MULTIMEDIA INFORMATION OBJECTS: A MODEL AND SCHEDULING ALGORITHM FOR SYNCHRONIZED REPLAY

by

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Submitted
in fulfillment of the requirements of the degree of Doctor of Philosophy

to the

INDIAN INSTITUTE OF TECHNOLOGY, DELHI
DECEMBER 1999

Certificate

This is to certify that the thesis titled "Multimedia Information Objects: A Model and Retrieval Algorithms for Synchronized Replay" being submitted by Neena Pahuja to the Indian Institute of Technology, Delhi, for the award of the Degree of Doctor of Philosophy, is a record of bonafide research carried out by her under my supervision. The results obtained in this thesis have not been submitted to any other University or Institute for the award of any other degree or diploma.

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Acknowledgments

I always wanted to go in for Ph.D from my B.Tech and M.Tech itself. Thanks to the encouragement and confidence shown by Mr. Arvind Pande, Chairman Steel Authority of India, I decided to take this opportunity after ten years of being in computer industry. I sincerely thank SAIL management for sponsoring me for this program, which enabled me to fulfill my long cherished ambition.

I am truly indebted to Prof. B.N. Jain, without whom this thesis would never taken its shape. I am thankful to him for being so generous with his time and for being so immensely patient with me. His vision, endeavor for perfection and insistence on precision coupled with simplicity has enabled me to develop skills which are helping me outside my research work also.

My guides, faculty members, friends, colleagues and my family members have helped me at all stages of my thesis. I thank Dr. Gautam Shroff for helping me in formulating my area of research work and for providing a critical analysis of my work. I know Prof. S.N. Maheshwari from last twenty years. He is known for being a source of inspiration for all his students. Although he was never directly involved with my research work, he has provided me guidance and much required confidence at various stages of my work.

I thank the other faculty members and staff of department for providing the facilities for my work and for their encouragement. Dr. Saroj Kaushik, Prof Biswas, Prof Anshul Kumar, Dr. Hazur Saran and in fact all the facility members have been very helpful. My special thanks to Dr. Naveen Garg and Dr. Sanjeev Kapoor who have helped me both as a friend and as a teacher.

For me, coming back to academics after ten years of stay in industry would have been very difficult, if I did not have good friends. I am extremely thankful to all my friends at IIT, Moorthy Ji, Rustogi Ji, Rekha, Neelima, Shoma, Nandini, Anand, Sunay, Anand, Mani, Sumantra and Murali. I am also thankful to all the students and staff working in the ERNET lab, for their cooperation and extended help.

All colleagues and seniors of both my offices, Steel Authority of India (SAIL) and UEC SAIL Information Technology (USIT), have been very helpful to me. I am extremely thankful to Mr. B. Rath, Vice President (USIT) and Late Mr. K.S. Chandra for motivating me and providing me all the required support to bring my work to the current shape. I am helpful to all my colleagues because of whom I could take off from office to be at IIT.

It is impossible to spell out the constant support I got from my family members. My parents have always been a constant source of inspiration for me and provided me the required will power to carry out impossible tasks also. My husband Karan has helped me all the sad moments of Ph.D and provided motivation, support and encouragement. I could not have achieved my results with out the help and affection of my mother-in-law. My children, Aman and Apoorva have been too accommodating in their requirements to adjust to my working hours. This thesis is dedicated to my family.

Neena Pahuja

Abstract

A multimedia information object consists of one or more information objects of various types, such as audio, video, text, graphics, and annotation. For instance, an object may consist of a sequence of graphic images, each of which has an associated voice annotation. Such multimedia information objects are encountered in several applications, including medical diagnosis, entertainment, and education. In all such applications, the time of replay of individual media components (and their durations) are *expected* to be fixed and pre-specified by the author(s). Such a replay is referred to as an *orchestrated* replay of the multimedia object.

Orchestrated replay can be achieved provided its author has a formal method to specify the structure of the entire object, together with details concerning individual components (such as associated data, required resources, and time duration). Many researchers have proposed the use of timed Petri-nets to model a multimedia object. In such a model, each *place* represents a *process* that corresponds to replay of the associated *component* object, while *transitions* facilitate orchestration, or inter-stream synchronization.

While Petri-net based models permit synchronization of the start of replay of two components, they have no means to end replay in a synchronized fashion. In this thesis we introduce the notion of a deadline with each component, and argue that such a limit on the time of end of replay of a component permits an author to exercise greater control over the time when replay of a component object ends. We also show how deadlines can be used in other way to emulate navigation between a number of multimedia objects.

In this thesis, the existing Petri-net based models to specify multimedia objects [1, 2, 21] have also been extended in two other ways.

First, we recognize that a multimedia information object, and its components,

may need to be available in a variety of forms, so that a variety of *views* of the multimedia object may be created. This is felt necessary in order to address the needs of a wide variety of workstation characteristics, available resources and even user preferences. We show how one may create views using either profiles or by creating a "projection" of the original object itself. The latter allows a user to view portions of the multimedia object that are of his/her interest.

The other significant extension we have proposed in this thesis has to do with user participation. In several applications, there is need for user intervention during presentation. Presently, such user intervention is expected to include operations such as "pause" a display, "select" a component object in preference to others, or to "skip" portions of the display. The other form of user intervention relates to controlling the progress of replay of a document, or navigating from the current multimedia object to another object.

In this thesis, we present a new and enhanced version of a Petri-Net based model by extending Object Composition Petri-Net Model (OCPN) [1] for multimedia synchronization, which we call *SOCPetrinet*. This model supports intra- and inter-stream synchronization, user- and profile-defined views of the object, user intervention and navigation.

Each place is itself characterized by object data, replay process, resource requirements, and timing constraints. In the proposed model, the timing constraints are specified in terms of nominal duration as well as deadline. The deadline itself may be specified in terms of other variables (such as start time, end time of processes corresponding to other components) in order to ensure tighter synchronization.

We also propose an algorithm to schedule the retrieval of data corresponding to various components of the *SOCPetriNet* object. For a given channel and buffer capacities, the scheduler attempts to minimize the relative asynchrony in the replay of different components, while limiting the loss of information to a minimum. Based on the specification of replay durations and deadlines associated with each component of the multimedia object, the *earliest* start time and the *latest* start times for the replay of each component are computed. The scheduler attempts to pre-fetch data such that all required data is available for replay on or before the *latest* start times. In case of excessive delays, the replay is forced to begin at the latest start time. As a consequence, some loss of information may occur. Since user interaction may change the earliest and/or latest start times of the successor object components, the schedule for replay is updated whenever there is user intervention. Use of *just-in-time* strategy for pre-fetching object components also minimizes buffer requirements for storing pre-fetched data.

A comparison of the algorithms with those given in the literature has been carried out with respect to *loss*, *programmed delay*, *relative asynchrony*, and *buffer requirements*.

Finally, a prototype implementation of the above model, together with that of user defined operations and user defined views has been developed.

Contents