

## Temporal Models Used in the Design of Distributed Multimedia Tutorials

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***Abstract*** – *In the e-learning field, the most attractive tutorials make use of various multimedia materials, which are structured in a synchronized manner. In a distributed environments such the WWW space, the synchronization of multimedia objects remains an open problem. In order to control the validity and the consistency of its temporal scenario, it is necessary that a multimedia presentation to be structured in accord with a certain formal model. We shall present in this paper a series of methods and models intended for the description of temporal relations inside the multimedia Web tutorials, making reference to the SMIL presentations.*

***Keywords:*** *World-Wide Web, Temporal Models, Multimedia, SMIL, E-learning*

### I. INTRODUCTION

World Wide Web space was enriched in the last time with a lot of *e-learning* systems, having more and more complex functionality. The most attractive tutorials make use of various multimedia technologies, manipulating synchronized multimedia objects.

The *multimedia technologies* could be defined as the modalities of creation, storage, retrieval, publication and usage of the documents compounded by multiple media, as text, graphics, still images, sound and video objects. A multimedia application has to include at least one continuous media (having a measurable and well-defined duration of execution – for example, sound, movie or animation), and at least one discrete media (without a clear duration – such text or images in the form of photos, charts or graphics) [6]. The temporal dimension represent an important aspect of the multimedia documents: the video and audio objects have an intrinsic duration, and the author of the document could describe a temporal organization of the compounded elements. This organization could be named a *temporal scenario*.

In the distributed environments such as the Web, the synchronization of multimedia objects remains an open problem because of the various aspects as the distributed storage of multimedia data, the multiple implications of human-computer interactions, the problems related with the network data transmission, performance limitations of the user computers.

The development of the multimedia documents implies two phases: *the specification* (or authoring) and *the presentation* (or running). A synchronization model describes the first phase, providing formalism for specifying the temporal scenario – which could be used as a base for various methods of implementation. For creating multimedia Web presentations, the actual standard is *SMIL (Synchronized Multimedia Integration Language)* [3].

As a quantification measure for the expressive power of a certain temporal model it is considered the capability of expressing all temporal operators introduced by J. F. Allen [1, 2]. Other requirements for the multimedia specifications expressiveness are discussed in [8].

In this paper we shall briefly present *ITL – Interval Temporal Logic* [1, 2], which is the base model for SMIL specifications, and some other few models derived from ITL in order to describe the temporal relations inside the multimedia Web presentations. We shall discuss the measure these are applicable to e-learning SMIL tutorials.

### II. SMIL LANGUAGE

*SMIL (Synchronized Multimedia Integration Language)* is an XML-based language developed since 1998 by the World-Wide Web Consortium in order to facilitate the creation of interactive multimedia presentations directly on Web [3, 6]. SMIL enables authors to describe the temporal behavior of a multimedia presentation, to associate hyperlinks with various media objects or to describe the layout of the presentation on a screen, in a platform independent manner.

A SMIL presentation consists of several components, each including different media types, such as audio, video, image or text streams, and could being executed in a sequential, parallel or combined way. Control buttons such as "stop", "fast-forward" and "rewind" allow users to interrupt the presentation and to move forwards or backwards to another point in the presentation.

SMIL 2.0 – the actual version of the language – is defined as a set of reusable markup modules. This allows reuse of SMIL syntax and semantics in other XML-based languages, in particular inside those that need to represent timing and synchronization. For example, SMIL 2.0 components are used for integrating timing into *XHTML (Extensible HyperText Markup Language)* [4] – the next

generation of HTML – and into *SVG (Scalable Vector Graphics)*.

These advantages lead in designing of more interactive and spectacular Web pages without the use of various commercial and proprietary solutions such as Flash presentations or ActiveX components.

Even Dave Raggett, one of the important HTML developers, approves that SMIL is great for timing media clips, e.g. presenting an HTML document along with an audio commentary and accompanying images.

Actually, different special players for SMIL are available, developed by different companies: *Real Player 10*, *GRiNS 2.0*, or *Ambulant Open SMIL Player*. The general trend is to give support for SMIL even in the Web browsers: *Internet Explorer* version 5.5 and later is able to render and play XHTML+SMIL presentations, Apple's *QuickTime* version 4.1 and later supports SMIL 1.0 and Adobe's *SVG Viewer* gives support for SMIL animations integrated into SVG documents.

*Example* The SMIL multimedia presentations are easy to be written and do not require sophisticated authoring tools, because there are simply text XML-based files. As an example, a short SMIL document is listed below. The presentation will split the computer screen into two regions, a movie (in the Real Media format) and a text file being displayed in parallel for 60 seconds, each in a specific region, while in the background a sound file is playing. This could be the skeleton of an e-learning tutorial

```
<!DOCTYPE smil PUBLIC
"-//W3C//DTD SMIL 2.0//EN"
"http://www.w3.org/TR/REC-smil/SMIL20.dtd">
<smil xmlns=
"http://www.w3.org/2001/SMIL20/Language">
<head>
<layout type="smil-basic-layout">
<!-- a region that will display
the video document -->
<region id="VideoReg" top="5" left="25"
width="875" height="650" />
<!-- a region that will display
the text content -->
<region id="TextReg" top="655" left="25"
width="875" height="20" />
</layout>
</head>
<body>
<par>
<!-- the multimedia content
will be rendered in parallel -->
<audio src="audio/backgr.rm" id="sound"
dur="80s" />
<video region="VideoReg" id="tutorial"
src="videos/tutorial01.rm" dur="60s"
/>
<text region="TextReg" id="explanation"
src="docs/course.html" dur="60s" />
</par>
</body>
</smil>
```

SMIL's membership in XML family provide various opportunities of processing SMIL documents by using DOM model or SAX, appealing to any programming language which offer support for XML (for example, C/C++ Java, Perl, JavaScript, PHP, etc.). Moreover, there exists a specialized Perl module which provide various

methods for dynamic generating the internal structure of a SMIL document [14].

### III. INTERVAL TEMPORAL LOGIC (ITL)

The way of representing time is a very important problem in the context of developing Web applications containing synchronized multimedia objects. A survey of temporal formal models used for representing dynamic properties of real-time distributed systems is presented in [5]. The main purpose of these proposals is the formal modeling of distributed systems together with their components.

Interval Temporal Logic was introduced in [1, 2], and is the basis for many implementations of systems specialized in multimedia synchronization. ITL constitute the formal model for some languages as *SMIL (Synchronized Multimedia Integration Language)* [3, 6], *TimeML* [11] or *DAML+TIME* [13].

ITL defines a temporal structure based on a linear model of time, using the *temporal interval* as the primary temporal unit. Between two intervals  $i$  and  $j$  there could be established 13 mutual exclusive relations, named Allen's relations. These are figured below, except  $i$  *Equals*  $j$  relation, which specify the identity of  $i$  and  $j$  intervals (the same start and finish moments):

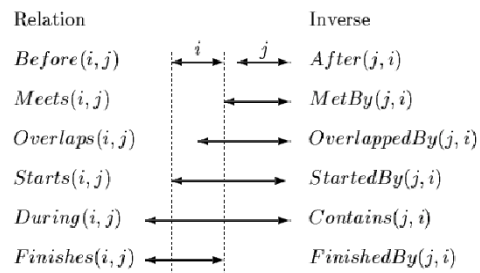


Fig. 1: Allen's Temporal Relations

All these temporal relations could be expressed in SMIL. Each interval correspond to the active duration (the duration of being exposed on the computer screen) of a multimedia object included in a SMIL presentation. For the previous example, we jot down with  $i$ ,  $j$ , and  $k$  the active duration of the three multimedia elements: video, text, and audio. For example, if we wish to express the relation *Meets*( $i$ ,  $j$ ) for specifying that the text shall appear on the screen immediately after the video finishes, we could attach the „begin = tutorial.end” attribute to the SMIL element having the „id = explanation”.

ITL offers a series of result which could be used for verifying the consistency of a temporal scenario. For example, the *Discrete Variation Axiom* specify that, if a predicate  $P$  isn't true over an interval  $t$ , there exist at least one interval  $t' \subseteq t$ , over the which the predicate  $P$  is entirely false. SMIL language doesn't provide facilities for make use of such results, but, as we mentioned, there exists many possibilities of processing SMIL documents, that could be applied for this purpose.

#### IV. WEAK SYNCHRONIZATION MODEL

By operating with temporal intervals, Allen's relations presume known both the start and the finish moments, for this reason being named precise relations. There exist various imprecise situations, as that when, for two multimedia objects  $A$  and  $B$ , is known only they have the same start time:  $A.start = B.start$ . In terms of Allen's relations, this situation could correspond at three cases:  $A$  equals  $B$ ,  $A$  starts  $B$  sau  $B$  starts  $A$ .

In 1994, Wahl and Rothermel presented an extended interval-based model, incorporating 29 temporal relations [12]. Besides the 13 Allen's precise relations, there where been included more 16 relations, 10 being original: *startin*, *endin*, *delays*, *cross*, *startendof*, *beforeendof*, *costarts*, *coends* and *all* (for example,  $A$  startin  $B$  denotes that object  $A$  has the start moment inside the active duration of the object  $B$ . Minglu demonstrated that each of these realations could be expressed using *before* and *costarts* operators [10]. Based on his theorem, Kun defined the weak synchronization model [9].

This model consider 6 possible states for a multimedia object: *defined*, *created*, *ready*, *running*, *retired*, and *dead*. Objects have also several properties, such *duration*, or *initial-delay*. By this way, there could be controlled more precisely the effective active duration of a multimedia object. In SMIL, the active duration is defined by the *start*, *end*, *dur* attributes, but, effectively, this duration includes the time spent with the download and the activation of the object.

The running process of a multimedia application is named in this model *sync-process*. There are defined three synchronization primitives: *sync*, *wait*, and *follow*. The term „weak synchronization” is illustrated by the two first primitives, which have associated types enabling a partial synchronization if a strict one is not possible.

For example, if a multimedia scenario for an e-learning tutorial starts with a picture  $P1$ , a background music object  $A1$ , and it is desirable that a text  $T1$  to start simultaneously, but not compulsive, the corresponding *sync* primitive shall have associate the *loose* type. This enables the text  $T1$  to start with a little delay. If the scenario necessitates the same start for other two objects – a picture  $P2$  and a video  $V1$  –, their synchronization shall has the *strict* type. The *wait* primitive specify the simultaneous termination of some object when the *first* or when the *last* one finishes. We give below the illustration of this multimedia scenario, and the associated *expression* in the weak synchronization model:

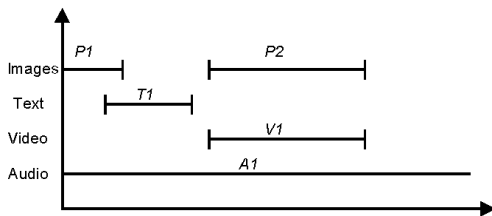


Fig. 2: Example of Temporal Scenario

```

Sync-process:
Objects P1 (0, b), T1(a, c), A1(0,-), P2(d, e),
V1(d, e)
SYNC (P1, A1, T1): loose
FOLLOW T1 BY (P2, V1)
WAIT (T1): last
SYNC (P2, V1): strict
WAIT (V1, A1): first
    
```

In SMIL language, there is no possibility to specify that it is better for the object  $T1$  to start simultaneously with  $A1$  and  $P1$ , but it could be accepted to have a certain delay. Also, there couldn't be specified that  $P2$  and  $V1$  shall start together, when both are downloaded and activated.

#### V. A SYNCHRONIZATION MODEL FOR HYPERMEDIA DOCUMENTS NAVIGATION

In [7] is exposed another model which take into account the different activities implied by the multimedia synchronization: download and the activation of multimedia objects, their coordination according to the structure of the whole hypermedia document, their playback taking into account the user interaction.

The model defines five synchronization primitives, demonstrating that a part of these must to be defined in the document design stage, but others could be automatically inferred from the definition of events associated with multimedia objects, or from the document structure. The five primitives are:

- $A$  activates  $B$ , marked as  $A \Rightarrow B$
- $A$  plays with  $B$ ,  $A \Leftrightarrow B$
- $A$  is replaced by  $B$ ,  $A \rightleftarrows B$
- $A$  has priority over  $B$ ,  $A \succ B$
- $A$  is terminated with  $B$ ,  $A \Downarrow B$

An e-learning tutorial includes some multimedia objects, each of these necessitating a *channel* for being displayed or for running. It is possible that many objects occupy the same channel in different moments. For example, if the tutorial includes two clips  $c1$  and  $c2$ , composed by the scenes  $sc1$  and  $sc2$ , respectively  $sc3$ ,  $sc4$  and  $sc5$ , which run simultaneous with the textual pages  $p1 - p5$ , and at a certain moment, inside the page  $p2$  the user follow a hyperlink to another page  $p6$ , the relations of the multimedia scenario could be illustrated as below:

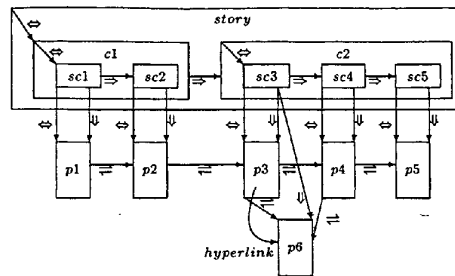


Fig. 3: Example of Synchronization Scheme

Examples of relations that must to be precisely defined in the document design stage are:  $c1 \Rightarrow c2$ ,  $sc1 \Leftrightarrow p1$ ,  $sc5 \Leftrightarrow p5$ , while relations as  $c1 \Leftrightarrow sc1$ ,  $sc1 \Rightarrow sc2$ ,  $sc4 \Rightarrow sc5$ ,  $sc2 \Rightarrow sc3$ ,  $p1 \Leftrightarrow p2$ ,  $p4 \Leftrightarrow p5$  could be automatically inferred.

In SMIL language could be expressed only the  $A \Rightarrow B$  and  $A \Downarrow B$  relations, by attaching the  $start = A.end$  attribute to object B, respectively the  $end = B.end$  attribute to object A. The others operators could provide a modality of extending SMIL functionality. Also, this model provide the idea of parsing a SMIL document in order to infer all existing temporal relations between multimedia elements, in addition to those explicitly defined by the document structure.

## VI. CONCLUSIONS AND FURTHER WORK

For e-learning tutorials, the multimedia synchronization over the Web space is a very important problem. The SMIL language provides opportunities of defining complex temporal scenarios, but offers a weak support for controlling their validity and their precise behavior for every user. The SMIL <switch> element could be used in order to provide display alternatives, depending on the user's computer performances, but effective behavior of the multimedia presentation couldn't be forecast: the network traffic (latency and congestion) or the distance between user and resources may have a certain influence.

Many temporal models were defined in order to describe the dynamic properties of the various distributed real-time systems. These models could be used in the design phase of a multimedia tutorial, or in the test phase – in order to verify the consistence of an existing presentation. Also, such models provide different

suggestion for the further enhancement of the SMIL language.

As a further work, we shall consider many other temporal models which could be applied for a better, more complete, definition of the synchronized multimedia Web presentations.

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