HYBRID NETWORK FOR BUSINESS AND INFORMATION SYSTEMS

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PREFACE

Local Area Networks provide a way of linking together computers for the purpose of sharing resources such as information, communication, high-speed printing facilities, etc., within a small area or over a complete site.

Computer networks for Information Systems are available in a number of different topologies utilizing different technologies. The main criterion for network use is that the networks are inexpensive to implement. The networks available range from dedicated networks with the main type of workstation designed for a single office environment (but also providing interface for the more popular personal computers), to third party networks designed to connect different networks over a large area.

The purpose of this thesis is both to design and to simulate a medium accessing technique for a local network. The thesis highlights some of the other medium accessing techniques available, the topologies used in these techniques, and their advantages and disadvantages.

The first chapter defines the problem and briefly proposes a solution to the problem. The second chapter puts the computer network into perspective by looking at different networks.

The third and fourth chapters cover the design of the Network Architecture and the Network Manager respectively. Chapter five briefly describes the Data Architecture which was implemented at Business and Economics Research, Oklahoma State University. Results of the simulation conducted are discussed in chapter six of this thesis.

Appendix-A provides the figures required in understanding the thesis. Figure (3), and Figures (4, 5 & 10) are referenced from [1] and [5] respectively. Appendix-B is a glossary of all important terms used in writing this thesis.

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CHAPTER I

DEFINITION OF THE PROBLEM

Introduction

Information systems of today concentrate on how to obtain data rather than how to use the data. This approach eventually leads to multiple problems. For example, a new user in an organization finds it difficult to retrieve data [1]; additionally, the user finds it difficult to structure and report data, because in an unfamiliar system it is difficult to change and to re-define the system standards [1]. Furthermore, before using a new system, the user must master network standards and must be well-versed with the network protocols. Finally, all of the users must endure a certain degree of network congestion. As a result of these major problems, today's Information Systems are not functional for the entire potential end-user community. This lack of limited user orientation ultimately impacts any organization using such a system, for any type of change in the system is complex and slow. Further, because naive users take a certain degree of lag time to become familiar with the network, these users inevitably complicate any start-up down-time as well as promote on-going delays.

The way out of this dilemma would be to design an Information System which provides a single source of data for end-user access. With the single source of data, there is only one logically consistent set of services the end-user needs to understand; further, such a system could become even more accessible to all end-users by providing a support organization that has the responsibility of promoting and supporting access to data by the end-user [1].

In the past decade many solutions to information systems have been proposed [1] . For example, IBM developed the E/ME/A Information System or the European Business and Information System (EBIS) (E/ME/A stands for Europe, the Middle East, and Africa). This Information System was aimed at providing a single data source for remote users in Europe, the Middle East, and Africa. However, this system did not take into consideration network parameters, such as throughput and efficiency of the system. Also some hybrid networks have been analyzed and proposed; important ones are those proposed by Wong and Gopal [17], Tobagi and Hunt [8].

To achieve better throughput and efficiency, the thesis presents an information system and analyses a network design with a technique for accessing the transmission medium which has a higher throughput. This design would allow the network to be operational even when the network manager or a station on the network fails. Apart from these characteristics it will also have the advantages of [17].

The Integrated System

The architecture for the above solution shall be called "Integrated System (IS)", a system based on two important architectures:

1. Network architecture, and
2. Data architecture.

The Integrated System defines the functions and inter-relationship of:

- Maintenance and services of the Intelligent Local Network,
- Information retrieval, and
- Reporting services.

Figure 1 shows a flow diagram of the Integrated System. The function of each architecture varies depending on the functional strategies of an establishment, which drives and controls the various components of the intended architecture.

Figure 2 illustrates a comparison of the Integrated System with the 7-layer OSI (Open System Interconnection) model defined by the International Standards Organization. Throughout the process of Integrated System design, much care has been taken to adhere to the 7-layer OSI model. The first two layers, the physical layer, and the data link layer, are designed in terms of a transceiver and a Medium Accessing Control (MAC). These two layers are the prime topics of this thesis.

The overall structure of the Integrated System is as shown in figure 3.

CHAPTER II

A PERSPECTIVE ON COMPUTER COMMUNICATION NETWORKS

Communication Overview

Data communication plays a major role in computer networks, therefore, it is necessary to understand the basic concept of communication systems. There are two types of communication systems: analog communication systems, and digital communication systems. An analog system is characterized by its bandwidth, that is, by the range of frequencies it can handle. Digital systems are discrete. They consist of a choice between two possible states, namely presence or absence of an electrical signal.

Synchronous And Asynchronous Transmission

Data is generally transmitted as large blocks composed of a string of characters rather than as individual bits. Thus, rather than each character passing its own timing signal, a timing signal for the entire block is transmitted. This mode of transmission is called "Synchronous Transmission". When these blocks of characters are transmitted, the timing devices in both computer peripherals are synchronized at the beginning of the block and each bit of data thereafter is interpreted according to this initial synchronization. This mode of transmission has the advantage of high speed; however, it suffers from the disadvantage of requiring expensive and complicated data transmission hardware. Also, special synchronization symbols have to be used to distinguish between the data files. Asynchronous Transmission is free from the above shortcomings and is widely used.

In Asynchronous Transmission, data is transmitted on the medium serially, bit-by-bit, to form characters on the receiving side. But in the case of Synchronous Transmission, data can be transmitted either in series or in parallel. To identify these packets of data start bit, end bit, and control structure are used in the data transmission.

Bit Serial Interface

Data transferred one bit at a time are typically represented at computer voltage levels of 0v and +5v for levels of '0' and '1' respectively. A string of voltage pulses represents a character. A string of pulses is usually character-coded either by the ASCII or EBCDIC code, and may be sent as a block of characters or individually. Bit-serial Asynchronous data transfer is frequently used for data transfer between computers.

To standardize bit-serial signals and plug connections between terminals, the Electronics Industry Assosiation (EIA) has adopted the RS232-C interface standard, which is equivalent to the international standard CCITT V24. All RS232-C pin assignments are not necessarily used in every interface application. The essential pins are Frame and Signal ground, Transmit data, Receive data, Request To Send(RTS), and Clear To Send(CTS).

Teletype printers on the network receive data signalled by 20mA of current flowing in a circuit loop, rather than by voltage levels of '0' and '5' volts. In such cases, similar bit serial input/output ports are used to interface teletypes, called "20 mA current loop". When a computer sends information directly to an adjacent printer, characters are commonly represented by an 8-bit ASCII character set. The transmission usually uses the standard RS232-C serial interface to realize the transmission. However, if the distance between the devices is increased, the voltage pulses reaching it become distorted from the original square shape and the overall voltage drops as a result of resistance and other electrical factors in the longer wires. Ultimately, the destination device may not receive the message at all. To overcome distortion due to noise, data coding is used. Non Return Zero (NRZ) is a commonly used coding method [10]. In NRZ, it is common to use negative voltage for '0', and positive voltage for '1'. The disadvantage of NRZ is that, it is difficult to determine where exactly one bit begins and another ends. One solution to this would be to use Manchester code [10]. Manchester code provides transition at the middle of each bit. The middle of such a bit serves as the clock and the data: a high to low transition represents a 1, and a low to high transition represents a 0. Xerox Ethernet uses Manchester coding [10].

Data Transmission Rate

The rate of data transmission in bits/seconds is called 'Baud'. At higher transmission frequencies, the capacity of the public telephone line limits the transmission rate. The characteristics of a telephone line that limit the data transmission capacity is called "Bandwidth", that is, the difference between the highest and lowest frequencies that are transmitted on the telephone line. Normal voice grade telephone lines accommodate frequencies between 300 and 3300 hertz and therefore have a bandwidth of 3000 hertz.

A fundamental law of information theory (Shannon's Law) applied to the telephone bandwidths indicates that the theoretical maximum transmission rate for bandwidth of a telephone line is about 25000 bits/second [7]. However, 9600 bits/second is the practical limit of typical telephone lines. But, even at this lower than theoretical maximum data transmission rate, complexity of the modulation system in the Modem results in higher Modem cost as well as a higher error rate. Due to the high cost and complexities involved in using Modems, there is a widespread use of RS232-C lines whenever possible.

The Local Network

The advent of low cost Local Area Networks (LAN) has made it possible to explore the possibilities of interconnecting a large number of computers and databases to form an efficient information system. This cost-effective solution has the advantage of providing each user of the processing nodes with sufficient local computing power while the inter-node communication allows for optional sharing of rare and expensive resources. These resources may be in the form of data from a database or some form of co-system needed by the node. The main bottleneck in such a system is the design of a suitable cost-effective communication between specially separated users and the data storage unit.

In order for an organization to function as a well-integrated and efficient unit, the computers that they depend upon must be able to communicate and exchange information quickly, easily, and reliably. Users at computer terminals and personal work stations must be able to send data via electronic mail exchange, access communication data bases to manipulate data and applications to speed up processes, to 'share' expensive storage devices (discs, tapes, etc) and output devices (copiers, high speed printers, graphic plotters), and to conduct these exchanges via local networks. These needs require that a Local Area Network offer reliable high speed communication channels for connecting information processing equipment in a limited geographic area.

General Characteristics of a Network

The method of networking used, whichever type it may be, should have certain principal characteristics. They are [14]:

a. Distributed Control: The switching, that is, the changing of a line between the send and receive node, should be distributed. Each station should provide channel access, that is, it should allocate appropriate bandwidth, to send or receive signals without a controller.

b. Reconfiguration: The network should provide a dynamic modification of the number of stations, permitting a station either physically to be connected or disconnected without disturbing the communication running on the rest of the network.

c. Connectivity: Because of the needs of geographical extension, the local network should have the facility to connect with the other networks through public networks.

d. Priority: For some special messages, the highest possible level of reliability and priority must be provided. The object of providing the priority mechanism is to allocate network capacity to the highest priority frame and send lower priority frames only when there is sufficient capacity.

Common Method Of Information Interchange Between Computers

An integrated combination of various communication facilities (channels and communication service), data circuit-terminating equipment (multiplexers, CRTs, etc) necessary for the transmission of data between various data input-output points and the host processor form a data network.

Basically the data networks are of two kinds:

. Local Area Network (LAN),

. Wide Area Network (WAN).

The basic distinction between these two network is that the LAN uses its own switching facilities and the WAN may either entirely use the switching facilities provided by the public telephone system or may use only its own switches.

The Advantage Of A Digital Data Network

A digital data network has significant advantages over an analog telephone network or a conventional I/O bus. The latter system is cumbersome, for it involves signal conversion, which brings multiple, unique problems. Since a voice signal is analog, transmission becomes very expensive as a Modem has to be used to convert a digital data signal into an analog signal, and then modulate them for transmission. The data conversation occurs in bursts that require the entire capacity of the channel for short periods of time. Also the amount of time between transmission is usually much longer than that of the transmission itself. Furthermore, since the telephone network has been designed to handle a limited number of calls, it is disadvantageous as a means for local communication.

Although the I/O Bus provides the advantage of carrying out transmission at higher speeds, this bus has basic problems:

. It connects the dependent components of one system and if one subsystem or component on the bus fails, the bus may be down until the problem is remedied.

. Overloads are not often solved via hardware or change of programming strategy.

. Messages are limited to a single fixed message size which is wasteful and inefficient.

. Protocols are usually designed only for system communication.

. Interfaces are only designed for the address and control structure of a particular computer and for short distance transmission.

The disadvantages of analog system and the I/O bus are overcome using a LAN. The salient features of LAN are:

. It connects many autonomous systems.

. It continues to function even if one of the connected system fails.

. It mediates demand for bandwidth in case of overload.

. It can be used to send different sized messages.

. It can have a generalized design for connecting a wide variety of devices.

Design Factors

The basic factors considered in the design of a LAN are [5]:

1. Topology,
2. Transmission medium, and
3. The method for Medium Access Control.

Topology

The term topology refers to the method in which different stations/nodes are connected to each other on the network or a method of point-to-point connection [5]. There are three different common topological forms. They are:

1. Star topology,
2. Ring topology, and
3. Bus and the Tree topology.

Figure 4 shows the three different topological structures.

Star Topology. Star topology consists of a central switching point to which all the stations on the network are connected. Communication between any two station is via this central switch. Once a connection is setup between two stations, they can communicate as long as they desire on a dedicated circuit. Any station needing to communicate with any one of these stations which share the network must wait for the dedicated circuit connection to cease.

The Star topology is used for a digital data switch and PBX products. Although such products can function as local networks, their operation has been standardized [5].

Ring Topology. In the Ring topology, stations are connected in a closed loop by means of a set of repeaters. Each repeater is joined to the next repeater to form a point-to-point connection. The repeater is a simple communication device; it receives data on one side extracts the noise and transmits it back on to the network in a bit-by-bit fashion. In effect the repeater thus allows noise-free communication. The links formed by these repeaters are unidirectional, that is, data can circulate around the ring only in one direction [5,6].

The disadvantage of star topology over the ring topology is that the star topology involves complex network protocols for the central switching unit. In contrast, the ring topology software is quite simple, but the software overhead on the stations involved in the ring is high.

Bus Topology and Tree Topology. In the Bus topology, all the stations desiring to communicate with each other capture the medium, the medium in this case is called the "Bus". All stations are connected to the medium by means of hardware equipment called transceivers. Tree topology is the same as bus topology with branching allowed on the transmitting medium.

The similarity of Bus topology with Ring topology is that both the topologies use a bit frame as the basic structure to transmit data. These frames are called Protocol Data Units (PDU). Each PDU contains the data to be transmitted, control commands from the higher layer, and addresses (source and destination).

Transmission Medium

"The transmission medium is the signal path between transmitter and receiver" [7]. Some common types of transmission mediums available are [5,7]:

a. Twisted pair (shielded and unshielded),
b. Coaxial cables (baseband 50-ohms and broadband 75-ohms), and
c. Optical fiber.

The type of medium to be used for the network depends on the entire span of the network, the number of stations on the network, and the type of topology that is going to be used to form the network.

From statistics [5,8], it is found that the performance of the Ring topology is better than that of the Bus topology. Using Bus topology, the stations are connected to the medium by means of a tap, causing considerable attenuation in the data transmitted; whereas in Ring topology the station is connected to the medium through repeaters where attenuation is very low. But the failure of even one repeater breaks the ring structure, causing the entire network to come to a standstill [5,6].

Medium Accessing Technique

On a local area network, all the stations or devices are connected on the same medium. So there must be some form of mechanism to capture the medium, otherwise more than one station will transmit at the same time, resulting in collisions of frames which leads to data loss or garbling. Different types of accessing mechanisms have been formulated by IEEE and described by the IEEE 802.X STANDARDS [5,9]. They are:

1. 802.3 CSMA/CD (Carrier sense multiple access/ collision detection),
2. 802.4 Token Bus, token mechanism for the bus structure, and
3. 802.5 Token ring for the ring structure.

CSMA/CD.

The Carrier Sense Multiple Access with Collision Detection (CSMA/CD) medium access control protocol is basically meant for Bus and Tree topology. CSMA/CD is the heart of the 802.3 STANDARDS. The CSMA/CD was developed with ALOHA and CSMA as its basic foundation.

DESCRIPTION OF CSMA/CD. Figure 5 shows the flowchart of CSMA/CD for receiving and transmitting data [5]. The following steps describe the functioning of the CSMA/CD:

1. If the medium is idle, transmit data frame and wait for certain amount of time to check for a collision. Else go to 2.
2. If the medium is busy, listen to medium. If it becomes idle, transmit the data immediately and check for collision.
3. If collision occurred then transmit a jamming signal and back off for a random amount of time. Else transmission was complete.
4. go to 1.

According to Hammond and O'Reilly [6], the main advantage of CSMA/CD is that the entire bandwidth of the channel can be used by a station once it successfully gains access. Under light load conditions, a user can, on the average, successfully access the channel after a short waiting period. Other advantages are: no central control is required, stations can be added or deleted easily, and most malfunctions are localized to single stations and do not affect the whole network.

Under a given set of conditions, load vs throughput characteristics of CSMA/CD varies with time. That is, the system is non-deterministic. Further, for a given number of stations, throughput decreases drastically at higher loads because of congestion on the network caused by collision.

<u>Token Ring and Token Bus.</u> The operation of the Token ring and the Token bus are the same in most of the major aspects, except that in case of the Token ring the physical structure is a ring and data circulates around the ring in a unidirectional fashion [5,6]. The Token bus topology, is similar to a Tree topology.

The idea behind the token concept is that any station on the network holding the token can transmit to any other station on the ring/bus until it finishes transmission. Each station wishing to transmit must wait for the token before it can transmit. All the stations poll and have a dynamic manager for the network. This manager controls the network in case of congestion, multiple token, lost token, duplicate address, etc.

The advantages of the Ring System are[6]:

a) Routing algorithms are not required;

b) Multiple addressing is straight forward; and

c) Efficiency does not degrade rapidly with load.

The disadvantages of Ring system are:

a) Operation depends on each station's network controller; so if an interface fails, the network is essentially broken [5,6];

b) The ring must be broken to add or delete stations;

c) The propagation delay depends on the number of stations; and

e) The cost of the system is very high because of the extra software involved at each station.

The next chapter discusses in detail the hybrid medium access technique for the information system.

CHAPTER III

NETWORK ARCHITECTURE

Introduction

The "Network Architecture" is the most important unit of the Integrated System. In this chapter, the design of a physical medium, an efficient medium accessing technique, and a support system necessary for a station on the LAN to communicate with the remote Data Bank and the other host stations are discussed.

Network Architecture is divided into three main units. The three units are :

1) The LAN unit,
2) The Network Manager (chapter IV), and
3) The gateway (chapter IV).

The LAN Unit

A LAN unit is necessary to connect the different entities into a distributed network which share data from a remote data bank. As an example, we could consider a system for a large establishment, where the data bank consists of different data regarding the company policies, employment strategies, etc. This data bank could be placed in the company corporate office and only controlled by the administrative staff under the guidance of the company management. This information could be accessed by any of its branch offices by having their own high-speed LAN unit connected to the data bank through a Gateway.

The design of the LAN needs to take into consideration the following aspects:

1. Topology,
2. The type of physical communication medium,
3. The type of accessing method that will be suitable for the new system and its real time applications,
4. The load on the system, and
5. The number of stations on the systems.

This thesis will address only topology and a medium access technique.

Topology

Different types of topologies that have been considered are the star topology, the ring topology, and the bus topology. As discussed in Chapter II, the Star topology is not suitable for information systems because the LAN Unit is entirely dependent on the central switching unit (CSU). The Bus topology is preferred even when the Ring topology has a better performance because the Ring structure becomes very expensive because of the repeaters involved in the physical medium [5]. Further, dynamic polling has to be used to overcome station contention or to resolve any problem on the network; resulting in very high software overhead on each station.

Physical Medium

This corresponds to the "Physical Layer" of the OSI model. The function of this layer is to provide transparency in the data transmitted on the network [5].

The bus structure is provided by means of a coaxial cable. The coaxial cable is preferable to the twisted pair since the former is able to:

a. Overcome data loss due to noise interference,

b. Lower the bandwidth problem, and

c. Overcome the Low data rate.

Lower data-rate and bandwidth make the capacity of the twisted pair far less than that of the coaxial cable. Fiber optics is not used in the design of the medium because of its very high cost.

The entire length of the medium is divided into sections called "Segments". The maximum length of each segment is limited to 500 meters. The length of the LAN could be increased by using Repeaters. A Repeater receives the data packet from one end, extracts data, reduces the noise level, and sends it back on the other side. In addition, a Repeater should provide data integrity, and should be transparent to the user.

Each station is physically connected to the medium by means of a RS232-C connector through a "Transceiver". Transceiver is a Data Communication Equipment (DCE), which is connected to the main cable by means of a tap. The definitions of DTE and DCE is given in Appendix-C.

Transceiver. The transceiver is a DCE. It is connected to the cable by means of a tap. The maximum number of tap points that can be used on any segment is 100, with a node spacing of 5 meters. This limit on the number of taps has been placed so as to overcome reflection of transmitted data from the adjacent transceiver. Depending on the environmental factors, the distance between transceivers could vary to a certain extent. Three Kilometers is the maximum distance that has ever successfully been attempted between two stations using four repeaters [5].

The Transceivers used on the cable are 10Mbs data communication equipment. Figure 6 shows the block diagram of the transmitter.

The receiver and the transmitter of the transceiver are basic communication equipment which are capable of operating between 1Mbs and 10Mbs. The two double-ended limit comparators are voltage comparators used to detect collision, normal data, ideal bus, and noise. The circuit diagram of a double ended comparator is as shown in Figure 7.

The operation of the entire unit is depicted by means of a truth table, as given in Figure 8. The receive (Rx) line of the logic unit is always high, indicating that the receiver is always reading the status of the medium. This is necessary because it is this unit which feeds data to the comparator circuit, which in turn detects collision or signals to the transmitter that the medium is idle. The voltage levels of the first Double-Ended-Comparator are so adjusted that V(hig) = V(low) = 0v; so that when a collision takes place on the medium, there is a swing in the voltage level on the line. This swing causes both the comparators to fire, causing output lines A and B to go high. This activates the Jammer, which in turn sends the jamming signal to the transmitter, which transmits the jamming signal. The purpose of this jamming signal is to indicate to all the stations on the network that a collision has occurred.

The function of the Logic Unit is to assure that there is no clash in the operation of the diffrent units of the Transceiver. The circuit diagram for the logic unit is designed using the truth table given in Figure 8. Figure 9 shows the resulting circuit diagram for the Logic Unit.

Medium Access Technique and Real Time Application

This corresponds to "Layer 2" of the OSI model. This layer provides for transferring data between two stations on the network, and detection of transfer errors.

As discussed in the chapter II, Ring structure is expensive and because of its dependence on the repeaters it is not suitable for an information system. On the other-hand, CSMA/CD, though cost effective and efficient under moderate loads, is unstable [6,8,12]. According to Kleinrock and Lam [13], "A random access protocol is said to be stable when its load line intersects (nontangentially) the throughput curve in exactly one place. Otherwise, the channel is said to be unstable."

But by slightly altering CSMA/CD technique, it could be made globally stable (that is, its equilibrium point is in operation for a finite period of time [6]) with a higher throughput than the conventional CSMA/CD; then this medium-accessing technique would be very well suited for a fast and efficient information system. Further, considering the fact that in general the total span of LAN unit will probably be small when compared to the total distance between the local LAN unit and the Data Bank, and that the LAN unit is going to be independent of the Data Bank, we could try a graft between the two different types of access methods discussed in the earlier chapter. This graft would consist of a combination of a cost effective CSMA/CD, and a deterministic TOKEN BUS. The advantage of this graft would be a cost effective medium accessing technique which is deterministic, with a higher throughput and reliability [17]. The cost of the new system is reduced since repeaters are not going to be involved in the physical structure.

Structure of the grafted CSMA/CD. In grafted CSMA/CD method, the stations on the network are connected into a logical ring on a bus. Each station on the logical ring knows its logical predecessor and follower. The entire network is controlled by a manager called the "Network Manager".

Operation. The Network Manager (as defined in chapter IV) has a status counter R. For every change of this status counter or at timeout, a new token is passed to the next station on the logical ring and simultaneously the station holding the old token gives it up. The status counter is changed for every change of the medium from "busy" to "idle".

In conventional CSMA/CD, every time the medium is idle, all the stations holding a packet transmit. This transmission may result in collision if more than one station transmits at the same time. Then all the stations involved in collision would back off for a random amount of time. But in the grafted network, all stations except the one holding the token back off for a random amount of time. The station holding the token continues retransmission efforts. This ensures that the station holding the token has a 100% probability of successful transmission given that the back off time of other stations is large enough [17].

Model of grafted CSMA/CD. Certain restrictions are put on the operation of the system in order to form a Markov Chain. The motivation of doing this is to make the characteristics of the hybrid protocol to approach that of a random access protocol. This approach was followed by Wong and Gopal [17] in their analysis of hybrid networks. These restrictions are:

1. The transmission of packets must be a discrete time-process,
2. The number of stations and the number of packets will form a finite state space, and
3. The entire process follows the Markov property[14].

A system that functions under these restrictions is called a Markov Chain [8,14].

In the Markov model, let

. the time axis be divided into slots with the time duration between slots being end-to-end propagation delay time, and let 't' be the size of each slot,

. Poisson arrival distribution for each station with inter-arrival time (it),

. 'T' be the size (slots) of each packet in slots, and

. 'M' be the number of stations on the network.

At any given instant of time there can be three types of stations on the network [8]. They are:

1. A dead station, which is no longer a member of the logical ring. If this station has to get back into the ring, then it should go through the insertion process all over again.
2. A station which has a packet to transmit but does not have hold of the medium, or on transmission is involved in a collision and thus is back-logged.

This station produces packets with a probability f.

3. A station which is not certain whether it has a packet to transmit, such a station is said to be in a thinking mode. This station produces packets with a probability r.

Depending upon the status of the medium, three probabilities are computed. P[s] the probability of success, P[i] the probability of idleness, and P[c] the probability of capture or contention. The relationship between the three probabilities should be:

$$P[s] + P[i] + P[c] = 1. \qquad --(1).$$

Calculation of P[s], P[c], P[i], and throughput.

Let,

b = the system backlog, the number of backlogged stations,

S(k) = probability of k stations being ready, will transmit in a slot when the backlog is b, given by [8]:

$$S(k) = k * r^k * (1-r^{(M-b-k)}) \qquad --(2).$$

B(k) = Probability of k stations being blocked will transmit in a slot when the backlog is b, given by [8]:

$$B(k) = b * f^k * (1-f)^{(b-k)} \qquad --(3).$$

(k) = probability of having more than or equal to one station ready when the backlog is b, given by

$$R = 1-S(0).B(0) \qquad --(4).$$

I = Duration of idle time with a backlog b.

The channel backlog on this network at an observation instant n+1 depends on :

a) the channel backlog at n,

b) the number of new arrivals between the observation point n+1 and n, and

c) whether or not the transmission immediately preceding the observation instant n+1 was successful.

With the restrictions [14] put on the system and with the above three points, it could be said that the system is a Markov chain. We can say so because the number of arrivals at a station and the success of a transmission is dependent on the backlog at the predecessor of the station from which these observations are being made.

The probability of Idleness, P[i] in terms of S(k) and B(k) is given by [17]:

$$P[i] = \frac{S(0).B(0)}{1-S(0).B(0)} * \frac{(M-k)}{M} \qquad \text{--(5).}$$

substituting k = 0, in equation (2) and (3), we get

$$P[i] = \frac{(b * (1-f)^b) * (M * (1-r)^{(M-b)})}{1 - M*b\ (1-r)^{(M-b)} * (1-f)^b} * \frac{(M-k)}{M} \qquad (6).$$

The probability of success, P[s] in terms of S(k) and B(k) is given by [17]:

$$P[s] = \frac{S(1).B(0) + S(0).B(1)}{1 - S(0).B(0)} * \frac{(M-k)}{k} \qquad \text{--(7).}$$

substituting values of k in equation (2) and (3), we get

$$P[s] = \frac{b.(M-k).(1-r)^{(M-b)}.(1-f)^{b}.(1/(1+r) + f/(1-f))}{1 - b.M.(1-r)^{(M-b)}.(1-f)^{b}} \quad (8).$$

But from equation (1), we get P[c] to be

$$P[c] = 1 - P[s] - P[i] \quad \text{--(9).}$$

substituting equation (6) and (8) in (9) we get the probability P[c].

Each transmitting station without the token, on sensing collision backs off for a random amount of time and retransmits the packet. The probability that this retransmission (rt) would be successful is given by [17] as

$$P[rt] = S(0).S(1)/P[s] \quad \text{--(10).}$$

Throughput. According to Kleinrock [10], the definition of throughput is " the fraction of the channel time occupied by the successful transmission". It is given by:

$$S = \frac{T * P[s]}{(\text{Average idle time}) * (\text{Average transmission time})} \quad (11)$$

where,

$$\text{Average idle time [10]} = \frac{t * P[i]}{1- P[i]} \quad \text{--(12).}$$

As discussed earlier, t is the length of the slot; that is, end-to-end propagation time.

The upper bound on the length of the slot depends on the upper bound on the time it takes to detect collision, the upper bound on the medium acquisition time, and finally, the upper bound on the length of the frames created by collision. By Ethernet standards [5], slot time is set at:

$(2t + T) <= \text{slot time} <= (4t + T)$, $(2t+T)$ is taken as the minimum because, 2t is the minimum time (in slots) required by a packet for end-to-end propagation and T (slots) is the length of a packets in slots.

The average transmission time TA, is given by

$$TA = (T + 2t).P[s] + (R + 2t).P[f] \quad --(13).$$

were 'R' is the collision detection time, where R = nt, n being the number of slots R is divided into; and

P[f] = 1 - P[s], the probability of failure.

Substituting equation (12) and (13) in equation (11), we get

$$S = \frac{T * P[s]}{\frac{t * P[i]}{1 - P[i]} + ((T + 2t) * P[s]) + ((R + 2t) * P[f])} \quad (14)$$

Equation (14) gives the throughput of the system.

<u>The Back off operation.</u> To overcome congestion on the medium, each station on the network is provided with a back-off system called the "Random Back-off" mechanism.

In the random back-off mechanism, after a certain number of retransmissions, a station assumes that there is some type of transmission error occurring and automatically goes into a back off response. The back-off operation allows a small amount of time during which a station stops transmission and listens to the medium. Back-off continues until the station is reinitialized by the network manager and thus is reintegrated into the network.

Each station is provided with a counter K, the value of which depends on the number of stations linked to the network. This counter is initialized by the Network Manager at the time of network initialization. After every unsuccessful retransmission, a random number generator fires, generating a random number N and this random number is subtracted from the counter K. On subtraction, if the value of K is less than or equal to zero, then the station assumes that there is some fault with the medium and backs-off until it is reinitialized by the network manager, or if on subtraction the value of K is still greater than zero, the station reschedules the packet and retransmits. In case of a successful retransmission, the value of K is reset to its original starting value by the station. The probability of success of retransmission is given by equation (10).

Frame format. According to 802.3 STANDARDS, there is a limit on the length of the packet transmitted on the medium. This restriction on frame length is put so as to achieve:

a. maximum collision detection,
b. fixed buffer sizes for the transmitter and the receiver of the transceiver, and finally,
c. if the frame size is too large, the station transmitting the frame will hold the medium for a very long time causing deadlock.

Xerox proposes a maximum frame size of 1518 Octets (8-bits) and a minimum of 64 octets at inter-frame gap of 9.6 seconds [5]. Figure A-10 shows the packet format; in which:

N/DB =	0	Address of the station on the network,
	1	Address of a location on the DataBank.
and I/G =	0	Single local address,
	1	Group address, used to pass universal messages by the Network manager or any other station on the network.

If all the bits in the destination address, except the N/DB bit are '1', this indicates that the source wants to transmit a message to all the stations on the network including the Network Manager. If the first bit of the source address is a '1', this indicates that the source is the Network Manager. If the network manager transmits a frame with all the bits in the source address as '1', it indicates an override command to other stations, and all stations back off for a random amount of time.

Acknowledgment system

Once the medium has been acquired and data transmitted, an absence of collision does not mean that the data has been delivered to the destination address, because data can get corrupted/garbled due to noise on the channel. To make sure that data has reached its destination, an acknowledgment system is used [15]. Two methods are discussed below.

Method-1. The source station on transmitting the data starts a timer. On receiving the data, the destination station could then check the validity of the data by means of the checksum and return an acknowledgment with the received frame number on it. The source station waits for the acknowledgment for a certain amount of time (maintained by the timer). If it does not get the acknowledgment within this time, the station retransmits the data with the same frame number. The problem with this system is that the station sending the acknowledgment should also fight for the medium using CSMA/CD, and this causes a delay in data transmission and duplicate frames at the destination.

Method-2. The source station could overcome this problem if it holds the medium for a little longer time so that the destination station could transmit the acknowledgment immediately on the same connection. This method is generally used in most random access techniques.

Network Architecture to a certain extent is controlled by the network manager; which is discussed in the next chapter.

CHAPTER IV

THE NETWORK MANAGER

Introduction

This chapter defines the functions of the Network Manager and its relationship with the network.

The network, as defined by the Network Architecture, is not free from problems. Some of the problems which may frequently occur are: multiple token on the logical ring, broken logical ring, missing token, and deadlock on the ring. Deadlock may occur when more than one station on the network is holding a token. During collision condition, all the stations holding a token will start transmission; this transmission will cause collision which causes a normal station to go into a back-off mode. This process of transmission and collision between token holding stations will cause deadlock. This will continue till the network is reinitialized.

To overcome these major problems, the network is provided with a control system called the "Network Manager". The functions of this manager are to collect system status data at regular intervals and make the required adjustments on the system, and to provide a communication link between a station on the local network and the Data Bank.

Network Manager

The network manager has five major units. They are :

1. Status collector,
2. Token generator,
3. Hypothetical knowledge-base,
4. Decision Machine, and
5. Communication unit.

Figure 11 shows the block diagram of the Network Manager.

Status Collector

The status collector collects status information from all the stations active on the network at regular intervals. This data collected by the Status Collector is stored in a table called "Status Table".

Structure and contents of the Status Table. The Status Table is divided into records and each active (records and each active) station on the network is identified with a record. Each record has a identification number which is the station node address. The Status table has a "Address-Table". The Address Table consists of a list of node addresses of all active stations on the network. Further each address in the Address Table contains a pointer to the record for that station in the Status Table. Figure 12 illustrates the structure of the

Status Table along with the Address Table. The entry into the Address Table is made on a first-in/first-out basis. The Decision Machine, during the process of making a decision, has to index the node address in the Address Table to extract data regarding a station.

The different parameters stored in the Status Table, characterizing each station are:

a) T1 = Time at initiation,

b) T2 = Time at start of idle state,

c) T3 = Time of obtaining the token,

d) PD = Predecessor address of the station, and

e) SD = Successor address.

In addition to storing the above parameters, some general purpose parameters pertaining to the network are also stored. These parameters are:

a) MaxToken = total number of tokens on the network,

b) HOLD = maximum time allowed to hold a token,

c) R = Status of the medium,
'0' for idle and '1' for busy,

d) Range = range of random number allowed, and

e) Ttime = Time when last token was passed.

Parameters, Predecessor Address, and Successor Address are stored so that in case of a deadlock, the Network Manager knows the position of each station relative to other stations during reinitiation. Furthermore, the manager must know the position of each station on the ring so that token passing becomes an easy task.

Token Generator

The function of the Token Generator is to generate a token of the required format at the command of the Decision Machine. The format of the token is same as that of the packet. The length of the token depends on the number of active stations.

For every change of state of the medium from busy to idle, the Decision Machine triggers the Token Generator to generate a token. Sometimes, it may happen that the medium may be occupied by one station for a very long time causing starvation to the other stations. To overcome this problem, each station is allowed to hold the token for a maximum time equal to HOLD. After this point, the Decision Machine will pre-empt the medium and reschedule the token to the next station on the logical ring.

Hypothetical Database

Hypothetical Database is a database containing facts [19]. These facts can either be changed by the system administrator or the Decision Machine, depending upon the threshold levels.

The parameters in the database have a threshold value. If the value of a particular parameter goes above the threshold repeatedly, then the old value of that threshold in the Hypothetical Database is changed by the Decision Machine to a new value. This new value may be the average of the last few readings. Parameters stored in this database could be considered as a belief factors. Each parameter has a minimum value; above this value, the parameter is considered as a belief. If the value of the datum collected by the Status Collector goes below the minimum, then the datum is considered to be false. But, if the value goes above the threshold, then the datum is considered to be a fact. The data stored in this database in the form of facts are used by the Decision Machine during data processing.

Decision Machine

The Decision Machine is the main unit of the Network Manager. It is responsible for taking every major decision on the network. Some of the major responsibilities are token scheduling, resolving multiple token problem, and to overcome the problem of starvation of the medium for a particular station.

A decision made by Decision Machine depends on few factors such as: the threshold values, how old the measurements are, and probability that the measurements will change between the time the decision is made and executed. In the process of overcoming some of these problems, the Decision Machine coordinates with the Hypothetical Database. It also initiates the Status Collector to collect data at regular intervals.

The Decision Machine is a Rule-Based system [16]. A rule-based system rather than a procedural system is used because, as the network progresses in time, adjustments may have to be made to the system; adding new rules to obtain the required adjustments is much simpler than writing an entire new procedure. Furthermore, a procedural system could be a very large program; sometimes, any changes to the system could mean changing the entire program.

In formulating the rules, mathematical formulas, numeric constants, and some predefined functions have been used.

The parameters used in forming the rules are:

T	:	System clock,
M	:	Number of stations on the network,
T1	:	Time at initiation,
T2	:	Start of idle time for each station,
T3	:	Time of obtaining the token,
Maxtoken	:	Number of tokens on the ring,
HOLD	:	Maximum time allowed to hold a token,
R	:	Status of the medium,
Ttime	:	Time when last token was passed,
Maxtro	:	Expected maximum throughput,
Midvalue	:	Value of number stations,

These values are set by the system administrator.

The rules are:

```
RULE 001: If  1. ( ( R changes from busy to idle ) OR
                   ( {T-T3} >= HOLD ) )

              2.   ( M > 0 )

          Then
             1. Activate the Token generator to send token
                to the next station on the logical ring.

             2. Send a message to the previous station
```

holding the token to give up the token.

RULE 002: If ((Insertion requested) AND (M = MaxStation))

Then
(Send a message to the requesting party of the non-availability of space on the network.)

RULE 003: If ((Insertion requested) AND (M < MaxStation))

Then
1. Select station address and send a token indicating to the station its predecessor and successor.

2. Send a token to the predecessor of the new station indicating who its new successor is.

3. Send a token indicating to successor of the new station indicating who its new predecessor is.

4. Increase the counter M by 1.

RULE 004: If ((Deletion requested) AND (M <= 0))

Then
Send a message to the system administrator indicating the error.

RULE 005: If ((Deletion requested) AND (M > 0))

Then
1. Delete the station from the Address Table.

2. Indicate to the neighbors (if present) of the deleted stations who its new neighbors are.

3. Decrease the counter M by 1.

RULE 006: If (Station present on the network and does not respond to the token for information.)

Then
1. Send signal to the station once again.

2. Wait for two propagation delay time.

3. repeat 1 and 2 three times.

4. if no response then delete station.

RULE 007: If 1. (Throughput is < Maxtro)

2. (M < Midvalue)

Then
Change HOLD to higher value by a factor m, where 'm' is the value set by the system administrator.

RULE 008: If 1. (Throughput < Maxtro)

2. (M > Midvalue)

Then
Change HOLD To higher value by a factor n, where 'n' is the value set by the system administrator.

RULE 009: If 1. (Throughput < Maxtro)

2. (M = MaxStation)

Then
1. Wait for a time = T5 (set by the administrator).

2. Check throughput.

3. Fire rule 010.

RULE 010: If 1. (Throughput < Maxtro)

2. (M = Maxstation)

Then
1. Generate a random number in the range of the node address present on the Address Table.

2. Delete the station with the node address generated by the random number generator.

3. Send message to the station before deletion indicating overload.

RULE 011: If (Station idle for > IDLE)

Then

1. Send signal to the station.

2. Wait for certain amount of time set by the system administrator for the station to respond.

3. If no response delete the station.

RULE 012: If 1. (Maxtoken < 1)

2. (M > 0)

Then

1. Initiate the token generator.

2. Search the table for the next logical station.

3. Send token to the station.

4. Set Maxtoken to 1.

RULE 013: If 1. (Maxtoken > 1)

2. (M > 0)

3. (No two stations have the same Max(T3))

Then

1. Check T3 of all the stations holding the token.

2. Allow station with the most recent token received time T3, to have the token.

3. Send message to all the other stations holding a token, to give it up.

RULE 014: If 1. (Maxtoken >1)

2. (M >0)

3. (Two or more stations have the same Max(T3))

Then

1. Send message to all the stations holding the token to give up the token.

2. Send a new token to the next logical station on the network.

RULE 015: If (M = 0)

Then

1. Wait for a time (T-Ttime) = twice the propagation time.
2. Send a token on the network.
3. Repeat this process till M >0.

Communication Unit

The Communication Unit of the Network manager is used to sort the data packets received at the Manager according to their destinations. For example, a station on the local network may want some data from the Data Bank; in such a case the communication unit routes the data to the Data Bank via the gateway. Likewise, there may be another packet for the Manager itself, or a packet to the station next to the manager; in such a case, the Manager should grab the packet, check the destination address and, if the destination address does not match with its own, retransmit the packet back on the network.

Operation

At regular intervals, the Decision Machine activates the Token generator and the Token generator in turn sends a token on the network. Destination address is the address of the station on to which a token is to be passed on the logical ring. As the token passes from one station to another, each station "piggybacks" information as requested by the manager. On receiving back the token, the Status Collector extracts all the data from the token. The rate at which the token is passed from one station to another is the rate of change of the status of the medium.

Each station on the network on sensing a token on the ring backs off for a time duration equal to thrice the token propagation time from the point of observation.

that is, 2 * [propagation time] for the propagation of the token

+ [propagation time] is the time for each station to piggyback information on the token.

Before backing off, each station piggybacks its information on the token. Information for each station starts with a Starting Delimiter = 01010101, and ends with a Ending Delimiter = 10101010.

Station Insertion

A station wishing to join the logical ring waits for the token. On receiving the token, it piggybacks just its node address. On receiving the node address between the Starting and Ending delimiter, the Decision Machine gets the message that the station sending its node address wants to be a member of the ring. The Decision Machine then creates a new record in the Status Table and includes the new station on the Address Table with a pointer to this record. It indicates to the new station who its neighboring stations are and also does the same to the two between which the new station is inserted.

Station Deletion

As in insertion, a station wishing to exit the logical ring, waits for the token. On receiving the token, the station piggybacks its node address along with a control information indicating that it wants to exit the ring. The manager on receiving this, indicates to the neighbors of the exiting station of its new neighbors and the station exits from the logical ring.

Gateway

Though this thesis does not address gateways, certain basic ideas regarding them are discussed.

A gateway, also called a Bridge [18], translates incompatible computer and terminal equipment protocols and thus boosts inter-network communications.

There are many commercially available gateways. For example, [18]: Bridge Communication, Inc. makes a gateway consisting of standard printed-circuit boards. This gateway allows an Ethernet to link with a broadband network. This system is based on a MC68000 16-bit microprocessor. Similarly, Intel has a communication server that connects 8 to 16 peripherals to Ethernet via RS232-C interface. This system can be configured as a bridge that accesses additional network services via user-supplied software.

A disadvantage of using a gateway is its frequent inability to map inter-network communications on a one-to-one basis, in which case additional software has to used.

CHAPTER V

DATA ARCHITECTURE

Introduction

Having defined and discussed the network, it is necessary to describe the structure of the Data architecture to make the system complete. In this chapter, Data Architecture is described very briefly. Data Architecture basically deals with information collection, retrieval and data analysis.

Data architecture is independent of the Network architecture. All communication between these two architectures takes place through the network manager which control the flow of information between the two. The design of the system is portable because of the fact that the network architecture is isolated from the Data architecture by means of a gateway. This gateway provides the needed flexibility in terms of probability.

Data Architecture

Data architecture is divided into different blocks. Of these, the three important blocks are:

1. Primary System,

2. Information System, and

3. Data Bank.

Primary System

The Primary System of the Data architecture is the main system program [1]. This is basically an operational system of any data architecture. This program takes care of the entire system data. Apart from this, primary system dynamically updates the data in the data base and also drives the DATA BANK.

Information System

Information system of the data architecture is an optional program. This could be a basic data retriever, to access and present data in the required format.

Relationship Between Primary and Information System

The primary and Information systems of the Data architecture are kept independent of each other. This ensures that the maintenance of the system will not hamper the entire network.

Data Bank

The Data architecture drives the Data Bank and the entire Data architecture is built around this Data Bank.

The Data Bank consist of all the information required by the business establishment [1].

Data Bank design, that is the design of the table layout and relationships, depends on the amount of data analysis and modeling that is being done in the company. The data on the Data Bank is stored in different forms. The advantages of doing this is that, different database tools require data in different formats, if this data on the Data Bank is present in a format required by the tool, or some format very close to that required, by very little manipulation different data base tools could be used. Furthermore, the user has access to different tables, the columns of which could be found in different data bases of the company, that is, the user can make direct data comparison with out making any changes to it. Figure 13 shows different views of the Data Bank.

The main functions of the Data Bank is to define the data structure, the relationship among the various elements of the data, recognize redundant data, and data elimination, and data normalization.

To avoid confusion and to help proper differentiation of different types of data, the Data Bank space is divided into two parts. They are:

1. System Dataspace, and
2. End-User Dataspace.

System Dataspace. System Dataspace is the memory space in the Data Bank controlled by the system manager.

Data in this space can only be read or copied by the end-user.

End-User Dataspace. End-User Dataspace in the Data Bank is the space which the end-user can use to store his data for future use [1]. This is the work area provided by the system for the end-user. This space helps the end-user to combine his data with that provided by the system to form his own new database. This end-user data base can only be accessed and used by the creator of that space.

The combination of the Network Architecture discussed in chapter III and IV, and the Data Architecture described in this chapter could form an efficient Information System. This information system could be used in establishments where real time application is not a parameter under consideration.

CHAPTER VI

SIMULATION

A series of simulations were run to compare the hybrid protocol with that of a standard CSMA/CD protocol. It was assumed that:

1. Inter-arrival of packets followed a Poisson distribution [8].
2. Packets generated were all of equal length.
3. Each station on the network had a buffer size of five packets. Any packet generated when the buffer was full, was considered lost [17].
4. Token passing was done by the station manager.
5. Collision detection time 'e' was very small and therefore neglected.
6. Distance between stations on the network was equal.

In this simulation, as the entire operation can be divided into distinct events, a discrete simulation technique with variable time approach was used [21]. The random number generator and the Poisson distribution function used in the simulation of this problem was taken from Bratley and Fox [22].

The conditions under which different simulations were conducted are:

1. Gamma, the inter arrival rate was = 0.01.
2. Token hold time was = 25 time slots.
3. Number of retransmissions allowed were = 16.
4. Simulation time = 10,000.

Initially simulation was conducted using SLAM II, but due to the problem encountered in simulating the token property required a switch had to be made to PASCAL.

Turbo Pascal 5.0 was used. The data structure used in the program are of two types:

1. A linear two way linked list used to represent the event list; that is the list indicating the different events that should occur at discrete time steps. This linked list is in an ascending order. The parameter under consideration is time at which an event should occur.

2. A linear linked list representing a single segment of the CSMA/CD network.

The results of the simulation are summarized in Figure 14 and 15. Figure 14 is a comparison graph between the hybrid model and the CSMA/CD. This graph is plotted for throughput vs number of stations. Figure 15 is a graph plotted for average number of packets transmitted vs the token hold time. This graph indicates the token characteristics of the Integrated Systems.

CHAPTER VII

CONCLUSION

From the simulation conducted the hybrid protocol shows improvement of throughput when the number of stations on the network is between 7 and 26. But as the number of stations on the network is increased, the throughput starts decreasing drastically. This feature of the hybrid model can be seen in the graph in Figure 14. The reason for this decrease in throughput is analyzed as follows: On sixteen retransmissions of a particular packet, a station assumes that there is something wrong with the medium and backs-off for a infinite amount of time; this station is reinitiated by the network manager in case of the conventional CSMA/CD. But, in the hybrid model, the station is reinitiated on receiving the token and not by the network manager. So, as the number of stations increase, the time duration from which a station gives up its token and later receives the new token increases. This increase keeps the station in the back-off mode for a longer duration of time and increases the number of backlogged stations causing a decrease in throughput.

This decrease in throughput can be clearly seen in Figure 15, which is a graph of average number of packets transmitted vs the token hold time. Initially, the average number of packets transmitted increases as the token hold time is increased; but, the throughput starts decreasing after a certain point as token hold time is increased.

From the graphs obtained, it can be seen that, the hybrid system would be a very efficient medium accessing technique if the number of stations on the local network was between seven and twenty-six. This number may vary depending on the different parameters selected for the simulation process. But, as the number of stations on the local network increases, CSMA/CD gains a upper hand, that is, it has a higher throughput than the hybrid model. Further, for CSMA/CD, when the number of stations is high, it can be seen that the throughput is steady, where as for the hybrid model, it continuously decreases.

The decrease in throughput for the hybrid network could be over-come to a certain extent by using a dynamic manager. Should a dynamic manager be used, it may reduce the token passing delay involved in this hybrid model which uses a static manager. That is, the number of stations remaining in the back-off mode would decrease. But the disadvantage of using a dynamic manager would be that, the software overhead on each station on the network would increase.

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APPENDICES

APPENDIX A

FIGURES

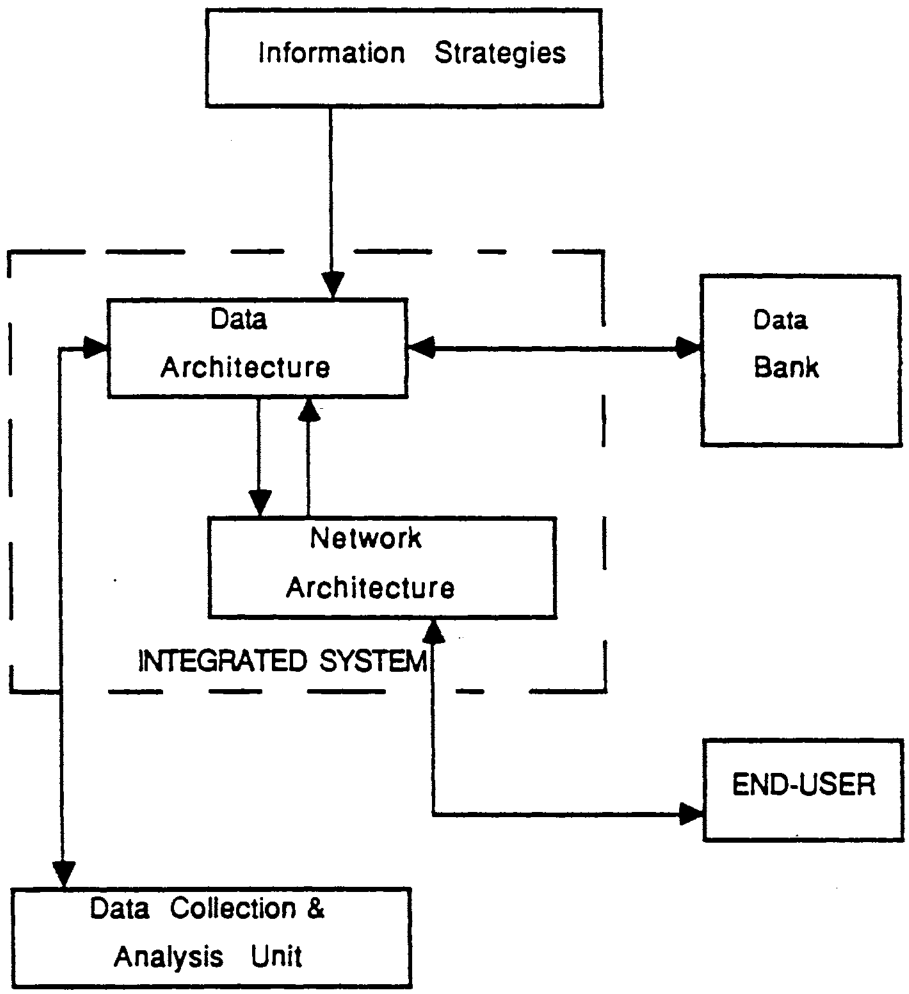

Figure 1. Flow Diagram of the Integrated System.

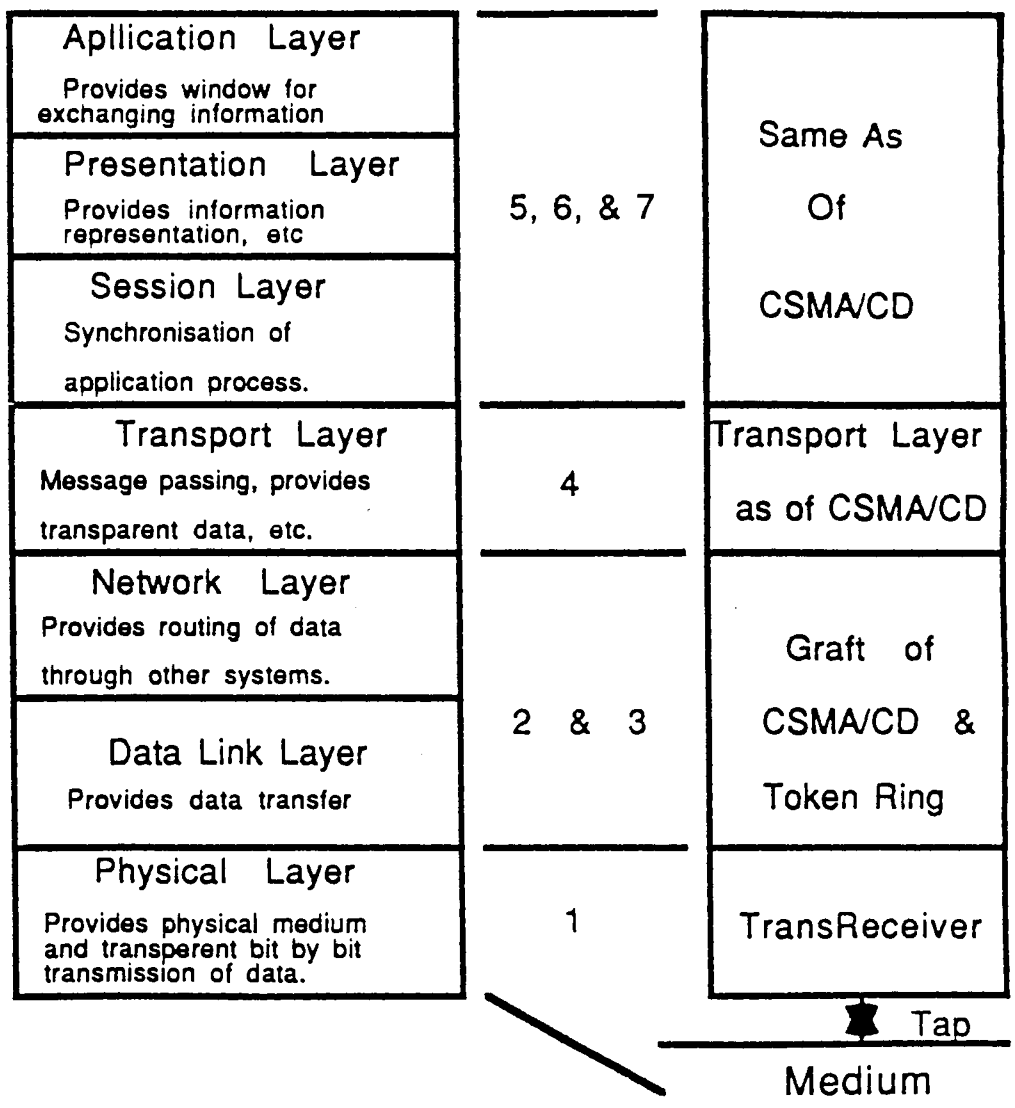

Figure 2. Comparison of the OSI 7-layer model defined by the International Standards Organisation with that of the Integrated System.

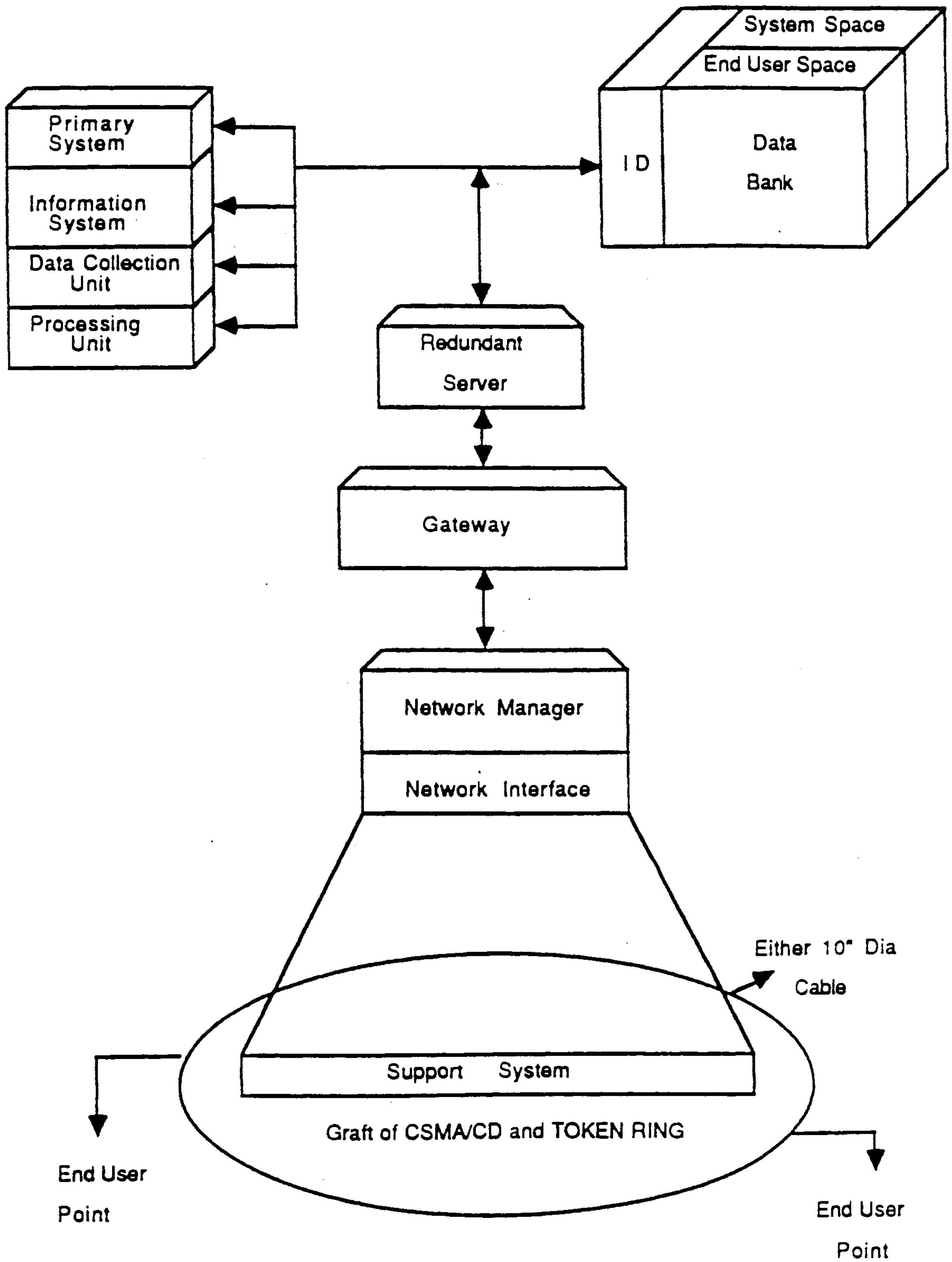

Figure 3. Integrated System Referenced from EBIS [1].

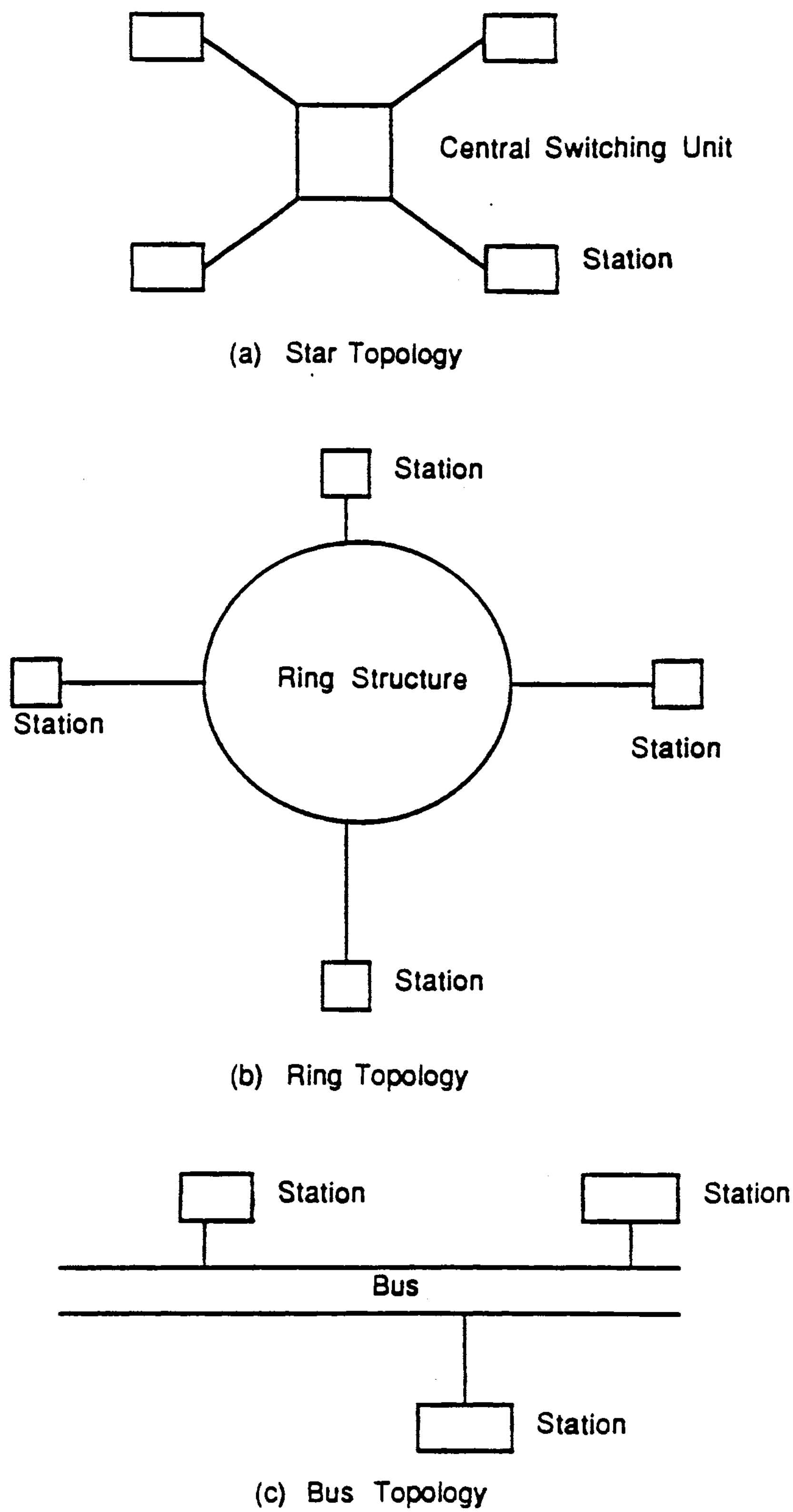

Figure 4. LAN Topological Structures [5].

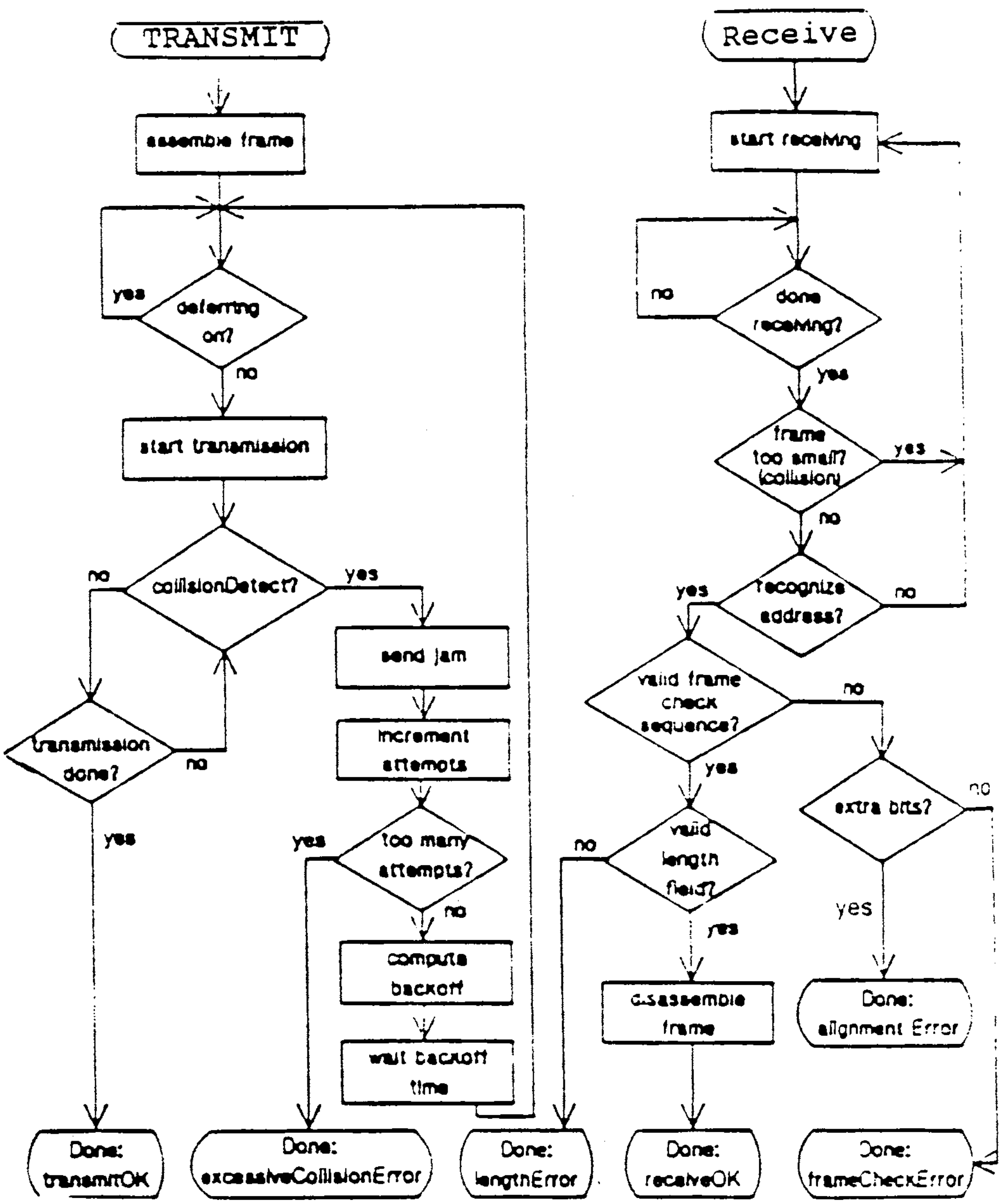

Figure 5a. Flow Chart of conventional CSMA/CD [5].

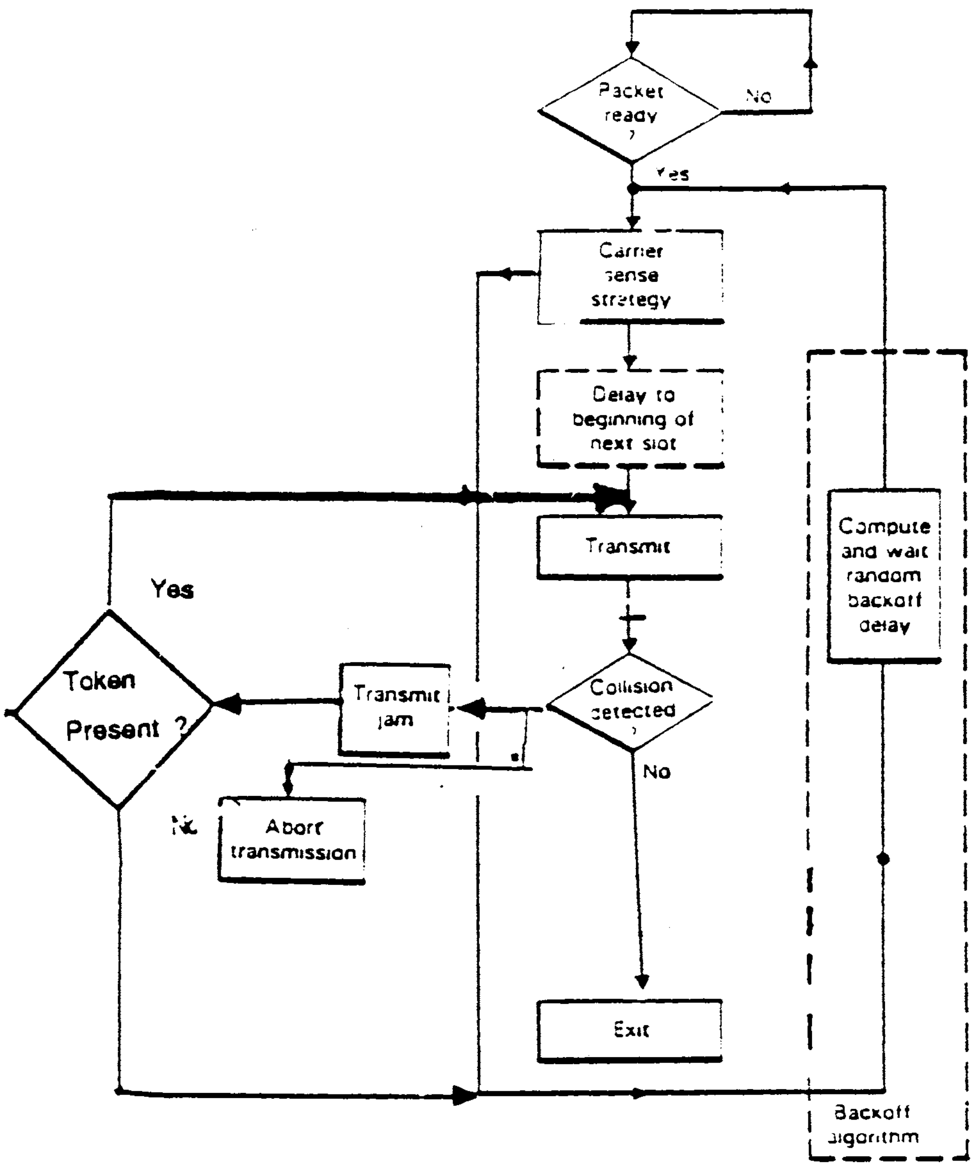

Figure 5b. Flow Chart of Hybrid network protocol.

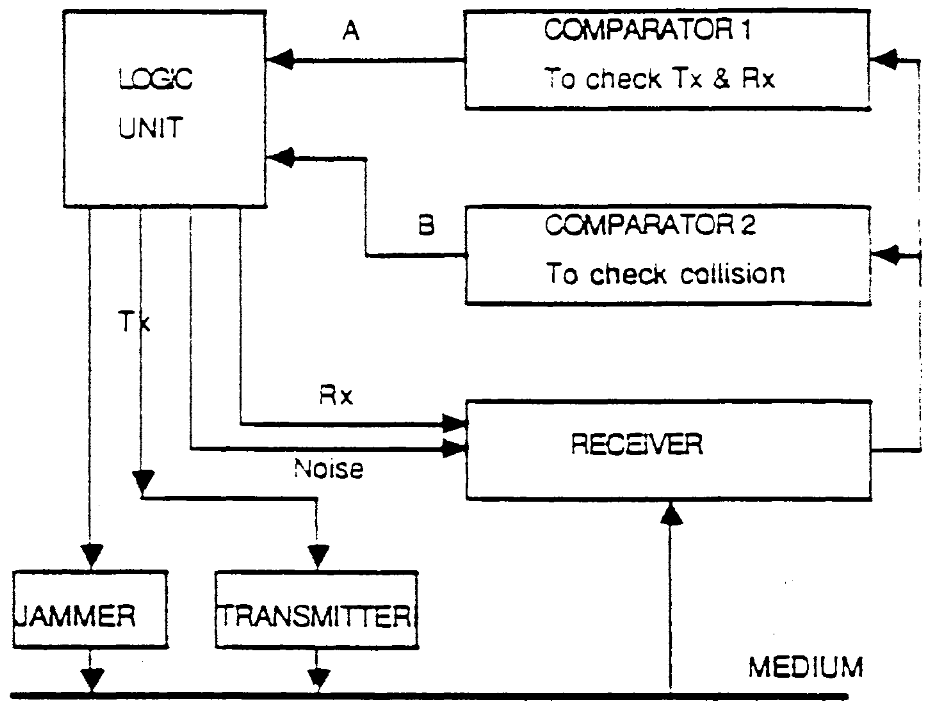

Figure 6. Block Diagram of the Transceiver.

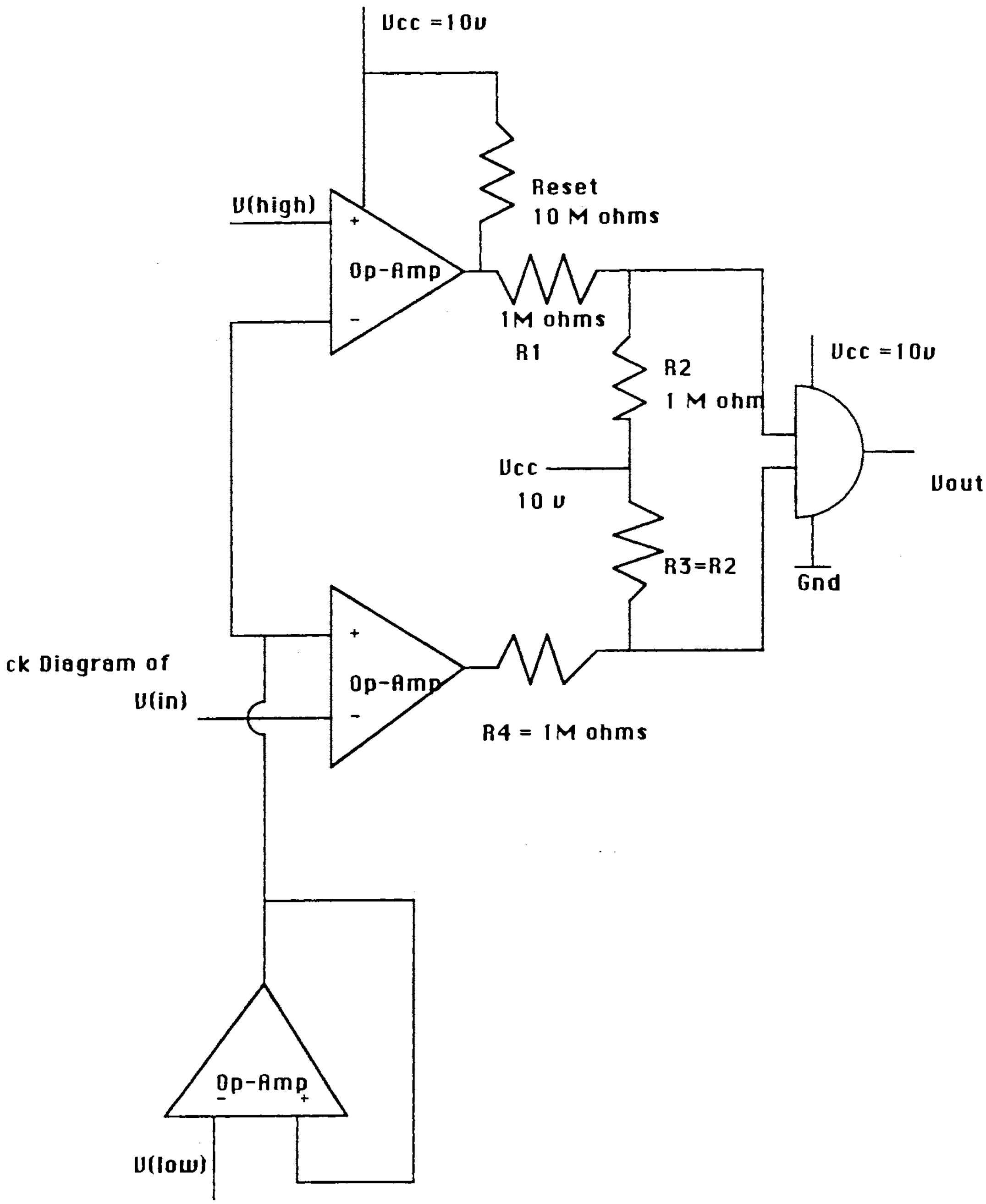

Figure 7. Circuit of Double Ended Comparator

INPUT LINES		OUTPUT	LINES		
A	B	JAMMING	Tx	Rx	NOISE
1	1	1	0	1	0
1	0	0	0	1	0
0	0	0	1	1	0
0	1	0	0	1	1

Figure 8. Truth Table Of Logic Unit

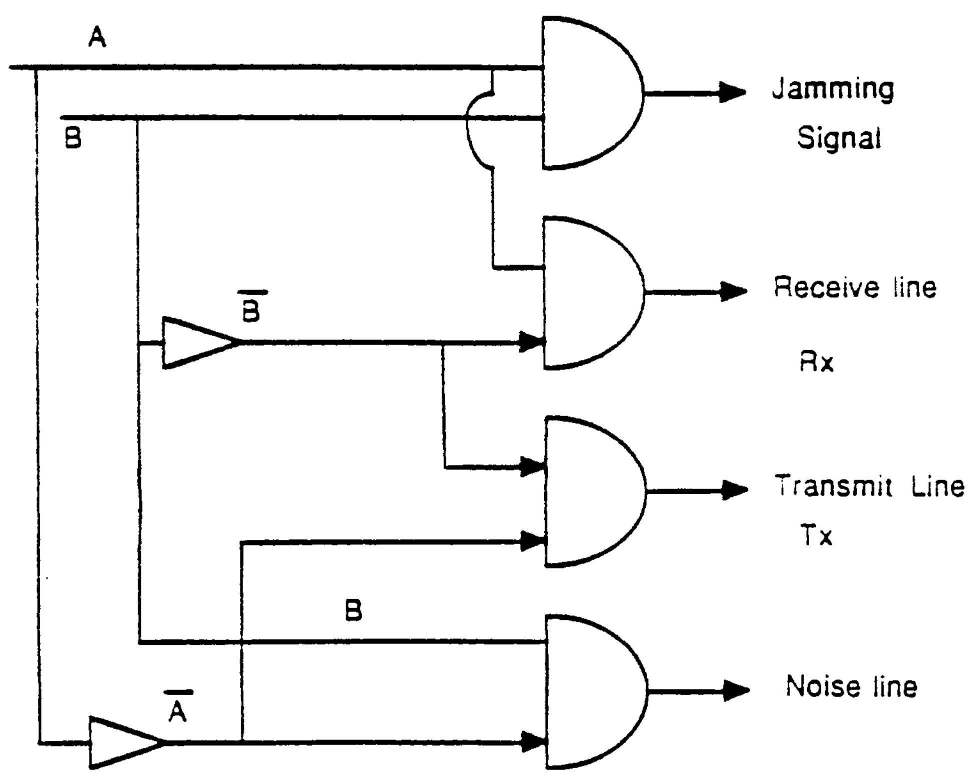

Figure 9. Circuit Diagram of Logic Unit.

PREAMBLE	Start Frame delimiter	N/DB	I/G	DATA BANK OR NODE ADDRESS	SOURCE ADDRESS
56	8	1	1	46	48
		← DESTINATION ADDRESS		→	

Length of LLC	LLC Data	PADDING	FCS
16			32

I.G stands for Individual Address/ Global Addressing mode.

N/DB stands for Node/ Data Bank.

Source & Destination Address are the addresses of the communicating stations.

Length indicates the length of the LLC packet.

Padding is the area to stuff bits, this is provided to achive minimum packet length.

FCS is frame check sequence.

Figure 10. Frame Structure Of A Packet In Hybrid Model

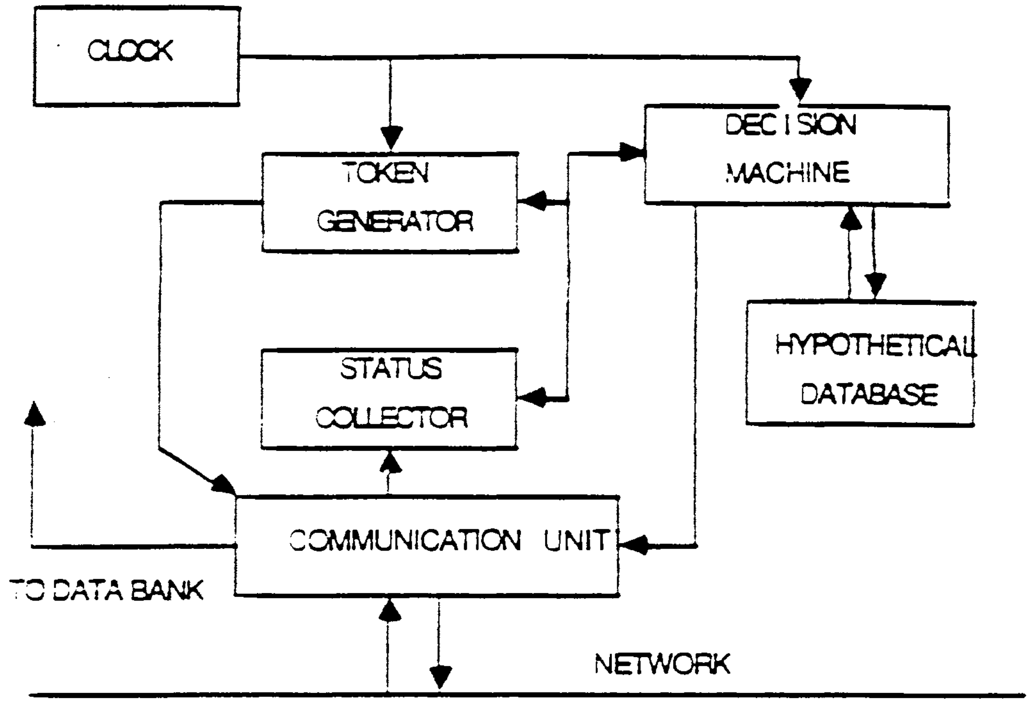

Figure 11. Block Diagram of The Network Manager.

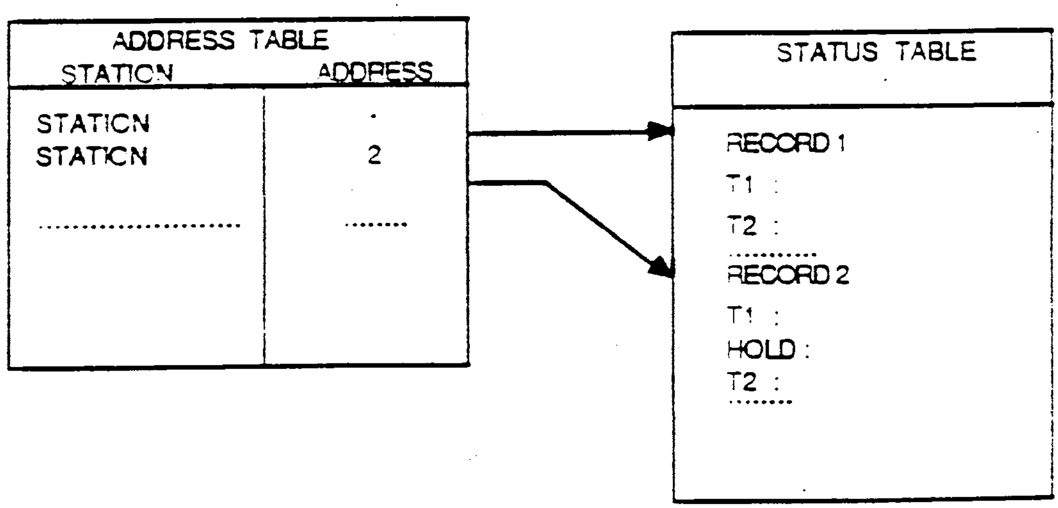

Figure 12. Structure of the Status Table Along with the Address Table

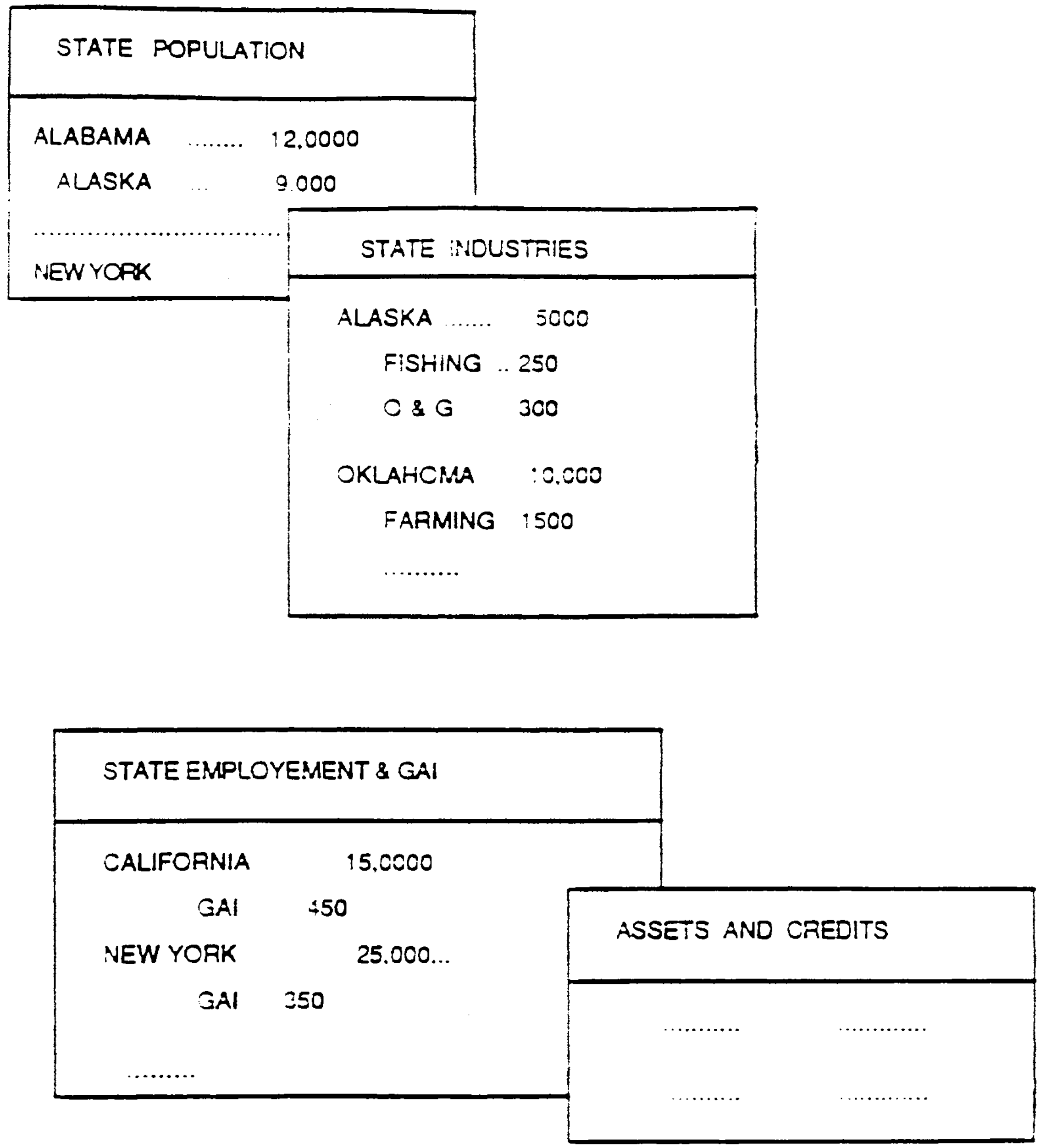

Figure 13. Different Views of the Data Bank tables.

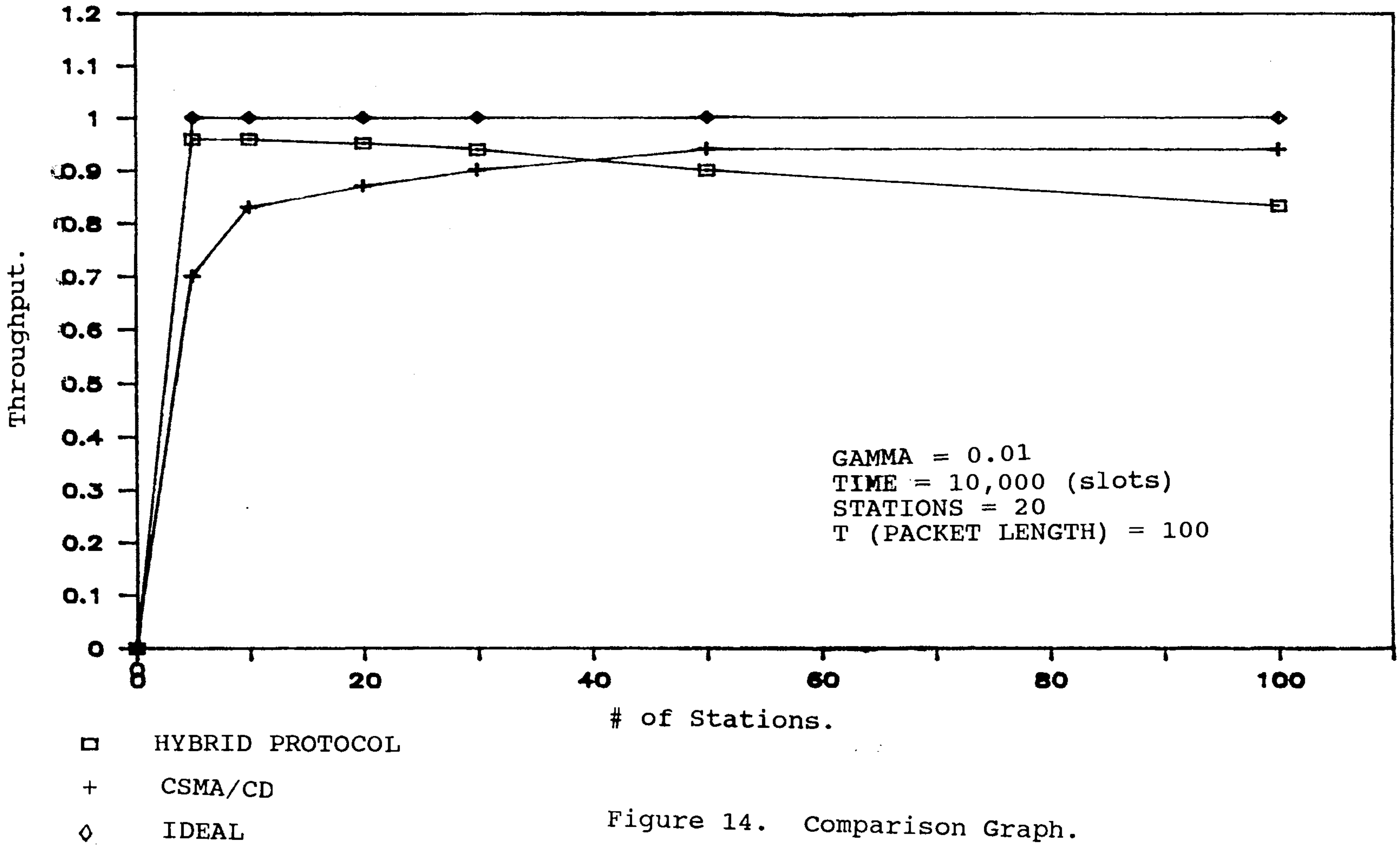

Figure 14. Comparison Graph.

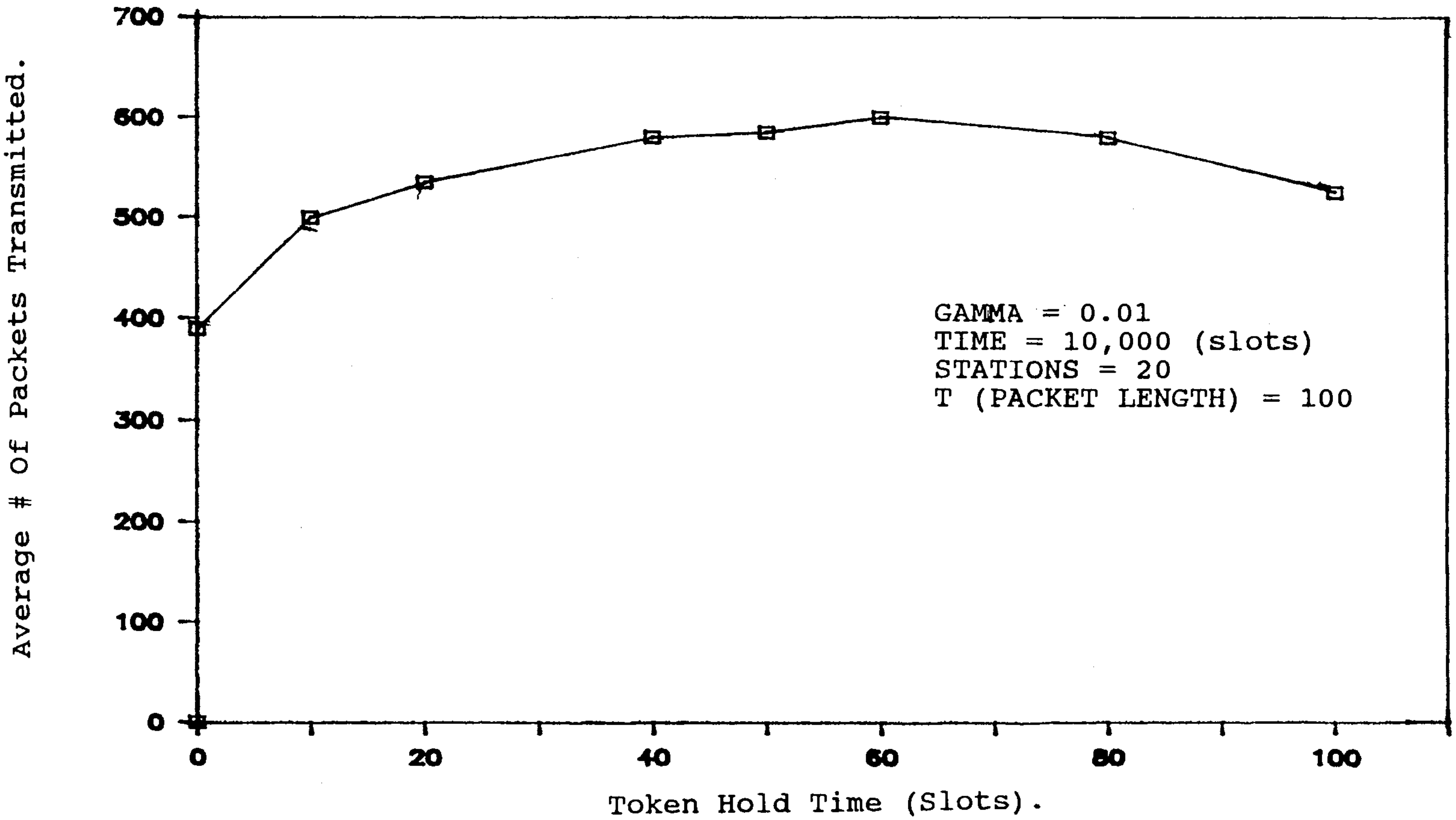

Figure 15. Token Characteristics.

APPENDIX B

GLOSSARY

ANALOG TRANSMISSION — Transmission of continuously variable signals.

ASYNCHRONOUS TRANSMISSION — Transmission in which there is no fixed time interval between characters. The start of a character is marked by a start signal and the character is terminated by a stop signal.

BANDWIDTH — The range of frequencies available for signalling in a communication channel.

BAUD RATE — The unit of discrete signalling speed per second; the modulation rate. The baud rate is equivalent to bits per second only if each signal represents exactly one bit.

BIT — Abbreviation of binary digit. The signal element of transmission in binary notation which take the two values '0'(OFF) or '1'(ON).

BIT-RATE — The number of bits transferred in unit time, usually expressed in bits per second(bps).

BUS — A single common data highway shared by a number of devices.

BYTE — A sequence of bits, normally eight, which represents one character.

CHECK BIT OR CHECK CHARACTER — A bit of character associated with a character or block of characters for error detection purpose.

CIRCUIT SWITCHING — Conventional interconnection where a two-way fixed bandwidth circuit is allocated exclusively to the parties concerned for the duration of the call.

CONNECTIVITY — The flexibility of network in providing connection to a number of different systems.

DATA COMMUNICATIONS EQUIPMENT (DCE)	In data network, a DCE is any device used to interface the data terminal equipment(DTE) to the communication line.
DATA LINK PROTOCOL	A set of rules used to ensure that transmission errors across a data link is detected and corrected. High Level Data Link Control is a typical example.
DATA TERMINAL EQUIPMENT(DTE)	In a data network, a DTE is any device attached to the network which originates data or is a destination device data.
DATA TRANSMISSION	Transmission of data characters by coding into discrete signals.
DISTRIBUTED COMPUTING	An arrangement of computing facilities where a number of computers are spread around a site with high-speed interconnecting links for resource sharing.
ELECTRONIC MAIL	A service for the transfer of documents between computer users attached to a network.
ERROR RATE	The probability, within a given sample size of bits, characters or blocks, of one being in error.
FILE	A logical organization of characters or data, stored on the computer memory, disk, tape or other storage medium.
FIXED SLOT	A network access method which gives each note on a ring a slot for its exclusive use.
FLOW CONTROL	A mechanism for ensuring that data can be exchanged between two devices in an orderly manner without loss.
INTERWORKING	The ability to exchange data between computers from different suppliers.
MEGA BITS PER SECOND (MB/s)	Million bits per second.

MICROCOMPUTERS	A small computer designed for personal use.
MICRONET	A local area network for microcomputers.
MICROPROCESSOR	A large-scale integrated circuit providing the control and arithmetic functions which form part of a complete microcomputer.
MODEM	Abbreviation for modulator/ demodulator, a device which converts digital information into an analogue form suitable for transmission over the analogue telephone network. The modem also performs the reverse function.
MULTIPLEXING	A mechanism for carrying a number of low speed data signals over one high speed channel.
OPERATING SYSTEM	Software which provides all the basic services required to run application programs, handle input/output devices and manage the storage medium for a computer.
PERIPHERAL INTERCHANGE PROGRAM (PIP)	A utility program which allows the transfer of files between the peripherals attached to the computer. A number of facilities are usually provided for the user such as converting upper-case letters to lower-case, or vice verse, and filtering form feeds from the source file.
POLLED NETWORK	A type of network in which each channel is periodically interrogated to determine if it is active.
POSTAL, TELEGRAPH AND TELEPHONE AUTHORITY (PTT)	Public authority responsible for providing the services of post, telegraph and telephone.
PROTOCOL	A set of rules governing the format and exchanging data between two devices such that

	reliable communication is maintained.
RESPONSE TIME	The time between sending the last character of a message from a terminal to the receipt of the first character of the reply. It includes terminal delay, network delay, and host computer delay.
SERIAL TRANSMISSION	The transmission of data in which each bit is transferred a long a single channel sequentially rather than simultaneously as in parallel transmission.
STAR NETWORK	A type of network topology which has a central hub with links radiating out from it.
STATISTICAL MULTIPLEXER	An intelligent time-division multiplexer that has unequal time slot to maximize the utilization of transmission capacity.
SYNCHRONOUS TRANSMISSION	A transmission technique in which data is sent without start and stop bits between characters at the start of transmission. A special group of characters is sent to synchronize the receiver with the incoming data stream.
TELEPHONE CIRCUIT	A communication link, characterized by limited bandwidth (300 Hz to 3,400 Hz) and poor noise and interface properties, designed to carry speech traffic.
TRANSPARENCY	A communication link is said to be transparent if it allows the transfer of all characters without altering the message or taking control action.
WIDE AREA NETWORK	A communication network which can be extend to a global scale, involving the use of circuits provided by various PTTs.

VITA

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