Chapter 4

Multimedia Networking System

15.1 Aims and Objectives

We will examine in the remainder of this chapter different networks with respect to their multimedia transmission capabilities. At the end of this lesson the learner will be able to

i. understand the networking concepts
ii. identify the features available in FDDI

15.2 Introduction

A multimedia networking system allows for the data exchange of discrete and continuous media among computers. This communication requires proper services and protocols for data transmission. Multimedia networking enables distribution of media to different workstation.

15.3 Layers, Protocols and Services

A service provides a set of operations to the requesting application. Logically related services are grouped into layers according to the OSI reference model. Therefore, each layer is a service provider to the layer lying above. The services describe the behavior of the layer and its service elements (Service Data Units = SDUs). A proper service specification contains no information concerning any aspects of the implementation. A protocol consists of a set of rules which must be followed by peer layer instances during any communication between these two peers. It is comprised of the formal (syntax) and the meaning (semantics) of the exchanged data units (Protocol Data Units = PDUs). The peer instances of different computers cooperate together to provide a service.

Multimedia communication puts several requirements on services and protocols, which are independent from the layer in the network architecture. In general, this set of requirements depends to a large extent on the respective application. However, without defining a precise value for individual parameters, the following requirements must be taken into account:

< Audio and video data process need to be bounded by deadlines or even defined by a time interval. The data transmission-both between applications and transport layer interfaces of the involved components-must follow within the demands concerning the time domains.

< End –to-end jitter must be bounded. This is especially important for interactive applications such as the telephone. Large jitter values would mean large buffers and higher end-to-end delays.

< All guarantees necessary for achieving the data transfer within the required time span must be met. This includes the required processor performance, as well as the data transfer over a bus and the available storage for protocol processing.

< Cooperative work scenarios using multimedia conference systems are the main application areas of multimedia communication systems. These systems should support multicast connections to save resources. The sender instance may often change during a single session. Further, a user should be able to join or leave a multicast group without having to request a new connection setup,which needs to be handled by all other members of this group.

< The services should provide mechanisms for synchronizing different data streams, or alternatively perform the synchronization using available primitives implemented in another system component.

< The multimedia communication must be compatible with the most widely used communication protocols and must make use of existing, as well as future networks. Communication compatibility means that different protocols at least coexist and run on the same machine simultaneously. The relevance of envisaged protocols can only be achieved if the same protocols are widely used. Many of the current multimedia communication systems are, unfortunately, proprietary experimental systems.

- The communication of discrete data should not starve because of preferred or guaranteed video/audio transmission. Discrete data must be transmitted without any penalty.
- The fairness principle among different applications, users and workstations must be enforced.
- The actual audio/video data rate varies strongly. This leads to fluctuations of the data rate, which needs to be handled by the services.

15.2.1 Physical Layer

The physical layer defines the transmission method of individual bits over the physical medium, such as fiber optics. For example, the type of modulation and bit-synchronization are important issues. With respect to the particular modulation, delays during the data transmission arise due to the propagation speed of the transmission medium and the electrical circuits used. They determine the maximal possible bandwidth of this communication channel. For audio/video data in general, the delays must be minimized and a relatively high bandwidth should be achieved.

15.2.2 Data Link Layer

The data link layer provides the transmission of information blocks known as data frames. Further, this layer is responsible for access protocols to the physical medium, error recognition and correction, flow control and block synchronization. Access protocols are very much dependent on the network. Networks can be divided into two categories: those using point-to-point connections and those using broadcast channels, sometimes called multi-access channels or random access channels. In a broadcast network, the key issue is how to determine, in the case of competition, who gets access to the channel. To solve this problem, the Medium Access Control (MAC) sublayer was introduced and MAC protocols, such as the Timed Token Rotation Protocol and Carrier Sense Multiple Access with Collision Detection (CSMA/CD), were developed.

Continuous data streams require reservation and throughput guarantees over a line. To avoid larger delays, the error control for multimedia transmission needs a different mechanism than retransmission because a late frame is a lost frame.

15.2.3. Network Layer

The network layer transports information blocks, called packets, from one station to another. The transport may involve several networks. Therefore, this layer provides services such as addressing, internetworking, error handling, network management with congestion control and sequencing of packets. Again, continuous media require resource reservation and guarantees for transmission at this layer. A request for reservation for later resource guarantees is defined through Quality of Service (QoS) parameters, which correspond to the requirements for continuous data stream transmission. The reservation must be done along the path between the communicating stations.

15.2.4. Transport Layer

The transport layer provides a process-to-process connection. At this layer, the QoS, which is provided by the network layer, is enhanced, meaning that if the network service is poor, the transport layer has to bridge the gap between what the transport users want and what the network layer provides. Large packets are segmented at this layer and reassembled into their original size at the receiver. Error handling is based on process-to-process communication.

15.2.5 Session Layer

In the case of continuous media, multimedia sessions which reside over one or more transport connections, must be established. This introduces a more complex view on connection reconstruction in the case of transport problems.

15.2.6 Presentation Layer

The presentation layer abstracts from different formats (the local syntax) and provides common formats (transfer syntax). Therefore, this layer must provide services for transformation between the application-specific formats and the agreed upon format. An example is the different representation of a number for Intel or Motorola processors. The multitude of audio and video formats also requires conversion between formats. This problem also comes up outside of the communication components during exchange between data carriers, such as CD-ROMs, which store continuous data. Thus, format conversion is often discussed in other contexts.

15.2.7 Application Layer

The application layer considers all application-specific services, such as file transfer service embedded in the file transfer protocol (FTP) and the electronic mail service. With respect to audio and video, special services for support of real-time access and transmission must be provided.

Exercise1

List the different layers used in networking.

15.3 Multimedia on Networks

The main goal of distributed multimedia communication systems is to transmit all their media over the same network. Depending mainly on the distance between end-points (station/computers), networks are divided into three categories: Local Area Networks (LANs), Metropolitan Area Networks (MANs), and Wide Area Networks (WANs).

Local Area Networks (LANs)

A LAN is characterized by (1) its extension over a few kilometers at most, (20) a total data rate of at least several Mbps, and (3) its complete ownership by a single organization. Further, the number of stations connected to a LAN is typically limited to 100. However, the interconnection of several LANs allows the number of connected stations to be increased. The basis of LAN communication is broadcasting using broadcast channel (multi-access channel). Therefore, the MAC sublayer is of crucial importance in these networks.

High-speed Ethernet

Ethernet is the most widely used LAN. Currently available Ethernet offers bandwidth of at least 10 Mbps, but new fast LAN technologies for Ethernet with bandwidths in the range of 100Mbps are starting to come on the market. This bus-based network uses the CSMA/CD protocol for resolution of multiple access to the broadcast channel in the MAC sub-layer-before data transmission begins, the network state is checked by the sender station. Each station may try to send its data only if, at that moment, no other station transmits data. Therefore, each station can simultaneously listen and send.

Dedicated Ethernet

Another possibility for the transmission of audio/video data is to dedicate a separate Ethernet LAN to the transmission of continuous data. This solution requires compliance with a proper additional protocol. Further, end-users need at least two separate networks for their communications: one for continuous data and another for discrete data. This approach makes sense for experimental systems, but means additional expense in the end-systems and cabling.

Hub

A very pragmatic solution can be achieved by exploiting an installed network configuration. Most of the Ethernet cables are not installed in the form of a bus system. They make up a star (i.e., cables radiate from the central room to each station). In this central room, each cable is attached to its own Ethernet interface.

Instead of configuring bus, each station is connected via its own Ethernet to a hub. Hence, each station has the full Ethernet bandwidth available, and a new network for multimedia transmission is not necessary.

Fast Ethernet

Fast Ethernet, known as 100Base-T offers throughput speed of up to 100 Mbits/s, and it permits users to move gradually into the world of high-speed LANs. The Fast Ethernet Alliance, an industry group with more than 60 member companies began work on the 100-Mbits/s 100 Base-TX specification in the early 1990s. The alliance submitted the proposed standard to the IEEE and it was approved. During the standardization process, the alliance and the IEEE also defined a Media-Independent Interface (MII) for fast Ethernet, which enables it to support various cabling types on the same Ethernet network. Therefore, fast Ethernet offers three media options: 100 Base-T4 for half-duplex operation on four pairs of UTP (Unshielded Twisted Pair cable), 100 Base-TX for half-or full-0duplex operation on two pairs of UTP oR STP (Shielded Twisted Pair cable), and 100 Base-FX for half-and full-duplex transmission over fiber optic cable.

Token Ring

The Token Ring is a LAN with 4 or 16 Mbits/s throughput. All stations are connected to a logical ring. In a Token Ring, a special bit pattern (3-byte), called a token, circulates around the ring whenever all stations are idle. When a station wants to transmit a frame, it must get the token and remove it from the ring before transmitting. Ring interfaces have two operating modes: listen and transmit. In the listen mode, input bits are simply copied to the output. In the transmit mode, which is entered only after the token has been seized, the interface breaks the connection between the input and the output, entering its own data onto the ring. As the bits that were inserted and subsequently propagated around the ring come back, they are removed from the ring by the sender.

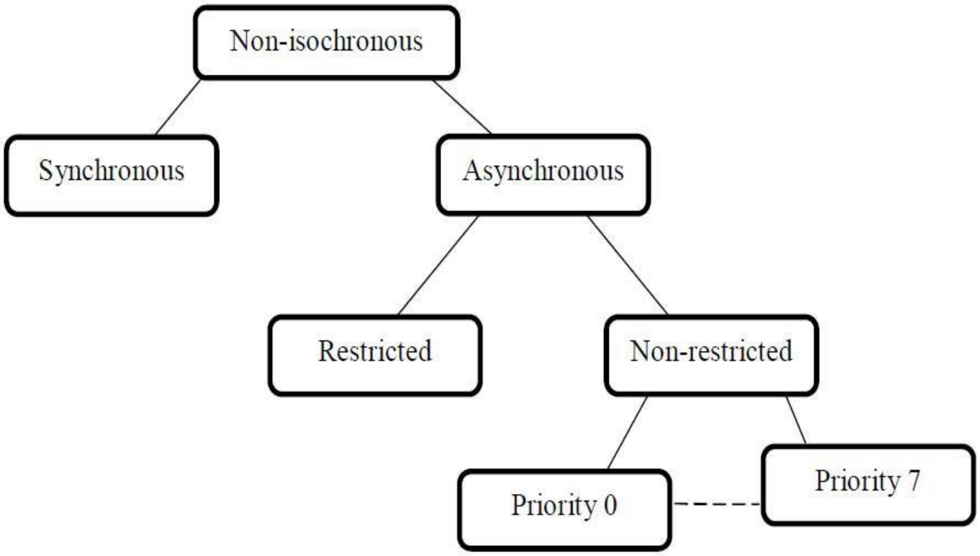
After a station has finished transmitting the last bit of its last frame, it must regenerate the token. When the last bit of the frame has gone around and returned, it must be removed, and the interface must immediately switch back into the listen mode to avoid a duplicate transmission of the data. Each station receives, reads and sends frames circulating in the ring according to the Token Ring MAC Sublayer Protocol (IEEE standard 8020.5). Each frame includes a Sender Address (SA) and a Destination Address (DA). When the sending station drains the frame from the ring, a Frame Status field is update, i.e., the A and C bits of the field are examined. Three combinations are allowed:

- A=0, C=0 : destination not present or not powered up.
- A=1, C=0 : destination present but frame not accepted.
- A=1, C=1 : destination present and frame copied.

15.4 FDDI

The Fiber Distributed Data Interface (FDDI) is a high-performance fiver optic LAN, which is configured as a ring. It is often seen as the successor of the Token Ring IEEE 802.5 protocol. The standardization began in the American Standards Institute (ANSI in the group X3T9.5 in 1982. Early implementations appeared in 1988. Compared to the Token Ring, FDDI is more a backbone than a LAN only because it runs at 100 Mbps over distances up to 100 km with up to 500 stations. The Token Ring supports typically between 50-2050 stations. The distance of neighboring stations is less than 20 km in FDDI.

The FDDI design specification calls for no more than one error in 20.5*10^10 bits. Many implementations will do much better. The FDDI cabling consists of two fiber rings, one transmitting clockwise and the other transmitting counter-clockwise. If either one breaks, the other can be used as backup. FDDI supports different transmission modes which are important for the communication of multimedia data. The synchronous mode allows a bandwidth reservation; the asynchronous mode behaves similar to the Token Ring protocol. Many current implementations support only the asynchronous mode. Before diving into a discussion of the different mode, we will briefly describe the topologies and FDDI system components.



An overview of data transmission in FDDI

15.4.1 Topology of FDDI

The main topology features of FDDI are the two fiber rings, which operate in opposite directions (dual ring topology). The primary ring provides the data transmission; the secondary ring improves the fault tolerance. Individual stations can be – but do not have to be – connected to both rings. FDDI defines two classes of stations, A and B:

- Any class A station (Dual Attachment Station) connects to both rings. It is connected either directly to a primary ring and secondary ring or via a concentrator to a primary and secondary ring.
- The class B station (Single Attachment Station) only connects to one of the rings. It is connected via a concentrator to the primary ring.

15.4.2 .2 FDDI Architecture

FDDI includes the following components which are shown in the following Figure:

- *PHYsical Layer Protocol (PHY)*

  Is defined in the standard ISO 9314-1 Information processing Systems: Fiver Distributed Data Interface-Part 1: Token Ring Physical Protocol.
- *Physical Layer Medium-Dependent (PMD)*

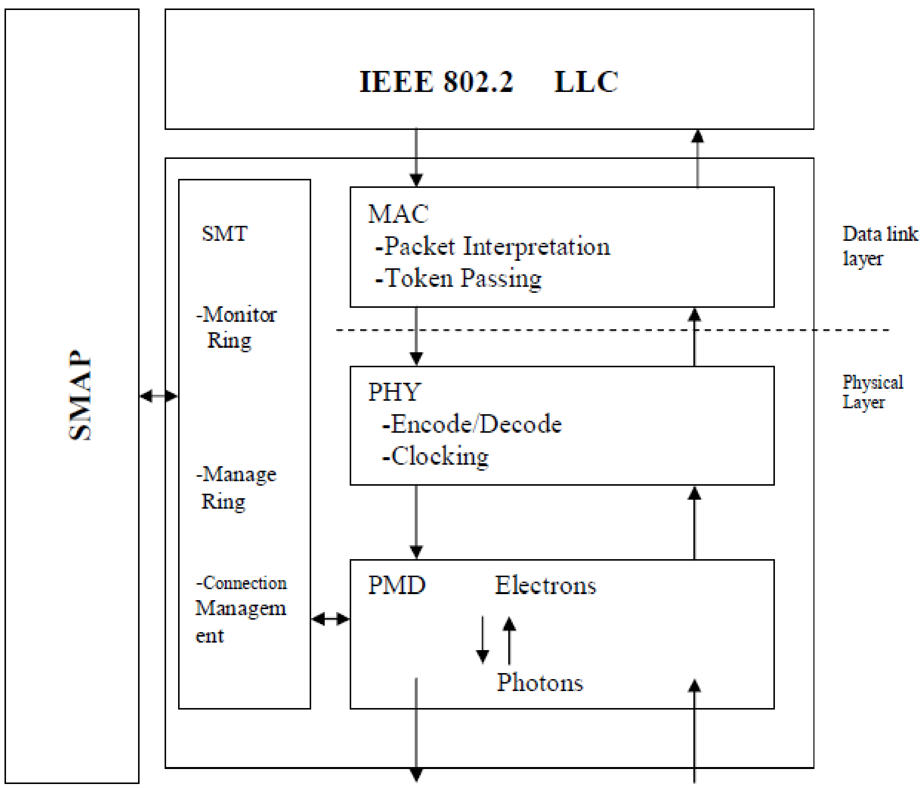
Is defined in the standard ISO 9314-1 Information Processing Systems: Fiver Distributed Data Interface-Part 1: Token Ring Physical Layer, Medium Dependent.

- *Station Management (SMT)*

  Defines the management functions of the ring according to ANSI Preliminary Draft Proposal American National Standard Z3T9.5/84-49 Revision 6.20, FDDI Station Management.

- *Media Access Control (MAC)*

  Defines the network access according to ISO 9314-20 Information Processing Systems: Fiber Distributed Data Interface-Part 20: Token Ring Media Access Control.



FDDI Reference model

Exercise

Explain the different components of FDDI.

15.4.3 Further properties of FDDI

Multicasting : The multicasting service became one of the most important aspects of networking. FDDI supports group addressing, which enables multicasting.

Synchronisation :

Synchronisation among different data streams is not part of the network; therefore it must be solved separately

Packet Size : The size of the packets can directly influence the data delay in applications.

Implementations: Many FDDI implementations do not support the synchronous mode, which is very useful for the transmission of continuous media. In asynchronous mode additionally, the same methods can be used as described by the token ring.

Restricted tokens : If only two stations interact by transmitting continuous media data, then one can also use the asynchronous mode with Restricted token Several new protocols at the network/transport layers in Internet and higher layers in BISDN are currently centers of research to support more efficient transmission of multimedia and multiple types of service.