

State-of-the-Art and Future Research in Stream Synchronization

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Synchronization is widely regarded as a fundamental problem in multimedia systems. One can distinguish between two levels of multimedia synchronization, continuous synchronization and event-based synchronization. While the first one aims at the synchronized play-out of data streams, the latter one orchestrates the presentation of possibly distributed multimedia objects. Multimedia objects may consist of a variety of timely related subobjects, such as video clips, audio, text fragments and images. If a multimedia object contains continuous media, object synchronization comprises stream synchronization at a lower level. Thus, object synchronization mechanisms are to be based on stream synchronization functions.

Multimedia synchronization is an end-to-end problem. This holds not only for the object-level synchronization but also for the synchronization performed at the stream-level. In complex multimedia applications, a multimedia stream may traverse several end-systems before it reaches the system, where it is finally played-out. Moreover, the distributed application itself may consist of a flow-graph of processing elements, each of which causes an individual delay and jitter. This implies that the stream synchronization functions should be placed as close as possible at the “point of play-out”. In other words, synchronization mechanisms are needed above the transport system.

Stream synchronization algorithms can be roughly decided into two classes, protocols that assume synchronized system clocks and ones that do not assume the existence of a global system time. Examples of the first class are the Flow Synchronization Protocol [3], the Orchestration Service [2], and the Adaptive Stream Synchronization Protocol [6]. Representatives of the other class are protocols proposed by Venkat Rangan’s research group [5] and Agarwal and Son [1].

The existence of synchronized clocks is a very realistic assumption for modern distributed systems. Various protocols for clock synchronization exist, which achieve clock accuracy in the lower millisecond range (e.g. [4]). Having synchronized clocks available not only simplifies the stream synchronization protocol but also allows for more efficient solutions. If stream synchronization is based on synchronized clocks, media time can be derived from global time. In other words, the message overhead for synchronizing time on different system has to be paid only once (on the clock synchronization level) rather than for each individual group of streams to be synchronized.

If media time is derived from global time, then the synchronization of streams is easy to achieve. All sources in a sync group (i.e. a group of streams to be synchronized) start sending at time t_0 , and all sinks in this group start the presentation at time $t_0 + \Delta$, where $\Delta = d_{MAX} + q$. Parameter

d_{MAX} is the maximum delay of all streams in a sync group and q can be used to adjust the stream quality. The bigger is q the longer is the end-to-end delay of the streams and the lower is the loss probability due to late arrivals.

Synchronous start-up of presentation can be achieved by a straight-forward protocol (e.g. see [3]). If we assume that Δ will never change after start-up, then no further control messages need to be exchanged, media time is just derived from global time. In this case synchronization is trivial. If however, network delays may change over time or even the application may modify q , then an adaptable protocol is needed that is able to monitor network delays or buffer states and adjust the Δ value when required. For example, adjustable protocols have been proposed in [3] and [6].

Stream synchronization protocols should be adaptable for various reasons. Not all multimedia applications will be implemented on networks that give (hard) guarantees regarding delay. Even if the network can guarantee an upper bound on delay, an adaptable protocol is needed to exploit the fact that the actual delay can be lower than the guaranteed delay bound over times. Moreover, if a deterministic service allows for QoS renegotiation, an adaptive protocol automatically adjusts to modified delay bounds.

At present, various (adaptive) stream synchronization algorithms are available. Future research should focus on a comparison of those protocols. An environment for comparing and measuring synchronization mechanisms has been described in [8]. Moreover, most protocols provide a rich set of parameters to customize the protocols to certain environments and applications. Extensive experiments with real-life applications are needed to understand the impact of these parameters on the quality of service perceived by end users. Another interesting area to look into is the interworking of stream synchronization algorithms and the mechanisms used at the object-level, such as MHEG or Hytime engines.

References

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