Modeling Distributed Multimedia Synchronization with DSPN

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Abstract
Multimedia synchronization is the essential technology for the integration of multimedia in distributed multimedia systems. The multimedia synchronization model has been recognized by many researchers as a premise of the implementation of multimedia synchronization. In distributed multimedia systems, the characteristic of multimedia synchronization is dynamic, and the key medium has the priority in multimedia synchronization. The previously proposed multimedia synchronization models cannot meet these requirements. So a new multimedia dynamic synchronization model—DSPN, based on the timed Petri-net has been designed in this paper. This model can not only let the distributed multimedia system keep multimedia synchronization in a more precise and effective manner according to the runtime situation of the system, but also allow the user to interact with the presentation of multimedia.

Keywords: Distributed multimedia system, multimedia synchronization, timed Petri-net, synchronization model.

1 Introduction
The development in multimedia workstations, distributed systems and high-performance communications has resulted in the emergence and development of the distributed multimedia systems. It can be predicted that the applications on "Information Highway" will mostly be the distributed multimedia applications whose areas will cover industry, business, finance, medicine, education, publishing, office automation, cultural activities, science and engineering, etc. The distributed multimedia systems are characterized by the integrated computer-controlled generation, storage, communication, manipulation and presentation of multimedia information. Multimedia refer to the integration of texts, images, pictures, audio and video. These data may be heavily time-dependent, such as audio and video in a movie, and require time-ordered presentation during use. The task of coordinating such temporal sequences is called multimedia synchronization. It is the essential technology for the integration of multimedia in the distributed multimedia systems and is regarded as a major characteristic of multimedia different from the conventional data. The studies in multimedia synchronization can be divided into two parts: the first is to model and specify timing requirements of multimedia scenarios; the second is to achieve the temporal specification via synchronization. The multimedia synchronization model is a premise of the implementation...
of multimedia synchronization and should meet the requirements of multimedia synchronization characteristics and applications of the distributed multimedia systems.

In distributed multimedia systems, the characteristic of multimedia synchronization is dynamic. It is shown in two aspects. On the one hand, the temporal variability dynamically induced by asynchronous systems (such as computer network) cannot be avoided in distributed multimedia systems. So the absolute and static multimedia synchronization cannot be implemented. Furthermore, the presentation of multimedia objects can accept a temporal variability around their nominal presentation duration (i.e. the semantics of multimedia objects are valid in this interval). This means that the jitter of intra-media and the screw of inter-media in a certain range are admissible by human, for example, the max. jitter of video is 10ms, and the max. screw between video and audio is 80ms. Therefore, the multimedia synchronization in distributed multimedia systems is a dynamic synchronization within a temporal validity interval, and can be controlled by the systems. On the other hand, the interaction synchronization needs to handle the user inputs to the multimedia presentation. The time when user inputs is undetermined and dynamic.

In distributed multimedia applications, a medium may be very important for the application or very jitter-sensitive, such as audio in desktop video conference systems. We call this kind of medium “key medium”, which is prior to the other media. The system should first provide resource and bandwidth for the key medium to guarantee the processing and transporting in real-time synchronization, especially when the system is overloaded and the performance of the system is decreasing. Further, the synchronization of multimedia should be controlled according to the synchronization requirements of the key medium, particularly when its requirements conflict with those of other media.

Although, some studies have been done in describing the synchronization model for multimedia applications, these models use nominal object duration only and fix synchronization on a time point without considering the temporal variability induced by asynchronous systems and the admissible jitter that is intrinsic to each multimedia object. So they cannot describe the dynamic characteristics of multimedia synchronization and meet the special requirements of the key medium in the distributed multimedia applications. In addition, the complete formal definitions of the Petri-net based models are obliterated.

A new multimedia dynamic synchronization model—DSPN, based on timed Petri-net, is proposed on the basis of the above analyses in this paper. And its formal definitions and an application example are given out.

2 Dynamic Synchronization Petri Net

DSPN is a new dynamic multimedia synchronization timed Petri-net with new formal semantics and syntax. The main differences between it and other models are that it introduces the “KEY” place and the “KEY” transition to describe the synchronization requirement of the key medium, adds the validity intervals of multimedia presentation (as the QoS parameters for a synchronization purpose) on the places to make the synchronization take place within a temporal validity interval instead of on a point, and provides some important new dynamic synchronization types. The requirements of the interaction synchronization can also be met.

Definition. A DSPN is a tuple \((P, T, X, B, F, C_e, C_m, M, R_e, D, SYN, K)\).

1. \(P = \{p_1, p_2, \ldots\}\) represents a set of places (circles). There are two classes of places: Normal and KEY. The ‘KEY’ places are graphically represented as bold circles.
2. \(T = \{t_1, t_2, \ldots\}\) represents a set of transitions (bars).