# Module
# 10
# MULTIMEDIA SYNCHRONIZATION

# Lesson
# 34
# References Model and Specification

## Instructional objectives

At the end of this lesson, the students should be able to :

1. State why a reference model is needed.
2. Give some examples of multi-layer reference model
3. Define the roles of media layer, stream layer, object layer and specification layer.
4. State why synchronization is more complex in distributed environment
5. State the mechanisms for achieving distributed environment synchronization

## 34.0 Introduction

In lesson-33, we had studied the basic synchronization requirements for multimedia communication. Although we explained the basic issues, run-time mechanisms to support execution of synchronization can only be explained with respect to a reference model. This will be our focus for this lesson. In addition, we shall also cover the synchronization aspects in distributed environment. We shall also study which specifications are needed to specify synchronization.

## 34.1 Multi layer reference model

The reference model that is used to execute synchronization is organized in multiple layers. At the highest layer of abstraction, we have the application layer and at the lowest layer, we have the physical, or the media layer. The reference model is used to classify the multiple synchronization systems and the existing classification methods are :

- Little and Ghafoor [1] identified a physical level, system level and a human level for synchronization but gave no description of synchronization.

- Gibbs *et al* [2] map a synchronized multimedia object to an uninterrupted byte stream.

- Ehley *et al* [3] classify intermedia synchronization techniques that are used to control jitter between media streams according to the type and location of the synchronization control.

- Meyer *et al* [4] proposed a three layer classification scheme. It consists of a media layer for intra-stream synchronization, a stream layer for inter-stream synchronization and an object layer for the presentation.

- Blackowski-Steinmetz [5] proposed a four layer reference model to be used for the synchronization classification. This will be presented in the next section.

## 34.2 Blackowski –Steinmetz four layer reference model

The four layer reference model is illustrated in fig 34.1

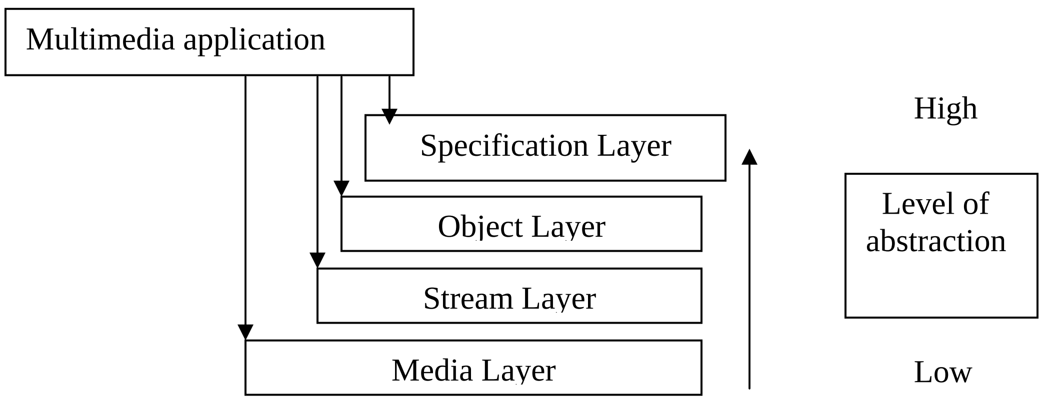


**Fig 34.1** Blackowski –Steinmetz four layer reference model.

As shown, the lower layers may be called by the upper layers or by the multimedia application itself. The roles of these individual layers are discussed as follows.

**34.2.1 Media Layer:**
At the media layer, an application operates on a single continuous media stream, which is treated as a sequence of LDUs. A continuous media stream can be set up by the application executing a process for each stream. Using the media layer, the application itself is responsible for intra-media synchronization.

**34.2.2 Stream Layer :**
The stream layer operates on continuous media streams, as well as on groups of media streams. In a group, all streams are presented in parallel by using mechanisms for inter-stream synchronization.

The streams are executed in a real time environment (RTE), where all processing is constrained by well-defined time specifications. The applications requiring stream layer services are executed in non real time environment (NRTE). Typical operations invoked by an application to manage stream are:

- Start stream
- Stop stream
- Create group (list of streams)
- Start group
- Stop group

The interaction with time-independent media objects and user interactions is performed by attachment of events to the continuous media streams.

**34.2.3 Object Layer:**

The object layer has one level of abstraction higher than the stream layer. To the application, it offers a complete, synchronized media. The object layer operates on all types of media and hides the differences between time independent and time-dependent media.

This layer takes a synchronization specification as input and is responsible for the correct schedule of the overall presentation. The object layer does not handle the inter-stream and intra-stream synchronization. For this purposes, it uses the services of the stream layer.

**34.2.4 Specification layer :**

This layer offers the highest level of abstraction in the four-layer reference model. This layer contains applications and tools that allow one to create synchronization specification. Examples of such tools are synchronization editors, multimedia document editors and authoring systems.

The specifications layer is also responsible for mapping QoS requirements of the user level to the qualities actually offered at the object layer.

Synchronization specification methods can be classified into the following main categories:

- ***Interval based specification* –** temporal relationships between the time intervals of the presentation of the media objects.

- ***Axes-based specification* –** relates presentation events to axes that are shared by the objects of presentation.

- ***Control flow based specification* –** at given synchronization points, the flow of the presentation is synchronized.

- ***Event-based specifications* –** the events in the presentation of media trigger presentation actions.

## 34.3 Synchronization in distributed environment

In a distributed multimedia environment, not only we have the source and the sink (receiver) at different physical locations, but even different media objects involved in the presentation may be located at different places. This makes synchronization more complex as compared to the local environment.

The reasons for such complex synchronization are:

- Distributed storage of synchronization information
- Additional delays and jitter due to the communication between the storage and the sint.
- Multi-party communication

## 34.4 Mechanism for distributed environment synchronization

To achieve synchronization in a distributed environment, the following mechanisms should be adopted.

**(a) *Transport of the synchronization specification*:**

It is necessary for the source node to send the synchronization specifications to the sink so that the presentation of the objects at the sunk can be done in a synchronized manner. There are three major approaches to such transportation :

- Delivery of complete synchronization information before the start of the presentation.
- Use of a separate synchronization channel, as shown in fig 34.2

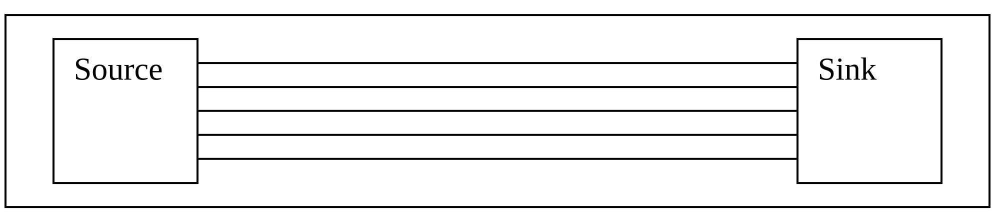


**Fig. 34.2** Use of a separate synchronization channel between the source and the sink.

- Using a multiplexed channel, so that the synchronization information is delivered, together with the media units. This is illustrated in fig 34.3


**Fig 34.3** Multiplexed media and synchronization channels

**(b) Combination of objects:** It is possible to synchronize media objects by combining them into a new media object. The object layers must support the mixing of objects, including the time dependent media objects, whereas the stream layer must support the mixing of the media streams.

**(c) Clock synchronization -** In distributed systems, the synchronization accuracy between the clocks of the source and sink nodes must be known.

This problem is especially important for the synchronization in case of multiple sources, as shown in fig 34.4

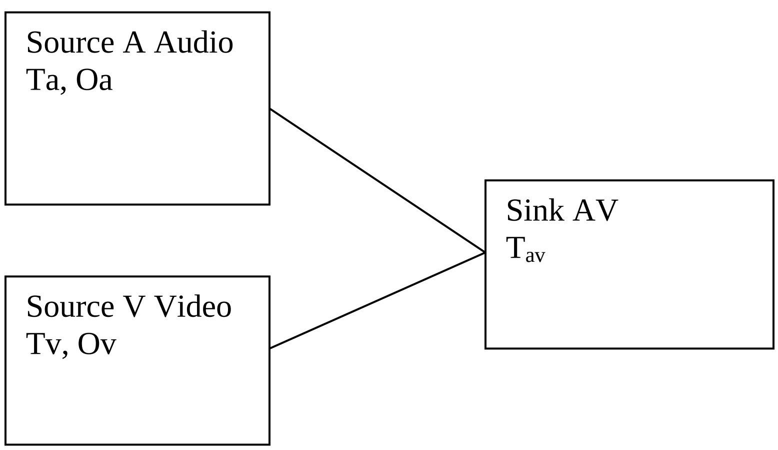


**Fig 34.4** Clock offsets in a distributed environment.

If the synchronized audio-video presentation has to start at the time $T_{av}$ at the sink node, the audio transmission of source A must start at

$$T_a = T_{av} - N_{la} - O_a$$

where, $N_{la}$ is the known network delay and $O_a$ is the unknown offset of the clock of the node-A with respect to the clock at the sink node. Likewise, the starting time of video transmission at the node-V is given by

$$T_v = T_{av} - N_{lv} - O_v$$

where, , $N_{lv}$ is the known network delay and $O_v$ is the unknown offset of the clock of the node-V. Although $O_a$ and $O_v$ are unknown, the resulting problem of delivery at the sink node can be solved by considering maximum possible values of the offsets. Buffers may be provided at the sink and transmissions from node-A and node-V may begin early to guarantee that the required media units are available. Low offset values ensure limited buffer requirements. To restrict the offset times, network time protocol [6] may be used, which allows synchronization with an accuracy in the range of 10 ms.

**(d) Multi-step synchronization:** In a distributed environment, it is necessary to maintain synchronization at each individual step, so that the final synchronization is guaranteed. The steps are as follows:

- Synchronization while digitizing the video frames.
- Synchronized retrieval of video frames.
- Synchronized delivery of the video frames to the transport service interface.
- Synchronization during the transport.
- Synchronized delivery to the sink, i.e. the output devices.
- Synchronization within the output devices.

## 34.5 Conclusion

In this lesson, we have presented a four-layer reference model that can be used for synchronization between the media streams and the roles of each layer have been explained. The problem of synchronization in distributed environment has been discussed in details. In the next lesson, we are going to focus on the architecture of media streams, as used in the MPEG-2 standards.

## REFERENCES


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