic absorption by the basic constituent atoms of the fiber material.

4.3 Physical Description:

An optical fiber consists of an inner cylinder of glass called the core, surrounded by a cylindrical shell or layer of glass or plastic called the cladding, which is covered by a jacket. The core guides the light waves, the cladding maintains the light waves within the core and reinforces the core. The outer layer which is called jacket protects the fiber from the outside changes of climate and weather (moisture, sun, ... etc.).

4.3.1 Dimensions

Optical fibers are usually made in length of 1 km without splices, connectors or couplers. An optical fiber is very small. Its outer diameter ranges from 0.05 - 0.15 mm. (To compare, the diameter of copper wire 0.32 - 1.2 mm). We can summarize the dimensions of the fiber layers as follows:

Layer	Range
Outer Diameter	0.05 —— 0.15 mm
Core Diameter	5 —— 600 μm
Cladding Diameter	125 —— 750 μm

The outer protective layer (Jacket) may add as much as 100 μm in diameter to the total diameter of fiber.

4.3.2 Strength

Optical glass fibers are quite tough, they have a high tensile strength which provides ability to hard pulling or stretching. We cannot get this advantage unless the fiber manufacturers try to keep the glass core and cladding free from microscopic cracks on the surface or flows in the interior. Optical fiber can be bent easily according to our requirements in transmission and receiving.

4.4 Optical Communication System:

The input electrical signal is converted to optical signal and transmitted by using LED's or laser diodes through the optical fibers. The wavelengths of transmission used are between 800 nm and 1550 nm.

At the receiving end, optical signals are converted to electrical signals by using optical detectors such as Avalanche Photodiodes.

Since the signals are converted from electrical to optical and from optical to electrical, couplers are used to connect fibers to interfacing equipment. Optical fibers are used actively in Local Area Networks (LANs).

4.5 Advantages of Optical Fibers:

(1) Large bandwidth 10^{14} Hz, that means a large volume of informations such as voice, data or video signals can be transmitted on the same circuit.

(2) Low loss, low attenuation (nearly 0.1 dB/km), so it is used for long distances over 100 km without using a repeater.

(3) Small physical dimensions up to 100 microns which is smaller than coaxial cables.

(4) Its small dimension, makes its weight light, and provides cost savings.

(5) It is immune to electromagnetic interference (EMI) and electromagnetic pulse (EMP) and free of sparking.

(6) It is expensive as a material, but the total cost of the project which uses optical fibers should be low because of low losses so few repeaters are used which means less maintenance.

(7) No crosstalk between parallel fiber optic circuits.

(8) Greater security which is important in military services, computer networks and banks.

(9) Greater safety as there is no spark when short circuit occurs.

(10) Long life time for fiber optic which is about 25-30 years, because glass and plastic are non-corrosive.

(11) High reliability and easy maintenance. The losses are less in fiber optics than that in the coaxial cable, in coaxial cable systems repeaters are placed every 2-4 km, while for optical fiber repeaters are placed every 50-100 km or more apart. Consequently less repeaters used mean less maintenance.

(12) Fiber optics systems can be easily expanded. This is done simply by changing the sources of light (LED or LASERs) without replacing the original cable.

5. CONCLUSIONS

In this project we have discussed three LAN alternatives for possible use by the College of Engineering, King Saud University: (1) Eriscsson (MD110) PABX, (2) ETHERNET, and (3) Fiber Optics.

We may deduce the following decisions:

- Ericsson (MD110) solution should be excluded because of its limited data rates.

- Our design should use the next two solutions such that the network inside College of Engineering should use Ethernet, while the connection between College of Engineering and Computer Center in the Administration Building will use fiber optics. Fig. (1) shows a schematic diagram of the proposed connections.

- It is recommended to use the Ethernet alternative in the College of Engineering for the following reasons:

  (1) Higher capacity, better utilization is obtained.

  (2) Ease of connection of mainframes computers such as VAX and IBM in addition to several types of electronic equipment (PCs, printers, terminals ... etc.).

  (3) Higher computer speed because of high capacity.

- We will use 100 Mbs/s, single mode fiber optics, between the College of Engineering and Computer Center, and this is easy to expand in future to connect more networks without changing this connection.

- We choose Ethernet and fiber optics alternatives because performance and cost are important factors and we have to make a balance between them.