

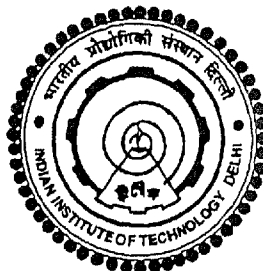
MULTIMEDIA INFORMATION OBJECTS: A MODEL AND SCHEDULING ALGORITHM FOR SYNCHRONIZED REPLAY

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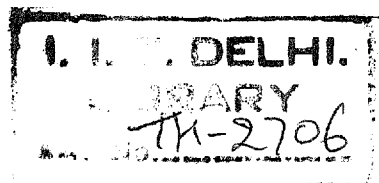
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Certificate

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.

A handwritten signature in black ink, consisting of a stylized 'B' followed by a series of loops and a horizontal line.

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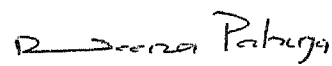
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Neena Pahuja

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

1	Introduction	1
1.1	Orchestrated Replay of Multimedia Object	2
1.2	Retrieving Components of a Multimedia Object	3
1.3	Approach to the Problem	5
1.4	Summary of Contributions of the Thesis	8
1.5	Structure of Thesis	8
2	A Model for Multimedia Objects	11
2.1	Synchronization Representation in Multimedia Systems	11
2.1.1	Timed Petri-net model	13
2.1.2	Object Composition Petri Nets (OCPN) model	13
2.1.3	Replay of Objects	15
2.2	Introducing Deadlines in Replay	17
2.3	A Model for Deadline	20
2.4	Conclusion	27
3	Modeling User Interaction	29
3.1	User Participation during Replay	29
3.2	Author Defined User Interaction	35
3.2.1	Modeling the Start of Replay	35
3.2.2	Controlling the Replay at Pre-determined points	37
3.2.3	Introducing Hyperlinks	38

3.2.4	Author Based Selection	40
3.2.5	Modeling User Profile Based Selection	41
3.3	Modeling User Defined Projections	43
3.4	Synchronization in the presence of User Interaction	46
3.5	Conclusion	51
4	Synchronized Object Composition Petri Net Model	53
4.1	A Synchronized Object Composition Petri Net Model	53
4.1.1	Firing Rules for a <i>SOCPetriNet</i> object	56
4.1.2	Analysis of SOCPetriNet model	57
4.2	Replay Time Computation	60
4.2.1	The Replay Process	60
4.2.2	Conversion of <i>SOCPetriNet</i> to Directed Graph	64
4.2.3	Algorithm for Replay Time Computation	67
4.2.4	Earliest Start Time Computation	67
4.2.5	Buffer/Resources Release Time Computation	69
4.3	Validation Algorithms for SOCPetriNet	69
4.3.1	Consistency in Specification of Synchronized Object	70
4.3.2	Resource Conflict Algorithm	70
4.4	Application Examples	71
4.4.1	A Multimedia Course	72
4.4.1.1	Synchronized Replay of the Multimedia Object	73
4.4.1.2	Views created for multimedia object	75
4.4.2	An Interactive Multimedia Document	77
4.4.2.1	Navigation in the Multimedia Information Object	78
4.4.2.2	Views of Multimedia object	78
4.5	Summary	80
5	Scheduling Algorithms for Retrieval	81
5.1	Quality of Service requirement for the replay	82

5.2	Model of Data	83
5.2.1	Nature of Static Data	83
5.2.2	Nature of Continuous Media Data	84
5.2.3	Channel and Buffer Requirements	85
5.3	Replay Requirement of Multimedia object	89
5.4	Scheduling Algorithm	91
5.4.1	Detailed Algorithm	93
5.4.2	Analysis	98
5.5	Application Examples & Simulation Results	99
5.5.1	Performance	102
5.5.2	Simulation Results	103
5.6	Conclusion	107
6	Prototype Implementation	109
6.1	Introduction	109
6.2	Prototype Development of SOCPetriNet	110
6.2.1	User Interaction During Replay	110
6.2.2	Resource Window Positioning	114
6.2.3	User Participation in the prototype	114
6.3	Results for model	114
6.3.1	Delays in Replay	115
6.3.2	Asynchrony in the Replay	117
6.4	Conclusions and Enhancements in the Prototype Implementation	117
7	Conclusion & Future Work	119
7.1	Major Contributions	120
7.1.1	Synchronization of Multimedia Object	120
7.1.2	Scheduling Algorithm for retrieval of Components	121
7.2	Future Work	121