LESSON 37:
DATA NETWORK STANDARDS AND SATELLITE BASED DATA NETWORKS

Objective

To provide a detailed understanding of the concepts of data network standards and satellite based data networks.

Introduction

Data Network Standards

Three major international bodies have been significantly contributing to the data network standards. The international bodies, their major area of contribution and standard series identifiers are given in Table 37.1.

Table 37.1 International bodies and their main standardisation.

International Bodies	Major area of Contribution	Standardisation Series
ISO	OSI reference model; End-to-End Layers (4 -7)	7XXX 8XXX 9XXX 10XXX
CCITT	Link-to-Link layers (1 -3) of WANs : PSTN, PDN and ISDN; Electronic Messaging and Directory Services	V-Series X-Series and I-Series
IEEE	Link-to-link Layers (1 -3) of LANs and MANs.	802.X

Standards lay down by ISO and CCITT have international legal standing. But IEEE standards have to be adopted by ISO to attain this legal standing. Standards work at IEEE is sponsored by ANSI which is affiliated to ISO. Standards evolved by CCITT are adopted by ISO under its own series number and vice-versa.

For example, ISO basic OSI reference model IS-7498 is adopted by CCITT as X.200.

As we know that a layer in OSI reference model offers services to the layer above. There are two types of services: connectionless and connection oriented. The peer entities in a layer communicate using peer protocols. Accordingly, standards for a layer deal with the two types of services and their associated protocols.

These standards are shown in Fig. 37.1. Some of the ISO standards for the end-to-end layers are given in Table 37.2.

ISO standards go through three stages:

1. Draft Proposal (DP)
2. Draft International Standards (DIS)
3. International Standards (IS or ISO)

The subject of distributed applications over networks has been the main concern of ISO subsequent to the evaluation of the basic OSI reference model.

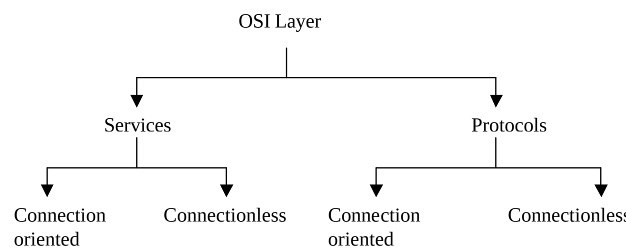


Fig.37.1 OSI layer standards

Table 37.2 Some ISO Standards for end-to-end layers

Number	Description
IS 8072	Connection oriented transport service definition
IS 8072 DADI	Connectionless transport service definition
IS 8073	Connection oriented transport protocol specification
IS 8602	Connectionless transport protocol specification
IS 8326	Connection oriented session service definition
IS 8327	Connection oriented session protocol specification
DIS 8822	Connection oriented presentation service definition
DIS 8823	Connection oriented presentation protocol definition
DIS 8824	Specification of Abstract Syntax Notation 1(ASN.1)
Application Layer Standards	
DP 9579	Remote database access
DP 9596	Management information protocol
DP 9594	Directory services
DIS 8571	File transfer access and management
DIS 8613	Office document architecture and interchange format
DIS 9040	Virtual terminal service definition
DIS 9041	Virtual terminal protocol specification
DP 10026	Distributed transaction processing
DP 10160	Interlibrary loan service definition
DP 10161	Interlibrary loan protocol specification
DP10162	Search and retrieve service definition
DP 10163	Search and retrieve protocol specification

Functionalities defined in the lower three layers of OSI reference model have traditionally been the responsibility of telecommunication network providers or common carriers as they are called in U.S.A. The voting members of CCITT are only the national telecommunication carriers of different countries. CCITT has been concentrating on the standards for the lower three layers functionalities.

In the context of data communication, CCITT is concerned with three classes of networks:

(1) GSTN

(2) PPN

(3) ISDN

Three types of connections are supported on the network:

(1) Circuit-Switched Network

(2) Leased-Circuit Network

(3) Packet Switched Network.

All the above three types of networks are supported on PDNs and ISDNs, but only the first two are supported on GSTNs. CCITT standards relate to these three types of connections.

A major aspect of the CCITT standards is the interfacing of the DTE and DCE. Here DTE is data terminal equipment and the DCE is the data circuit terminating equipments.

In the context of standards, DTEs may be placed under four categories:

(1) Asynchronous or Start/Stop type

(2) Synchronous

(3) Packet Mode

(4) ISDN

Categories (1) and (2) may be designed for operation on GSTNs or PDNs.

Category (3) is designed for operation on PDNs. Category (4) is designed on ISDNs.

The first three categories are also called non-ISDN terminals. Maintaining compatibility with earlier systems is an important requirement of any telecommunication network operation. It is possible to use GSTN terminals on PDN or ISDN, and PDN terminals on ISDN.

Standards take care of this aspect. DTE - DCE interfaces are specified in the V-series for PSTNs, in the X-series for PDNs, and in the 1- series for ISDNs.

Five different types of DTEs are required to be supported on PDNs as given in Table 37.3. This table also shows the applicable X-series standard along with the relevant network connection type.

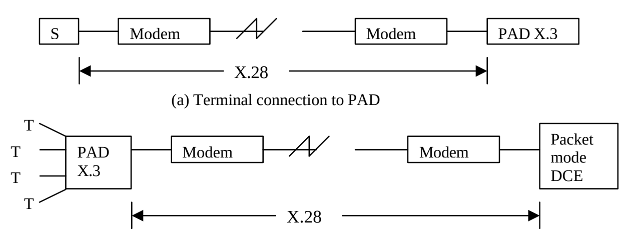
Table 37.3 DTE-DCE interface standards for operation in

DTE type	Standard	Relevant Network Connection
Asynchronous designed for GSTN	X.20 bis	Circuit switched or leased
Synchronous designed for GSTN	X.21 bis	Circuit switched or leased
Asynchronous designed for PDN	X.20	Circuit switched or leased circuit
Synchronous designed for PDN	X.21	Circuit switched or leased circuit
Packet mode	X.25	Packet switched (dedicated circuit between DTE & DCE)
Asynchronous	X.3, X.28, X.29	Packet Switched (circuit switched or leased circuit between DTE & DCE)

A start-stop DTE, which is a dumb terminal, is connected to a PDN via an interface known as Packet Assembler/ Deassembler (PAD). PAD converts the character stream from the dumb terminal into a X.25 packet by assembling the characters for transmission through the packet switched network.

At the receiving end, a PAD converts the X.25 packet back into an asynchronous character stream for passing onto the receiving terminal. Three separate X-series CCITT recommendations are popularly known as triple X standard.

Triple X-standard is associated with the PAD interface. The standard X.3 defines the PAD parameters, X.28 defines the terminal- to-PAD interface and X.29 defines PAD-to-packet mode DCE interface. These illustrated in Fig. 37.2. Terminals maybe directly connected to the PAD or via MODEMs as shown in Fig. 37.2 (a). Fig. 37.2 (b) shows the applicability of X.29 Standard. This defines PAD-to-PAD communication protocols.



(b) PAD –to –packet mode DCE connection
Fig.37.2 Triple X protocol

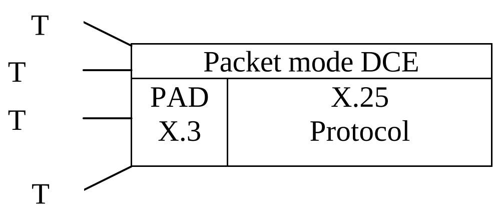
Fig.37.2 Triple X protocol

When a user of a terminal initially establishes contact with a PAD, he may set up certain parameters describing the conversion between the PAD and the terminal. There are 18 PAD parameters in CCITT X.3 and these are numbered. For setting up a parameter, a user specifies the parameter number and its value. Some sample parameters and their permitted values are given as follows.

1	Should the PAD echo the characters back to the terminal?	0 = No 1 = Yes
2	Is the PAD allowed to send service signals to the terminal?	0 = No 1 = Yes
3	Should PAD add filler characters after line feeds? If so, how many?	0 = No 1 = Yes
4	Does PAD allow editing?	0 = No 1 = Yes

Fig. 37.3 An integrated PAD and X.25 DCE.

A PAD may be standing alone or integrated as part of the packet mode DCE. It is shown in Fig. 37.3.



The standards X.20 and X.21 were defined by CCITT in the mid 1970s with the expectation that computers would be able to interface directly to DCEs associated with the digital networks. This did not happen. As a result, there are very few networks that support X.21. As an interim measure and to permit existing DTEs to interface to digital networks. X.20 bis and X.21 bis were defined. These have the same interface definitions, as the V Series but are capable of working with digital networks. It includes call establishment and control procedures.

The Standard X.25 defines the DTEIDCE interface for a packet mode DTE to communicate with the packet switching exchange (PSE) or a DCE in a PDN. The standard is an integrated set of three levels protocols corresponding to layers 1-3 of OSI reference level. At the physical layer level, it uses X.21 and X.21 bit protocol. At the data link layer level, it uses a balanced link access procedure (LAP-B). LAP-B is similar to the bit oriented sliding window protocol. At the network level, X.25 supports virtual circuit (VC) and permanent virtual circuit (PVC) connections. The connectionless datagram service was initially introduced in X.25 but was dropped in 1984 recommendation and reintroduced in 1988 recommendation. For managing circuit connections, X.25 uses 5 different types of PDUs. These PDUs are called Network PDUs (NPDUs) or simply as packets.

1. Call Setup and clear packets
2. Data and interrupt packets
3. Flow control and reset packets
4. Diagnostic packets
5. Registration packets.

Call Setup and Clear Packets

Call setup and clear packets are used for exchanging messages like a call request, call accept, clear request, clear confirmation etc.

Data and Interrupt Packets

Interrupt packets are used to cope with unusual situations that may arise during normal data transfer, e.g. a terminal user wants to stop data transmission from a host. These packets are given priority over data packets and delivered in an expedited manner. An interrupt may be generated by a DTE or a DCE.

Flow control and reset packets

Flow control packets give information regarding the readiness of the receiver and are used to negotiate flow control parameters, viz., window and packet sizes. Reset is used to recover from errors or malfunctions related to a specific connection. It has the effect of reinitializing the window parameters to zero. For more serious failures like the crash of a DTE or a DCE, a restart facility is available. The restart facility abandons all the existing connections and a clean state is provided to re-establish the connections as initial.

Diagnostic Packet

This packet allows the network to inform the user of problems including errors in the packet sent by user.

Registration Packet

This packet permits a DTE to request changes to the currently agreed facilities between itself and the network.

Several LAN standards and MAN standards have been produced by IEEE under a project known as IEEE 802. The summary of these standards is given in Fig. 37.4.

OSI Layer	IEEE 802 Project 802.1 General aspects of 802 standards			IEEE layer	
Data link	802.2 LLC			Logical link control	
	802.3 CSMA /CD	802.4 Token hub	802.5 Token ring	802.6 MAN DQDB	Media access
Physical					Physical

Fig. 37.4 IEEE LAN and MAN standards.

IEEE 802 recommendations propose a three-layer architecture, which corresponds to the first two layers of ISO-OSI reference model. In the original version, logical link control (LLC) and media access control (MAC) layers are considered as sublayers of OSI data link layer.

In recent days, there is a trend among many researchers to consider MAC layers as a sublayer belonging to the OSI physical layer. MAC layers and physical layers are described in standards IEEE 802.3 through 802.6. All these standards are compatible at the 802.2 LLC level.

Unacknowledged and acknowledged connectionless service and connection-oriented service are defined at the LLC level.

The IEEE 802.1 gives an overview and the architectural aspects of the set of standards.

The IEEE 802.3 defines one-persistent CSMA/CD.

The IEEE 802.4 defines token passing bus.

The IEEE 802.5 specifies single token ring access mechanisms.

At the physical layer IEEE 802.3 standard permits two versions of baseband coaxial cables. These are commercially called thin and thick internet cables. Both cables are operating at 10 Mbps.

The thin cable version is also called the cheapernet. The thick cable can have a maximum segment length of 500 m and thin cable 185 m. In addition, unshielded twisted pair baseband cables operating at 1 or 10 Mbps covering a distance of 250 m or 100 m respectively. A 75-0hm broadband coaxial cable operating at 10 Mbps covering a distance of 3600 m are supported. A star wiring topology (known as star LAN) is recommended in the case of 1-Mbps unshielded twisted pair medium. When operating speed is the same, the cable can be mixed freely in the same network.

The IEEE 802.4 recommendations specify two options for the physical medium. A 75 W carrier band cable (operating at 1, 5 or 10 Mbps speed) or a 75 W broadband cable (operating at same speed but covering larger distance- 760 m) can be used.

The IEEE 802.5 standard specifies a shielded twisted pair operating at 1 or 4 Mbps as the physical medium.

The IEEE 802.5 standard has been extended by the ANSI Committee X3T9.5 to use optical fiber as a medium to operate at 100 Mbps. This standard is called Fiber Distributed Data Interface (FDDI). LAN standards with data rate up to 20 Mbps is placed under the purview of IEEE and LAN standards with data rates above 50 Mbps under X3T9.5 committee. The responsibility of this committee is computer I/O interface standards.

FDDI has been designed to serve two primary areas of applications:

1. High performance inter connection among main frames, and main frames and their associated peripheral subsystems.
2. Backbone network for use with low speed LANs.

FDDI was originally specified as a packet switched network. FDDI-II (a recent version of FDDI) specifies a circuit switched mode of operation. Here, the bandwidth is allocated in increments of 6.144 Mbps isochronous channels. Each isochronous channel supports up to a maximum of 16 channels. Each of the isochronous channels may be dynamically reassigned as three 2048 Kbps or four 1536 kbps channels to European and North American telephone channels, respectively.

A number of new physical medium and transmission methods are being introduced for data and multimedia transmission. Additional physical and data link layer standards are being specified to support these new arrivals. Internet working is becoming complex, calling for additional specifications at the network layer. Side by side, more and more distributed applications involving heterogeneous data types are being supported in the OSI environment. This brings about a host of service and protocol specifications at the application and presentation layers of the OSI model. However, the session and transport layer service and protocol definitions are more or less static. This phenomenon is changing the shape of the OSI reference model. This modified OSI model is called OSI wine Glass Model after its shape. It is shown in Fig. 39.5.

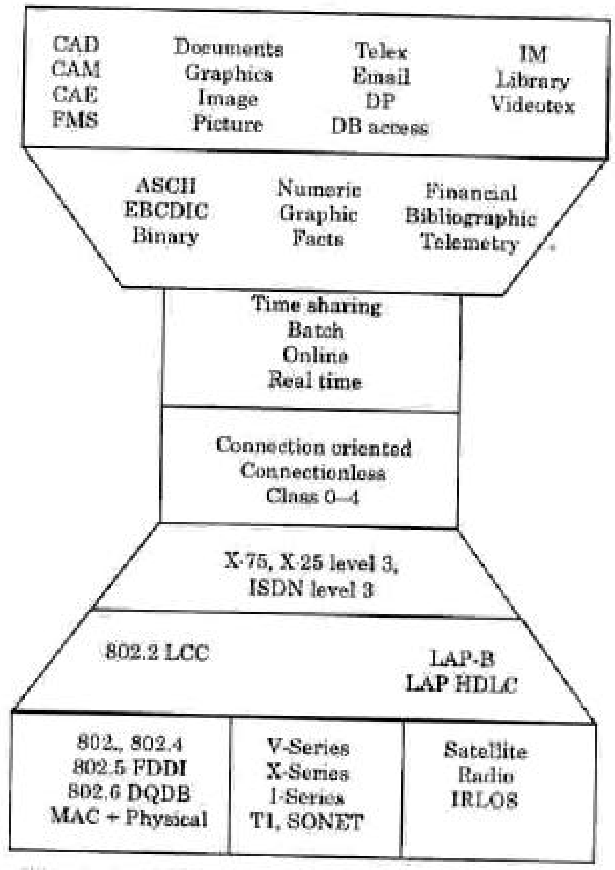


Fig. 39.5 OSI wine glass structure model.
DQDB → Distributed Queue Dual Bus
FDDI → Fibre Distributed Data Interfa

Satellite Based Data Networks

There are some important aspects of satellite communication systems in the study of data networks and the OSI reference model. It requires following considerations:

(1) Satellite Network topology and configurations, modulation schemes and bandwidth utilisation. These aspects are related to the physical layer functions of the OSI reference model

(2) Satellite communication being broadcast in nature, routing becomes a trivial function. Satellite Communication organises point-to-point or point-to-multipoint connections in broadcast environment needs some considerations.

(3) There is a common communication resource which is accessible by all or a group of earth stations simultaneously.

Therefore, media access becomes a nontrivial function in the data link layer.

(4) Since a geostationary communication satellite is placed at an altitude of about 36,000 km above the equator, the signal will have to travel a distance of 72,000 km or more between the source and the destination. Thus, signal results in a significant propagation delay of 250.300 ms. Session layer and transport layer have to be concerned about this factor.

A satellite-based data Network has star topology. In this case, the satellite being the central hub, if the central hub fails then the entire communication network comes to a standstill. In this case, reliability and redundancy considerations are important when designing satellites.

Demand Assigned Multiple Access (DAMA) techniques function well when the number of stations is moderate (say, a few hundreds). These schemes become unwieldy if the number of stations runs into thousands. In such cases, another class of multiple access protocols (known as ALOHA protocols) becomes attractive particularly for data transmission. These protocols can also be used when number of stations is small.

ALOHA protocols originated with radio networks. This scheme was proposed and studied by Prof. A.N. Abramson and his colleagues at University of Hawaii in 1970.

In the simplest form of ALOHA, often called 'pure ALOHA' to distinguish from other forms of ALOHA protocols, a station or terminal starts transmission as soon as it is ready.

In this case, anyone of the following three things may happen:

1. There may be an ongoing transmission already in the channel and the new transmission may collide with existing one, thereby affecting both transmissions.
2. The channel is free and this transmission goes on successfully.
3. The channel is free to start with, but another station gets ready and starts transmission when this transmission is in progress. The transmissions collide with each other and no useful data transfer takes place. ,

Above three events are illustrated in Fig.37.6.

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Fig.37.6 Collision in pure ALOHA access.

Part of the frame A collides with an ongoing transmission. The end part of the frame B is corrupted by transmission of frame C. Therefore, it results that both the frames are not transmitted successfully. Frame D is safely transmitted. Frames E and F collide once again. Throughput obtainable from this scheme is likely to be very low. In fact, it is limited to a maximum of 18.4% if the traffic is Poisson distributed. It can be shown by a simple analysis. The analysis is done in the context of fixed frame sizes and Poisson traffic.

Poisson arrival is given by the following equation:

$$P_K(t) = \frac{(Rt)^K e^{-Rt}}{\angle K} \quad \cdots\cdots \quad \textbf{Eq.1}$$

where,

$P_K(t)$ = Probability that there are *K* arrivals in time t.

R = Mean arrival rate in packets per second

Let

t = the frame time. It is the time, which is required to transmit a frame.

G = Load offered to the system per frame time. It includes the retransmitted frames.

G = G s ………Eq.2

Now consider a frame F being placed on the channel at any instant of time.

The frame will be transmitted successfully only if two conditions are met:

1) There is no ongoing transmission at the time of placement of this frame.
2) No new station should begin transmission during the transmission of this frame.

Condition 1 will be true if and only if no transmission has originated during the time period t seconds prior to the placement of the present frame on the channel.

Condition 2 implies that no transmissions should occur during the period t seconds after the frame is placed on the channel. This situation is sown in Fig. 37.7. The time duration 2t is called the vulnerability period.

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Fig.37.7 Vulnerability period in pure ALOHA scheme

From Eq.1, we get

$$P_0 \quad (2\,t) = \frac{(R\,2\,t)^0\, e^{-2Rt}}{0}$$

Using eq.2, we get

$Po(2t) = e^{-2G}$ ……….Eq.3

Eq.3 is the probability of successful transmission of one packet. As there are G packets being offered to the system per frame time. The throughput of the system in terms of frames per frame is given by

$S = G\, e^{-2G}$ ………..Eq.4

The maximum throughput is obtainable from the system at some optimum loading value G. Lower values of G mean reduced load on the system. Higher values of G would result in excessive collisions.

Maximum throughput can be determined by differentiating Eq.4 with respect to G.

$$\frac{dS}{dG} = \frac{d(G e^{-2G})}{dG}$$

$$= e^{-2G} - 2 G e^{-2G} \quad \ldots\ldots\ldots\ldots\ldots\ldots\text{Eq.5}$$

Putting dS / dG = 0, we get the value of G for maximum throughput; as 0.5 frame per frame time. Therefore, the maximum throughput in the pure ALOHA access scheme is

$$S_{max} = \frac{1}{2e} = 18.4\%$$

Slotted ALOHA

The throughput of the pure ALOHA scheme can be doubled by introducing time slots in the channel and permitting a new transmission to start only at the beginning of a time slot. Such a scheme is called slotted ALOHA. A time slot is equal to the frame time t. The vulnerability period for a slotted ALOHA scheme is shown in Fig. 37.8.

A frame F is placed on the channel at the beginning of the time slot period 2-3. The frame will be transmitted successfully only if no other transmission commences during the beginning of the same slot.

Another transmission can exist only if any other station got ready during the slot period 1-2.

A station getting ready during the slot period 2-3 does affect the transmission of frame F as it can commence its transmission only at the beginning of the slot period 3-4. Hence, the vulnerability period in slotted ALOHA slot is the period preceding the slot in which the frame is placed on the channel. Therefore, the probability of successful transmission of the frame is the same as the probability of zero arrival in the time period t:

$$P_0 (t) = e^{-G} \quad \ldots\ldots\ldots\ldots\ldots\ldots\text{Eq.6}$$

The probability of success for the full load G gives the throughput in frames per frame time:

$$S = G e^{-G} \quad \ldots\ldots\ldots\ldots\ldots\text{Eq.7}$$

The maximum throughput is obtained by differentiating eq.7 w.r.t. ‘G’, putting dS / dG = 0 and getting the optimum value of G. In this case, the value of G works out to be 1 frame per frame time. The maximum throughput works out to be

$S_{max} = 1 / e = 36.8\%$ Eq.8

There are two other parameters that are of interest in ALOHA systems:

(1) Percentage of empty slots

(2) Percentage of collisions.

The values of these parameters for the optimum load conditions are shown in Table 37.5 for both pure and slotted ALOHA.

Table 37.5 Performance Parameters of ALOHA Protocols:

Parameter	Pure ALOHA (%)	Slotted ALOHA (%)
Maximum Throughput	18.4	36.8

Notes