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Chapter XVI

An Isochronous Approach to Multimedia Synchronization in Distributed Environments

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In this chapter, we provide a new look at the synchronization issue in distributed environments. We attempt to explore the power of isochronous protocols, as advocated by Lamport, to the multimedia synchronization. It is based on the use of synchronized physical clock time instead of any form of logical clock or sequence numbers, and thus the clock synchronization across the distributed system is assumed. An isochronous protocol for achieving multimedia synchronization is presented. Derived from the globally synchronized clock, there exists a lattice structure in a system. Media conference participating processes in the system execute a simple clock-driven protocol, and all significant events (the sending and delivering of media data) are restricted to occur at lattice points of the globally synchronized space/time lattice.

This lattice structure greatly simplifies the multimedia synchronization and readily maintains the temporal and causal relationship among the media. The basic simplicity of the approach makes it easier to understand the precise properties and behavior of a system. The availability of globally synchronized clock (for example, the new version of Internet NTP) and predictable quality of service of advanced communication networks make the isochronous synchronization approach not only attractive but also practical.

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INTRODUCTION

A multimedia system is characterized by the integrated computer-controlled generation, manipulation, presentation, storage and communication of independent discrete and continuous media data. The presentation of any data, and the synchronization between various kinds of media data, are the key issues for this integration (Georganas, Steinmetz and Nakagawa, 1996). Clearly, multimedia systems have to precisely coordinate the relationships among all media. These relationships include temporal and spatial relationships. Temporal relationships are the presentation schedule of media, and spatial relationships are the location arrangements of media. In this chapter, we are mainly concerned with temporal relationship and multimedia synchronization mechanism to ensure a temporal ordering of events in a multimedia system.

Synchronization Problems and Approaches

Three types of multimedia synchronization can be distinguished*: intra-stream synchronization*, *inter-stream synchronization* and *inter-media synchronization* (Schulzrinne, 1993; Crowcroft, Handley and Wakeman, 1999).

Intra-stream synchronization, also called playout synchronization, ensures that the receiver plays out the medium a fixed time after it was generated at the source and experienced variable end-to-end delay. In other words, intra-stream synchronization assures that a constant rate source at the sender again becomes a constant rate source at the receiver, despite delay jitter in the network. The example of intra-stream synchronization is the single stream of video frames. For a video with a rate of 25 frames per second, each of the frames must be displayed for 40 ms. If the arrival rate is abnormal due to network delay, which is not uncommon, the *jitter* phenomenon occurs. Intra-stream synchronization affects the rate of presentation. Intra-stream synchronization is a base part of the H.261 and MPEG coding systems. H.261 and MPEG systems (ITU 1993; Mitchell, Gall & Fogg, 1996) specify an encapsulation of multiple streams, but also how to carry timing information in the stream. In the Internet, the RTP media specific timestamp provides a general-purpose way of carrying out the same function.

Inter-stream synchronization ensures all receivers play the same segment of a medium at the same time. Inter-stream synchronization may be needed in collaborative environments. For example, in a collaborative session the same media information may be reacted upon by several participants.

The easiest way of synchronizing between streams at different sites is to use a single time reference. There are several ways to provide this time reference, such as:

- The network will have a clock served as a single reference. This approach is used in H.261/ISDNbased systems. A single clock time is propagated around a set of CODECs and multipoint control units (MCS).
- The network deploys a clock synchronization protocol, such as NTP (the Network Time Protocol) (Mills, 1993). The timestamps of media packets will be derived from the globally synchronized clocks. In this chapter, we will elaborate this approach.

Inter-media synchronization is concerned with maintaining the requirements of the temporal relationships between two or more media. Lip-synchronization between video and audio is the example of inter-stream synchronization where the display of video must synchronize with audio.

The approaches used for inter-stream synchronization can also be used for inter media synchronization.