Synchronized Multimedia Integration Language (SMIL) Boston Specification

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Abstract

This document specifies the "Boston" version of the Synchronized Multimedia Integration Language (SMIL, pronounced "smile"). SMIL Boston has the following two design goals:

- Define a simple XML-based language that allows authors to write interactive multimedia

presentations. Using SMIL Boston, an author can describe the temporal behavior of a multimedia presentation, associate hyperlinks with media objects and describe the layout of the presentation on a screen.

- Allow reusing of SMIL syntax and semantics in other XML-based languages, in particular those who need to represent timing and synchronization. For example, SMIL Boston components should be used for integrating timing into XHTML.

Status of this document

This section describes the status of this document at the time of its publication. Other documents may supersede this document. The latest status of this document series is maintained at the W3C.

This document is the first working draft of the specification for the next version of SMIL code-named "Boston". It has been produced as part of the W3C Synchronized Multimedia Activity. The document has been written by the SYMM Working Group *(members only)*. The goals of this group are discussed in the SYMM Working Group charter *(members only)*.

Many parts of the document are still preliminary, and do not constitute full consensus within the Working Group. Also, some of the functionality planned for SMIL Boston is not contained in this draft. Many parts are not yet detailed enough for implementation, and other parts are only suitable for highly experimental implementation work.

At this point, the W3C SYMM WG seeks input by the public on the concepts and directions described in this specification. Please send your comments to www-smil@w3.org. Since it is difficult to anticipate the number of comments that come in, the WG cannot guarantee an individual response to all comments. However, we will study each comment carefully, and try to be as responsive as time permits.

This working draft may be updated, replaced or rendered obsolete by other W3C documents at any time. It is inappropriate to use W3C Working Drafts as reference material or to cite them as other than "work in progress". This document is work in progress and does not imply endorsement by the W3C membership.

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A. About SMIL Boston

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1 Introduction

This document specifies the "Boston" version of the Synchronized Multimedia Integration Language (SMIL, pronounced "smile"). SMIL Boston has the following two design goals:

- Define a simple XML-based language that allows authors to write interactive multimedia presentations. Using SMIL Boston, an author can describe the temporal behavior of a multimedia presentation, associate hyperlinks with media objects and describe the layout of the presentation on a screen.
- Allow reusing of SMIL syntax and semantics in other XML-based languages, in particular those who need to represent timing and synchronization. For example, SMIL Boston components should be used for integrating timing into XHTML.

SMIL Boston is defined as a set of markup modules, which define the semantics and an XML syntax for certain areas of SMIL functionality. All modules have an associated Document Object Model (DOM).

SMIL Boston deprecates some SMIL 1.0 syntax in favor of more DOM friendly syntax. Most notable is the change from hyphenated attribute names to mixed case (camel case) attribute names, e.g., clipBegin is introduced in favor of clip-begin. The SMIL Boston modules do not contain these SMIL 1.0 attributes so that integration applications are not burdened with supporting them. SMIL document players, those applications that support playback of "application/smil" documents (or <smil></smil> documents (or however we denote SMIL documents vs. integration documents)) must support the SMIL 1.0 attribute names.

This specification is structured as follows: Section B presents the individual modules in more detail, and gives example profiles. Section 2 defines the animation module. Section C defines the animation module. Section D defines control elements such as the switch element. Section E

defines the SMIL event model. Section F defines syntax that is only used when SMIL modules are integrated into other XML-based languages. Section G defines the elements that can be used to define the layout of a SMIL presentation. Section H provides for XML linking into SMIL documents. Section I defines elements and attributes allowing to describe media objects. Section J defines the meta element functionality. Section K defines the elements that form the sceleton of a SMIL document (head, body etc.). Section L defines the Timing and Synchronization elements. In particular, this Section defines the time model used in SMIL. Section M explains how SMIL timing can be integrated into other XML-based languages.

2 Acknowledgements

This document has been prepared by the Synchronized Multimedia Working Group (WG) of the World Wide Web Consortium. The WG includes the following individuals:

- Jeff Ayars, RealNetworks
- Dick Bulterman, CWI
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- Warner ten Kate, Philips
- Ted Wugofski, Gateway (Invited Expert)

- Jin Yu, Compaq

In addition to the working group members, the following people contributed to the SMIL effort: Dan Austin (CNET), Rob Glidden (Web3D), Mark Hakkinen (The Productivity Works), Jonathan Hui (Canon), Rob Lanphier (RealNetworks), Tony Parisi (Web3D), Dave Raggett (W3C).

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B. Synchronized Multimedia Integration Language (SMIL) Modules

Previous version (W3C members only):

http://www.w3.org/AudioVideo/Group/Modules/symm-modules-19990719

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Abstract

This is a working draft of a specification of synchronized multimedia integration language (SMIL) modules. These modules may be used to provide multimedia features to other XML based languages, such as the Extensible Hypertext Markup Language (XHTML). To demonstrate how these modules may be used, this specification outlines a set of sample profiles based on common use cases.

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1 Introduction

The first W3C Working Group on Synchronized Multimedia (SYMM) developed SMIL, the Synchronized Multimedia Integration Language [SMIL]. This XML-based language [XML] is used to express timing relationships among media elements such as audio and video files. SMIL 1.0 documents describe multimedia presentations that can be played in a SMIL-conformant viewer.

Since the publication of SMIL 1.0, interest in the integration of SMIL concepts with the HTML, the Hypertext Markup Language [HTML], and other XML languages, has grown. Likewise, the W3C HTML Working Group is exploring how the XHTML, the Extensible Markup Language [XHTML], can be integrated with other languages. Both Working Groups are considering modularization as a strategy for integrating their respective functionality with each other and other XML languages.

Modularization is a solution in which a language's functionality is partitioned into sets of semantically-related elements. Profiling is the combination of these feature sets to solve a particular problem. For the purposes of this specification we define:

element
: An element is a representation of a semantic feature. An element has one representation in any given syntax.

module
: A module is a collection of semantically-related elements.

module family
: A module family is a collection of semantically-related modules. Each element is in one and only one module family. Modules in a module family are generally ordered by increasing functionality (each module is generally inclusive of the previous module in the module family).

profile
: A profile is a collection of modules particular to an application domain or language. For example, the SMIL profile corresponds to the collection of modules that make up the SMIL language. Likewise, an enhanced television profile would correspond to the collection of modules for media-enhancement of broadcast television. In general, a profile would include only one module from a particular module family.

SMIL functionality is partitioned into modules based on the following design requirements:

1. Ensure that a profile may be defined that is completely backward compatibility with SMIL 1.0.
2. Ensure that a module's semantics maintain compatibility with SMIL 1.0 semantics (this includes content and timing).

3. Specify modules that are isomorphic with other modules based on W3C recommendations.
4. Specify modules that can complement XHTML modules.
5. Adopt new W3C recommendations when appropriate and not in conflict with other requirements.
6. Specify how the modules support the document object model.

The first requirement is that modules are specified such that a collection of modules can be "recombined" in such a way as to be backward compatible with SMIL (it will properly play SMIL conforming content).

The second requirement is that the semantics of SMIL must not change when they are embodied in a module. Fundamentally, this ensures the integrity of the SMIL content and timing models. This is particularly relevant when a different syntax is required to integrate SMIL functionality with other languages.

The third requirement is that modules be isomorphic with other modules from other W3C recommendations. This will assist designers when sharing modules across profiles.

The fourth requirement is that specific attention be payed to providing multimedia functionality to the XHTML language. XHTML is the reformulation of HTML in XML.

The fifth requirement is that the modules should adopt new W3C recommendations when they are appropriate and when they do not conflict with other requirements (such as complementing the XHTML language).

The sixth requirement is to ensure that modules have integrated support for the document object model. This facilitates additional control through scripting and user agents.

These requirements, and the ongoing work by the SYMM Working Group, led to a partitioning of SMIL functionality into nine modules.

2 SMIL Modules

SMIL functionality is partitioned into nine (9) modules :

- Animation Module
- Content Control Module
- Event Module
- Layout Module
- Linking Module
- Media Object Module

- Metainformation Module
- Structure Module
- Timing and Synchronization Module

Each of these modules introduces a set of semantically-related elements, properties, and attributes.

2.1 Animation Module

The Animation Module provides a framework for incorporating animation onto a timeline (a timing model) and a mechanism for composing the effects of multiple animations (a composition model). The Animation Module defines semantics for the animate, set, move, and colorAnim elements.

2.2 Content Control Module

The Content Control Module provides a framework for selecting content based on a set of test attributes. The Content Control Module defines semantics for the switch element.

2.3 Event Module

The Event Module provides a framework for realizing the event model specified in the W3C Document Object Model Level 2. The Event Module defines semantics for the eventhandler and event elements.

2.4 Layout Module

The Layout Module provides a framework for spatial layout of visual components. The Layout Module defines semantics for the layout, root-layout, and region elements.

2.5 Linking Module

The Linking Module provides a framework for relating documents to content, documents and document fragments. The Linking Module defines semantics for the a and anchor elements.

2.6 Media Object Module

The Media Object Module provides a framework for declaring media. The Media Object Module defines semantics for the ref, animation, audio, img, video, text, textstream, xref,

xanimation, xaudio, ximg, xvideo, xtext, xtextstream elements.

2.7 Metainformation Module

The Metainformation Module provides a framework for describing a document, either to inform the human user or to assist in automation. The Metainformation Module defines semantics for the meta element.

2.8 Structure Module

The Structure Module provides a framework for structuring a SMIL document. The Structure Module defines semantics for the smil, head, and body elements.

2.9 Timing and Synchronization Module

The Timing and Synchronization Module provides a framework for describing timing structure, timing control properties, and temporal relationships between elements. The Timing and Synchronization Module defines semantics for par, seq, excl, and choice elements. In addition, this module defines semantics for properties such as begin, beginAfter, beginWith, beginEvent, dur, end, endEvent, endWith, eventRestart, repeat, repeatDur, timeAction, and timeline. These elements and attributes are subject to change.

3 Isomorphism

A requirement for SMIL modularization is that the modules be isomorphic with other modules from other W3C recommendations. Isomorphism will assist designers when sharing modules across profiles.

Table -- Isomorphism between SMIL modules and their corresponding HTML modules.

SMIL modules		HTML modules	
Animation	animate	-	-
Content Control	switch	-	-
Event	event, eventhandler	Intrinsic Events	on*event*
		Event	event, eventhandler
Layout	layout, region, root-layout	Stylesheet	style
		Hypertext	a

Linking	a, anchor	Link	link
		Base	base
		Image Map	map, area
Media Object	ref, audio, video, text, img, animation, textstream	Object	object, param
		Image	img
		Applet	applet, param
Metainformation	meta	Metainformation	meta
Structure	smil, head, body	Structure	html, head, body, title
		???	div and span
Timing and Synchronization	par, seq	-	-

As can be seen in the table, there are two modules that appear in both SMIL and HTML: Event and Metainformation. Work is underway to define a single module that can be shared by both SMIL and HTML.

4 Multimedia Profiles

There are a range of possible profiles that may be built using SMIL modules. Four profiles are defined to inform the reader of how profiles may be constructed to solve particular problems:

- Lightweight Presentations Profile
- SMIL 1.0 Profile
- XHTML Presentations Profile
- Web Enhanced Media Profile

These example profiles are non-normative.

4.1 Lightweight Presentations Profile

The Lightweight Presentations Profile handles simple presentations, supporting timing of text content. The simplest version of this could be used to sequence stock quotes or headlines on constrained devices such as a palmtop device or a smart phone. This example profile might include the following SMIL modules:

- Animation Module

- Timing and Synchronization Module

This profile may be based on XHTML modules [XMOD] with the addition of Timing and Synchronization Module. Transitions might be accomplished using the Animation Module.

4.2 SMIL-Boston Profile

The SMIL-Boston Profile supports the timeline-centric multimedia features found in SMIL language. This profile might include the following SMIL modules:

- Animation Module
- Content Control Module
- Events Module
- Layout Module
- Linking Module
- Media Object Module
- Metainformation Module
- Structure Module
- Timing and Synchronization Module

4.3 XHTML Presentations Profile

The XHTML Presentations Profile integrates multimedia, XHTML layout, and CSS positioning. This profile might include the following SMIL modules:

- Animation Module
- Content Control Module
- Event Module
- Linking Module
- Media Object Module Level
- Timing and Synchronization Module Level

This profile would use XHTML modules for structure and layout and SMIL modules for multimedia and timing. The linking functionality may come from the XHTML modules [XMOD] or from the SMIL modules.

4.4 Web Enhanced Media Profile

The Web Enhanced Media Profile supports the integration of multimedia presentations with broadcast or on-demand streaming media. The primary media will often define the main timeline. This profile might include the following SMIL modules:

- Event Module
- Linking Module
- Media Object Module
- Timing and Synchronization Module

This profile is similar to the XHTML Presentations Profile with additional support to manage stream events and synchronization of the document's clock to the primary media.

5 Appendices

A Normative References

[SMIL] "Synchronized Multimedia Integration Language (SMIL) 1.0 Specification", P. Hoschka, 15 Jun 98. This is available at http://www.w3.org/TR/REC-smil.

[XLINK]

[XML] "Extensible Markup Language (XML) 1.0", T. Bray, J. Paoli, C. M. Sperberg-McQueen, 10 Feb 98. This is available at http://www.w3.org/TR/REC-xml.

[XPTR]

B Informative References

[HTML] "HTML 4.0 Specification", D. Raggett, A. Le Hors, I. Jacobs, 24 Apr 98. This is available at http://www.w3.org/TR/REC-html40.

[XHTML] "Extensible Markup Language (XHTML) 1.0 Specification"

[XMOD] "Modularization of XHTML Working Draft"

C Document Type Definitions

We will probably want to follow the HTML WG's lead on architecting module DTDs and the drivers for combining these DTDs automatically. We might want to consider our schedule in light of the XML Schema schedule.

D Document Object Model Bindings

The modules defined in this WD need to clearly align with the interfaces defined in the SMIL DOM WD and the existing DOM Level 1 and DOM Level 2 interfaces.

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C. SMIL Boston Animation

Previous version (W3C members only):

http://www.w3.org/AudioVideo/Group/Animation/symm-animation-990702.html

Editors:

Ken Day (Macromedia),
Patrick Schmitz (Microsoft),
Aaron Cohen (Intel)

Abstract

This is a working draft of a specification of animation functionality for XML documents. It is part of work in the Synchronized Multimedia Working Group (SYMM) towards a next version of the SMIL language and modules. It describes an animation framework as well as a set of base XML animation elements, included in SMIL and suitable for integration with other XML documents.

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1. Introduction

The first W3C Working Group on Synchronized Multimedia (SYMM) developed SMIL - Synchronized Multimedia Integration Language. This XML-based language is used to express synchronization relationships among media elements. SMIL 1.0 documents describe multimedia presentations that can be played in SMIL-conformant viewers.

SMIL 1.0 was focused primarily on linear presentations, and did not include support for animation. Other working groups (especially Graphics) are exploring animation support for things like vector graphics languages. As the timing model is at the heart of animation support, it is appropriate for the SYMM working group to define a framework for animation support, and to define a base set of widely applicable animation structures. This document describes that support.

Where SMIL 1.0 defined a document type and the associated semantics, the next version modularizes the functionality. The modularization facilitates integration with other languages, and the development of profiles suited to a wider variety of playback environments. See also "Synchronized Multimedia Modules based upon SMIL 1.0" (W3C members only). The Animation Module described herein is designed with the same goals in mind, and in particular to satisfy requirements such as those of the Graphics Working Group.

1.1 Overview of support

This document describes a framework for incorporating animation onto a time line and a mechanism for composing the effects of multiple animations. A set of basic animation elements are also described that can be applied to any XML-based language that supports a Document Object Model. A language in which this module is embedded is referred to as a *host language*.

Animation is inherently time-based. SMIL animation is defined in terms of the SMIL timing model, and is dependent upon the support described in the SMIL Timing and Synchronization Module. The capabilities are described by new elements with associated attributes and associated semantics, as well as the SMIL timing attributes. Animation is modeled as a local time line. An animation element is typically a child of the target element, the element that is to be animated.

While this document defines a base set of animation capabilities, it is assumed that host languages

will build upon the support to define additional and/or more specialized animation elements. In order to ensure a consistent model for document authors and runtime implementors, we introduce a framework for integrating animation with the SMIL timing model. Animation only manipulates attributes of the target elements, and so does not require any specific knowledge of the target element semantics.

An overview of the fundamentals of SMIL animation is given in Animation Framework. The syntax of the animation elements and attributes is specified in Animation Syntax. The semantics of animation is specified in Animation Semantics. The normative definition of syntax is entirely contained in Animation Syntax, and the normative definition of precise semantics is entirely contained in Animation Semantics. All other text in this specification is informative. In cases of conflicts, the normative form sections take precedence. Anyone having a detailed question should refer to the Animation Syntax and Animation Semantics, as appropriate.

1.2 Requirements

- Must integrate cleanly with the SMIL timing model [SMIL-TIME].
- The mechanisms defined should be generally applicable to XML-based languages which might wish to add animation. To that end, animation elements should be independent of the specific semantics of the objects being animated. If not, the elements should be widely applicable.
- It must sufficiently meet the needs of [SVG] that a separate animation module is not needed for that language.
- Serve as an adequate basis for transitions(@@ lower priority?)

2. Animation Framework

This section is informative. Readers who need to resolve detailed questions of syntax or semantics should refer to Animation Syntax and Animation Semantics, respectively, which are the only normative forms.

Animation is inherently time-based, changing the values of element attributes over time. The SYMM Working Group defines a generalized model for timing and synchronization that applies to SMIL documents, and is intended to be included in other XML-based host languages. While this document defines a base set of animation elements, it is assumed that other host languages will build upon the support to define additional and/or more specialized elements. In order to ensure a consistent model for both document authors and runtime implementors, we introduce a framework for integrating animation with the SMIL timing model.

[@@Ed: We intend that this section be a useful discussion of our central animation concepts, using simple examples. Feedback on its usefulness and clarity will be appreciated. In particular, the syntax elements used are not introduced prior to their use. It is hoped that the examples are sufficiently simple that an intuitive understanding of from/to/by will be sufficient. Details are in Section 3, Animation Syntax.]

@@@[Issue] This draft is written in terms of XML attribute animation. However, there is a need to

animate DOM attributes which are not exposed as XML attributes. This applies in particular to structured attributes. A mechanism for naming these attributes is needed.

2.1 Basic Animation

Animation is defined as a time-based manipulation of a target element (or more specifically of some *attribute* of the target element, the *target attribute*). The definition expresses a function, the *animation function*, of time from 0 to the simple duration of the animation element. The definition is evaluated as needed over time by the runtime engine, and the resulting values are applied to the target attribute. The functional representation of the animation's definition is independent of this model, and may be expressed as a sequence of discrete values, a keyframe based function, a spline function, etc. In all cases, the animation exposes this as a function of time.

For example, the following defines the linear animation of a bitmap. The bitmap appears at the top of the region, moves 100 pixels down over 10 seconds, and disappears.

```
<par>
   <img dur="10s" ...>
      <animate attribute="top" from="0" to="100" dur="10s"/>
   </img>
</par>
```

Animation has a very simple model for time. It just uses the animation element's local time line, with time varying from 0 to the duration. All other timing functions, including synchronization and time manipulations such as repeat, time scaling, etc. are provided (transparently) by the timing model. This makes it very simple to define animations, and properly modularizes the respective functionality.

Other features of the SMIL Timing and Synchronization module may be used to create more complex animations. For example, an accelerated straight-line motion can be created by applying an acceleration time filter to a straight-line, constant-velocity motion. There are many other examples.

2.2 Additive Animation

It is frequently useful to define animation as a change in an attribute's value. Motion, for example, is often best expressed as an increment, such as moving an image from it's initial position to a point 100 pixels down:

```
<par>
   <img dur="10s" ...>
      <animate attribute="top" by="100"
               dur="10s" additive="true"/>
   </img>
</par>
```

Many complex animations are best expressed as combinations of simpler animations. A corkscrew path, for example, can be described as a circular motion added to a straight-line motion. Or, as a simpler example, the example immediately above can be slowed to move only 40 pixels over the same period of time by inserting a second additive `<animate>` which by itself would animate 60 pixels the other direction:

```
<par>
   <img dur="10s" ...>
      <animate attribute="top" by="100"
               dur="10s" additive="true"/>
      <animate attribute="top" by="-60"
               dur="10s" additive="true"/>
   </img>
</par>
```

When there are multiple animations active for an element at a given moment, they are said to be *composed*, and the resulting animation is *composite*. The active animations are applied to the current underlying value of the target attribute in activation order (first begun is first applied), with later additive animations being applied to the result of the earlier-activated animations. When two animations start at the same moment, the first in lexical order is applied first.

A non-additive animation masks all animations which began before it, until the non-additive animation ends.

Numeric attributes generally can have additive animations applied, though it may not make sense for some. Types such as strings and booleans, for which addition is not defined, cannot.

As long as the host language defines addition of the target attribute type and the value of the animation function, additive animation is possible. For example, if the language defines date arithmetic, date attributes can have additive animations applied, perhaps as a number of days to be added to the date. Such attributes are said to *support composite animation*.

2.3 Cumulative Animation

The author may also select whether a repeating animation should repeat the original behavior for each iteration, or whether it should build upon the previous results, accumulating with each iteration. For example, a motion path that describes an arc can repeat by drawing the same arc over and over again, or it can begin each repeat iteration where the last left off, making the animated element bounce across the window. This is called *cumulative* animation.

Repeating our 100-pixel-move-down example, we can move 1,000 pixels in 100 seconds.

```
<par>
   <img dur="100s" ...>
      <animate dur="10s" repeat="indefinite" accumulate="true"
               attribute="top" by="100"/>
   </img>
</par>
```

This example can, of course, be coded as a single 100-second, 1000-pixel motion. With more complex paths, additive animation is much more valuable. For example, if one created a motion path for a single sine wave, a repeated sine wave animation could easily be created by cumulatively repeating the single wave.

Typically, authors expect cumulative animations to be additive (as in the example directly above), but this is not required. The following example is not additive. It starts at the absolute position given, 20.

It moves down by 10 pixels to 30, then repeats. It is cumulative, so the second iteration starts at 30 and moves down by another 10 to 40. Etc.

```
<par>
   <img dur="100s" ...>
      <animate dur="10s" repeat="indefinite"
               attribute="top" from="20" by="10"
               additive="false" accumulate="true"/>
   </img>
</par>
```

Cumulative animations are possible for any attribute which supports animation composition. When the animation is also additive, as composite animations typically are, they compose just as straight additive animations do (using the cumulative value).

2.4 Freezing Animations and Holding Values

When an animation element ends, its affect is normally removed from the target. For example, if an animation moves an image and the animation element ends, the image will jump back to its original position. For example:

```
<par>
   <img dur="20s" ...>
      <animate begin="5s" dur="10s" attribute="top" by="100"/>
   </img>
</par>
```

The image will appear stationary for 5 seconds (`begin="5s"` in the `<animate>`), then move 100 pixels down in 10 seconds (`dur="10s"`, `by="100"`). At the end of the movement the animation element ends, so it's effect ends and the image jumps back where it started (to the underlying value of the `top` attribute). The image lasts for 20 seconds, so it will remain back at the original position for 5 seconds then disappear.

The standard timing attribute `fill` can be used to maintain the value of the animation after the simple duration of the animation element ends:

```
<par>
   <img dur="20s" ...>
      <animate begin="5s" dur="10s" fill="freeze"
               attribute="top" by="100"/>
   </img>
</par>
```

The `<animate>` ends after 10 seconds, but `fill="freeze"` keeps its final effect active until it is ended by the ending of its parent element, the image.

However, it is frequently useful to define an animation as a sequence of additive steps, one building on the other. For example, the author might wish to move an image rapidly for 2 seconds, slowly for another 2, then rapidly for 1, ending 100 pixels down. It is natural to express this as a `<seq>`, but each element of a `<seq>` ends before the next begins.

The attribute `hold` keeps final effect applied until ended by target element itself, the image, ends:

```
<par>
   <img dur="100s" ...>
      <seq>
         <animate dur="2s" attribute="top" by="50" hold="true"/>
         <animate dur="2s" attribute="top" by="10" hold="true"/>
         <animate dur="1s" attribute="top" by="40" hold="true"/>
      </seq>
   </img>
</par>
```

The effect of the held animations are essentially attached to the target to achieve the desired result. In this example, it will have moved 50 pixels after 2 seconds and 60 after 4. At 5 seconds it will reach 100 pixels and stay there. Note that not only does each `<animate>` end before the image, but the `<seq>` containing the animation elements also ends (when the last `<animate>` ends). The effect of the held animations is retained until the image ends.

The difference between `hold="true"` and `fill="freeze"` is that `hold` causes the animation to "stick" to the target element until the target element ends, while the duration of the `fill` is determined by the parent of the animation element.

The above example is equivalent to both of the following examples, but easier to visualize and maintain:

```
<!-- Equivalent animation using a <seq> -->
<img dur="100s" ...>
   <seq>
      <animate dur="2s" attribute="top" by="50"/>
      <animate dur="2s" attribute="top" values="50 60"
               additive="true"/>
      <animate dur="1s" attribute="top" values="60 100"
               additive="true" fill="freeze"/>
   </seq>
</img>
<!-- Equivalent animation using a <par> -->
<img dur="100s" ...>
   <par>
      <animate dur="2s"
               attribute="top" by="50" fill="freeze"/>
      <animate begin="prev.end" dur="2s"
               attribute="top" by="10" fill="freeze"/>
      <animate begin="prev.end" dur="1s"
               attribute="top" by="40" fill="freeze"/>
   </par>
</img>
```

The trick here is that `fill="freeze"` causes the animation elements to last until the end of the `<seq>` or `<par>`, respectively, which in turn lasts until the image ends. With more complex paths,

the arithmetic would be impractical and difficult to maintain.

2.5 Nested Animation (?)

@@@Issue If animation elements were allowed to animate the parameters of other animation elements, certain use cases become very easy. For example, a dying oscillation could be created by placing an undamped oscillation animation, then animating the length of the oscillation's path (decreasing it over time). The SYMM WG is uncertain whether the complexity of this feature is worth its benefit.

2.6 Interaction with DOM Manipulations

@@@ Issue We need to define what it means to animate an attribute that has been changed by scripting or by another DOM client while the <animate> is active. This involves some implementation issues. Some alternatives: changing an attribute with script cancels the animation, changing an attribute simply changes the "initial state" of that attribute and the animation proceeds as if the attribute started out with that values.

2.7 Animation Elements as Independent Timelines

By default, the target of an animation element will be the closest ancestor for which the manipulated attribute is defined. However, the target may be any (@@@??) element in the `<body>` of the document, identified by its element id. [@@@Should be limited to elements which are known when the animation begins, or perhaps to those known when the animation is encountered in the text -- should be similar to other limitations on idrefs. Probably no forward references past the point in document loading at which playback starts.]

An animation element affects its target only if both are active at the same time. The calculation of the target attribute at a given moment in time uses the animation element's timeline (current position on its timeline and simple duration) to compute the new value of the animated attribute of the target.

For example, in the following animation the image repeatedly moves 100 pixels down, from 0 to 100, and jumps back to the top. The 10 second animation begins 5 seconds before the target element. So, the target appears at 50, moves down for 5 seconds to 100, jumps back to the top, and goes into a series of 10-second motions from 0 to 100.

```
<par>
   <img id="a"         begin="5s" .../>
   <animate target="a" begin="0s" dur="10s" repeat="indefinite"
                       attribute="top" from="0" to="100"/>
</par>
```

Note that in this example, the animation is running before the target exists, so it cannot be a child of the target. It must explicitly identify the target.

This is very useful for starting part of the way into spline-based paths, as splines are hard to split.

2.8 Limits on Animation

The definitions in this module could be used to animate any attribute. However, it is expected that host languages will constrain what elements and attributes animation may be applied to. For example, we do not expect that most host languages will support animation of the `src` attribute of a media element. A host language which included a DOM might limit animation to the attributes which may be modified through the DOM.

Any attribute of any element not specifically excluded from animation by the host language may be animated, as long as the underlying datatype supports discrete values (for discrete animation) or addition (for additive animation).

3. Animation Syntax

This section defines the XML animation elements and attributes. It is the normative form for syntax questions. See Animation Semantics for semantic definitions; all discussion of semantics in this section is informative.

3.1 Common Attributes

All animation elements use the common timing markup described in the SMIL Timing and Synchronization module. In addition, animation elements share attributes to control composition, and to describe the calculation mechanism.

Common attributes:

`additive`

Controls whether or not the animation is additive. Possible values are `"true"` and `"false"`. Default is `"false"`, unless another attribute is used which specifies otherwise. This attribute is ignored if the target attribute does not support addition.

`accumulate`

Controls whether or not the animation is cumulative. Possible values are `"true"` and `"false"`. Default is `"false"`. This attribute is ignored if the target attribute does not support addition.

`hold`

Controls whether or not the effect of the animation when the animation element ends is applied to the target attribute until the target element ends. Possible values are `"true"` and `"false"`. Default is `"false"`.

`attribute`

This attribute specifies the attribute to animate. This is the name of an XML attribute. Any constraints on attributes which may be animated must be specified in the definition of the host language.

`target` [@@@Issue: should we change this to "`element`"? Would that be clearer?]

This attribute specifies the element to be animated. The value is the XML identifier of the

target element. It defaults to the parent element if no id is specified. If the target does not support the named attribute, the animation element has no effect.

@@@Issue: The id mechanism is important to support timed sets of animations (e.g. sequences) that introduce parent nodes between the animated element and the animation behavior. Xpointer/Xpel syntax may be preferable (since it is a uniform mechanism already supported by future XML processors) than new attributes called target and attribute.

3.2 Animate Element

The **<animate>** element introduces a generic attribute animation that requires no semantic understanding of the attribute being animated. It can animate numeric scalars as well as numeric vectors. It can also animate discrete sets of non-numeric attributes.

attributes

`calcMode`

Specifies the interpolation mode for the animation. This can take any of the following values:

`"discrete"`

This specifies that the animation function will jump from one value to the next without any interpolation.

`"linear"`

Simple linear interpolation between values is used to calculate the animation function. Treated as `"discrete"` if the attribute does not support linear interpolation. This is the default `calcMode`.

`"spline"`

As for linear, interpolating from one value in the values list to the next by the the amount of time elapsed defined by a cubic Bezier spline. The knots of the spline must be specified in the `values` attribute. A values array must be specified. @@@[Issue] Syntax of values attribute to specify splines is TBD. Needs to cover both open & closed paths.

There are two ways to define the animation function, lists of values or from-to-by.

list of values specification of animation function

The basic form is to provide a list of values:

`values` attribute of the `<animate>` element:

A space-separated list of one or more values, compatible with the target attribute and interpolation mode, and agreeing with the value syntax of the host language. Vector-valued attributes are supported using the vector syntax of the host language. [@@@Issue, Patrick] Space separation may be a pain for some types of values. I would describe some explicit separator, and would add that parens around the values are legal, and ignored. In particular, consider a list of triplets for something like HSL or x,y,z values.

The `values` array and `calcMode` together define the animation function. For discrete animation, the duration is divided into even time periods, one per value. The animation function takes on the values in order, one value for each time period. For linear animation, the duration is divided into `n-1` even periods, and the animation function is a linear interpolation between the values at the associated times. Note that a linear animation will be a nicely closed loop if the first value is repeated as the last.

from/to/by specification of animation function

For convenience, the values for a simple discrete or linear animation may be specified using a from/to/by notation, replacing the `values` and `additive` attributes. `From` is optional in all cases. `To` or `by` (but not both) must be specified. If a `values` attribute or an `additive` attribute is specified, none of these three attributes may be specified. [@@@Issue] Need to specify behavior in error cases.

`from` attribute of the `<animate>` element:

> Optional. Specifies the starting value of the animation. If `from` is specified, its value must match the `to` or `by` type. If the from value is not specified, zero is used for additive animations.

`to` attribute of the `<animate>` element:

> Specifies the ending value of the animation. The argument value must match the attribute type. Specifies a non-additive animation with 2 elements in the values array, the value of the `from` attribute and the value of the `to` attribute. The `from` attribute defaults to the base value of the attribute for the animation when `to` is used.

`by` attribute of the `<animate>` element:

> Specifies a relative offset value for the animation. The host language must define addition of the `by` value to the target attribute, and the result must be compatible with the target attribute. Specifies an additive animation with two elements in the values array, `from` and `by`. The `from` attribute defaults to zero when `by` is used.

Animations expressed using from/to/by are equivalent to the same animation with `from` and `to` or `by` replaced by `values`. Examples of equivalent <animate> elements:

`from/to/by` form	**`values` form**
`<animate ... by="10"/>`	`<animate ... values="0 10" additive="true"/>`
`<animate ... from="5" by="10"/>`	`<animate ... values="5 15" additive="true"/>`
`<animate ... from="10" to="20"/>`	`<animate ... values="10 20" additive="false"/>`
`<animate ... to="10"/>`	`<animate ... values="`*b* `10" additive="false"/>`, where *b* is the base value for the animation.

3.3 Set Element

The **<set>** element is a convenience form of the <animate> element. It supports all attribute types, including those that cannot reasonably by interpolated, and that more sensibly support semantics of setting a value over the specified duration (e.g. strings and boolean values). The <set> element is non-additive. While this supports the general set of timing attributes, the effect of the "repeat" attribute is just to extend the defined duration. In addition, using "fill=freeze" will have largely the same effect as an indefinite duration.

<Set> takes the "attribute" and "target" attributes from the generic attribute list described above, as well as the following:

to

Specifies the value for the attribute during the duration of the <set> element. The original value of the attribute (before the animation started) is restored when the animation completes (i.e. ends). The argument value must match the attribute type. This can be used with any attribute, but it is primarily intended for use with String and Boolean attributes.

Formally, <set ... to=z .../> is defined as <animate ... calcMode="discrete" additive="false" values=z .../>.

3.4 Motion Animation

[@@@ Issue] The WG does not agree on the inclusion of this element in SMIL. This would be a very reasonable extension in other host languages, and there is value in a standardized motion animation element. We are interested in feedback from others who are defining potential host languages.

In order to abstract the notion of motion paths across a variety of layout mechanisms, we introduce the **<move>** element. This takes all the attributes of <animate> described above, as well as two additional attributes:

origin

Specifies the origin of motion for the animation. The default origin for an element is relative to the parent container, and is generally relative to the top left of the parent (although this depends upon the layout model in the document). However, it is often useful to place the origin at the position of the element as it is laid out. This allows for motion relative to the default layout position (e.g. from off screen left to the layout position, specified as from="(-100, 0)" and to="(0, 0)". This is especially useful for flow-layout models like HTML and CSS.

Legal values are:

parent

The origin is the top left of the parent layout container. This is the default.

layout

The origin is the default layout position of the element being animated, as set by the layout manager.

path

Specifies the curve that describes the attribute value as a function of time. @@@ The path

syntax is TBD. Should address the issue of mapping time to control points, so that control points need not be spaced evenly in time.

3.5 Color Animation

[@@@ Issue] SYMM WG would like there to be a standard animation tag for color, e.g. interpreted in the HSL space. However, some of the members do not see this as part of our charter. We are interested in feedback from others who are defining potential host languages.

The following is one such possible definition:

In order to abstract the notion of color animation, we introduce the **`<colorAnim>`** element. This takes all the generic attributes described above, supporting string values as well as RGB values for the individual argument values. The animation of the color is defined to be in HSL space. [@@@ need to explain why & interaction with RGB values -- examples. Might want rgb-space animation for improved performance when it's "good enough" for the author]. This element takes one additional attribute as well:

direction

This specifies the direction to run through the colors, relative to the standard color wheel. If the to and from are the same values and clockwise or cclockwise were specified, the animation will cycle full circle through the color wheel.

Legal values are:

clockwise

Animate colors between the from and to values in the clockwise direction on the color wheel. This is the default

cclockwise

Animate colors between the from and to values in the counter-clockwise direction on the color wheel.

nohue

Do not animate the hue, but only the saturation and level. This allows for simple saturation animations, ignoring the hue and ensuring that it does not cycle.

We may need to support extensions to the path specification to allow the direction to be specified between each pair of color values in a path specification. This would allow for more complex color animations specified as a path.

4. Animation Semantics

@@@ Need a section with precise mathematical definitions of animation semantics

5. Document Object Model Support

@@@Need DOM for animation elements.

Need to mention and point to DOM Core and SMIL DOM specs. May want to discuss issues which host languages must specify: Interaction between animation and DOM manipulations, the mechanism for determining property type, definition of addition. Animation of DOM attributes not exposed as XML attributes discussion may belong here.

Related section: Interaction with DOM Manipulations

6. References

@@@Ed: Need to review

[HTML]

"HTML 4.0 Specification", D. Raggett, A. Le Hors, I. Jacobs, 24 April 1998.

Available at http://www.w3.org/TR/REC-html40.

[SMIL]

"Synchronized Multimedia Integration Language (SMIL) 1.0 Specification W3C Recommendation 15-June-1998 ".

Available at: http://www.w3.org/TR/REC-smil.

[SMIL-DOM]

"SMIL Document Object Model", Nabil Layaïda, Patrick Schmitz, Jin Yu.

Available at http://www.w3.org/AudioVideo/Group/DOM/symm-dom (W3C members only).

[SMIL-MOD]

"Synchronized Multimedia Modules based upon SMIL 1.0", Patrick Schmitz, Ted Wugofski, Warner ten Kate.

Available at http://www.w3.org/TR/NOTE-SYMM-modules.

[SMIL-TIME]

... SMIL timing module, Patrick Schmitz, ...other editors.

Available at http://www.w3.org/@@@.

[SVG]

@@@ an appropriate public reference describing the activities of the Graphics WG and/or information about the SVG language.

Available at http://www.w3.org/@@@

[XML]

"Extensible Markup Language (XML) 1.0", T. Bray, J. Paoli, C.M. Sperberg-McQueen, editors, 10 February 1998.

Available at http://www.w3.org/TR/REC-xml

Appendix 1. Collected Issues to be resolved

In no particular order:

- There is a need to animate DOM attributes which are not exposed as XML attributes. This applies in particular to structured attributes. A mechanism for naming these attributes is needed.
- A number of sections and important details are missing:
  - Formal animation semantics
  - DOM for animation elements
  - DTD (In what document should it appear?)
  - Specification of error cases, such as invalid attribute combinations and type mismatches (Will appear in the normative sections)
  - Syntax of spline specification in values attribute
- The interaction of animation with DOM manipulations (e.g. scripting) needs to be defined.
- <move>: The SYMM WG does not agree on inclusion of this element. Also, it's origin attribute may be unnecessary, and the syntax of the path attribute is TBD.
- <colorAnim>: SYMM WG is not expert in this area, and is seeking guidance. We feel that a standard color animation tag which other host languages could include would be valuable.
- Denotation of target elements. XPtr within the doc? XPel? id="identifier"? This draft uses the latter form.
- Should nested animation (animation of the parameters of an animation) be supported? Can decaying repeated motion, such as a dying oscillation, be otherwise expressed?

H. The SMIL Linking Module

Previous version:

http://www.w3.org/AudioVideo/Group/Linking/extended-linking-19990623 (W3C member only)

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Table of Contents

1. Introduction

The SMIL linking module defines the user-initiated hyperlink elements that can be used in a SMIL document. It describes

- How other documents can use XPointer to link into SMIL documents
- How XPointer is used to reference document component referencing in certain attributes in SMIL
- How XLink is used for encoding hyperlinks

XPointer [XPTR] allows components of XML documents to be addressed in terms of their placement in the XML structure rather than on their unique identifiers. This allows referencing of any portion of an XML document without having to modify that document. Without XPointer, pointing within a document may require adding unique identifiers to it, or inserting specific elements into the document, such as a named anchor in HTML. XPointers are put within the fragment identifier part of a URI.

XLink (XML Linking Language) [XLINK] defines a set of generic attributes that can be used when defining linking elements in an XML-encoded language. Using these generic XLink attributes has the advantage that users find the same syntactic constructs with the same semantics in many XML-based languages, resulting in a faster learning curve. It also enables generic link processors to process the hyperlinking semantics in XLink documents without understanding the details of the DTD. For example, it allows users of a generic XML browser to follow SMIL links.

Both XLink and XPointer are subject to change. At the time of this document's writing, neither is a full W3C recommendation. This document is based on the public Working Drafts ([XLINK], [XPTR]). It will change when these two formats change.

2. XPointer Support

2.1 Linking into SMIL documents

SMIL 1.0 allowed authors to playing back a SMIL presentation at a particular element rather than at the beginning by using a URI with a fragment identifier, e.g. "doc#test", where "test" was the value of an element identifier in the SMIL document "doc". This meant that only elements with an "id" attribute could be the target of a link.

The SMIL Linking module defined in this specification allows using any element in a SMIL document as target of a link. SMIL software must fully support the use of XPointers for fragment identifiers in URIs pointing into SMIL documents.

Example:

The following URI selects the 4th par element of an element called "bar":

```
http://www.w3.org/foo.smil#id("bar").child(4,par)
```

Note that XPointer only allows navigating in the XML document tree, i.e. it does not actually understand the time structure of a SMIL document.

Error handling

When a link into a SMIL document contains an unresolvable XPointer ("dangling link") because it identifies an element that is not actually part of the document, SMIL software should ignore the XPointer, and start playback from the beginning of the document.

When a link into a SMIL document contains an XPointer which identifies an element that is the content of a "switch" element, SMIL software should interpret this link as going to the parent "switch" element instead. The result of the link traversal is thus to play the "switch" element child that passes the usual switch child selection process.

2.2 Use of Xpointer in SMIL attributes

The use of XPointer is not restricted to XLink attributes. Any attribute specifying a URI can use an XPointer (unless, of course, prohibited for that attributes document set).

XPointer can be used in various SMIL attributes which refer to XML components in the same SMIL document or in external XML documents. These include

- hyperlink attributes referring to link resource, through the "href" attribute, if the media object referenced in the link supports XPointer
- the media that get integrated into the presentation, through the "src"attribute, if the media object referenced in the link supports XPointer
- the temporal synchronization of one timeline component to another, through the "begin" and "end" attributes. This use assumes that the scope of synchronization is broadened to beyond just between siblings, as it is in SMIL 1.0. For example, the following selects the 2nd par element of an element called "intro":
  <audio src="foo.wav" begin="#id('intro').child(4,par)">

  (@@ whether to use Xpointer for "begin" and "end" needs to be decided in the timing module)

3. Link Elements

3.1 The a Element

The "a" element has the same syntax and semantics as the SMIL 1.0 "a" element. All SMIL 1.0 attributes can still be used. The following lists attributes that are newly introduced by this specification, and attributes that are extended with respect to SMIL 1.0:

actuate

The value of this XLink attribute is fixed to "user". This indicates that traversal of this link is triggered by an

external event, typically by user interaction.

behavior

This XLink attribute controls the temporal behavior of the presentation containing the link when the link is traversed. It can have the following values:

- "play": When the link is traversed, the presentation containing the link continues playing.
- "pause": When the link is traversed, the presentation containing the link pauses. When the display of the destination resource ends (@@ define what "end" means exactly: user closes display window (is this an end event ?) OR continuous media object ends), the originating presentation resumes playing.
- "stop": When the link is traversed, the presentation containing the link stops, i.e. it is reset to the beginning of the presentation. The termination of the destination resource will not cause the originating presentation to continue or restart.

The default value of the "behavior" attribute depends on the value of the "show" attribute.

href

This XLink attribute is equivalent to the SMIL 1.0 "href" attribute.

inline

The value of this attribute is fixed to "true" (since the content of the "a" element is the local resource of the link).

sourceVolume

This attribute sets the volume of audio media objects in the presentation containing the link when the link is followed. Ignored if the presentation does not contain audio media objects. This attribute can have the same values as the "volume" property in CSS2. [CSS2]

destinationVolume

This attribute sets the volume of audio media contained in the remote resource. Ignored if the remote resource does not contain audio media. This attribute can have the same values as the "localVolume" attribute.

destinationPlaystate

This attribute controls the temporal behavior of the resource identified by the href attribute when the link is followed. It only applies when this resource is a continuous media object. It can have the same values as the "behavior" attribute.

show

This XLink attribute specifies how to handle the current state of the presentation at the time in which the link is activated. The following values are allowed:

- "new": Semantics as defined in SMIL 1.0. In SMIL 1.0, the presentation containing the link continues playing when a link with show="new" is followed. As a refinement to SMIL 1.0, if both the presentation containing the link and the remote resource contain audio media, both are played in parallel.
  This specification allows authors to change the SMIL 1.0 behavior by setting the "behavior" attribute to a value other than "play". To model the SMIL 1.0 behavior, the default value of "behavior" is "play" when the "show" has the value "new".
- "pause": Semantics as defined in SMIL 1.0. Use of this value is deprecated in favor of the "behavior" attribute, since it is not a legal value for "show" in XLink, and thus will not be understood by generic XLink software.
  To achieve SMIL 1.0 behavior, the "show" attribute should be set to "new", and the "behavior" attribute should be set to "pause".
- "replace": Semantics as defined in SMIL 1.0. In SMIL 1.0, the presentation containing the link pauses when a link with show="replace" is followed.
  This specification allows authors to change the SMIL 1.0 behavior by setting the "behavior" attribute to a value other than "play". To model the SMIL 1.0 behavior, the default value of "behavior" is "pause" when the "show" has the value "replace".

The default value of "show" is "replace".

tabindex

This attribute provides the same functionality as the "tabindex" attribute in HTML 4.0 [HTML4]. It specifies the position of the element in the tabbing order for the current document. The tabbing order defines the order in which elements will receive focus when navigated by the user via the keyboard. At any particular point in time, only elements with an active timeline are taken into account for the tabbing order, and inactive elements that are are ignored for the tabbing order.

target

This attribute defines either in which existing display environment the link should be opened (e.g. a SMIL region, an HTML frame or another named window), or triggers opening a new display environment. Its value is the identifier of the display environment. If no currently active display environment has this identifier, a new display environment is opened and assigned the identifier of the target. When a presentation uses different types of display environments (e.g. SMIL regions and HTML frames), the namespace for identifiers is shared between these different types of display environments. For example, one cannot use a "target" attribute with the value "foo" twice in a document, and have it point once to an HTML frame, and then to a SMIL region. If the element has both a "show" attribute and a "target" attribute, the "show" attribute is ignored.
@@ linking into "excl" needs to be resolved

title

This XLink attribute provides human-readable text describing the link. It has the same significance as in SMIL 1.0. It is now also recognized as the XLink title attribute, whose semantics are consistent with that of the "title" attribute in SMIL 1.0.

xml:link

The value of this XLink attribute is fixed to "simple". This establishes the element as being an XLink simple link element. XLink processors will recognize this attribute assignment and know to process this element as an XLink simple link. Because the attribute is fixed in the DTD, it is not assigned in any SMIL document instance, and authors need not be aware of its use.

All XLink attributes not mentioned in the list above are not allowed in SMIL.

Element Content

No changes to SMIL 1.0.

3.2 The `area` Element

This element extends the syntax and semantics of the HTML 4.0 "area" element with constructs required for timing. The SMIL 1.0 "anchor" element is deprecated in favor of "area".

The "area" element can have the attributes listed below, with the same syntax and semantics as in HTML 4.0:

- id
- class
- style
- title
- lang
- dir
- onclick
- ondblclick
- onmousedown
- onmouseup
- onmouseover
- onmousemove
- onmouseout
- onkeypress
- onkeydown

- onkeyup
- shape
- coords
- href
- nohref
- alt
- accesskey
- onfocus
- onblur

The following lists attributes that are newly introduced by this specification, and attributes that are extended with respect to HTML 4.0:

actuate
: Defined in Section on "a" element.

begin
: Defined in "SMIL Timing and Synchronization" module.

behavior
: Defined in Section on "a" element.

inline
: The value of this attribute is fixed to "false" ("area" element are out-of-line links, since they do not element content, and thus do not have a local resource as defined by XLink).

dur
: Defined in "SMIL Timing and Synchronization" module.

end
: Defined in "SMIL Timing and Synchronization" module.

sourceVolume
: Defined in Section on "a" element.

destinationVolume
: Defined in Section on "a" element.

destinationPlaystate
: Defined in Section on "a" element.

show
: Defined in Section on "a" element.

tabindex
: Defined in Section on "a" element.

target
: Defined in Section on "a" element.

title
: Defined in Section on "a" element.

xml:link
: If the "anchor" element contains an "href" attribute, this attribute must be present, and set to "simple", if the "area" element should be interpreted as an XLink. It must not be present if there is no "href" attribute. (Explanation: SMIL uses "anchor" elements without href to e.g. allow jumping into a video. However, an "area" element without href is not an Xlink. The disadvantage is that in the case in which "anchor" is used to define a link, it will have to have an explicit xml:link attribute (see examples below)).

Element Content

An "area" elements can contain "seq" and "par" elements for scheduling other "area" elements over time.

seq

Defined in Timing module.
When used in the content of an "area" element, a "seq" element may only contain "seq" and "par" elements, and none of the other elements that can be used when a "seq" element is used outside of an "area" element.

par

Defined in Timing module.
When used in the content of an "area" element, a "par" element may only contain "seq" and "par" elements, and none of the other elements that can be used when a "par" element is used outside of an "area" element.

Examples

1) Decomposing a video into temporal segments

In the following example, the temporal structure of an interview in a newscast (camera shot on interviewer asking a question followed by shot on interviewed person answering) is exposed by fragmentation:

```
<smil>
  <body>
    <video src="video" title="Tom Cruise interview 1995" >
      <seq>
        <area dur="20s" title="first question" />
        <area dur="50s" title="first answer" />
      </seq>
    </video>
  </body>
</smil>
```

2) Associating links with spatial segments In the following example, the screen space taken up by a video clip is split into two sections. A different link is associated with each of these sections.

```
<smil>
  <body>
    <video src="video" title="Tom Cruise interview 1995" >
      <area shape="rect" coords="5,5,50,50"
              title="Journalist" href="http://www.cnn.com" xml:link="simple" />
      <area shape="rect" coords="5,60,50,50"
              title="Tom Cruise" href="http://www.brando.com" xml:link="simple" />
   </video>
  </body>
</smil>
```

3) Associating links with temporal segments

In the following example, the duration of a video clip is split into two sub-intervals. A different link is associated with each of these sub-intervals.

```
<smil>
  <body>
    <video src="video" title="Tom Cruise interview 1995" >
      <seq>
        <area dur="20s" title="first question"
              href="http://www.cnn.com" xml:link="simple" />
        <area dur="50s" title="first answer"
              href="http://www.brando.com" xml:link="simple" />
      </seq>
   </video>
  </body>
</smil>
```

References

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[XLINK]

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I. The SMIL Media Object Module

Previous version:

http://www.w3.org/AudioVideo/Group/Media/extended-media-object-19990713 (W3C members only)

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Table of Contents

1 Introduction

This Section defines the SMIL media object module. This module contains elements and attributes allowing to describe media objects. Since these elements and attributes are defined in a module, designers of other markup languages can reuse the SMIL media module when they need to include media objects into their language.

Changes with respect to the media object elements in SMIL 1.0 include changes required by basing SMIL on XLink [XLINK], and changes that provide additional functionality that was brought up as Requirements in the Working Group.

2 The `ref, animation, audio, img, video, text` and `textstream` elements

These elements can contain all attributes defined for media object elements in SMIL 1.0 with the changes described below, and the additional attributes described below.

2.1 Changes to SMIL 1.0 Attributes

clipBegin, clipEnd, clip-begin, clip-end

Using attribute names with hyphens such as "clip-begin" and "clip-end" is problematic when using a scripting language and the DOM to manipulate these attributes. Therefore, this specification adds the attribute names "clipBegin" and "clipEnd" as an equivalent alternative to the SMIL 1.0 "clip-begin" and "clip-end" attributes. The attribute names with hyphens are deprecated. Software supporting SMIL Boston must be able to handle all four attribute names, whereas software supporting only the SMIL media object module does not have to support the attribute names with hyphens. If an element contains both the old and the new version of a clipping attribute, the the attribute that occurs later in the text is ignored.

Example:

```
<audio src="radio.wav" clip-begin="5s" clipBegin="10s" />
```

The clip begins at second 5 of the audio, and not at second 10, since the "clipBegin" attribute is ignored.

The syntax of legal values for these attributes is defined by the following BNF:

```
Clip-value          ::= [ Metric ] "=" ( Clock-val | Smpte-val ) |
                        "name" "=" name-val
Metric              ::= Smpte-type | "npt"
Smpte-type          ::= "smpte" | "smpte-30-drop" | "smpte-25"
Smpte-val           ::= Hours ":" Minutes ":" Seconds
                        [ ":" Frames [ "." Subframes ]]
Hours               ::= Digit Digit
                    /* see XML 1.0 for a definition of ´Digit´*/
Minutes             ::= Digit Digit
Seconds             ::= Digit Digit
Frames              ::= Digit Digit
Subframes           ::= Digit Digit
name-val            ::= ([^<&"] | [^<&´])*
                    /* Derived from BNF rule [10] in [XML]
                       Whether single or double quotes are
                       allowed in a name value depends on which
                       type of quotes is used to quote the
                       clip attribute value */
```

This implies the following changes to the syntax defined in SMIL 1.0:

- If the attribute consists only of a clock value without further specification, it is assumed to be specified in normal play time, i.e. to have the metric "npt".
- A new metric called "name" can be used to define a clip using named time points in a media object, rather than using clock values or SMPTE values.
  Example: Assume that a recorded radio transmission consists of a sequence of songs, which are separated by announcements by a disk jockey. The audio format supports named time points, and the begin of each song or announcement with number X is named songX or djX respectively. To extract the first song using the "name" metric, the following audio media element can be used:

  ```
  <audio clipBegin="name=song1" clipEnd="name=dj1" />
  ```

Handling of new syntax in SMIL 1.0 software

Authors can use two approaches for writing SMIL Boston presentations that use the new clipping syntax and functionality ("name", default metric) defined in this specification, but can still can be handled by SMIL 1.0 software.

First, authors can use non-hyphenated versions of the new attributes that use the new functionality, and add SMIL 1.0 conformant clipping attributes later in the text.

Example:

```
<audio src="radio.wav" clipBegin="name=song1" clipEnd="name=moderator1"
       clip-begin="0s" clip-end="3:50" />
```

SMIL 1.0 players implementing the recommended extensibility rules of SMIL 1.0 [SMIL] will ignore the clip attributes using the new functionality, since they are not part of SMIL 1.0. SMIL Boston players, in contrast, will ignore the clip attributes using SMIL 1.0 syntax, since they occur later in the text.

The second approach is to use the following steps:

1. Add a "system-required" test attribute to media object elements using the new functionality. The value of the "system-required" attribute must be the URI of this specification, i.e. @@ http://www.w3.org/AudioVideo/Group/Media/extended-media-object19990707
2. Add an alternative version of the media object element that conforms to SMIL 1.0

3. Include these two elements in a "switch" element

Example:

```
<switch>
  <audio src="radio.wav" clipBegin="name=song1" clipEnd="name=moderator1"
   system-required=
     "@@http://www.w3.org/AudioVideo/Group/Media/extended-media-object19990707" />
  <audio src="radio.wav" clip-begin="0s" clip-end="3:50" />
</switch>
```

alt, longdesc

If the content of these attributes is read by a screen-reader, the presentation should be paused while the text is read out, and resumed afterwards.

New Accessibility Attributes

readIndex

This attribute specifies the position of the current element in the order in which `longdesc` and `alt` text are read out by a screen reader for the current document. This value must be a number between 0 and 32767. User agents should ignore leading zeros. The default value is 0.
Elements that contain `alt` or `longdesc` attributes are read by a screen reader according to the following rules:

- Those elements that assign a positive value to the readindex attribute are read out first. Navigation proceeds from the element with the lowest readindex value to the element with the highest value. Values need not be sequential nor must they begin with any particular value. Elements that have identical readindex values should be read out in the order they appear in the character stream of the document.
- Those elements that assign it a value of "0" read out in the order they appear in the character stream of the document.
- Elements in a switch statement and that have test-attributes which evaluate to "false" are not read out.

2.2 XLink Attributes

To make SMIL 1.0 media objects elements XLink-conformant, the attributes defined in the XLink specification are added as described below.

Note: Due to a limitation in the current XLink draft, only the "src" attribute is treated as an Xlink locator, the "longdesc" attribute is treated as non-XLink linking mechanism (as allowed in Section 8 of the XLink draft). See Appendix for an XLink-conformant equivalent of SMIL 1.0 elements that contain a "longdesc" attribute.

actuate

The value of this attribute is fixed to "auto", i.e. the link is followed automatically.

behavior

This attribute does not apply to simple-link media object elements

content-role

This attribute does not apply, since media object elements are not inline links.

content-title

This attribute does not apply, since media object elements are not inline links.

inline

Defined in Xlink specification.
The value of this attribute is fixed to "false". SMIL media object elements are out-of-line links, since they do not have any content, and thus do not have a local resource as defined by XLink.
@@ since this is also a "simple link", this seems to be a "one-ended" link as described in Section 4.2 of the XLink draft (description there is not very clear)

role

@@ could be used to describe the role of the remote resource, i.e. the value of the "src" attribute. Can't think of a

use case, so don't think this is needed

show

This attribute is defined in the Xlink specification. Its value is fixed to "embed". The media object behaves in the same way as SMIL 1.0 media objects, i.e. the media object is inserted into the presentation.

src

Equivalent to the SMIL 1.0 "src" attribute. Remapped via XLink attribute remapping onto the XLink "href" attribute.
Note: Attribute remapping is costly when the document does not contain a DTD definition, because in this case, FIXED attributes need to be included explicitly. This means the author has to use the following syntax to be XLink conformant:

```
<smil>
  <body>
    <audio src="audio.wav" xml:attributes="href src" />
  </body>
</smil>
```

title

Equivalent to SMIL 1.0 "title" attribute.

xml:link (required)

This attribute is required for an element to be an Xlink element. For simple media object elements, its value is fixed to "simple".
@@ same disadvantage for fixed attributes when DTD is missing as with "src" attribute.

2.3 SDP Attributes

When using SMIL in conjunction with the Real Time Transport Protocol (RTP, [RFC1889]), which is designed for real-time delivery of media streams, a media client is required to have initialization parameters in order to interpret the RTP data. These are typically described in the Session Description Protocol (SDP, [RFC2327]). This can be delivered in the DESCRIBE portion of the Real Time Streaming Protocol (RTSP, [RFC2326]), or can be delivered as a file via HTTP.

Since SMIL provides a media description language which often references SDP via RTSP and can also reference SDP files via HTTP, a very useful optimization can be realized by merging parameters typically delivered via SDP into the SMIL document. Since retrieving a SMIL document constitutes one round trip, and retrieving the SDP descriptions referenced in the SMIL document constitutes another round trip, merging the media description into the SMIL document itself can save a round trip in a typical media exchange. This round-trip savings can result in a noticeably faster start-up over a slow network link.

This applies particularly well to two primary usage scenarios:

- Pure multicast implementations. This is traditional IETF model where the SDP is sent via some other transport protocol such as SAP, HTTP, or via email.
- RTSP delivery. In this case, the primary value of the SDP description is in the description of media headers delivered in the RTSP DESCRIBE phase, and not in the transport specification. The transport information (such port number negotiation and multicast addresses) is handled in RTSP separately in the SETUP phase.

(see also "The rtpmap element" below)

SDP-related Attributes

port

This provides the RTP/RTCP port for a media object transferred via multicast. It is specified as a range, e.g., port="3456-3457" (this is different from "port" in SDP, where the second port is derived by an algorithm). Note: For transports based on UDP in IPv4, the value should be in the range 1024 to 65535 inclusive. For RTP compliance it should start with an even number. For applications where hierarchically encoded streams are being sent to a unicast address, this may be necessary to specify multiple port pairs. Thus, the range of this request may contain greater than two ports. This attribute is only interpreted if the media object is transferred via RTP and

without using RTSP.

rtpformat

This field has the same semantics as the "fmt list" sub-field in a SDP media description. It contains a list of media formats payload IDs. For audio and video, these will normally be a media payload type as defined in the RTP Audio/Video Profile (RFC 1890). When a list of payload formats is given, this implies that all of these formats may be used in the session, but the first of these formats is the default format for the session.For media payload types not explicitly defined as static types, the rtpmap element (defined below) may be used to provide a dynamic binding of media encoding to RTP payload type. The encoding names in the RTP AV Profile do not specify a complete set of parameters for decoding the audio encodings (in terms of clock rate and number of audio channels), and so they are not used directly in this field. Instead, the payload type number should be used to specify the format for static payload types and the payload type number along with additional encoding information should be used for dynamically allocated payload types. This attribute is only interpreted if the media object is transferred via RTP.

transport

This attribute has the same syntax and semantics as the "transport" sub-field in a SDP media description. It defines the transport protocol that is used to deliver the media streams. The standard value for this field is "RTP/AVP", but alternate values may be defined by IANA. RTP/AVP is the IETF's Realtime Transport Protocol using the Audio/Video profile carried over UDP. The complete definition of RTP/AVP can be found in [RFC1890]. Only applies if media object is transferred via RTP.
@@ this may be better to derive from the "src" parameter, which could optionally be rtp://___. This would mean that an RTP URL format would need to be defined.

Example

```
<audio src="rtsp://www.w3.org/test.rtp" port="49170-49171"
       transport="RTP/AVP" fmt-list="96,97,98" />
```

Element Content

Media object elements can contain the following elements:

anchor

Defined in Linking Module

par

Defined in Timing Module

rtpmap

Defined below

seq

Defined in Timing Module

3 The `rtpmap` element

If the media object is transferred using the RTP protocol, and uses a dynamic payload type, SDP requires the use of the "rtpmap" attribute field. In this specification, this is mapped onto the "rtpmap" element, which is contained in the content of the media object element. If the media object is not transferred using RTP, this element is ignored.

Attributes

payload

The value of this attribute is a payload format type number listed in the parent element's "rtpformat" attribute. This is used to map dynamic payload types onto definitions of specific encoding types and necessary parameters.

encoding

This attribute encodes parameters needed to decode the dynamic payload type. The attribute values have the following syntax:

```
encoding-val    ::= encoding-name "/" clock-rate "/" encoding-params
```

```
encoding-name   ::= name-val
clock-rate      ::= +Digit
encoding-params ::= ??
```

Legal values for "encoding-name" are payload names defined in [RFC1890], and RTP payload names registered as MIME types [draft-ietf-avt-rtp-mime-00].

For audio streams, "encoding parameters" may specify the number of audio channels. This parameter may be omitted if the number of channels is one provided no additional parameters are needed. For video streams, no encoding parameters are currently specified. Additional parameters may be defined in the future, but codec specific parameters should not be added, but defined as separate rtpmap attributes.

Element Content

"rtpmap" is an empty element

Example

```
<audio src="rtsp://www.w3.org/foo.rtp" port="49170"
       transport="RTP/AVP" fmt-list="96,97,98">
  <rtpmap payload="96" encoding="L8/8000" />
  <rtpmap payload="97" encoding="L16/8000" />
  <rtpmap payload="98" encoding="L16/11025/2" />
</audio>
```

4 Support for media player extensions

A media object referenced by a media object element is often rendered by software modules referred to as media players that are separate from the software module providing the synchronization between different media objects in a presentation (referred to as synchronization engine).

Media players generally support varying levels of control, depending on the constraints of the underlying renderer as well as media delivery, streaming etc. This specification defines 4 levels of support, allowing for increasingly tight integration, and broader functionality. The details of the interface will be presented in a separate document.

Level 0

Must allow the synchronization engine to query for duration, and must support cue, start and stop on the player. To support reasonable resynchronization, the media player must provide pause/unpause controls with minimal latency. This is the minimum level of support defined.

Level 1

In addition to all Level 0 support, the media player can detect when sync has been broken, so that a resynchronization event can be fired. A media player that cannot support Level 1 functionality is responsible to maintain proper synchronization in all circumstances, and has no remedy if it cannot (Level 1 support is recommended).

Level 2

In addition to all Level 1 support, the media player supports a tick() method for advancing the timeline in strict sync with the document timeline. This is generally appropriate to animation renderers that are not tightly bound to media delivery constraints.

Level 3

In addition to all Level 2 support, the media player also supports a query interface to provide information about its time-related capabilities. Capabilities include things like canRepeat, canPlayBackwards, canPlayVariable, canHold, etc. This is mostly for future extension of the timing functionality and for optimization of media playback/rendering.

References

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[SMIL]

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L. SMIL Timing and Synchronization

Previous version:

http://www.w3.org/AudioVideo/Group/Timing/smil-timing-990727.html (W3C members only)

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Abstract

This is a working draft specification of timing and synchronization functionality for SMIL and other XML documents that incorporate SMIL Timing and Synchronization. It is part of the work in the Synchronized Multimedia Working Group (SYMM) towards a next version of the SMIL language (SMIL Boston) and associated modules. This version extends the Timing and Synchronization support available in the SMIL 1.0 specification.

Table of Contents

1.0 Introduction

SMIL 1.0 solved fundamental media synchronization problems and defined a powerful way of choreographing multimedia content. SMIL Boston extends the timing and synchronization support, adding capabilities to the timing model and associated syntax. This section of the document specifies the Timing and Synchronization module.

There are two intended audiences for this module: implementers of SMIL Boston document viewers or authoring tools, and authors of other XML languages who wish to integrate timing and synchronization support.

In the process of extending SMIL 1.0 for modularization and use in other XML languages, some alternate syntaxes have been defined. If a document would otherwise be SMIL 1.0 compatible except for use of alternate syntax, the use of the SMIL 1.0 syntax is recommended so the document will be playable by SMIL 1.0 as well as later document players.

As this module is used in different profiles, the associated syntax requirements may vary. Differences in syntax should be minimized as much as is practical. The semantics of the timing model and of the associated markup must remain consistent across all profiles. Any document type that includes SMIL Boston Timing and Synchronization markup (either via a hybrid DTD or via namespace qualified extensions) must preserve the semantics of the model defined in this specification.

The specification of timing and synchronization is organized in the following way. Time model concepts are introduced first, followed by a normative description of the time model and time graph construction. Clarification is provided for aspects of the model that were insufficiently documented in SMIL 1.0. The associated SMIL-DOM interfaces are described next. Open issues and examples are separated into appendices for readability purposes.

2.0 Background and Concepts

There are several important terms and concepts that must be introduced to describe the time model. This section first describes general terms and then defines basic timing concepts used throughout the document. This section ends with a discussion of how the SMIL timing model is being extended to support not only scheduled but also interactive presentations.

Note that certain areas of the model are still under discussion. A future draft will more precisely define the complete model, and interactions among the new functionality.

2.1. General concepts

The following concepts are the basic terms used to describe the timing model.

2.1.1. Time Graph

A time graph is used to represent the temporal relations of elements in a document with SMIL timing. Nodes of the time graph represent elements in the document. Parent nodes can "contain" children, and children have a single parent. Siblings are elements that have a common parent. The links or "arcs" of the time graph represent synchronization relationships between the nodes of the graph.

Note that this definition is preliminary.

2.1.2. Descriptive Terms for Times

The time model description uses a set of adjectives to describe particular concepts of timing:

implicit

> This describes a time that is defined intrinsically by the element media (e.g. based upon the length of a movie), or by the time model semantics.

explicit

> This describes a time that has been specified by the author, using the SMIL syntax.

desired

This is a time that the author intended - it is generally the explicit time if there is one, or the implicit time if there is no explicit time.

effective

This is a time that is actually observed at document playback. It reflects both the constraints of the timing model as well as real-world issues such as media delivery.

2.1.3. Scheduled Timing

An element is considered to have scheduled timing if the element's start time is given relative to the begin or end of another element. A scheduled element can be inserted directly into the time graph.

2.1.4. Events and Interactive Timing

Begin and end times in SMIL Boston can be specified to be relative to events that are raised in the document playback environment. This supports declarative, interactive timing. *Interactive* in this sense includes user events such as mouse clicks, events raised by media players like a mediaComplete event, and events raised by the presentation engine itself such as an onPause event.

More information on the supported events and the underlying mechanism is described in the DOM section of this draft [SMIL-DOM].

2.1.5. Timebases

In scheduled timing, elements are timed relative to other elements. The timebase for an element *A* is the other element *B* to which element *A* is relative. More precisely, it is the begin or end of the other element. The timebase is not simply a scheduled point in time, but rather a point in the time graph.

Note that this definition is preliminary. The name may also change.

2.1.6. Sync Arcs

"Sync-arc" is an abbreviation for "synchronization arc". Sync-arcs are used to relate nodes in the time graph, and define the timing relationship between the nodes. A sync-arc relates an element to its timebase. The sync-arc may be defined implicitly by context, explicitly by id-ref or event name, or logically with special syntax.

Note that this definition is preliminary.

2.1.7. Clocks

A Clock is a particular timeline reference that can be used for synchronization. A common example that uses real-world local time is referred to as **wall-clock** timing (e.g. specifying 10:30 local time). Other clocks may also be supported by a given presentation environment.

2.1.8. Hyperlinking and Timing

A hyperlink into or within a timed document may cause a seek of the current presentation time or may activate an element (if it is not in violation of any timing model rules).

2.1.9. Activation

During playback, an element may be activated automatically by the progression of time, via a hyperlink, or in response to an event. When an element is activated, playback of the element begins.

2.1.10. Discrete and Continuous Media

SMIL includes support for declaring media, using element syntax defined in [SMIL-MEDIA]. The media that is described by these elements is described as either *discrete* or *continuous*:

discrete

The media does not have intrinsic timing, or intrinsic duration. These media are sometimes described as "rendered" or "synthetic" media. This includes images, text and some vector media.

continuous

The media is naturally time-based, and generally supports intrinsic timing and an intrinsic notion of duration (although the duration may be indefinite). These media are sometimes described as "time-based" or "played" media. This includes most audio, movies, and time-based animations.

2.2. Timing Concepts

2.2.1. Time Containers

Time containers group elements together in time. They define common, simple synchronization relationships among the grouped child elements. In addition, time containers constrain the time that children may be active. Several containers are defined, each with specific semantics and constraints on its children.

2.2.2. Content/Media Elements

SMIL timing and synchronization support ultimately controls a set of content or media elements. The content includes things like video and audio, images and vector graphics, as well as text or HTML content. SMIL documents use the SMIL media elements to reference this content. XML and HTML documents that integrate SMIL Boston functionality may use SMIL media elements and/or content described by the integrated language (e.g. paragraphs in HTML).

2.2.3. Basic Markup

All elements - content/media as well as time containers - support timing markup to describe a begin time and a duration, as well as the ability to play repeatedly. There are several ways to define the begin time. The semantics vary somewhat depending upon an element's time container.

2.2.4. Simple, Active and Complete Durations

The time model defines three concepts of duration for each element - simple, active and complete durations. These definitions are closely related to two other concepts: playing something repeatedly (generally called "repeat"), and applying a "fill" - a presentational modifier that effectively extends the ending state of an element (e.g. the last frame of a movie) to fill out time within the time container.

simple duration

This is the duration defined by the basic begin and duration markup. It does not include any of the effects of playing repeatedly, or of fill. The simple duration is defined by the explicit begin and duration, if one is specified. If the explicit times are not specified, the implicit duration of the element is used.

active duration

This is the duration during which the element plays normally. If no repeating behavior is specified, the active duration is the same as the simple duration. If the element is set to play repeatedly, the simple duration is repeated for the active duration, as defined by the repeat markup. The active duration does not include the effect of fill.

complete duration

This is the sum of the active duration and the duration of any fill. The fill may be specified explicitly, or defined implicitly by the time container. The duration of the fill is defined by the constraints of the time container.

The constraints of a parent time container may override the duration of its children. In particular, a child element may not play beyond the end of the time container.

The terms for these durations can be modified with the Descriptive Terms for Times, to further distinguish aspects of

the time graph.

2.2.5 Time Manipulations

Time manipulations allow the element's time (within the simple duration) to be filtered or modified. For example the speed of time can be varied to make the element play faster or slower than normal. The filtered time affects all descendents of the element. Several time manipulations are proposed for SMIL Boston. Time manipulation is primarily intended to be used with animation (W3C members only).

Note that any time manipulation that changes the effective play speed of an element's time may conflict with the basic capabilities of some media players. The use of these manipulations is not recommended with linear media players, or with time containers that contain linear media elements, such as streaming video.

There are a number of unresolved issues with this kind of time manipulation, including issues related to event-based timing and negative play speeds, as well as many media-related issues.

2.2.6. Determinate and Indeterminate Schedules

Using simple, scheduled timing, a time graph can be described in which all the times have a known, defined sync relationship to the document timeline. We describe this as *determinate* timing.

When timing is specified relative to events or external clocks, the sync relationship is not initially defined. We describe this as *indeterminate* timing.

A time is *resolved* when the sync relationship is defined, and the time can actually be scheduled on the document time graph.

Indeterminate times that are event-based are resolved when the associated event occurs at runtime - this is described more completely below. Indeterminate times that are defined relative to external clocks are usually resolved when the document playback begins, and the relationship of the document timeline to the external clock reference is defined.

A determinate time may initially be unresolved, e.g. if it is relative to an unknown end such as the end of a streaming MPEG movie (the duration of an MPEG movie is not known until the entire file is downloaded). When the movie finishes, determinate times defined relative to the end of the movie are resolved.

2.2.7. Hard and Soft Sync

SMIL 1.0 introduced the notion of synchronization behavior, describing user agent behavior as implementing either "hard synchronization" or "soft synchronization". Using hard sync, the entire presentation would be constrained to the strict description of sync relationships in the time graph. Soft sync allowed for a looser (implementation dependent) performance of the document.

While a document is playing, network congestion and other factors will sometimes interfere with normal playback of media. In a SMIL 1.0 hard sync environment, this will affect the behavior of the entire document. In order to provide greater control to authors, SMIL Boston extends the hard and soft sync model to individual elements. This support allows authors to define which elements and time containers must remain in strict or "hard" sync, and which elements and time containers can have a "soft" or slip sync relationship to the parent time container.

2.3. Unifying Scheduling and Interactive Timing

A significant motivation for SMIL Boston is the desire to integrate declarative, determinate scheduling with interactive, indeterminate scheduling. The goal is to provide a common, consistent model and a simple syntax.

Note that "interactive" content does not refer simply to hypermedia with support for linking between documents, but specifically to content within a presentation (i.e. a document) that is *activated* by some interactive mechanism (often user-input events, but including local hyperlinking as well).

Background

SMIL Boston represents an evolution from earlier multimedia runtimes. These were typically either pure, static schedulers or pure event-based systems. Scheduler models present a linear timeline that integrates both discrete and continuous media. Scheduler models tend to be good for storytelling, but have limited support for user-interaction. Event-based systems, on the other hand, model multimedia as a graph of event bindings. Event-based systems provide flexible support for user-interaction, but generally have poor scheduling facilities; they are best applied to highly interactive and experiential multimedia.

The SMIL 1.0 model is primarily a scheduling model, but with some flexibility to support continuous media with unknown duration. User interaction is supported in the form of timed hyperlinking semantics, but there was no support for activating individual elements via interaction.

Modeling interactive, event-based content in SMIL

To integrate interactive content into SMIL timing, the SMIL 1.0 scheduler model is extended to support several new concepts: *indeterminate timing* and *event-activation*.

With *indeterminate timing*, an element is described as a child of a time container, but with an undefined begin or end time. The element still exists within the constraints of the time container, but the begin or end time is determined by some external activation (such as a user-input event). From a scheduling perspective, the time can be thought of as *unresolved*.

The event-activation support provides a means of associating an event with the begin or end time for an element. When the event is raised (e.g. when the user clicks on something), the associated time is *resolved* to a *determinate* time. For event-based begin times, the element becomes active (begins to play) at the time that the event is raised. The element plays from the beginning of the media (subject to any explicit clipBegin). For event-based end times, the element becomes inactive (stops playing) when the associated event is raised.

The constraints imposed on an element by its time container are an important aspect of the event-activation model. In particular, when a time container is itself inactive (e.g. before it begins or after it ends), no events are passed to the children. No event-activation takes place unless the time container of an element is active. For example:

```
<par begin="10s" end="15s">
   <audio src="song1.au" beginEvent="btn1.onClick" />
</par>
```

If the user clicks on the "btn1" element before 10 seconds, or after 15 seconds, the audio element will not play. In addition, if the audio element begins but would extend beyond the specified end of the <par> container, it is effectively cut off by the end of the <par> container. Finally, an endEvent cannot happen until an element has already begun (any specified endEvent is ignored before the element begins).

Related to event-activation is *link-activation*. Hyperlinking has defined semantics in SMIL 1.0, and when combined with indeterminate timing, yields a variant on interactive content. In particular, hyperlinking is not constrained by the time container as event-activation is. This is because a hyperlink will seek the document timeline as needed to ensure that the time container is active.

3.0 Language Definition

SMIL 1.0 defines the model for timing, including markup to define element timing, and elements to define parallel and sequence time containers. This version introduces some syntax variations and additional functionality, including:

- A new time container for hypermedia interactions
- Additional control over the repeat behavior
- A syntax for indeterminate (event-based) timing
- Change in constraints on sync-arcs
- An alternative syntax for specifying sync arcs
- A means of specifying a logical time-base relationship

- Support for wall-clock timing
- Support for time manipulations

The complete syntax is described here, including syntax that is unchanged from SMIL 1.0.

3.1 Time Container

SMIL Boston specifies three time containers: <par>, <seq>, and <excl>.

3.1.1. par

`<par>`

A <par> container defines a simple parallel time grouping in which multiple elements can play back at the same time. The timebase of the child elements of the <par> are the same as the timebase of the <par>. This is the same element introduced with SMIL 1.0.

The <par> element supports all element timing.

3.1.2 seq

`<seq>`

A <seq> container defines a sequence of elements in which elements play one after the other. This is the same element introduced with SMIL 1.0, but the semantics (and allowed syntax) for child elements of a <seq> are clarified. The timebase of a child element is the end of the previous element. The timebase of the first child of the <seq> element is the timebase of the <seq> itself. Child elements may define an offset from the timebase, but may not define a different timebase (i.e. they may not define a begin time relative to another element, or to an event). Child elements may define a duration or end time, but may not define an end relative to another timebase (i.e. they may not end relative to any element). Child elements *may* define an endEvent.

Reviewers - Note the proposed semantics above that constrain the child elements of a seq to not use timebase specification. This simplifies the model for seq. This proposal is still under discussion.

The <seq> element supports all element timing.

3.1.3 excl

The new time container, <excl>, is defined here. A normative description is given first, followed by an informative discussion of the container's behavior.

`<excl>`

This defines a time container with semantics based upon par, but with the additional constraint that only one child element may play at a time. If any element begins playing while another is already playing, the element that was playing is stopped.

The default timebase of the child elements of the <excl> is indeterminate (i.e. equivalent to beginEvent="none").

A common request from SMIL 1.0 authors is the ability to play optional content without loading a new SMIL presentation. It should be possible to add or replace content without disrupting playback of the main presentation. The optional content should be allowed to be arbitrarily-complex, i.e., multiple, synchronized media elements. Examples of this are a hypermedia presentation with access to optional, more detailed information and a navigation bar or table of contents that provides for the selection of multiple content sections.

SMIL 1.0 does not allow optional content to be defined nor does it permit playback of a subsection of a presentation in isolation. All content defined in a SMIL 1.0 document is played back unless the current presentation is stopped or replaced with a different presentation. To simulate the above use cases, the author would have to hyperlink to another SMIL document containing the shared parts of the presentation plus the new content.

Interactive, event based timing allows authors to define optional content that can be shown in response to user (or other)

events. The new <excl> time container makes use of this support, and supports the semantic that only one child is active at a given time. Thus, several playback options can be collected into an <excl>, instead of being placed in separate documents. In the following example, only the button graphics are shown initially. When the user clicks on one of the buttons, only then is the selection played. If the user selects "TopStory" then selects "Weather", "TopStory" is stopped and "Weather" is played. If nothing is selected, the optional content is never played.

```
<par>
    <excl>
        <par id="TopStory">
            <video src="video1.mpg" .../>
            <text src="captions.html" .../>
        </par>
        <par id="Weather">
            <img src="weather.jpg" .../>
            <audio src="weather_rpt.mp3" .../>
        </par>
    </excl>

    <a href="#TopStory">
        <img src="button1.jpg"  .../>
    </a>
    <a href="#Weather">
        <img src="button2.jpg"  .../>
    </a>
</par>
```

Because the optional content is played back within the context of the presentation, the same layout regions can be reused by the children of the <excl> container.

Children of the <excl> can be activated by hyperlinks or by events. When using events, the <excl> time container must be active for child elements of the <excl> to be activated by an event. When using hyperlinks, if the <excl> is not active, a seek will occur to the begin time of the <excl> and the children of the element will be activated. If the <excl> is currently active when the hyperlink is selected, a seek does not occur and playback of the child element begins. Playback of other active elements outside the scope of the `<excl>` is unaffected.

In the example above, an external link to the "Weather" child of the <excl> would activate the <par> containing the <excl>, as well as the target of the hyperlink. The two images would display, and weather.jpg and weather_rpt.mp3 would play back in parallel.

A pause functionality has been proposed as an option on exclusive time containers. With this, instead of stopping an element when another begins, the first element would be paused while the new element plays. When the new element completes, the previously playing element would resume. Open issues are:

- On what element do we model the pause? One option is the link, another option is the <excl> element, and a third option is the <excl> element children.
- Does pausing stack?
- The main example for pausing seems to be commercial breaks. It may be easier to handle this through another means, for instance by having a default item in the <excl>. The default child will start playing when the <excl> begins, activation of another child will pause the default child, and when the activated child ends, the default child will resume playback.

3.1.4 endSync

`endSync`

> endSync is only valid for the <par> and <excl> time containers. It controls the end of these containers, as a function of the children. This is particularly useful with children that have "unknown" duration, e.g. an mpeg movie, that must be played through to determine the duration.

Legal values for the attribute are:

`first`

The <par> ends with the earliest end of all the child elements. This does not refer to the lexical first child, or to the first child to start, but rather refers to the first child to end. This value has no effect when used with <excl>.

`last`

The <par> ends with the last end of all the child elements. This does not refer to the lexical last child, or to the last child to start, but rather refers to the last child to end.

The end of the <excl> container occurs when no more child elements are playing. Used with the stacking pause, this means that at the point when no element is playing, the <excl> time container is defined to end.

`id-ref`

The <par> or <excl> ends with the specified child. The id must correspond to one of the immediate children of the <par> time container. Example: `<par ... endSync="id(movie1)" ...>`

3.1.5. Time Container duration

The implicit duration of a time container is defined in terms of the children of the container. The children can be thought of as the "media" that is "played" by the time container element. The semantics are specific to each of the defined time container variants.

Implicit duration of <par> containers

By default, a <par> will play until all the contained children have completed. More formally, the implicit duration of a <par> element is defined by the maximum *extent* of the children. The *extent* of an element is the sum of any begin offset and the active duration. The begin offset is the computed offset relative to the begin of the <par> container (this may be different from the delay value, if the timebase for a child is not the par container).

If any child of a <par>is defined with an indefinite active duration (e.g. it repeats indefinitely), then the default duration of the <par> container is also indefinite. If any child of a par container has an interactive (event-based) begin or end, the default duration of the <par> container is indefinite. Reviewers: This entire paragraph is under scrutiny for compliance with SMIL 1.0.

The duration of a <par> container can also be controlled using the endSync attribute. The end of the <par> can be tied to the end of a particular child element, or to the end of the first child that finishes, or to the end of the last child to finish (which corresponds to the default behavior using maximum extent). Reviewers: What if the referenced child has an indefinite duration?

Implicit duration of <seq> containers

By default, a <seq> will play until the desired end of the last child of the <seq>. If any child of a sequence has an indefinite desired end and the child refers to continuous media, the implicit end of the sequence is also indefinite.

Implicit duration of <excl> containers

The implicit duration of an <excl> container is defined much the same as for a <par> container. Since the default timing for children is interactive, the typical case will define an indefinite implicit duration for <excl>. This is consistent with the common use-cases for interaction having open-ended durations.

3.1.6. Time Container constraints on child durations

A child element is subject to the overriding begin and end constraints of the parent time container. No element can begin before the parent time container begins. No element can remain active past the end of the simple duration of the

parent time container (although it may be active in each repeat iteration of a parent time container).

3.1.7. Time Container constraints on sync-arcs and events

Probably need to define "active" and "inactive" more formally.

We need a few good examples to illustrate these concepts.

SMIL 1.0 defined constraints on sync-arc definition (e.g., begin="id(image1)(begin)"), allowing references only to qualified siblings. SMIL Boston explicitly removes this constraint. SMIL Boston also adds event-based timing. Both sync-arcs and event-timing are constrained by the parent time container of the associated element as described above.

Specifics for sync-arcs

While a sync-arc is explicitly defined relative to a particular element, if this element is not a sibling element, then the sync is resolved as a sync-relationship *to the parent*. If the defined sync would place the element effective begin before the parent time container begin, part of the element will simply be cut off when it first plays. This is not unlike the behavior obtained using clipBegin. However unlike with clipBegin, if the sync-arc defined child element also has repeat specified, only the first iteration will be cut off, and subsequent repeat iterations will play normally.

Note that in particular, an element defined with a sync-arc begin will not automatically force the parent or any ancestor time container to begin.

For the case that an element with a sync-arc is in a parent (or ancestor) time container that repeats: for each iteration of the parent or ancestor, the element is played as though it were the first time the parent timeline was playing. This may require a reset of some sort in the implementation to ensure that the sync relationship to the parent time container is recalculated.

Specifics for event-based timing

The parent time container must be active for the child element to receive events.

3.1.8 Negative Begin delays

A negative begin (delay) value defines a clipBegin for the first -- and only the first -- iteration of a repeated element. Without specifying a repeat attribute, a negative begin value and clipBegin are synonymous.

3.2. Shared Timing support

This section defines the set of timing attributes that are common to all of the SMIL synchronization elements.

3.2.1. Basics - begin, end, dur

`begin`

Defines when the element should begin or become active. The begin time is relative to the timebase of the element.

The attribute value can be either of:

delay-value

Describes an offset from the timebase. The offset is measured in local time on the parent time container. Legal values are signed clock values.

timebase-value : "id(" id-ref ")" ("(begin)" | "(end)")? (signed-clock-val)?

Describes a timebase and an offset from the timebase. The offset is measured in local time on the timebase element.

The syntax follows the XPointer syntax, using "id()" to specify an element, followed by an optional

time-point ("begin" or "end"), and/or an optional offset value.
If no time-point is specified, "begin" is assumed.
If no offset value is specified, "0" as assumed.
This is renamed from "event-value" to disambiguate from event timing which has a more general connotation.
Note that the syntax is extended to support offsets from either begin or end, and to support signed offsets.

wall-clock

The syntax for a wall-clock reference will likely follow ISO 8601, and might look like:
`"wallClock(15:45)"`

This defines the start time to be 3:45 in the afternoon, in local time.

logical-timebase-value: "(prev)" ("(begin)" | "(end)") (signed-clock-val)?

Describes a logical timebase and an offset from the timebase. The offset is measured in local time on the timebase element.

The timebase is the lexical predecessor within the parent time container. If there is no predecessor, the parent begin is used as a timebase.
If no offset value is specified, "0" as assumed.

end

This defines the end time for the simple duration of the element. The specified time is relative to the timebase of the element.

The attribute value can be either of:

delay-value

Describes an offset from the timebase. The offset is measured in local time on the parent time container. Legal values are signed clock values. Note that this is signed, to end before another element ends.

timebase-value : "id(" id-ref ")" ("(begin)" | "(end)")? (signed-clock-val)?

Describes a timebase and an offset from the timebase. The offset is measured in local time on the timebase element.

The syntax follows the XPointer syntax, using "id()" to specify an element, followed by an optional time-point ("begin" or "end"), and/or an optional offset value.
If no time-point is specified, "begin" is assumed.
If no offset value is specified, "0" as assumed.
This is renamed from "event-value" to disambiguate from event timing which has a more general connotation.
Note that the syntax is extended to support offsets from either begin or end, and to support signed offsets.

wall-clock

The syntax for a wall-clock reference will likely follow ISO 8601, and might look like:
`"wallClock(15:45)"`

This defines the start time to be 3:45 in the afternoon, in local time.

logical-timebase-value: "(prev)" ("(begin)" | "(end)") (signed-clock-val)?

Describes a logical timebase and an offset from the timebase. The offset is measured in local time on the timebase element.

The timebase is the lexical predecessor within the parent time container. If there is no predecessor, the parent begin is used as a timebase.
If no offset value is specified, "0" as assumed.

If the end specifies a time that is before the effective begin time of the element, the end specification is ignored.

Only one of dur and end should be specified. If both are specified (and are otherwise legal), the simple duration is defined to be the minimum of the specified end, and the time computed from the desired begin and dur.

`dur`

This defines the simple duration for the element. It is an offset from the begin time of the element.

Only one of dur and end should be specified. If both are specified (and are otherwise legal), the simple duration is defined to be the minimum of the specified end, and the time computed from the desired begin and dur.
Legal values are clock values greater than 0.

For continuous media, the implicit duration is typically a function of the media itself - e.g. video and audio files have a defined duration. For all discrete media, the implicit duration is defined to be 0. Note the related example.

If the author specifies an explicit duration (using either `end` or `dur`) that is *longer* than the intrinsic duration for a continuous media element, the ending state of the media (e.g. the last frame of video) will be shown for the remainder of the explicit duration. This only applies to visual media - aural media will simply stop playing. See also the discussion of the `fill` attribute, below.

3.2.1.1 Alternative begin/end syntax

An alternative syntax has been proposed for sync-arc specification. This is under review. In particular, the names are under discussion, as some feel that they imply constraint-based behavior.

`beginWith`

Defines the timebase to be the start of the referenced element. This supports relative timing between elements. The current element will begin at the same time as the referenced element (plus or minus any offset value).

There are problems with separating the begin offset from the timebase. It is good because it more closely matches the SMIL-DOM that will be exposed, but it is bad because it requires two attributes. We will also consider a syntax that specifies the offset after the ID: beginWith="video1+5s".
Legal values are element IDs within the current document. We could also move this over to the XPointer syntax.
No more than one of beginWith, beginAfter or beginEvent should be specified.

`beginAfter`

Defines the timebase to be the end of the referenced element. This supports relative sequential timing between elements. The current element will begin when the referenced element ends (plus or minus any offset value). If the referenced timebase element does not have a specified determinate duration (e.g. is active indefinitely or has an event-timed end), the current element may never be active/displayed (although this is not an error).

Legal values are element IDs within the current document. We could also move this over to the XPointer syntax.
No more than one of beginWith, beginAfter or beginEvent should be specified.

`endWith`

Defines the end of the **active** duration to be the end of the referenced element. This supports end-point sync between elements. The current element active duration will end at the same time that the referenced element active duration ends (plus or minus any end offset).

Legal values are element IDs within the current document. We could also move this over to the XPointer syntax. This should be defined to end the repeat, and not the simple duration (as for endEvent below). Ending with another element and then repeating seems less than useful. An open issue is whether the timebase is the simple end or the active end of the referenced element.

3.2.2. Interactive, Event-based Timing

Elements can be specified to begin and/or end in response to an event. The event is specified with a new attribute, to clearly distinguish the form of timing being used. In this example, the audio element begins when the event is received (in this case, when the element "btn1" is clicked by the user):

```
<audio src="song1.au" beginEvent="btn1.onClick" />
```

It is possible to combine scheduled and interactive timing, e.g.:

```
<par dur="30s">
   <img id="mutebutton" src="mute.jpg"/>
   <text  src="description.html" />
   <audio src="audio.wav" endEvent="mutebutton.onClick"/>
</par>
```

The image and the text appear for the specified duration of the <par> (30 seconds). The audio will stop early if the image is clicked; otherwise it will play normally. Note that if the audio is stopped, the <par> still appears until the specified duration completes.

While an element can only have one defined begin (e.g. a defined time, or a beginEvent), it is possible to define both a determinate end or duration, as well as an endEvent. This facilitates what are sometimes called "lazy interaction" use-cases, such as a slideshow that will advance on its own, or in response to user clicks:

```
<seq>
   <img src="slide1.jpg" dur="10s" endEvent="onClick" />
   <img src="slide2.jpg" dur="10s" endEvent="onClick" />
   <img src="slide3.jpg" dur="10s" endEvent="onClick" />
   <!-- etc., etc. -->
</seq>
```

In this case, the end of each element is defined to be the earlier of the specified duration, or a click on the element. This lets the viewer sit back and watch, or advance the slides at a faster pace.

If an event-timed element has begun and then receives a second begin event before it completes, it can either ignore the second event or restart, as though it had not received the first event. This behavior is controlled with the eventRestart attribute. Note that if an event timed element receives an event and then completes its duration, it can be restarted by another event (independent of eventRestart). This came up in many user scenarios where authors tied an element beginEvent to a button, but did not want to restart (e.g. music) on every click. It is particularly useful when the beginEvent is mouseOver, which has a tendency to fire continuously...

The specific syntax used is still under review. Current proposals are:

- beginEvent and endEvent. These help mark the timing as event-based, to distinguish interactive from scheduled timing. This approach has the potential disadvantage that it introduces new attributes. This approach requires specific rules for combining the sematics of begin/beginEvent and end/endEvent.

  begin=id(element)(event-name) and end=id(element)(event-name). These build upon the SMIL 1.0 syntax. This approach maintains a smaller set of attributes, but may define a more complex syntax for these attributes. In addition, there is a conflict with the semantics of end and the semantics of endEvent described below. The end attribute controls the simple duration, and the endEvent attribute controls the active duration.

The following attributes have been proposed to describe event-based (interactive) timing constructs.

`beginEvent`

Defines the timebase to be the referenced event. The current element will begin when the referenced event is raised (plus or minus any delay value). If the referenced event is never raised, the current element may never be activated.

More than one event may be specified. The element will begin when the first event among the set is raised.

If the argument value is "none", this element will simply wait to be turned on (e.g. by script or a local hyperlink). Only one timebase may be specified for the begin of a given element (i.e. beginEvent cannot be combined with begin). If more than one timebase is specified, only the (lexical) first specification is used; all others are ignored.
Legal values are:

event-base-value-list : event-base-value (";" event-base-value-list)?

A semi-colon separated list of event base values.

event-base-value : ("id(" id-ref ")")? (event-ref) (signed-clock-val)?

Any defined event name, referenced by the associated element ID.

E.g. beginEvent="id(button1)(onclick)(3s)".
Note that if the id-ref is omitted, the current element is assumed.
The delay value may be omitted; it defaults to 0.
An alternative syntax would follow ECMAScript conventions:
[id-ref "."]? event-ref ["+"|"-" clock-val]?
E.g. beginEvent="button1.onclick+3s"

"none"

The string "none".

`endEvent`

Defines the end of the ***active*** duration to be relative to the referenced event. The active duration of the current element will end when the referenced event is raised (plus any delay value). If the referenced event is never raised, the current element may remain active indefinitely (subject to time container constraints).

Note that negative delay values may not be used.
More than one event may be specified. The element will end when the first event among the set is raised.
This attribute may be combined with a scheduled specification for the element end and/or a repeat specification. If a finite active duration is defined for the element (with the end or dur attributes and/or repeatCount/repeatDur), the element will end at the earlier of the scheduled duration or the endEvent time. This allows authors to specify an interactive end, but with a maximum active duration.
If the named event is "none", and no end time has been specified this element will simply wait to be turned off (e.g. by script or hyperlinking).
Legal values include:

event-base-value-list : event-base-value (";" event-base-value-list)?

A semi-colon separated list of event base values.

event-base-value : ("id(" id-ref ")")? (event-ref) (clock-val)?

Any defined event name, referenced by the associated element ID.

E.g.endEvent="id(button1)(onclick)(3s)".
Note that if the id-ref is omitted, the current element is assumed.
The delay value may be omitted; it defaults to 0.
endEvent uses the same arg-value name as beginEvent, but endEvent does not allow signed clock values. We need to clean this up.
An alternative syntax would follow ECMAScript conventions:
[id-ref "."]? event-ref ["+"|"-" signed-clock-val]? E.g. endEvent="button1.onclick+3s"

"none"

The string "none".

`eventRestart`

Controls whether the element can be restarted while it is playing (i.e. during the active duration of the element). If set to true, then a second beginEvent (or a method call via the SMIL-DOM interfaces) that occurs during the element's complete duration will restart the element. If set to false, a second event will be ignored.

Argument values are Booleans.
The default value is true.

3.2.3. repeat, repeatCount and repeatDur

SMIL 1.0 introduced the repeat attribute, which is used to repeat a media element or an entire time container. SMIL Boston introduces two new controls for repeat functionality that supercede the SMIL 1.0 repeat attribute. The new attributes, repeatCount and repeatDur, provide a semantic that more closely matches typical use-cases, and the new attributes provide more control over the duration of the repeating behavior. The SMIL 1.0 repeat attribute is deprecated in SMIL Boston (it must be supported in SMIL document players for backwards compatibility).
The repeatCount and repeatDur attributes are used to cause an element to copy or loop the contents of the element media (or an entire timeline in the case of a time container). Using repeatCount causes the element to repeat the simple duration of the element, effectively multiplying the simple duration by the value of the repeatCount attribute. In this example, the first 3 seconds of the "snd1" audio will play three times in succession for a total of 9 seconds:

```
<audio src="snd1.au" dur="3s" repeatCount="3" />
```

The repeatDur attribute is used to specify that an element should repeat just as with repeatCount, but for a specified total duration. This can be useful when matching a repeat duration the duration of other elements. In this simple example, the "snd2" audio will repeat for a total of 10 seconds:

```
<audio src="snd2.au" dur="3.456s" repeatDur="10s" />
```

The repeatCount and repeatDur attributes can also be used to repeat an entire timeline, e.g.:

```
<seq begin="5s" repeat="indefinite" >
   <img src="img.jpg" end="5s" />
   <img src="img2.jpg" dur="4s" />
   <img src="img3.jpg" dur="4s" />
</seq>
```

The sequence has an implicit duration of 13 seconds. It will begin to play after 5 seconds, and then will repeat indefinitely (i.e. subject to the constraints of the parent time container of the <seq>).

The repeatCount and repeatDur attributes modify the active duration of an element. If repeatCount is specified, the active duration is the simple duration multiplied by the repetition count. If a repeatDur is specified, the active duration is equal to the specified repeat duration.

Need to create normative examples that demonstrate new the controls, and the interaction with implicit and explicit simple durations. Examples must also demonstrate the interaction of repeating behavior and time container constraints.

`repeatCount`

This causes the element to play repeatedly (loop) for the specified number of times.

A repeat count of less than 1 will cut short the specified simple duration.
A repeat count of 1 is a no-op.
Legal values are integer or fractional iterations, greater than 0.

`repeatDur`

This causes the element to play repeatedly (loop) for the specified duration.

A repeat duration less than the simple duration will cut short the duration.
A repeat duration equal to the simple duration is a no-op.
Legal values are clock values greater than 0.

For both repeatCount and repeatDur, the attributes have no affect if the element's simple duration is 0 or indefinite.

For both attributes, "indefinite" may be specified to indicate that the element should repeat indefinitely (subject to the time container semantics).
At most one of `repeatCount` or `repeatDur` should be specified (if both are specified, the repeat duration is defined as the minimum of the specified repeatDur, and the simple duration multiplied by repeatCount.

3.2.3.1. SMIL 1.0 repeat attribute (deprecated)

The SMIL 1.0 repeat attribute defined repeat in manner similar to repeatCount, but it specified that the semantic was equivalent to a sequence that contained the specified number of *copies* of the element without the repeat attribute. Thus, if the element has a begin delay, the SMIL 1.0 repeat included the delay with each iteration. See also the Issues item Semantics of SMIL 1.0 repeat and sync arcs.

`repeat`

This attribute has been deprecated in SMIL Boston in favor of the new repeatCount and repeatDur attributes.

This causes the element (including any begin delay) to play repeatedly for the specified number of times. It is equivalent to a seq element with the stated number of copies of the element without "repeat" attribute as children.
Legal values are integer iterations, greater than 0, and "indefinite".
See also the SMIL 1.0 specification.

3.2.4. fill

The fill attribute allows an author to specify whether the complete duration of an element should be extended beyond the active duration, especially to fill gaps in the parent time container. The semantics of the fill attribute are the same as in SMIL 1.0.

The fill attribute allows an author to specify that the effective duration of an element should be extended beyond the active duration, by "freezing" the ending state of the element and continuing to display the frozen state for the duration of the parent container. The semantics of the fill attribute are the same as in SMIL 1.0.

`fill`

Legal values are "remove" and "freeze".

The default value is generally "remove", but is dependent upon the parent time container and the use of indeterminate durations.
Setting this attribute to "remove" ensures that the complete duration will not exceed the active duration. Setting this to "freeze" will extend the complete duration by "freezing" the element state at the active end, and showing this for the remainder of the complete duration. The actual fill duration is subject to the constraints of the parent time container.
This attribute only has effect on visual media elements. Non-visual media elements (audio) should ignore this.
Links are still active during fill="freeze". See also the SMIL 1.0 specification.

3.3. Time Manipulations

New element controls for element time behavior are under discussion. Note that an Accessibility requirement for control of the playback speed is related to (but may end up with different syntax different from) the speed control. In general, these time manipulations are suited to animation and non-linear or discrete media, rather that linear continuous media.

In the model for time manipulations, the element's local time can be filtered or modified. The filtered time affects all descendents. Any filter that changes the effective play speed of element time may conflict with the basic capabilities of some media players. The use of these filters is not recommended with linear media players, or with time containers that contain linear media elements.

The proposed extensions support use-cases commonly associated with graphic animation.

There are a number of unresolved issues with this kind of time manipulation, including issues related to event-based timing and negative play speeds, as well as many media-related issues.

3.3.1. speed

The speed attribute controls the local playspeed of an element, to speed up or slow down the effective rate of play. Note that the speed does not specify an absolute play speed, but rather modifies the playspeed of the parent time container. Thus if a <par> and one of its children both specify a speed of 50%, the child will play at 25% of normal playspeed. Also note that a speed of -100% is equivalent to playing the media backwards.

Proposed syntax:

`speed`

Defines the playback speed of element time. The value is specified as a percent of normal (parent time container) play speed.

Legal values are signed percentage values. The default is +100%.

3.3.2. accelerate and decelerate

These attributes define a simple acceleration and deceleration of element time. This is useful for animation, motion paths, etc. The values are expressed as a percentage of the simple durations, and are defined such that the simple duration is not affected (the normal playspeed is increased to compensate). If these are combined with repeating behavior, the acceleration and/or deceleration occurs within each repeat interation.

The sum of acceleration and deceleration must not exceed 100. If it does, the deceleration value will be reduced to make the sum legal.

Proposed syntax:

`accelerate`

Defines a simple acceleration of time for the element. Element time will accelerate from a rate of 0 at the beginning up to a run rate, over the course of the specified percentage of the simple duration. The default value is 0% (no acceleration).

Legal values are percentage values between 0 and 100.

`decelerate`

Defines a simple deceleration of time for the element. Element time will decelerate from a run rate down to 0 at the end of the simple duration, over the course of the specified percentage of the simple duration.

The default value is 0% (no deceleration).
Legal values are percentage values between 0 and 100.

3.3.3. autoReverse

This defines "play forwards then backwards" functionality. The use of autoReverse effectively doubles the simple duration. When combined with repeating behavior, each repeat iteration will play once forwards, and once backwards. This is useful for animation, especially for mechanical and pendulum motion.

Proposed syntax:

`autoReverse`

Controls autoReverse playback mode.

Argument values are Booleans.
The default value is false (i.e. play normally).

3.4. Controlling Runtime Synchronization Behavior

Proposed new support in SMIL Boston introduces finer grained control over the runtime synchronization behavior of a document. The syncBehavior attribute allows an author to describe for each element whether it must remain in a hard sync relationship to the parent time container, or whether it can be allowed slip with respect to the time container. Thus, if network congestion delays or interrupts the delivery of media for an element, the syncBehavior attribute controls whether the media element can slip while the rest of the document continues to play, or whether the time container must also wait until the media delivery catches up.

The syncBehavior attribute can also be applied to time containers. This controls the sync relationship of the entire timeline defined by the time container. In this example, the audio and video elements are defined with hard or "locked" sync to maintain lip sync, but the "speech" <par> time container is allowed to slip:

```
<par>
   <animation src="..." />
   ...
   <par id="speech" syncBehavior="canSlip" >
      <video src="speech.mpg" syncBehavior="locked" />
      <audio src="speech.au"  syncBehavior="locked" />
   </par>
   ...
</par>
```

If either the video or audio must pause due to delivery problems, the entire "speech" par will pause, to keep the entire timeline in sync. However, the rest of the document, including the animation element will continue to play normally. Using the syncBehavior attribute on elements and time containers, the author can effectively describe the "scope" of runtime sync behavior, defining some portions of the document to play in hard sync without requiring that the entire document use hard synchronization.

This functionality also applies when an element first begins, and the media must begin to play. If the media is not yet ready (e.g. if an image file has not yet downloaded), the syncBehavior attribute controls whether the time container must wait until the element media is ready, or whether the element begin can slip until the media is downloaded.

The syncBehavior can affect the effective begin and effective end of an element, but the use of the syncBehavior attribute does not introduce any other semantics with respect to duration.

When the syncBehavior attribute is combined with interactive begin timing for an element, the syncBehavior only applies once the sync relationship of the element is resolved (e.g. when the specified event is raised). If at that point the media is not ready and syncBehavior is specified as "locked", then the parent time container must wait until the media is ready. Once an element with an interactive begin time has begun playing, the syncBehavior semantics described above apply as thought the element were defined with scheduled timing.
Note that the semantics of syncBehavior do not describe or require a particular approach to maintaining sync; the approach will be implementation dependent. Possible means of resolving a sync conflict may include:

- Pausing the parent time container (i.e. first ancestor time container with canSlip behavior) until the element that slipped can "catch up".
- Pausing the element that is playing too fast until the parent (document) time container catches up.
- Seeking (i.e. resetting the current position of) the element that slipped, jumping it ahead so that it "catches up" with the parent time container. This would only apply to non-linear media types.

Additional control is provided over the hard sync model using the syncTolerance attribute. This specifes the amount of slip that can be ignored for an element. Small variance in media playback (e.g. due to hardware innaccuracies) can often be ignored, and allow the overall performance to appear smoother.

3.4.1. Sync Behavior Attributes

`syncBehavior`

Defines the runtime synchronization behavior for an element.

Legal values are:

`canSlip`

Allows the associated node to slip with respect to the parent time container.

When this value is used, any syncTolerance attribute is ignored.

`locked`

Forces the associated node to maintain sync with respect to the parent time container. This can be eased with the use of the syncTolerance attribute.

`syncTolerance`

This attribute on timed elements and time containers defines the sync tolerance for the associated element. It has an effect only if the element has syncBehavior="locked". This allows a locked sync relationship to ignore a given amount of slew without forcing resynchronization. resolution.

Legal values are clock values.

There may be a non-zero default value for this attribute, to be determined through testing (a proposed guess is something between 0.1 seconds and 0.5 seconds).

3.4.2. Sync Master Support

An additional proposed extension allows the author to specify that a particular element should define or control the synchronization for a time container. This is similar to the default behavior of many players that "slave" video and other elements to audio, to accommodate the audio hardware inaccuracies and the sensitivity of listeners to interruptions in the audio playback. The syncMaster attribute allows an author to explicitly define that an element defines the playback "clock" for the time container, and all other elements should be held in sync relative to the syncMaster element.

In practice, linear media often need to be the syncMaster, where non-linear media can more easily be adjusted to maintain hard sync. However, a player cannot always determine which media behaves in a linear fashion and which media behaves in a non-linear fashion. In addition, when there are multiple linear elements active at a given point in time, the player cannot always make the "right" decision to resolve sync conflicts. The syncMaster attribute allows the author to specify the element that has linear media, or that is "most important" and should not be compromised by the syncBehavior of other elements.

The syncMaster attribute interacts with the syncBehavior attribute. An element with syncMaster set to true will define sync for the "scope" of the time container's synchronization behavior. That is, if the syncMaster element's parent time container has syncBehavior="locked", the syncMaster will also define sync for the ancestor time container. The syncMaster will define sync for everything within the closest ancestor time container that is defined with syncBehavior="canSlip".

The syncMaster attribute only applies when an element is active. If more than one element within the syncBehavior scope has the syncMaster attribute set to true, and the elements are both active at any moment in time, the behavior will be implementation dependent.

`syncMaster`

Boolean attribute on media elements and time containers that forces the time container playback to sync to this element.

The default value is false.
The associated property is read-only, and cannot be set by script.

3.5 Syntax Production Rules

clock value

Clock values have the following syntax. This is the same as in SMIL 1.0 except that the hours subtoken is not limited to 2 digits:

```
Clock-val             ::= Full-clock-val | Partial-clock-val | Timecount-val
Full-clock-val        ::= Hours ":" Minutes ":" Seconds ("." Fraction)?
Partial-clock-val     ::= Minutes ":" Seconds ("." Fraction)?
Timecount-val         ::= Timecount ("." Fraction)?
                          ("h" | "min" | "s" | "ms")? ; default is "s"
Hours                 ::= DIGIT+; any positive number
Minutes               ::= 2DIGIT; range from 00 to 59
Seconds               ::= 2DIGIT; range from 00 to 59
Fraction              ::= DIGIT+
Timecount             ::= DIGIT+
2DIGIT                ::= DIGIT DIGIT
DIGIT                 ::= [0-9]
```

The following are examples of legal clock values:

- Full clock value: 02:30:03 = 2 hours, 30 minutes and 3 seconds
- Partial clock value: 02:33 = 2 minutes and 33 seconds
- Timecount values:

3h = 3 hours
45min = 45 minutes
30s = 30 seconds
5ms = 5 milliseconds

A fraction x with n digits represents the following value:

x * 1/10**n

Examples:

00.5s = 5 * 1/10 seconds = 500 milliseconds
00:00.005 = 5 * 1/1000 seconds = 5 milliseconds

4. Constructing the Time Graph

This is largely a placeholder for content that must be refined in later drafts.

Need to review all the stuff in SMIL that was not clearly enough described. Need to nail down issues on cyclic graphs and other illegal constructs.

Graph structure, rules, implications (acyclic time graphs, etc.). Need to describe what happens when have conflicting syntax (e.g. dur and end, repeat and repeatDur). Need to describe what happens when have invalid specification (illegal argument values, etc.).

We may want to add an additional informative document that is more of an authoring guide.

Consider inclusion of algorithm to support normative description.

4.1 Graph Structure

A document with SMIL timing is parsed incrementally and during that process a graph structure is built.

More to come here, explaining precisely how syntax is translated to formal semantics and graph structure.

4.2 Conflicts and Conflict Resolution

When an element is parsed, it is introduced into the graph according to the temporal relation where it appears. In order to clarify the process of graph creation and graph consistency, we must consider the way the graph is built. When an element is parsed, the insertion into the graph follows these operations:

1. **Node creation.** Create a node with begin and end references.
2. **Arc creation**. Build the sync-arc and event-arc relationships for the node.

Arc creation is a source of potential inconsistencies. These must be detected and resolved according to a set of fixed rules, to ensure consistent performance across implementations.

More to come here.

5.0 Document Object Model Support

Much of the related SMIL-DOM functionality is proposed in the [SMIL-DOM] section. We may need to go into further detail on the specific semantics of the interfaces - the sections below are placeholders.

5.1 Element and Attribute manipulation, mutation and constraints

Define rules on element and attribute access (inherit from and point to Core DOM docs for this). Define mutation constraints. This is currently covered in the [SMIL-DOM] section.

5.2 Supported Methods

Describe the methods and their semantics. Interfaces are currently defined in the [SMIL-DOM] section.

5.3 Event Model

We need to describe how the Core DOM Level 2 event model, affects the timing model. The [SMIL-DOM] section defines the initial set of time-related events that have been proposed.

6.0 References

[DOMReqts]

"Document Object Model Requirements for Synchronized Multimedia", P. Schmitz.
Available at http://www.w3.org/AudioVideo/Group/DOM/DOM_reqts. (W3C members only)

[HTML]

"HTML 4.0 Specification", D. Raggett, A. Le Hors, I. Jacobs, 24 April 1998.
Available at http://www.w3.org/TR/REC-html40.

[ISO-8601]

"Data elements and interchange formats - Information interchange - Representation of dates and times", International Organization for Standardization, 1998.

[SMIL1.0]

"Synchronized Multimedia Integration Language (SMIL) 1.0 Specification W3C Recommendation 15-June-1998 ".
Available at: http://www.w3.org/TR/REC-smil.

[SMIL-CSS2]

"Displaying SMIL Basic Layout with a CSS2 Rendering Engine".
Available at: http://www.w3.org/TR/NOTE-CSS-smil.html.

[SMIL-DOM]

"SMIL Document Object Model", Nabil Layaïda, Patrick Schmitz, Jin Yu.
Available at http://www.w3.org/1999/08/WD-smil-boston-19990803/DOM/smil-dom

[SMIL-MEDIA]

"The SMIL Media Object Module", Philipp Hoschka, Rob Lanphier.
Available at http://www.w3.org/1999/08/WD-smil-boston-19990803/Media/extended-media-object.

[SMIL-MOD]

"Synchronized Multimedia Modules based upon SMIL 1.0", Patrick Schmitz, Ted Wugofski, Warner ten Kate.
Available at http://www.w3.org/TR/NOTE-SYMM-modules.

[XML]

"Extensible Markup Language (XML) 1.0", T. Bray, J. Paoli, C.M. Sperberg-McQueen, editors, 10 February 1998.
Available at http://www.w3.org/TR/REC-xml

Appendix A: Annotated Examples

Example 1: Simple timing within a Parallel time container

This section includes a set of examples that illustrate both the usage of the SMIL syntax, as well as the semantics of specific constructs. This section is informative.

Note: In the examples below, the additional syntax related to layout and other issues specific to individual document types is omitted for simplicity.

All the children of a <par> begin by default when the <par> begins. For example:

```
<par>
   <img id="i1" end="5s"  src="img.jpg" />
   <img id="i2" end="10s" src="img2.jpg" />
   <img id="i3" begin="2s" dur="5s" src="img3.jpg" />
</par>
```

Elements "i1" and "i2" both begin immediately when the par begins, which is the default begin time. "i1" ends at 5 seconds into the <par>. "i2" ends at 10 seconds into the <par>. The last element "i3" begins at 2 seconds since it has an explicit begin offset, and has a duration of 5 seconds which means it ends 7 seconds after the <par> begins.

An image that illustrated the timeline might be useful here.

Example 2: Simple timing within a Sequence time container

Each child of a <seq> begins by default when the previous element ends. For example:

```
<seq>
   <img id="i1" begin="0s" dur="5s" src="img1.jpg" />
```

```
   <img id="i2" end="10s" src="img2.jpg" />
   <img id="i3" begin="1s" dur="5s" src="img3.jpg" />
</seq>
```

The element "i1" begins immediately, with the start of the <seq>, and ends 5 seconds later. Note: specifying a begin time of 0 seconds is optional since the default begin offset is always 0 seconds. The second element "i2" begins, by default, 0 seconds after the previous element "i1" ends, which is 5 seconds into the <seq>. Element "i2" ends 10 seconds later, at 15 seconds into the <seq>. The last element, "i3", has a begin offset of 1 second specified, so it begins 1 second after the previous element "i2" ends, and has a duration of 5 seconds, so it ends at 21 seconds into the <seq>.

Insert illustration.

Example 3: excl time container with child timing variants

1. Exclusive element, children activated via link-based activation:

   ```
   <par>
     <excl>
       <par id="p1">
          ...
       </par>
       <par id="p2">
          ...
       </par>
     </excl>
     <a href="p1"><img src="Button1.jpg"/></a>
     <a href="p2"><img src="Button2.jpg"/></a>
   </par>
   ```

   This example models jukebox-like behavior. Clicking on the first image activates the media items of parallel container "p1". If the link on the second image is traversed, "p2" is started (thereby deactivating "p1" if it would still be active).

   Shouldn't we say, here, exactly where the elements of the selected par in the excl should begin when a click happens, e.g., if we are 10 seconds into the outer par and we click on button 2, does the MPG video in p2 start 10 seconds into its stream (in-sync), or does it start at its time 0?

2. Exclusive element combined with event-based activation:

   Note that the specific syntax for beginEvent argument values is still under discussion.

   ```
   <par>
     <excl>
       <par beginEvent="btn1.onclick">
          ...
       </par>
       <par beginEvent="btn2.onclick">
          ...
       </par>
     </excl>
     <img id="btn1" src=... />
     <img id="btn2" src=... />
   </par>
   ```

   The same jukebox example, using event-based activation.

   In these two examples event-based and anchor-based activation look almost identical, maybe we should come up with examples showing the difference and the relative power of each.

3. Exclusive element using determinate declarative timing:

```
<excl>
  <ref id="a" begin="0s" ... />
  <ref id="b" begin="5s" ... />
</excl>
```

In the example above, the beginning of "b" deactivates "a" (assuming that a is still active after 5 seconds). Note that this could also be modeled using a sequence with an explicit duration on the children. While the determinate syntax is allowed, this is not expected to be a common use-case scenario.

Issue - should we preclude the use of determinate timing on children of excl? Other proposals would declare one child (possibly the first) to begin playing by default. Proposals include an attribute on the <excl> container that indicate one child to begin playing by default.

Example 4: default duration of discrete media

For all discrete media, the implicit duration is defined to be 0. This can lead to surprising results, as in this example:

```
<seq>
   <img src="img1.jpg" />
   <video src="vid2.mpg" />
   <video src="vid3.mpg" />
</seq>
```

This will not show the image at all, as it defaults to a duration of 0, and so the second element will begin immediately. Authors will generally specify an explicit duration for any discrete media elements.

Example 5: endEvent specifies end of active dur, *not* end of simple dur

There is an important difference between the semantics of endEvent and end/dur.
The end and dur attributes, in conjunction with the begin time, specify the simple duration for an element.

This is the duration that is repeated when the element also has a repeat specified. The attribute endEvent on the other hand overrides the active duration of the element. If the element does not have repeat specified, the active duration is the same as the simple duration. However, if the element has repeat specified, then the endEvent will override the repeat, but will not affect the simple duration. For example:

```
<seq repeat="10" endEvent="stopBtn.onClick">
   <img src="img1.jpg" dur="2s" />
   <img src="img2.jpg" dur="2s" />
   <img src="img3.jpg" dur="2s" />
</seq>
```

The sequence will play for 6 seconds on each repeat iteration. It will play through 10 times, unless the user clicks on a "stopBtn" element before 60 seconds have elapsed.

Example 6: SMIL-DOM-initiated timing

When an implementation supports the SMIL-DOM, it will be possible to make an element begin or end using script or some other browser extension. When an author wishes to describe an element as interactive in this manner, the following syntax can be used:

```
<audio src="song1.au" beginEvent="none" />
```

The element will not begin until the SMIL-DOM beginElement() method is called.

Appendix B: Open Issues

B.1. (rules for backwards compatibility - resolved).

B.2. Need to document the formal requirements.

B.3. SMIL 1.0 "event" syntax

SMIL 1.0 supported a means of defining one element to begin relative to the begin or end of another element. This was referred to as "event" timing in SMIL 1.0, however the syntax described a determinate synchronization relationship, and did not require an implementation to use events. To reduce confusion with more traditional events such as user-input events, the SMIL 1.0 description and syntax for this has been deprecated (although conforming SMIL Boston players will support the SMIL 1.0 syntax).

We have not yet formally agreed upon this, but there seemed to be some growing consensus on the mailing list for the need to disambiguate event-based timing in the sense of interactive content, and SMIL 1.0 "event" based timing (which is really just a terminology for describing sync-arcs).

B.4 - preface to examples - resolved

B.5 - click- on, click-off semantics

This is a proposal that needs discussion.

When the same event is specified for both the beginEvent and the endEvent, the semantics of the "active" state define the behavior. If the element is not active, then the beginEvent is sensitive, and responds to the event, making the element active. Since the endEvent is not sensitive when the element is not active, it does not respond to this initial event. When the element is active, the endEvent is sensitive and responds to a second event, making the element inactive. This supports the common use-case of clicking an element to turn it on, and clicking it again to turn it off.

B.7 - Semantics of <excl> with combined scheduled and interactive timing

Concerns have been expressed about the linking aspects and the combination with `<excl>`. It is not a problem if all the children have indeterminate begin times, as you could happily play one child instead of any other. If we allow scheduled timing with children of `<excl>`, you may be stopping a child that was temporally bound to its parent and in turn to other synchronized elements. So you could be stopping something that was part of a prescheduled presentation and continuing the others parts, while still assuming that the determined synchronization is taking place.

Linking to children of an `<excl>` actually violates the notion that the children of the `<excl>` can have any determined relationship with the parent.
What happens when child #2 has a determined start time of 15s (w.r.t. the parent) and then the user follows a link at time 14s (w.r.t.the parent) to child #3. Does child #3 get replaced by child #2 when 15s is reached? Highly annoying if you've just followed a link to it. Does child #3 continue playing, thus violating the determined start time of child #2. We may require some extra information in the link specification (e.g. multiple source link ends) to allow the author to specify the wished-for behavior. It may only require that authors are aware that they may sometimes have to introduce an extra layer of structure to obtain the behavior they want.

Again, there is the choice of whether we implement pausing, and how we model it, that will influence this.

B.8 - Precise definition of timing relative to another node Resolved.

B.9 - Alternative syntax for begin and end - Described in section on Alternative begin/end syntax.

B.10 - Various issues with logical Timebases.

- @@@ What other logical reference 'operators' do we have besides "prev"? How rich is the logical reference syntax? Can an element refer to the previous <img> element? The first textstream of my parent? The longest duration element preceding me in my parent? Elements that are siblings of my parent? My parents parents

siblings?

- Syntax for logical time references has not been decided on. Possible alternate syntaxes for the above example include `beginAfter="prev"`, `begin="(previous)(end)"`, and `begin="preceding-siblings::*[position()=1]"`
- Name for previous element reference: "previous", "prev", and "preceding" have all been suggested.
- If compelling use cases can be found, a "next" logical reference may be included as well.
- Need to nail down rules for determining time precedent vs. language lexical precedent. Mention fallback for first child rules.

B.11 - Definition of syncBehavior and scope

Should the syncBehavior scope be defined with respect to the lexical parent (simple) or to the timebase? HTML+TIME defined it using the simpler parent model. As we experiment with it, and especially when using long sync-arcs, it may make more sense to enforce the sync relationship to the timebase rather than to the parent.

A separate but closely related comment:

Issue: need to resolve whether the sync relationship is resolved to be relative to the time container, or to the specified time-base. In a hard sync world, this is moot. However, if we ever add controls on the runtime sync management behavior, we have to decide if the element must stay in sync with the parent and siblings, or with the time-base. The former is cleaner and may be simpler to support, but the latter may more accurately reflect the author's intent. This is tied to the section on "Controlling Runtime Synchronization Behavior", and so will get more attention in later drafts.

B.12 - Open issues on excl semantics

Open issues for excl time container:

- Should children default to being interactive? So many use cases are interactive that a good argument can made that the default semantics for children should be beginEvent="none" rather than begin="0" as for par children. However this will confuse novices when nothing shows up. One proposal would require timing, but then the default timing will be begin="0", and the rules will make the last element play, and nothing else. Not exactly intuitive either!
- Should anything begin by default? Another suggestion is to make the default semantics be more like sequence, but without constraining to sequence semantics. I.e. the default for children would be beginAfter="%priorSibling" (or some such logical identifier).

The proposal partially described above is that we support the same notion that the linking introduces, but for children of the excl. This is, if an element is playing when another begins (or is begun), that the playing element can optionally be made to stop and then resume when the new element completes. This is useful for situations where you define a primary program and some potential interruptions (like commercials). You want to pause the primary timeline and then resume it when the insertion completes. This is useful for the same reasons that the linking behavior is useful, but supports the control over a specific timeline segment rather than on an entire document. The requirement came from someone who wants to use the time syntax for another XML application, rather than in a SMIL-like scenario. We are still discussing where this behavior should be described (on the element that is interrupted, or on the inserted element). There are arguments and use-cases for both.

B.13 - Semantics of negative begin times

Issue: negative offsets for begin times, etc. Note that more generally it defines sync. Given constraints of parent begin/end, begin times fall out. See related notes on sync-arcs and time container constraints.

B.14 - Semantics of SMIL 1.0 repeat and sync arcs.

An additional issue with the SMIL 1.0 repeat semantics: Given that the semantic describes repeat as a sequence of copies of the element (without the repeat attribute), and given the constraints placed upon sync-arc specifications for begin and end, it would seem that repeat cannot (in SMIL 1.0) be combined with sync-arc specifications (any sync-arc would necessarily reference an element that was out of scope in the sequence defined by the repeat). The SMIL Boston

semantics for repeat would preclude this conflict (although the sync-arc restrictions are also removed in SMIL Boston).

M. Integrating SMIL Timing into Other XML-Based Languages

Previous version:

http://www.w3.org/AudioVideo/Group/Integrate/WD-Time-Integrate-19990718 (W3C members only)

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Table of Contents

Abstract

This segment of the working draft specifies an architecture for applying timing information to XML documents. It specifies the syntax and semantics of the constructs that provide timing information. This approach builds on SMIL by preserving SMIL's timing model and maintaining the semantics of SMIL constructs.

This part of the working draft does not attempt to describe the exact syntax required to apply timing to XML documents as multiple options are still under consideration by the W3C SYMM Working Group. There are examples containing several possible syntaxes throughout this segment of the working draft, but these are for illustration purposes only and are likely to change.

1. Introduction

Currently there exists no standardized method for adding timing to elements in any arbitrary XML document. This segment of the working draft defines the mechanisms for doing so.

1.1. Background

Prior to SMIL 1.0 becoming a W3C recommendation, a significant number of W3C members expressed interest in integrating SMIL timing functionality with XHTML and other XML-based languages.

SMIL 1.0 describes timing relationships between objects, including complete XML documents. SMIL 1.0 can not control the timing of individual elements contained within these documents, e.g., the display of a single XHTML heading before the bulk body text appears, or the sequential display of the items in a list. When using SMIL 1.0 for this, a content author is forced to contain each temporal element set in a separate document, leading to very small documents in some cases. For example, consider the split up of text that must occur when creating closed captioning from a subtitle track using SMIL 1.0.

The SMIL 1.0 architecture assumes that SMIL documents will be played by a SMIL-based presentation environment. It does not treat the case where timing is an auxiliary component, and the presentation environment is defined by another language, like XHTML, a vector-graphics language, or any user-defined XML-based language and stylesheet.

This segment of the working draft specifies how SMIL timing can be used in other XML languages, providing a solution to the above cases. The work is driven by the following goals:

- *G1:* To provide a solution for integrating timing into XML applications, in particular XHTML.

The XML application can be user defined.

- *G2:* To base that solution on SMIL. In case SYMM settles on a syntax different from SMIL, e.g., a CSS-based solution, the semantics, names, values, functionality and the timing model should be preserved as used by SMIL.
- *G3:* To strive for a single solution, rather than multiple alternatives. Duplication of functionality is allowed only if it is well-justified.

1.2. Use cases

The following cases require the application of timing. These use cases are not listed in any particular order:

1. **Change media presentation over time.**
   Various media objects contained in or referenced in an XML-based document are made to appear and disappear over time. Note: the media can be any element that models content: a video, a paragraph, a database record, etc. An example is a series of images and captions timed to appear as a slide show.

2. **Schedule the presentation of elements of a Web page.**
   E.g., an HTML[*] page could be made to change over time by controlling the display of its elements.

   [*] Note: This assumes that the HTML document is a valid XML document.

   - **Use case 2A:** Add in-line timing to an `<H1>` element of an HTML document to schedule the display of that header's text.

   - **Use case 2B:** Add timing to the existing structure of an HTML document in order to schedule the presentation of the elements of a list or of sections of the document. There are many ways that elements of a list or the sections of a document could be presented. A common way might be to have the elements' content appear one after the other with the prior element's content remaining displayed at least until the list is completely displayed. Another way might be to have each list item display for a period of time and then be replaced, spatially, by the next.
     Consider the script of a play where each line of dialog is within a `<P>...</P>` container. Such a document could be turned into a textual performance of the play by adding the timing necessary to sequentially present each of the child `<P>` elements of the `<BODY>` of the document.

   - **Use case 2C:** Add timing to a document where the timing is independent of the structure of that document. Consider the following example:
     Assume a human body display language. In this example different parts appear and disappear in different combinations at different times regardless of the content structuring, i.e., regardless of the order of the data in the document body. The document DTD uses the human structure: human = { face, torso, 2 arms, 2 legs }. A leg has a thigh, knee, calf and foot. Etc. The document merely describes the structure of the human form.

3. **Add timing to an immutable document.**
   Without modifying the original content document due to copyright and/or other issues, and without being able to assume IDs are used throughout that document, apply an external timing document to that content document. In some cases, timing will be applied externally to elements based on the names of their XML mark-up tags, while in other cases timing will be applied externally to elements of certain classes or to individual elements based on their unique IDs. For example, The Daisy Consortium's "talking book" applications use HTML documents containing the text of a book whose pages are marked with <SPAN> elements containing unique IDs. An external timing document could then be used to apply unique timing to each of these <SPAN> elements.

4. **Add timing to links.**
   Links could be made to be active only during certain periods.
   Note: this can already be done within a SMIL 1.0 document.

5. **Change the appearance of graphical objects over time.**
   For example, add timing to elements of a graphical display so that individual graphical elements appear, disappear, and move in front of and behind each other over time.

6. **Change the style, as opposed to the visibility, of textual data over time.**
   For example, make something appear red for 5 seconds and then yellow for the remainder of its duration.

1.3. Assumptions

1. The XML language to which the timing is applied can be of any type. The language can be:
   - presentation agnostic
   - presentation oriented
2. The XML language can cooperate with a stylesheet. The style language used is assumed, but not restricted, to be CSS.

1.3.1 Assumptions that may need further refinement

1. The XML language can cooperate with the content document's Document Object Model (DOM).
2. If the full document is exposable to the content document's DOM, that DOM models the data along the tree as spanned in the body.

1.4. Requirements

1. Should follow the SMIL time model as it evolves.
2. Should be compatible/interoperable with SMIL.
3. Should be possible to apply the timing model to any XML application.
4. Should enable authoring across documents, e.g., temporal specification may be separated from

the content document.

5. Should enable timing of styles as specified in the stylesheet accompanying the XML document.
6. Should cooperate with events as specified by the content document's DOM.
7. Should cooperate with dynamic changes invoked through the content document's DOM. For example, if a media element's begin time is based on the end time of another media element that has ended early, the former should begin right away rather than wait until its originally-scheduled begin time is reached.
8. Should enable construction of temporal templates, such that timing styles can be developed and taken as an authoring basis for further refinement. The precedence rules are the same as for CSS.

2. Framework

This section outlines the conceptual approach to adding timing to XML applications. The Specification section specifies the constructs used. There are three proposed methods of adding this timing:

1. Through In-line Timing. In-line timing is simply the addition of timing syntax into a content document to schedule the presentation of its objects.
2. Through Cascading Style Sheet (CSS) Timing. CSS Timing treats timing as style attributes and allows the application of these timing style attributes to elements of the content of a document in the same way that CSS level-1 and level-2 currently allow other styles (e.g., color, spacing) to be applied to the content. CSS timing may be added to the content document or may be contained in an external document that is referenced by the content document.
3. Through Timesheets. Timesheets are a new concept under development that apply timing to elements in the content document. The order of the items in a timesheet determines the order of presentation of the referenced content elements. Unlike CSS Timing, a Timesheet separates timing from the content document's structure. A timesheet may be added to the content document, may be contained in an external document that is referenced by the content document, or may be a document that references the content document external to itself.

How to ensure that in-line timing cooperates uniformly with CSS Timing or Timesheets is still under consideration.

In cases where SMIL timing is placed within an XML document, a hybrid DTD may be needed containing the DTD for the SMIL Timing and Synchronization module as well as the DTD for the XML language in which the original content document was written.

2.1. Framework: In-line Timing

Reminder: the various syntaxes specified in this segment of the working draft are likely to change prior to the finalization of the working draft.

In some cases in-line timing will make authoring easier, especially in cases where the author wants the timing to flow with the structure of the content. In other cases, CSS Timing or Timesheets may be needed.

The semantics of in-line timing are the same as that of SMIL 1.0 timing, but the syntax is different. SYMM is currently considering two ways to add in-line timing to XML content.

1. The first is to add `<par>...</par>` and `<seq>...</seq>` elements to create time blocks that apply timing to all child elements. For instance, an author could place a seq element as a parent of a list of items and consequently make those list items display one after the other.
2. The second way is to add timing attributes within the existing XML mark-up elements. This has the advantage of not requiring the use of an additional element that might make it harder to manage the layout and other behavior of the document.
   An element would be made to act as a parent `par` or `seq` (or other time container types under consideration, e.g., `<excl>`), along with optional SMIL timing attributes like duration, begin time (relative to that of any parent element), and end time, to name a few. In order to declare that an element should act as a time container, a new attribute is needed, possibly named "timeLine" or "timeContainer". This attribute is only legal within grouping elements in XML documents, and specifically cannot be applied to any of the time container elements including `par`, `seq` and `excl`.
   Children of an element with this attribute have the same semantics as children of the respective time container elements.
   Possible syntaxes might be `timeLine="t"`, or `timeContainer="t"`, where "t" is `par`, `seq`, or some other time container under consideration.
   Legal values may include:

   `par`

   Defines a parallel timeline with the same timing and synchronization semantics as a par element.

   `seq`

   Defines a sequence timeline with the same timing and synchronization semantics as a seq element.

   `excl`

   Defines an exclusive or choice timeline with the same timing and synchronization semantics as an excl element.

   `none`

   Default value. Defines the current element to *not* have timeline container behavior (i.e. to behave as a simple time leaf).

   For example, to add timing to an XHTML `<DIV>` element so that it acts as a "par" SMIL time container and has a duration of display of 10 seconds, the syntax might be:
   `<DIV timeLine="par" dur="10s">`.

   Another attribute under consideration is the action associated with the timing. This attribute would allow the author to specify how the element's timing should be applied, e.g., to the display of its content or to style attributes like the color of its content. One syntax currently under consideration is "timeAction". In SMIL 1.0, the begin, end, duration, and other times specified in elements are always used to place the element on its parent element's timeline. A new attribute must be created to allow alternate application of the specified time values, e.g., the begin time could be applied to a style like the color of an element without affecting the true begin time of the element.
   The syntax for making the contents of a paragraph be red starting at 5 seconds relative to the

parent's timeline might look like the following. Note that the begin time of the element is not specified and is assumed to be the begin time of its parent (or the end time of its sibling if its parent is a <seq> time container):

```
<P begin="5s" style="color: red" timeAction="style">
```

Open issue: using in-line timing, how do you set, say, the begin time of an element as well as the begin time of its style?

Here is an example of in-line timing being used to schedule the application of color style attributes as specified in the document's style sheet: Consider the playback of a music album where the audio track plays in concert with a list of the songs. Timing is added to the list so that the song that is currently playing is colored differently from the others. "timeAction" in this example means that the style of the class "playing" should be applied (only) to the text during the duration specified. Note that, in this example, "song 1", "song 2", and "song 3" all appear throughout the entire presentation; it is only their color that has been modified over time using (in-line) timing:

```
<head>
  <style>
     body { color: black; }
    .playing { color: red; }
  </style>
</head>
<body>
  <audio ...>
  <p dur="227s" timeAction="class:playing"> song 1 </p>
  <p begin="228s" dur="210s" timeAction="class:playing"> song 2 </p>
  <p begin="439s" dur="317s" timeAction="class:playing"> song 3 </p>
</body>
```

2.2. Framework: Cascading Style Sheet Timing

Reminder: the various syntaxes specified in this segment of the working draft are likely to change prior to the finalization of the working draft.

CSS Timing is the use of SMIL timing within a style sheet, where timing is a style attribute, just like, for example, color and font-weight in CSS, that is applied to elements in the content document. The resultant timing structure is based on and depends on the structure of the content document. In some cases, in-line timing may be inefficient, difficult, or impossible to add particular timing. In these cases, either CSS Timing or Timesheets may be needed. Some possible cases where CSS Timing will provide a better solution than in-line timing are:

- where adding the same timing attributes to all elements of a class is needed, e.g., making all list items in the document display for 3 seconds.
- where reuse of the CSS Timing is desired for use with other content documents.
- where the content document can not be altered due to copyright or other restrictions.
- where it is desired to have two possible presentations of the same content, one a static (non-timed) presentation, and the other a timed one. This is possible when the timing is in a separate document.

The same two attributes mentioned in the In-Line Timing Framework section, above, will be needed. The first (possibly "timeContainer" or "timeline") is needed to be able to declare that an element should act as a time container. The second (possibly "timeAction") is needed to be able to specify how the timing should be applied, e.g., to the visibility of the object(s) or alternatively to a style applied to the object(s).

How to ensure that CSS timing and in-line timing cooperate uniformly is still under consideration.

Here is a simple example containing one possible syntax for integrating timing using CSS. In this example, the list will play in sequence as dictated by the style sheet in the HEAD section of the document. Note: the style sheet, like any CSS, could alternatively exist as a separate document.

```
</HEAD>
  <STYLE>
    UL { timeLine: seq; }
    LI { font-weight: bold; duration: 5s; }
  </STYLE>
</HEAD>
<BODY>
  <UL>
    <LI>This list item will appear at 0 seconds
        and last until 5 seconds.
    </LI>
    <LI>This list item will appear after the prior
        one ends and last until 10 seconds.
    </LI>
  <UL>
</BODY>
```

2.3. Framework: Timesheets

Timesheets refer to both the conceptual model along which timing, including the structure of the timing, is integrated into an XML document, as well as one possible syntax implementation. This approach provides a solution where time can be brought to any XML document regardless of its syntax and semantics.

A Timesheet uses SMIL timing within a separate document or separate section of the content document and imposes that timing onto elements within the content document. The resultant timing structure is not necessarily related to the structure of the content document. Some possible cases where a Timesheet will provide a better solution than in-line timing are a superset of such CSS Timing cases (which are included in the list below):

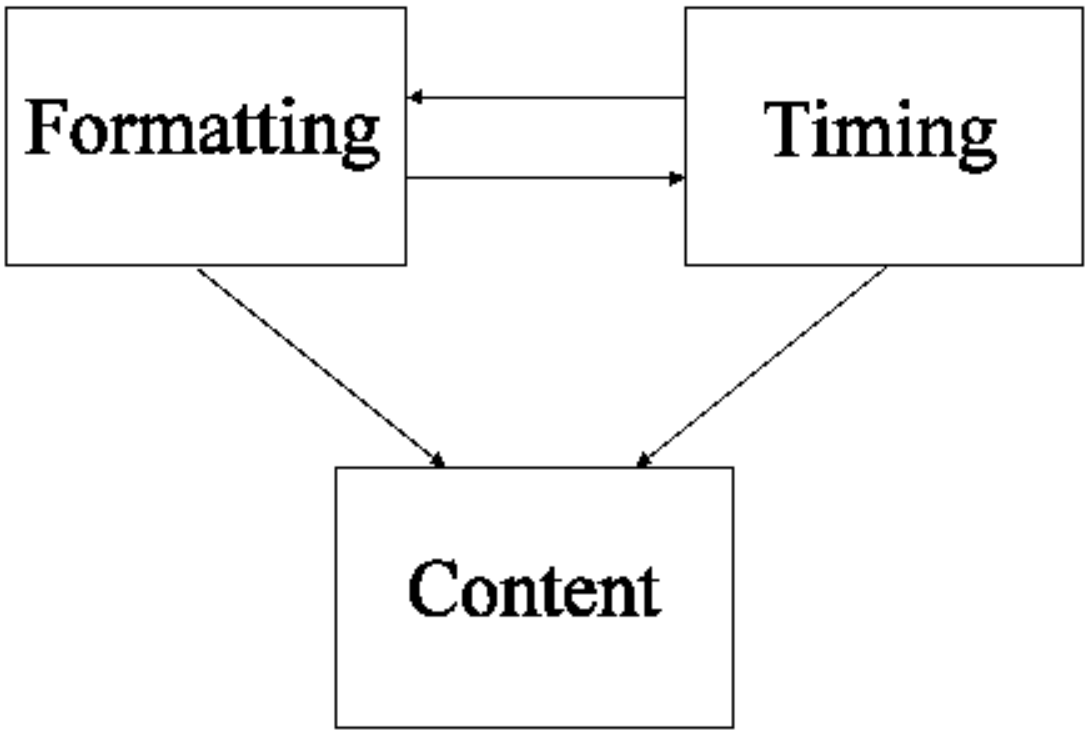
- where the timing structure doesn't match the structure of the content, e.g., making the elements in a list appear out of order
- where adding the same timing attributes to all elements of a class is needed, e.g., making all list items in the document display for 3 seconds.
- where reuse of the Timesheet is desired for use with other content documents.

- where the content document can not be altered due to copyright or other restrictions.
- where it is desired to have two possible presentations of the same content, one a static (non-timed) presentation, and the other a timed one. This is possible when the timing is in a separate document.

2.3.1. Three document sections

Timesheets assume an XML document conceptually composed of three presentation related sections:

1. the content part.
2. the formatting part.
3. the timing part.



The first section, *content*, relates to the particular XML document. It conforms to a DTD written for an XML language. The content part describes the media and its structure.

The second section, *formatting*, provides control of the properties of the elements in the content section. It conforms to a style language, which, for the purpose of this discussion, we assume to be CSS. The style section describes the style and (spatial) layout of presenting the content. "Formatting" might include matters like routing of audio signals to loudspeakers.

The third section, *timing*, provides control of the temporal relations between the elements in the content section. It conforms to SMIL's timing model. The time section describes the time at which content is

presented as well as the time at which style is applied. The time section contains the information to prepare a presentation schedule.

Sections two and three provide presentation information to the content: the stylesheet on style and positional layout, the timesheet on temporal layout. The stylesheet and timesheet may influence each other, but there should be no circular dependencies.

The idea is that each section operates independent from and compliant with the others.

2.3.2. Principles

1. The temporal structure is not necessarily implied by the content structure. Here is an example.
2. A timesheet may not be sufficient to build a time graph to provide a timing structure. A timesheet can consist of independent *rules* (time relations), which, together with the content, build the timing graph. For example, a selector in a timesheet may apply to multiple items in the content.
3. Unspecified timing may be left to the implementation to fill in. For example, items in a list can be declared to appear sequentially, while the temporal relations between lists and other content remain unspecified. When the author does not supply these, the template is still to be obeyed.
4. A timesheet may over-specify time relations. Unused rules are ignored. Conflicting time relations which concern the same element are either resolved using the timesheet cascading rules (to be specified, e.g. in-line overrides a template) or are an error (also to be made explicit). For example, when the timesheet declares sequential presentation of list items, while there are none of them in the document, the rule is simply ignored. Another example is where two rules select list items specifying different durations, e.g., all list item elements have a duration of 5 seconds except the first in each list has a duration of 8 seconds.

Here is a simple example where a timesheet exists, but in-line timing is also specified and overrides the timing imposed by the timesheet:

This example has a timesheet that specifies that each `"li"` element will have a begin time of 10 seconds and a duration of 15 seconds. However, the in-line timing in the second `"li"` element has presidence over the timesheet and thus the second line item ends up having a begin time of 0 seconds and a duration of 5 seconds. Note: this example could have been done just as easily using CSS Timing; the added power of Timesheets will be made clearer in the next example.

```
<time>
 <par>
  li { begin=10s dur=15s }
 </par>
</time>
<body>
 <ul>
  <li>This first line will begin at 10 sec and run for 15 sec.</li>
  <li begin="0s" dur="5s">This second line's timing is dictated
     by the in-line timing which overrides the timesheet timing
         for each child "<li>" element.  It will thus
         begin at 0 seconds and last 5 seconds.</li>
```

```
 </ul>
</body>
```

Following is an example showing some HTML extended with timing via a Timesheet. As with the CSS example, the Timesheet could just as well have been contained in a separate document and applied externally. CSS selector syntax [CSS-selectors] has been used. The use of CSS selectors here should not be confused with CSS Timing, proposed in the prior section of this segment of the working draft. The expected presentation of this would be to have the two Headings appear together followed by the first list item in each list, namely Point A1 and Point B1, appearing at 3 seconds followed thereafter by the second list item in each list, namely Points A2 and B2, appearing at 6 seconds. All items would disappear at 10 seconds which is the duration of the outer <par>.

```
<html>
  <head>
    <time>
      <par dur="10">
        <par>
          h1 {}
        </par>
        <par begin="3">
          <!-- Selects the first LI in each list:     -->
          OL > LI:first-child { }
        </par>
        <par begin="6">
          <!-- Selects the second LI in each list:    -->
          OL > LI:first-child + LI { }
        </par>
      </par>
    </time>
  </head>
  <body>
    <h1>Heading A</h1>
    <ol>
      <li id="PA1">Point A1</li>
      <li id="PA2">Point A2</li>
    </ol>
    <h1>Heading B</h1>
    <ol>
      <li id="PB1">Point B1</li>
      <li id="PB2">Point B2</li>
    </ol>
  </body>
</html>
```

Note: the property fields {.} could contain duration and syncarc relations if the author wished to add more complex timing.

Here is another example as mentioned in Use Case 2C. Assume a human body display language. In this example different parts appear and disappear in different combinations at different times regardless of the content structuring, i.e., regardless of the order of the data in the document body. The document DTD uses the human structure: human = { face, torso, 2 arms, 2 legs }. A leg has a thigh, knee, calf and foot. Etc. The document merely describes the structure of the human form. Here is an example of such a document:

```
<human>
    <face id="face" ...>
       <eye id="leftEye" color="green" .../>
       <eye id="rightEye" color="blue" .../>
       ...
    </face>
    ...
    <torso>
       ...
    </torso>
    <arm id="leftArm" ...>
       ...
       <hand id="leftHand" .../>
    </arm>
    ...
    <leg id="leftLeg" ...>
       <thigh id="leftThigh" .../>
       <knee id="leftKnee" .../>
       <calf id="leftCalf" .../>
       <foot id="leftFoot" .../>
    </leg>
    ...
</human>
```

Both of the following examples are possible by applying a different timesheet in each case to the same XML document. For these examples, we use the XML "human" document, above. Note: these examples demonstrate the timesheet's ability to allow a content element to be displayed as if its parent were but with the parent not displayed, in other words the child element is displayed in the same place, spatially, as if the parent was displayed. "These examples presume that the XML language allows a content element to be displayed as if the full document was, but with some parents not displayed. In other words the child element is displayed in the same place, spatially, as if the entire document was displayed. Not all XML languages support this."

- One example is to first display hands, then add feet, then each calf and forearm, then knees and elbows, etc., building the whole human form up from the extremities. The (abbreviated) timesheet might look like this:

```
<time>
  <par dur="60s">
```

```
    <par>
          #leftHand { }
          #rightHand { }
    </par>
    <par begin="10s">
          #leftFoot { }
          #rightFoot { }
    </par>
    <par begin="20s">
          #leftCalf { }
          #rightCalf { }
          #leftForearm { }
          #righForearm { }
    </par>
    ...
  </par>
</time>
```

- A second example is to combine <seq>s and <par>s in the time section. In sequence, show a finger, the face, and a thigh. In parallel with that, accumulate the foot, calf and knee of the same leg as the thigh. The inner <par> elements are not necessary but are there to help delineate the two separate but parallel accumulations of human body parts. The (abbreviated) timesheet might look like this:

```
<time>
  <par dur="60s">
    <par>
      #rightIndexFinger { }
      #face { begin: 5s }
      #rightThigh { begin: 10s }
    </par>
    <par>
      #rightFoot { }
      #rightCalf { begin: 5s }
      #rightKnee { begin: 10s }
    </seq>
  </par>
</time>
```

3. Specification

Once SYMM has settled on the approach to integrating timing into XML-based documents, this section will precisely define the syntax and semantics of each. To reiterate: the exact syntax and the respective semantics are still being debated. The sample syntax in this part of the working draft currently serve as only a hint as to what is being considered as well as to what issues are in the process of being resolved.

3.1. Specification: In-line Timing

In-line timing syntax has not been specified, but several possibilities are under consideration. The In-line Timing Framework section contains an example using SMIL timing.

3.2. Specification: CSS Timing

CSS timing syntax has not been specified, but several possibilities are under consideration.

The exact specification of CSS Timing selectors is still being considered. Selector algebra will most likely be that defined by CSS2 [CSS Selectors].

The CSS Timing Framework section contains an example using SMIL timing.

3.3. Specification: Timesheets

Timesheet syntax has not been specified, but several possibilities are under consideration. The Timesheets Framework section contains several examples (1, 2) using SMIL timing.

3.3.1. Structure copying

The structure of the body may be used to impose temporal semantics, where a time property is assigned to an element. It is important to realize that time relations are imposed between the elements selected. For instance, when selecting a <ol> in a <seq> relation, it means that the ordered list is going to be displayed after or before some other element. It does not mean that the list items contained by the ordered list are to be presented in a sequence.

In order to provide a syntax for denoting temporal relations in line with the body structure, a new type of selectors is added to those already available from CSS.

CSS has the notion of class selectors. These selectors imply that the rule (time relation) they are part of should be applied for each element in the body that is a member of that class.

Timesheets add a new type of class selectors, henceforth to be called **structure selectors**. These selectors imply that the time relation they are part of applies to the result of expanding the structure selector into id selectors of all elements in the body that are members of that structure class. The id selectors have to appear in the order in which the elements lexically appear in the body. In this way, by selecting the class of descendants, the structure of the body section can be copied into the time section, such that the copied structure receives the temporal semantics required.

3.3.2. Structure ownership

Another form of using the structure in the XML body is called **ownership**. Ownership dictates whether a temporal relationship imposed on an element applies to all of its descendants or only on the element itself. Ownership applies for example in the sequenced <ol> case when child <li> element(s) contain further markup. By specifying that ownership is on, the children of <li> element(s) will also take on the same temporal relationship as their parents.

3.3.3. Timesheet selectors

As discussed earlier, in timesheets there are two ways to expand class selectors:

1. *Class selector*. The timesheet's rule applies per member in the class. This is the traditional CSS meaning; the timesheet's rule is repeated per element in that class.
2. *Structure selector*. The timesheet's rule applies to the set elements resulting from expanding the class selector into all its elements. For example, a structure selector is used to create a `<seq>` of `<li>` without identifying all these <li> individually.

The exact specification of timesheet selectors is still being considered. Selector algebra will most likely be that defined by CSS2 [CSS Selectors] with some additional algebra defined as necessary.

3.3.4. Timing style

In addition to selecting elements, style rules should be selectable. This enables changing style properties over time, just as we saw in the In-Line Timing color style example.

3.4. Cascading Rules

In the case where in-line timing and another method are active simultaneously, in-line timing always takes precedence if a conflict arises. This enables the creation of CSS Timing or Timesheets to be used as templates whose rules can be easily modified locally by in-line constructs.

4. DTD

This section provides the formal specification which has not yet been specified.

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Appendix. Examples

1. Consider an XML-based image-list language. Each document contains a list of references to JPEG images. Timing of the images relative to one another is done in line. Here is an example of such a document, where each image in the list exists on the timeline for its specified duration and is then replaced, both spatially as well as on the timeline, by the next image. The final image will be active on the timeline for only 8 of its 10-second duration because the parent is explicitly specified to end at that time. Note: the presentation of the elements is implied in this example.

```
<imagelist timeLine="seq" end="28s">
  <image dur="5s" src="image1.jpg" />
  <image dur="3s" src="image2.jpg" />
  <image dur="12s" src="image3.jpg" />
  <image dur="10s" src="image4.jpg" />
</imagelist>
```

2. This example uses CSS Timing to cause an otherwise static HTML list to grow over time, where each list item shows up below the prior item, 10 seconds after the prior item began its display. Because the UL becomes a "par" time container, its list items do not disappear until the UL's end time is reached.

```
/* style sheet document "growlist.css": */
.seqtimecontainer { timeLine: seq; dur: 30s}
LI { dur: 10s; }


<!-- HTML document (which happens to be well-formed XML): -->
<HTML>
  <HEAD>
   <LINK rel="stylesheet" type="text/css" href="growlist.css" />>
  </HEAD>
  <BODY>
    <UL class="seqtimecontainer">
          <LI>This is item 1.  It appears from 0 to 30 seconds.
          </LI>
          <LI>This is item 2.  It appears from 10 to 30 seconds.
          </LI>
          <LI>This is item 3.  It appears from 20 to 30 seconds.
          </LI>
        </UL>
  </BODY>
</HTML>
```

3. Consider a document written in some graphics language where three big squares are layed out inside a rectangle, and each square contains a smaller square. We should be able to create a timesheet that can schedule the appearance of each square at different times from the others. Note: the presentation of the elements is implied in this example.

```
<rectangle id="window" geometry="..." fill="...">
  <square id="b1" ... >
    <square id="s1" ... / >
  </square>
  <square id="b2" ... >
    <square id="s2" ... / >
  </square>
  <square id="b3" ... >
    <square id="s3" ... / >
  </square>
</rectangle>
```

In order to time the presentation of the elements so that the big squares pop up one after the other, followed by the simultaneous appearance of the small ones, the timesheet might look like this:

```
<time>
  <seq>
    <par>
```

```
      #b1 { dur: 2s }
      #b2 { dur: 2s; begin: 2s; }
      #b3 { dur: 2s; begin: 4s; }
    </par>
    <par>
      #s1 { }
      #s2 { }
      #s3 { }
    </seq>
  </seq>
</time>
```

Note: the outer "window" rectangle has not been given any explicit timing. for this example, we assume that the lack of timing implies a begin time of zero and an infinite duration if the element does not have an implicit duration.

O. Synchronized Multimedia Integration Language (SMIL) Document Object Model

Previous version:

http://www.w3.org/AudioVideo/Group/DOM/smil-dom-990721.html (W3C members only)

Editors:

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Abstract

This is a working draft of a Document Object Model (DOM) specification for synchronized multimedia functionality. It is part of work in the Synchronized Multimedia Working Group (SYMM) towards a next version of the SMIL language and SMIL modules. Related documents describe the specific application of this SMIL DOM for SMIL documents and for HTML and XML documents that integrate SMIL functionality. The SMIL DOM builds upon the Core DOM functionality, adding support for timing and synchronization, media integration and other extensions to support synchronized multimedia documents.

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1.0 Introduction

The first W3C Working Group on Synchronized Multimedia (SYMM) developed SMIL - Synchronized Multimedia Integration Language. This XML-based language is used to express synchronization relationships among media elements. SMIL 1.0 documents describe multimedia presentations that can be played in SMIL-conformant viewers.

SMIL 1.0 did not define a Document Object Model. Because SMIL is XML based, the basic functionality defined by the Core DOM is available. However, just as HTML and CSS have defined DOM interfaces to make it easier to manipulate these document types, there is a need to define a specific DOM interface for SMIL functionality. The current SYMM charter includes a deliverable for a SMIL-specific DOM to address this need, and this document specifies the SMIL DOM interfaces.

Broadly defined, the SMIL DOM is an Application Programming Interface (API) for SMIL documents and XML/HTML documents that integrate SMIL functionality. It defines the logical structure of documents and the way a document is accessed and manipulated. This is described more completely in "What is the Document Object Model".

The SMIL DOM will be based upon the DOM Level 1 Core functionality. This describes a set of objects and interfaces for accessing and manipulating document objects. The SMIL DOM will also include the additional event interfaces described in the DOM Level 2 Events specification. The SMIL DOM extends these interfaces to describe elements, attributes, methods and events specific to SMIL functionality. Note that the SMIL DOM does not include support for DOM Level 2 Namespaces, Stylesheets, CSS, Filters and Iterators, and Model Range specifications.

The SYMM Working Group is also working towards a modularization of SMIL functionality, to better support integration with HTML and XML applications. Accordingly, the SMIL DOM is defined in terms of the SMIL modules.

2.0 Requirements

The design and specification of the SMIL DOM must meet the following set of requirements.

General requirements:

- Inherit DOM Level 1 core functionality - the SMIL DOM will be based upon the generic Core DOM foundation.
- Support constraints on DOM core functionality (e.g. mutation), especially at runtime.
- Support both SMIL documents as well as hybrid documents that integrate XML/HTML and SMIL functionality.
- Support and reflect the modularization of SMIL functionality. It must be possible to design hybrid documents combining XML/HTML and SMIL functionality, that can in turn support a hybrid or combined DOM.

SMIL specific requirements

- Support SMIL specific elements. It must be possible to access and manipulate all SMIL elements with a SMIL document or a hybrid document that integrates XML and SMIL modules.
- Support SMIL specific attributes and methods. It must be possible to access and manipulate the SMIL attributes and methods on SMIL elements as well as XML/HTML elements in a hybrid documents.
- Support SMIL specific events, including:
  - Specification of statically defined SMIL events
  - Support for dynamically defined events
  - The ability to create and raise all the above events
- Support SMIL semantics. This includes various constraints on document structure, attribute values and method invocation.
- Define basic control interface for media player/renderers. Do not define a plug-in API, but rather just the timing and sync control interface.

It is not yet clear what all the requirements on the SMIL DOM will be related to the modularization of SMIL functionality. While the HTML Working Group is also working on modularization of XHTML, a modularized HTML DOM is yet to be defined. In addition, there is no general mechanism yet defined for combining DOM modules for a particular profile.

3.0 Core DOM: the SMIL DOM Foundation

The SMIL DOM has as its foundation the Core DOM. The SMIL DOM includes the support defined in the DOM Level 1 Core API, and the DOM Level 2 Events API.

3.1 DOM Level 1 Core

The DOM Level 1 Core API describes the general functionality needed to manipulate hierarchical document structures, elements and attributes. The SMIL DOM describes functionality that is associated with or depends upon SMIL elements and attributes. Where practical, we would like to simply inherit functionality that is already defined in the DOM Level 1 Core. Nevertheless, we want to present an API that is easy to use, and familiar to script authors that work with the HTML and CSS DOM definitions.

Following the pattern of the HTML DOM, the SMIL DOM follows a naming convention for properties, methods, events, collections and data types. All names are defined as one or more English words concatenated

together to form a single string. The property or method name starts with the initial keyword in lowercase, and each subsequent word starts with a capital letter. For example, a method that converts a time on an element local timeline to global document time might be called "localToGlobalTime".

Properties and methods

In the ECMAScript binding, properties are exposed as properties of a given object. In Java, properties are exposed with get and set methods.

Most of the properties are directly associated with attributes defined in the SMIL syntax. By the same token, most (or all?) of the attributes defined in the SMIL syntax are reflected as properties in the SMIL DOM. There are also additional properties in the DOM that present aspects of SMIL semantics (such as the current position on a timeline).

The SMIL DOM methods support functionality that is directly associated with SMIL functionality (such as control of an element timeline).

Note that the naming follows the DOM standard for XML, HTML and CSS DOM. This matches the HTML attribute naming scheme, but is on conflict with the SMIL 1.0 (and CSS) attribute naming conventions (all-lower with dashes between words). Given that the DOM Level 2 CSS API follows the primary DOM naming conventions, I think we should as well. Although this presents a naming conflict with the SMIL attributes (unless we reconsider attribute naming in the next version of SMIL), it presents a consistent DOM API.

Constraints on Core interfaces

In some instances, the SMIL DOM defines constraints on the Level 1 Core interfaces. These are introduced to simplify the SMIL associated runtime engines. The constraints include:

- Read-only properties, precluding arbitrary manipulation of the SMIL element properties at runtime.
- Disallowed structural changes, precluding certain changes to the structure of the document (and the associated time graph) at runtime.

These constraints are defined in detail below.

This section will need to be reworked once we have a better handle on the approach we take (w.r.t. modality, etc.) and the details of the interfaces.

We probably also want to include notes on the recent discussion of a presentation or runtime object model as distinct from the DOM.

3.2 DOM Level 2 Event Model

One of the goals of DOM Level 2 Event Model is the design of a generic event system which allows registration of event handlers, describes event flow through a tree structure, and provides basic contextual information for each event. The SMIL event model includes the definition of a standard set of events for synchronization control and presentation change notifications, a means of defining new events dynamically, and the defined contextual information for these events.

3.2.1 SMIL and DOM events

The DOM Level 2 Events specification currently defines a base Event interface and three broad event classifications:

- UI events

- UI Logical events
- Mutation events

In HTML documents, elements generally behave in a passive (or sometimes reactive) manner, with most events being user-driven (mouse and keyboard events). In SMIL, all timed elements behave in a more active manner, with many events being content-driven. Events are generated for key points or state on the element timeline (at the beginning, at the end and when the element repeats). Media elements generate additional events associated with the synchronization management of the media itself.

The SMIL DOM makes use of the general UI and mutation events, and also defines new event types, including:

- Object Temporal Events
- Logical Temporal Events
- Synchronization Events
- Media-delivery Events

Some runtime platforms will also define new UI events, e.g. associated with a control unit for web-enhanced television (e.g. channel change and simple focus navigation events). In addition, media players within a runtime may also define specific events related to the media player (e.g. low memory).

The SMIL events are grouped into four classifications:

Static SMIL events

> This is a group of events that are required for SMIL functionality. Some of the events have more general utility, while others are specific to SMIL modules and associated documents (SMIL documents as well as HTML and XML documents that integrate SMIL modules).

Platform and environment specific events

> These events are not defined in the specification, but may be created and raised by the runtime environment, and may be referenced by the SMIL syntax.

Author-defined events

> This is a very important class of events that are not specifically defined in the DOM, but that must be supported for some common use-case scenarios. A common example is that of broadcast or streaming media with embedded triggers. Currently, a media player exposes these triggers by calling script on the page. To support purely declarative content, and to support a cleaner model for script integration, we allow elements to raise events associated with these stream triggers. The events are identified by names defined by the author (e.g. "onBillWaves" or "onScene2"). Declarative syntax can bind to these events, so that some content can begin (or simply appear) when the event is raised. This is very important for things like Enhanced Television profiles, Enhanced DVD profiles, etc.
> This functionality is built upon the DOM Level 2 Events specification.

Property mutation events

> These are mutation events as defined in the DOM Level 2 Events specification. These events are raised when a particular property is changed (either externally via the API, or via internal mechanisms).

3.2.2 Event propagation support

In addition to defining the basic event types, the DOM Level 2 Events specification describes event flow and mechanisms to manipulate the event flow, including:

- Event Capturing
- Event Bubbling
- Event Cancellation

The SMIL DOM defines the behavior of Event capture, bubbling and cancellation in the context of SMIL and SMIL-integrated Documents.

In the HTML DOM, events originate from within the DOM implementation, in response to user interaction (e.g. mouse actions), to document changes or to some runtime state (e.g. document parsing). The DOM provides methods to register interest in an event, and to control event capture and bubbling. In particular, events can be handled locally at the target node or centrally at a particular node. This support is included in the SMIL DOM. Thus, for example, synchronization or media events can be handled locally on an element, or re-routed (via the bubbling mechanisms) to a parent element or even the document root. Event registrants can handle events locally or centrally.

Note: It is currently not resolved precisely how event flow (dispatch, bubbling, etc.) will be defined for SMIL timing events. Especially when the timing containment graph is orthogonal to the content structure (e.g. in XML/SMIL integrated documents), it may make more sense to define timing event flow relative to the timing containment graph, rather than the content containment graph. This may also cause problems, as different event types will behave in very different ways within the same document.

Note: It is currently not resolved precisely how certain user interface events (e.g. onmouseover, onmouseout) will be defined and will behave for SMIL documents. It may make more sense to define these events relative to the regions and layout model, rather than the timing graph.

4.0 Constraints imposed upon DOM

We have found that the DOM has utility in a number of scenarios, and that these scenarios have differing requirements and constraints. In particular, we find that editing application scenarios require specific support that the browser or runtime environment typically does not require. We have identified the following requirements that are directly associated with support for editing application scenarios as distinct from runtime or playback scenarios:

4.1 Document modality

Due to the time-varying behavior of SMIL and SMIL-integrated document types, we need to be able to impose different constraints upon the model depending upon whether the environment is editing or browsing/playing back. As such, we need to introduce the notion of modality to the DOM (and perhaps more generally to XML documents). We need a means of defining modes, of associating a mode with a document, and of querying the current document mode.

We are still considering the details, but it has been proposed to specify an active mode that is most commonly associated with browsers, and a non-active or editing mode that would be associated with an editing tool when the author is manipulating the document structure.

4.2 Node locking

Associated with the requirement for modality is a need to represent a lock or read-only qualification on various elements and attributes, dependent upon the current document mode.

For an example that illustrates this need within the SMIL DOM: To simplify runtime engines, we want to disallow certain changes to the timing structure in an active document mode (e.g. to preclude certain structural changes or to make some properties read-only). However when editing the document, we do not want to impose these restrictions. It is a natural requirement of editing that the document structure and properties be mutable. We would like to represent this explicitly in the DOM specification.

There is currently some precedent for this in HTML browsers. E.g. within Microsoft Internet Explorer, some element structures (such as tables) cannot be manipulated while they are being parsed. Also, many script authors implicitly define a "loading" modality by associating script with the document.onLoad event. While this mechanism serves authors well, it nevertheless underscores the need for a generalized model for document modality.

4.3 Grouped, atomic changes

A related requirement to modality support is the need for a simplified transaction model for the DOM. This would allow us to make a set of logically grouped manipulations to the DOM, deferring all mutation events and related notification until the atomic group is completed. We specifically do not foresee the need for a DBMS-style transaction model that includes rollback and advanced transaction functionality. We are prepared to specify a simplified model for the atomic changes. For example, if any error occurs at a step in an atomic change group, the atomicity can be broken at that point.

As an example of our related requirements, we will require support to optimize the propagation of changes to the time-graph modeled by the DOM. A typical operation when editing a timeline shortens one element of a timeline by trimming material from the beginning of the element. The associated changes to the DOM require two steps:

- Change the begin time of the element to be later in time
- Change the duration of the element to preserve the end time

Typically, a timing engine will maintain a cache of the global begin and end times for the elements in the timeline. These caches are updated when a time that they depend on changes. In the above scenario, if the timeline represents a long sequence of elements, the first change will propagate to the whole chain of time-dependents and recalculate the cache times for all these elements. The second change will then propagate, recalculating the cache times again, and restoring them to the previous value. If the two operations could be grouped as an atomic change, deferring the change notice, the cache mechanism will see no effective change to the end time of the original element, and so no cache update will be required. This can have a significant impact on the performance of an application.

When manipulating the DOM for a timed multimedia presentation, the efficiency and robustness of the model will be greatly enhanced if there is a means of grouping related changes and the resulting event propagation into an atomic change.

5.0 SMIL specific extensions

In all the interfaces below, the details need discussion and review. Do not assume that the defined types, return values or exceptions described are final.

The IDL interfaces will be moved to specific module documents once they are ready.

5.1 Document Interface

Cover document timing, document locking?, linking modality and any other document level issues. Are there issues with nested SMIL files?

Is it worth talking about different document scenarios, corresponding to differing profiles? E.g. Standalone SMIL, HTML integration, etc.

5.2 SMIL Interfaces

A separate document should describe the integrated DOM associated with SMIL documents, and documents for other document profiles (like HTML and SMIL integrations).

The `SMILElement` interface is the base for all SMIL element types. It follows the model of the `HTMLElement` in the HTML DOM, extending the base `Element` class to denote SMIL-specific elements.

Note that the `SMILElement` interface overlaps with the `HTMLElement` interface. In practice, an integrated document profile that include HTML and SMIL modules will effectively implement both interfaces (see also the DOM documentation discussion of Inheritance vs Flattened Views of the API).

Interface SMILElement

Base interface for all SMIL elements.

```
interface SMILElement : Element {
        attribute  DOMString            id;
        // etc. This needs attention
}
```

5.2.1 Structure Elements Interface

This module includes the SMIL, HEAD and BODY elements. These elements are all represented by the core SMIL element interface.

5.2.2 Meta Elements Interface

This module includes the META element.

Interface SMILMetaElement (<meta>)

```
interface SMILMetaElement : SMILElement {
        attribute  DOMString            content;
        attribute  DOMString            name;
        attribute  DOMString            skipContent;
        // Types may be wrong - review

}
```

5.2.3 Layout Interfaces

This module includes the LAYOUT, ROOT_LAYOUT and REGION elements, and associated attributes.

Interface SMILLayoutElement (<layout>)

Declares layout type for the document. See the LAYOUT element definition in SMIL 1.0

```
interface SMILLayoutElement : SMILElement {
        attribute  DOMString            type;
        // Types may be wrong - review
}
```

Interface SMILRootLayoutElement (<root-layout>)

Declares layout properties for the root element. See the ROOT-LAYOUT element definition in SMIL 1.0

```
interface SMILRootLayoutElement : SMILElement {
        attribute  DOMString            backgroundColor;
        attribute  long                 height;
        attribute  DOMString            skipContent;
        attribute  DOMString            title;
        attribute  long                 width;
        // Types may be wrong - review
}
```

Interface SMILRegionElement (<region>)

Controls the position, size and scaling of media object elements. See the REGION element definition in SMIL 1.0

```
interface SMILRegionElement : SMILElement {
        attribute  DOMString            backgroundColor;
        attribute  DOMString            fit;
        attribute  long                 height;
        attribute  DOMString            skipContent;
        attribute  DOMString            title;
        attribute  DOMString            top;
        attribute  long                 width;
        attribute  long                 zIndex;
        // Types may be wrong - review
}
```

The layout module also includes the region attribute, used in SMIL layout to associate layout with content elements. This is represented as an individual interface, that is supported by content elements in SMIL documents (i.e. in profiles that use SMIL layout).

Interface SMILRegionInterface

Declares rendering surface for an element. See the region attribute definition in SMIL 1.0

```
interface SMILRegionInterface {
        attribute  SMILRegionElement    region;
}
```

5.2.4 Timing Interfaces

This module includes the PAR and SEQ elements, and associated attributes.

This will be fleshed out as we work on the timing module. For now, we will define a time leaf interface as a placeholder for media elements. This is just an indication of one possibility - this is subject to discussion and review.

Interface SMILTimeInterface

Declares timing information for timed elements.

```
interface SMILTimeInterface {
        attribute  InstantType          begin;
        attribute  InstantType          end;
        attribute  DurationType         dur;
```

```
        attribute  DOMString            repeat;
        // etc. Types may be wrong - review

            // Presentation methods
        void                            beginElement();
        void                            endElement();
        void                            pauseElement();
        void                            resumeElement();
        void                            seekElement(in InstantType seekTo);
}
```

Attributes

`begin`

The date value of the begin instant of this node, relative to the parent timeline.

`end`

The date value of the end instant of this node, relative to the parent timeline.

`duration`

The duration value of this node.

etc.

Presentation Methods

`beginElement`

Causes this element to begin the local timeline (subject to sync constraints).

Parameters

None

Return Value

None

Exceptions

None

`endElement`

Causes this element to end the local timeline (subject to sync constraints).

Parameters

None

Return Value

None

Exceptions

None

`pauseElement`

Causes this element to pause the local timeline (subject to sync constraints).

Parameters

None

Return Value

None

Exceptions

None

`resumeElement`

Causes this element to resume a paused local timeline. If the timeline was not paused, this is a no-op.

Parameters

None

Return Value

None

Exceptions

None

`seekElement`

Seeks this element to the specified point on the local timeline (subject to sync constraints). If this is a timeline, this must seek the entire timeline (i.e. propagate to all timeChildren).

Parameters

seekTo:
The desired position on the local timeline.

Return Value

None

Exceptions

None

Events

`onBegin`

This event is raised when the element local timeline begins to play. It will be raised each time the element begins (but not on repeats - see the onRepeat Event). It may be raised both in the course of normal (i.e. scheduled) timeline play, as well as in the case that the element was begun with the beginElement() method. Note that if an element is not yet ready to play (e.g. if media is not ready), the onBegin event should not be raised until the element timeline actually begins to play and local time begins to advance.

As a composite timeline begins to play, each element will raise an onBegin event as it in turn begins to play. A parent element will raise an onBegin event before any child elements do.

`onEnd`

This event is raised when the element local timeline ends play. It will be raised when the element ends (NOT on each repeat - see the onRepeat event). It may be raised both in the course of normal (i.e. scheduled) timeline play, as well as in the case that the element was ended with the endElement() method. As a composite timeline ends play, each element will raise an onEnd event as it in turn ends play.

`onRepeat`

This event is raised when the element local timeline repeats. It will be raised each time the element repeats, after the first iteration.

This event should support an integer attribute to indicate the current repeat iteration.

`onPause`

This event is raised when the element local timeline is paused. This is only raised when the element pauseElement() method is invoked.

When pausing a timeline, I do not think that all descendents should also raise onPause events. However, it may be useful to have media descendents raise an onPause event. This needs attention.
I think we should consider supporting a "reason" attribute on this event. This would allow authors to disambiguate a pause due to a method call, and a pause forced by the timing engine as part of handling an out-of-sync problem.

`onResume`

This event is raised when the element local timeline resumes after being paused. This is only raised when the element resumeElement() method is invoked, and only if the element was actually paused. When resuming a timeline, I do not think that all descendents should also raise onResume events. However, it may be useful to have media descendents raise an onResume event. This needs attention.

`onOutOfSync`

This event is raised when an element timeline falls out of sync (either for internal or external reasons). The default action of the timing model is to attempt to reestablish the synchronization, however the means may be implementation dependent. Depending upon the synchronization rules, this event may propagate up the time graph for each timeline that is affected.

`onSyncRestored`

This event is raised when an element that has fallen out of sync has been restored to the proper sync relationship with the parent timeline. This will only be raise after an onOutOfSync event has been raised. Depending upon the synchronization rules, this event may propagate down the time graph, effectively "unwinding" the original onOutOfSync stack.

Interface SMILTimelineInterface

This is a placeholder - subject to change. This represents generic timelines.

```
interface SMILTimelineInterface : SMILTimeInterface {
        attribute NodeList        timeChildren;

        // Presentation methods
        NodeList                  getActiveChildrenAt();
        NodeList                  getActiveChildrenAt(
                                       in instant InstantType instant);
}
```

Attributes

`timeChildren`

A NodeList that contains all timed children of this node. If there are no timed children, this is a Nodelist containing no nodes.

Presentation Methods

`getActiveChildrenAt`

Causes this element to begin the local timeline (subject to sync constraints).

Parameters

instant: The desired position on the local timeline.

Return Value

NodeList: List of timed child-elements active at instant.

Exceptions

None

Interface SMILParElement (<par>)

```
interface SMILParElement : SMILTimelineInterface, SMILElement {
        attribute DOMString       endsync;
}
```

Interface SMILSeqElement (<seq>)

```
interface SMILSeqElement : SMILTimelineInterface, SMILElement {

}
```

5.2.5 Media Element Interfaces

This module includes the media elements, and associated attributes. They are all currently represented by a single interface, as there are no specific attributes for individual media elements.

Interface SMILMediaInterface

Declares media content.

```
interface SMILMediaInterface : SMILTimeInterface {
        attribute  DOMString           abstract;
        attribute  DOMString           alt;
        attribute  DOMString           author;
        attribute  ClipTime            clipBegin;
        attribute  ClipTime            clipEnd;
        attribute  DOMString           copyright;
        attribute  DOMString           fill;
        attribute  DOMString           longdesc;
        attribute  DOMString           src;
        attribute  DOMString           title;
        attribute  DOMString           type;
        // Types may be wrong - review
}
```

Interface SMILRefElement (<ref>)

```
interface SMILRefElement : SMILMediaInterface, SMILElement {
}
// audio, video, ...
```

5.2.6 Transition Interfaces

This module will include interfaces associated with transition markup. This is yet to be defined.

5.2.7 Animation Interfaces

This module will include interfaces associated with animation behaviors and markup. This is yet to be defined.

5.2.8 Linking Interfaces

This module includes interfaces for hyperlinking elements.

Interface SMILAElement (<a>)

Declares a hyperlink anchor. See the A element definition in SMIL 1.0.

```
interface SMILAElement : SMILElement {
            attribute  DOMString            title;
            attribute  DOMString            href;
            attribute  DOMString            show;
        // needs attention from the linking folks
}
```

5.2.9 Content Control Interfaces

This module includes interfaces for content control markup.

Interface SMILSwitchElement (<switch>)

Defines a block of content control. See the SWITCH element definition in SMIL 1.0

```
interface SMILSwitchElement : SMILElement {
        attribute  DOMString            title;
        // and...?
}
```

Interface SMILTestInterface

Defines the test attributes interface. See the Test attributes definition in SMIL 1.0

```
interface SMILTestInterface {
        attribute  DOMString            systemBitrate;
        attribute  DOMString            systemCaptions;
        attribute  DOMString            systemLanguage;
        attribute  DOMString            systemOverdubOrCaption;
        attribute  DOMString            systemRequired;
        attribute  DOMString            systemScreenSize;
        attribute  DOMString            systemScreenDepth;
        // and...?
}
```

5.3 Media Player Interfaces

This is NOT a plug-in interface, but rather a simple interface that describes some guaranteed methods that any application plug-in interface must support. This provides a means of standardizing extensions to the timing model, independent of the specific application.

5.3.1 Media Player Level 1 Interface

5.3.2 Media Player Level 2 Interface

5.3.3 Media Player Level 3 Interface

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