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TAL—Template Authoring Language

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Abstract This paper presents TAL (Template Authoring Language), an authoring language for hypermedia document templates. Templates describe document families with structural or semantic similarities among them. TAL supports the description of templates independently of the target hypermedia authoring language. The paper also presents a TAL processor that generates complete hypermedia documents taking as input a template specification in TAL and a data file with the information that makes that document particular in its family.

Keywords TAL · Nested context language · Template oriented programming · Hypermedia authoring · Hypermedia design patterns · iDTV

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1 Introduction

Hypermedia documents define presentations of media objects (text, audio, video, images, etc.) spatially and temporally related. The creation of such documents is usually achieved by using declarative languages, among which structure-based XML languages, such as NCL [1], SMIL [15], SVG [17], etc.

Some structure-based languages include the concept of hypermedia composition as one of the most important abstractions authors can use. Hypermedia compositions include media objects and other hypermedia compositions, recursively, in addition to relationships among these elements. Hypermedia compositions may implicitly define relationships among their child elements, as is the case of "par" and "seq" SMIL containers with their embedded temporal semantics. But they can also have relationships explicitly defined, as is the case with NCL links. In either case, hypermedia compositions encapsulate semantic relationships among objects. We should note that even with languages that do not support composition abstraction, the whole body of the document denotes a composition. In other words, the concept of composition still prevails, although not allowing composition nesting.

Precisely because compositions encapsulate semantic relationships, hypermedia languages that support them allow for the creation of extensively reusable documents [14]. However, to the best of our knowledge, all structure-based hypermedia languages fail to let authors create compositions with unspecified internal content or unspecified relationships, that is, with incomplete content. As a simple example, such languages allow us to create a slideshow with a fixed number of images being presented together with a background audio. However, they do not allow us to define a slideshow "pattern" of presentation (note that we are not talking about layout but about document content), so that it can be reused and customized in specific instances. We must define which images we are going to use, and which background music we want to be played. This is because this sort of authoring languages aims at specifying *particular* hypermedia documents and not a *family* of documents.

A family of documents is defined as a set of documents that share the same specification for their compositional structure, which we call a *template* [1].

In this paper we present TAL: Template Authoring Language. TAL is a modular declarative language that supports the specification of templates: *incomplete hypermedia compositions*. TAL defines a family (a set) of compositions, and it is independent of any authoring language used to specify hypermedia applications that benefit from TAL compositions to define a particular member of the template family. In the paper, we also present a TAL processor, developed to instantiate final hypermedia documents (application specifications) from TAL templates.

TAL is an evolution of the XTemplate [11] language. It is also a kind of XML schema having as its main purpose to let expert authors specify templates to be used by other authors (possibly non-experts) in a simple, quick and error-free document creation process.

There are many good reasons for template-based development. First, templates promote coherent application *branding*, enabling content producers to define and follow the same hypermedia-application pattern. Second, as a consequence of having hypermedia presentations following the same interface patterns, thanks to a common source template, they can be more usable for those who view and interact with different documents of the same family. Third, template-based authoring promotes reuse, allowing authors to concentrate on filling out only the blanks that make a particular document unique within the family to which it belongs. Finally, templates can also encode domain concepts across related applications, creating a specific vocabulary and defining a set of constraints on this vocabulary, to be followed by all documents of a given family.

In this work, a template is formally described by means of a vocabulary of allowed child-object types, a set of relations allowed between those types, rules that constraint the instantiation of these child-object types and relations, and a set of fixed composition's components (media or composite objects and relationships). In this sense, a template is an incomplete hypermedia composition that has certain blanks that must be filled out in accordance with rules that constrain the content and relationships that authors can insert.

After this brief introduction, the next sections are structured as follows. Section 2 briefly discusses related work. Section 3 presents TAL; the language concepts are defined, the language elements and attributes are presented, and an example is discussed in detail. Section 4 shows how templates can be extended given rise to other templates, and how template definitions can be nested. Finally, Sect. 5 presents our conclusions and final remarks.

2 Related work

Several hypermedia applications embed common design patterns. Design patterns have been intensively studied and proposed in the literature [3], including those targeting hypermedia applications [4, 10].

In line with design patterns principles, SMIL Timesheets [18] allow for adding temporal behavior to hypermedia applications independent of the language used by the application. Indeed, SMIL Timesheets, is a temporal counterpart of CSS [16], also developed in W3C recommendation groups. More precisely, SMIL Timesheets aims to allow any language to incorporate the XML elements and attributes of the SMIL temporal control modules. SMIL Timesheets specify which elements are active at a given time moment and their temporal scope within a document.

Unlike SMIL Timesheets, which allow for embedding temporal aspects in documents written in some timeless specification languages, the TAL language allows for specifying temporal semantics to be applied to compositions *outside* of them, and as first-class entities. The aim is to incorporate the defined semantics in hypermedia application specifications that are defined using languages that allow temporal behavior specifications.

TAL allows for defining not only common design patterns but also a series of constraints on their uses, as is discussed extensively in the next sections. TAL can be considered as a specification language to a set of high level hypermedia design patterns expressed as a template.

A key basis for TAL development was the composition templates proposed in previous versions of XTemplate language [9]. The XTemplate model is based on the style and configuration concepts introduced in Architecture Description Languages (ADLs) [2]. In ADLs, a style describes the conceptual architecture of a system, and a configuration an instance of the style. There is a clear similarity between the composition template and the architectural style concept, and also between the hypermedia composition and architectural configuration concepts. However, the open hypermedia composition concept of XTemplate is at the same time a style and a configuration. Open hypermedia compositions define not only a vocabulary of types and restrictions on the instantiations of these types (similar to styles in ADLs) but also enable the definition of resources, which are elements present in all documents based on these compositions (similar to the purposes of configurations in ADLs).

The new version of XTemplate (3.0) [11] targets families of documents written in NCL 3.0. Unlike TAL, XTemplate 3.0 was developed to a specific target hypermedia language. On the other hand, TAL can be processed together with a padding document to generate applications in different target languages, depending only on the specific processor used. TAL specifications can thus be used to generate hypermedia applications in declarative languages such as SMIL [15], SVG [17], HTML/ECMAScript [20], NCL [1], etc.

XTemplate focus on easing the authoring performed by experts. However, all XTemplate users need to have some technical pre-requisites such as XPath and XSLT [11] knowledge, even if they only need to instantiate composition templates. On the contrary, TAL has as one of its goals to reduce the need for expert authors. TAL avoids the use of external notations different from those of the target-language conceptual model, and notations that are beyond the abstraction level of the target language (like XSLT processing instructions of XTemplate 3.0 do).

In a previous work, we have established the characteristics and methods that may govern the template oriented authoring process [13]. In that paper two main roles involved in the process are described: (i) the role played by the template author, which is an expert responsible for the identification and design of templates, and (ii) the role played by the document author, which can usually be a non-expert since he/she only needs to understand how to fill the gaps described in templates (in what we call, in this paper, the padding document).

One challenge raised in the mentioned work [13] is how to smoothly communicate the template semantics, typically related to the abstraction level of the template authors, to final document authors to allow them to perform their main task: to instantiate the template in some target language. In the current work, TAL templates are designed to allow the final document author to understand templates, without needing further pre-programming requirements. Ideally, we tried to reduce the cognitive distance between the two roles. Although we know that in some cases a meta language for template semantic description will be necessary, for simple scenarios, this proves to be possible.

3 Template authoring language

TAL is a XML-based language that follows the modular approach. In Sect. 3.1 we present a simple use case, defined by the "Button-Text-Image" template, which will be worked out in the remaining subsections. Section 3.2 introduces TAL language concepts, while Sect. 3.3 describes the language elements and attributes. Section 3.4 presents the syntax for defining the language selectors, and Sect. 3.5 the syntax for defining constraints. Section 3.6 deals with how relationships among child objects of a composition must be specified.

3.1 Use case: Button-Text-Image template

Figure 1 shows two authentic examples of hypermedia applications for digital TV. In them, we can recognize the "Button-Text-Image" template used in our examples throughout Sect. 3. In both applications there is a menu (made up by a set of buttons). When a button is selected, by using remote control key navigation, a new text frame and a new image is presented, replacing the display of the previous text frame and image. Text frames and images are always exhibited in the same screen position. This interaction pattern is very common in digital TV applications (as can be seen by browsing the NCL Club public repository [8] of applications developed for the Brazilian Terrestrial Digital TV System) from where the two examples were downloaded.

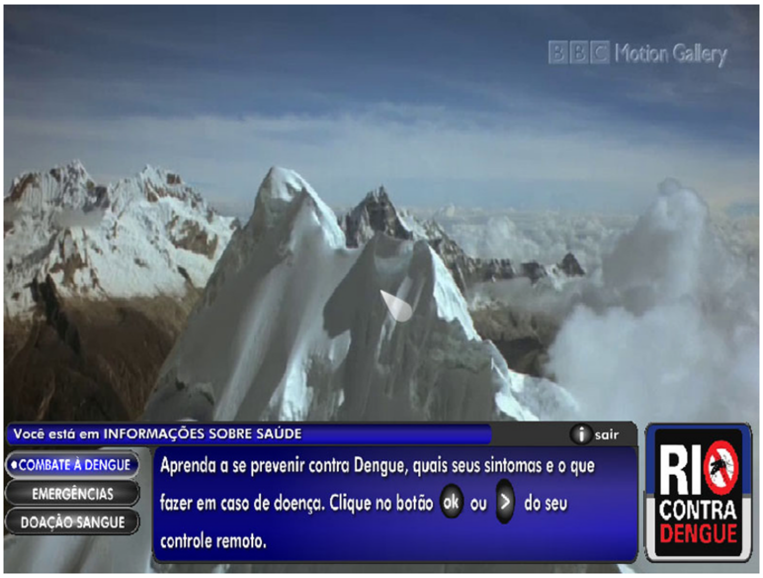
It is very simple, but laborious, to specify these applications as complete hypermedia compositions; in these specific cases, using NCL. Figure 2 presents a structural view of the composition representing the navigational menu for the first application, which has only three buttons. As aforementioned, it is not possible, using NCL, to specify a variable number of child objects of a composition. That is why we had to repeatedly define three buttons, three images and three text objects, and all the relationships among them, although they have the same behavior. Moreover, that is why we cannot reuse the same structure for the second application that has four selection possibilities instead of three. In Fig. 2, three similar NCL <link> elements give the navigational temporal semantics. As for example, the one shown in the figure has the selection of the button 1 as condition. If this condition is satisfied, the presentation of all text frames and images are stopped (ending the presentation of any text frame and image previously selected) and then the presentation of the first image and the first text frame is started. The other <link> elements are only partially shown to no pollute the sketch. Also in the figure, three interfaces associated with the composition indicate that it starts presenting the three buttons. Note how tediously repetitive this specification task could be, especially for a menu with a large number of selection options.

3.2 TAL concepts—overview

In TAL, a *template* is an open-composition (an incomplete composition), or even, a pattern for a composition, whose content is given by:

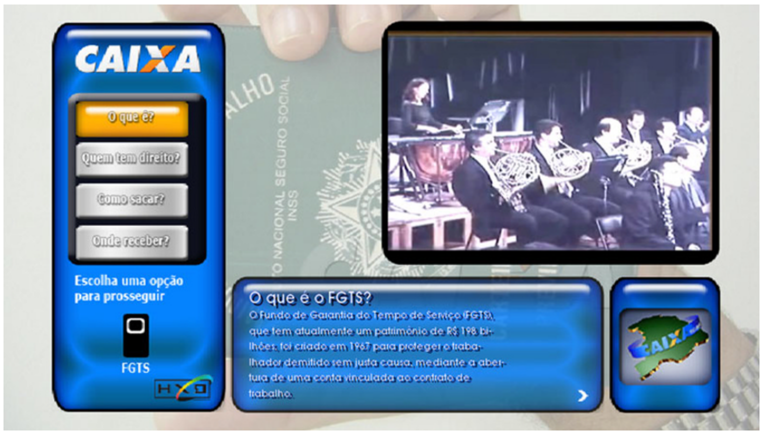
- Vocabulary: defining the allowed types of child object (the components) of the *template*, the allowed types of interfaces for these child objects and for the template itself, and the allowed relations to be used in relationships among child objects.
- Constraints: defining rules on the types defined in the vocabulary.

Fig. 1 Examples of applications that share the same model, from where we can derive the "Button-Text-Image" template



Aprenda a se prevenir contra Dengue, quais seus sintomas e o que fazer em caso de doença. Clique no botão ok ou > do seu controle remoto.

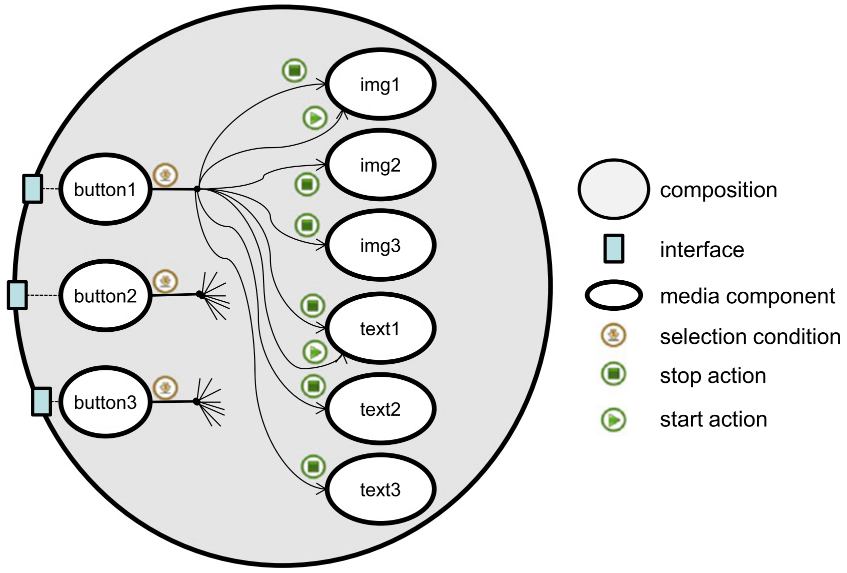
(a) Health application developed by Proderj



O que é o FGTS?
O Fundo de Garantia do Tempo de Serviço (FGTS), que tem atualmente um patrimônio de R$ 198 bilhões, foi criado em 1967 para proteger o trabalhador demitido sem justa causa, mediante a abertura de uma conta vinculada ao contrato de trabalho.

(b) CAIXA$^{®}$ Home-Banking application developed by HxD Interactive Television

Fig. 2 Structural view of a composition representing the navigational menu



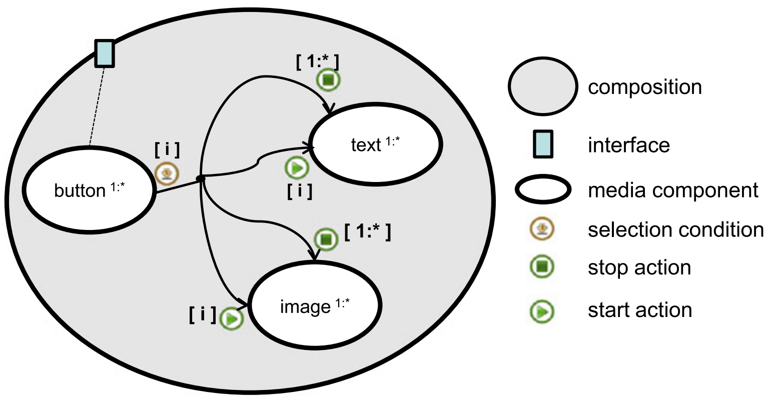


Fig. 3 "Button-Text-Image" template

- Resources: instantiated child objects that shall be inherited by all compositions that use (follow) the template.
- Relationships: relating child-object types and resources.

Child objects of templates can be media objects (any object whose content is to be processed for exhibition) or other nested compositions. An interface can define part of the content of a media object, or can define a child object property, like its positioning on the screen, etc. Child composite objects and the template itself may also have interfaces that externalize interfaces of their internal child objects. Note that in defining the vocabulary we are also defining the hierarchy imputed to the child objects, given by the composition nesting.

It should be stressed that the number of child objects of a template may be left undefined, improving the template expressiveness. The vocabulary allows for defining types. A type for child objects can entail several instantiations.

Constraints are used to verify the correctness of the component instantiation process of a template. They specify rules on the component types and interface types of templates. They can also define algebraic expressions that correlate the cardinality of different types of components and interfaces.

Resources are the unchangeable part of a template. An example of its use is found when an author wants to include a required company logo to all application derived from the template.

Relationships give semantics to a composition. They relate child object interfaces. Since child objects of a composition (and their interfaces) can be left undefined by a template, relationships can also be established among child-object types, and among child objects types and resources. Therefore, relationships referring to child-object types need also to specify how to iterate on the interfaces of the instances of these child objects. As an example, it is possible to create relationships from each instantiated child object of a given type to all other instances of another type.

Interfaces of child objects of a composition may be mapped to interfaces of the composition in order to externalize these internal interfaces to be used in relationships defined outside the composition. Similarly to relationships, since interfaces of a composition can be left undefined by a template, mappings can be established between interface types of child objects and interface types of the composition. Therefore, mappings must also to specify how to iterate on interface instances.

Turning back to the "Button-Text-Image" template, it could be now represented as shown in Fig. 3. In the figure, three component types are defined: "button", "text" and "image". A cardinality constraint could require at least one instance of each type, and that the number of instances of each type is the same. Another constraint could require that the number of interface instances for the template is the same of the number of "button" component type instances. Mapping between each of the template interface instances and each "button" component type instances must be established, in order that applications that follow the template start presenting the menu (the set of buttons). In TAL, when any composition is started without specifying an interface, all its internal interfaces mapped to interfaces of the composition start.

Still in Fig. 3, there is a relationship among the "button", "text" and "image" types. It specifies for each "button" type instance that its selection must result in stopping all instances of the "text" and "image" types, and afterwards in starting the presentation of the "text" and "image" instances correlated with the "button" instance.

Once the template is defined, an application author, for example an NCL author, may create a *padding document* quickly and easily; for example, the document of Listing 1 targeting the application of Fig. 2. Note that it is not necessary to define any NCL interface mappings (mappings to NCL <port> elements) or relationships (NCL <link> elements), since they are already defined in the template, and, as such, they will appear in the resultant (final) NCL document after the template processing. Note that the template is referred in the padding document by using the *template* attribute of the <context> element that inherits the template specification, as it is discussed in the next section.

As aforementioned, TAL must be processed together with a padding document to generate applications in differ-

Listing 1 NCL padding-document based on the "Button-Text-Image" template

```
<context id="myMenu" template="templates.xml\#ButtonTextImage">
  <port id="pButton1" ... class="pButton"/>
  <port id="pButton2" ... class="pButton"/>
  <port id="pButton3" ... class="pButton"/>
  <media id="button1" ... class="button"/>
  <media id="text1" ... class="text"/>
  <media id="img1" ... class="image"/>
  <media id="button2" ... class="button"/>
  <media id="text2" ... class="text"/>
  <media id="img2" ... class="image"/>
  <media id="button3" ... class="button"/>
  <media id="text3" ... class="text"/>
  <media id="img3" ... class="image"/>
</context>
```

ent target languages, depending only on the specific TAL Processor used. A specific TAL Processor could use the template of Fig. 3 and the padding document of Listing 1 to generate the final NCL application; another specific TAL Processor could use the same template and padding document to generate the final application in SMIL. Moreover, a padding document could be easily defined for the template of Fig. 3 in SMIL, for example, or in HTML. Other particular TAL Processors could then generate final documents in NCL, SMIL, HTML, etc. based on this SMIL, or HTML, padding document and the template defined in TAL.

3.3 TAL specification

TAL language is composed of eight modules. Two are used in the definition of padding documents[1] and the others for template definitions.

The *Classification* module and the *TemplateBase* module are used by the padding document to extend its specification language to support templates. The *Classification* module defines the *template* attribute and the *class* attribute (the last one discussed in Sect. 3.4). The *template* attribute extends a composition specification in the padding document. It refers to the template to be used together with the open composition specification to generate the target-language final document. The *TemplateBase* module defines the <templateBase> element used by the padding language to define a template base. Templates used in the padding document can be imported to the <templateBase> using <importTal> child elements.

Table 1 summarizes the hierarchical structure of the elements and attributes defined in the other TAL modules. These elements and attributes are used in template definitions. Attributes that are required are underlined. Also in the table, the following symbols are used: (?) optional (zero or one occurrence); (|) or; (*) zero or more occurrences; (+) one or more occurrences. In some elements the textual content (Cdata) is a relation, or a relationship, or a mapping specification, or even an error message, as explained in what follows.

The *Structure* module defines the root element, called <tal>. This element has the *id* attribute. As any *id* attribute of TAL, it may receive any string value that begins with a letter or an underscore and that only contains letters, digits, "." and "_". The *id* attribute univocally identifies an element in a TAL document.

The *Importing* module allows for importing templates defined in other TAL documents. The <importBase> element is used for this purpose. Its *documentURI* attribute must have the URI of the imported TAL document as value. The *alias* attribute specifies a name to be used when referring to the imported template. Imported templates can be used in compositions of the importing template or else to be extended generating new templates, as discussed in Sect. 4.

The *Template* module defines the <template> element and its attributes. More than one template may be specified in a TAL document. A <template> must have the *id* attribute. The *extends* attribute can be used if the template extends another template, referenced by this attribute value. In this case, the template inherits the vocabulary, constraints, resources, and relationships defined in the extended template.

The *Vocabulary* module defines entity types of a template, through the <component>, <interface> and <relation> elements.

Types for child objects of a template are defined by the <component> element. Interface types, both for the template itself and for its child objects, are defined by the <interface> element. A relation type is defined by the <relation> element. These elements have the required *id* attribute, and the *selects* attribute, which establishes to which target padding language elements the corresponding types must be applied. The syntax of allowed values for the *selects* attribute is described in Sect. 3.4.

The <component> element can also have property-names as attributes. Each property-name and respective value should be converted by the TAL processor to a property/-value of the instance of the <component> type. In other

[1]A template must be processed together with a padding document given rise to a new document in some specification language, called target language. Usually a specific processor is required for each target language.

Table 1 XML elements and attributes of TAL Language

Element	Attribute	Element's content
tal	id	(template | importBase)+
importBase	documentURI, alias	
template	id, extends	(component | interface | relation | assert | report | warning | link)*
component	id, selects, (property-name)*	(component | interface)*
interface	id, selects, componente, interface	Cdata = mapping specification (forEach)?
relation	id, selects	Cdata = relation specification
assert	test	Cdata = message
report	test	Cdata = message
warning	test	Cdata = message
link	id	Cdata = link specification (forEach)*
forEach	instanceOf, iterator, step	Cdata = link specification (forEach)*

words, each <component> instance inherits the properties defined in the property-name attributes of the <component> type, whose interpretations are responsibility of the TAL processor. If the padding document declares a property that has already been defined by the template, the value declared by the padding document has precedence.

When an <interface> element defines an interface type for a composition, in particular for the template, it can also define a mapping to an interface of a child object of the composition, externalizing this mapped interface. As mappings can be established among types, <forEach> child elements can be used to iterate on these type instances.

The content of the <relation> element specifies a sentence that defines causal or constraint relation. Relations are used to specify relationships (discussed in Sect. 3.6).

The *Constraint* module establishes constraint rules by using <assert>, <report> and <warning> elements. Rules are specified similarly to Schematron [6]. In all three elements the *test* attribute specifies the logical test to be evaluated, following the syntax described in Sect. 3.5. The error or warning message is defined in the content of these elements. The <assert> element requires the test evaluation returns "true", otherwise its error message should be presented. The <report> element is similar but requires that the test be evaluated as false to not exhibit its error message. The <warning> element requires that the test be evaluated as false to exhibit its warning message. When an error message occurs, the template evaluation is aborted and no final document is generated by the template processor. On the other hand, a warning message does not stop the template processing to generate the final document in some target language.

The *Relationship* module allows for specifying relationships. Relationships are defined by using <link> elements. As relationships can be established among types, <forEach> child elements can be used to iterate on these type instances. More details about relationships are presented in Sect. 3.6.

Resources (any target-language element) can be directly inserted in the template using the target-language namespace when defining them. The template processor interprets each element outside the template namespace as an element to be included in the final (target language) document. Listing 2 exemplifies the use of resources including a logo to be exhibited during the template presentation. Listing 2 gives the complete specification of the template of Fig. 3 (the "Button-Text-Image" template), including the logo previously mentioned. In this section, only the general template structure is explained, leaving the description of some specific attribute values to the next sections.

In Listing 2, line 1 is the standard XML header. Lines 2 to 45 define the template base that, in this case, has only one template: the "Button-Text-Image" template (lines 3 to 44). This template can be applied to padding document compositions whose *template* attribute has "ButtonTextImage" as value.

Lines 4 and 10 define two resources to be included in the target-language document after the template processing.

Lines 5 to 9 define an interface type for the template. This type selects every <port> element in the padding document whose *class* attribute has "pButton" as value. Concerning indexation, the first element found in the padding document that agrees with the "port[class = pButton]" selector is related to the pButton [1] identifier; the second to the pButton [2] and so on. This procedure is particularly useful to understand the *mapping* specifications, defined in lines 6 to 8, between each "pButton" interface to each corresponding "button" component. Note in line 6 how iteration is defined on each pButton[i] interface instance. In line 7 the interface of a child object is specified, by using *component* attribute and omitting the *interface* attribute. When the *interface* parameter is omitted, it is assumed that the child object interface corresponds to the one representing the whole content of the object.

Listing 2 The "Button-Text-Image" template specification

```
1: <?xml version="1.0" encoding="UTF-8"?>
2: <tal:tal id="templateExample">
3:  <tal:template id="ButtonTextImage">
4:   <port id="pLogo" component="logo"/>
5:   <tal:interface id="pButton" selects="port[class=pButton]">
6:     <tal:forEach instanceOf="pButton" iterator="i">
7:        component="button[i]"
8:     </tal:forEach>
9:     </tal:interface>
10:    <media id="logo" src="../media/telemidia.png" ... />
11:    <tal:component id="button" selects="media[class=button]"/>
12:    <tal:component id="text" selects="media[class=text]"/>
13:    <tal:component id="image" selects="media[class=image]"/>
14:    <tal:link id="buttonSelection">
15:     <tal:forEach instanceOf="button" iterator="i">
16:        onSelection button[i] then
17:        <tal:forEach instanceOf="text" iterator="j">
18:           stop text[j], stop image[j],
19:        </tal:forEach>
20:        start text[i], start image[i] end
21:     </tal:forEach>
22:     </tal:link>
23:     <tal:assert test="\#logo<2">
24:      It must be only one LOGO element.
25:     </tal:assert>
26:     <tal:assert test="\#button==\#pButton">
27:      The cardinality of BUTTON and the template's interface must be the same.
28:     </tal:assert>
29:     <tal:assert test="\#button>0">
30:      It must be at least one BUTTON element.
31:     </tal:assert>
32:     <tal:assert test="\#text>0">
33:      It must be at least one TEXT element.
34:     </tal:assert>
35:     <tal:assert test="\#image>0">
36:      It must be at least one IMAGE element.
37:     </tal:assert>
38:     <tal:assert test="\#button==\#text">
39:      The cardinality of BUTTON and TEXT must be the same.
40:     </tal:assert>
41:     <tal:assert test="\#button==\#image">
42:      The cardinality of BUTTON and IMAGE must be the same.
43:     </tal:assert>
44:   </tal:template>
45: </tal:tal>
```

Lines 11 to 13 define component types for child objects of the template. The component type "button" selects every <media> element in the padding document whose *class* attribute has "button" as value. They represent the set of menu buttons to be exhibited. Once more, the first element found in the padding document that agrees with the "media[class = button]" selector is related to the button [1] identifier; the second to the button [2] and so on. This procedure is particularly useful to understand *relationship* and *mapping* specifications. Likewise, the component types "text" (for the corresponding text frames) and "image" (for the corresponding images) select every <media> element in the padding document whose *class* attribute has "text" and "image" as value, respectively.

Lines 14 to 22 define relationships established among child objects of the template, when any of the buttons is selected. Section 3.6 presents relationship specifications in more details. Note, however, that the order to apply the actions defined by a relationship is the order of their definition in the <link> specification; in this case first "stop" and then "start".

Cardinality constraints are defined in lines 23 to 43. The first constraint requires at most one "logo" instantiation. The second one requires that the number of "button" components is equal to the number of "pButton" interfaces. The third to fifth constraints require at least one "button", one "text", and one "image" component, respectively. The sixth and seventh constraints require that the numbers of "button", "text", and "image" instances are the same.

3.4 Selectors of TAL

Templates and types defined in TAL may use selectors similar to CSS selectors [16]. Selectors are used to identify which elements of the padding document must be processed in agreement with the type or template they are associated with. Table 2 summarizes the different selectors that may be used.

Table 2 TAL Language selectors

Pattern	Meanning
*	Selects any element
E	Selects any element whose name is E
EF	Selects any F element descendant of an E element
E > F	Selects any F element child of an E element
E: i-child	Selects an E element when it is the *i*th child
E + F	Selects any F element that is immediately preceded by an E element
E[foo]	Selects any E element that has the “foo” attribute
E[foo = val]	Selects any E element whose “foo” attribute has “val” as a value
E[foo ∼= val]	Selects any E element whose “foo” attribute is a list of values, and one of them is equal to “val”
E.val	The same as E[class ∼= val]
E#myId	Selects any E element whose identifier is equal to “myId”

Figure 4 EBNF of the constraint language to be embedded in TAL

```
constraint = exp cmp exp;
exp        = term { operand exp };
term       = "(" exp ")" |
             integer |
             "#" id |
             "#" "{" selector "}";
cmp        = "==" | " ==" | "<" | ">" | "<=" | ">=";
integer    = [0-9]+;
id         = "*" | [a-zA-z_][a-zA-Z0-9_]*;
selector   = TAL selector ;
operand    = "+" | "-" | "*" | "/" | "^";
```

Turning back to our example in Listing 1, the “myMenu” composition refers the template having its *template* attribute equal to “templates.xml#ButtonTextImage”. The “button1”, “button2” and “button3” <media> elements, all of them with the *class* attribute equal to “button”, are associated to the “button” component type (see Listing 2) by means of the selector “media[class = Button]”. The same happens with the other component types and interface types of the template.

3.5 Constraint language

As previously exemplified, template authors can establish constraints on the use of entity types they define in padding documents.

Constraint rules are defined based on constraint programming paradigm [19], in which authors specify properties (the constraints) to be obeyed by a solution, instead of a sequence of algorithmic steps that gives the solution.

The same purpose was pursued in previous TAL version, called XTemplate [9], using XPath [11] and XSLT [11] technologies. However, that proves to be of hard use, especially for non-expert programmers, which led us to this new proposition.

Figure 4 gives the EBNF [12] syntax of the new constraint language embedded in TAL. The terms in brackets and bold are the terminals of the grammar. The braces ({ }) denote an optional section. The | symbol defines an optional list for a grammatical rule.

In Fig. 4, note that TAL selectors can be used in defining constraints, which makes the language more versatile. Usually, constraints are defined as logical sentences that result from comparing two expressions (possibly nested between parentheses), which can contain integer constants, cardinality of component and interface types, or the result of a selector clause.

3.6 Specifying relationships in TAL

Figure 5 presents the EBNF syntax for defining relationships in TAL. As usual, the terms in brackets and bold are the terminals of the grammar. The braces ({ }) denote an optional section. The | symbol defines an optional list for a grammatical rule.

Relationships in TAL are defined by <link> elements that follow the same semantics of causal links of NCL [1], in which conditions must be satisfied to cause the execution of a set of actions. As in NCL, relationships are based on events. The current version of TAL supports the following event types:

– *presentation event*, which is defined by the presentation of a subset of the information units of a media object. Presentation events can also be defined on compositions,

Figure 5 Language syntax for defining relationships in TAL

```
link      = condlist "then" actlist "end";
condlist = "(" condlist ")" withparams
             {lop condlist}?
            | condition {lop condlist}?;
condition = condname perspective withparams
             | assessment withparams;
assessmt = assessexpr rop assesexpr;
assesxpr = perspective {"+" string}?
            | string {"+" perspective}?;
condname = "onAbort" | "onBegin" | "onEnd"
           |"onBeginAttribution" | "onEndAttribution"
           |"onPause" | "onResume" |"onSelection";
actlist  = "(" actlist ")" withparams
           {aop actlist}?
          | action {aop actlist}?;
action   = actnoset perspective withparams
          | "set" perspective "=" string withparams
          | "set" perspective "=" perspective
           withparams;
actnoset = "abort" | "pause" | "resume"
            | "start" | "stop";
perspective = idref {"." idref}?;
withparams ={"with"{parameter,}*parameter{","}?}?;
parameter = idref "=" string;
string     = """character sequence"□"
           | "`"character sequence"'";
aop   = "||" | {";"}?;
lop   = "and" | "or";
rop   = "<" | ">" | "<=" | ">=" | "==" | "=";
idref = XML IDRef
```

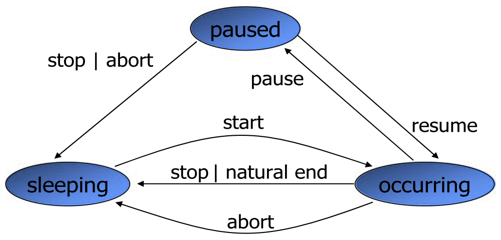


Figure 6 Event state machine

representing the presentation of the information units of any object inside it;
- *selection event*, which is defined by the selection of a subset of the information units of a media object being presented;
- *attribution event*, which is defined by the attribution of a value to a property of an object.

Each event defines a state machine (see Fig. 6). Moreover, every event has an associated attribute, named *occurrences*, which counts how many times the event transits from occurring to sleeping state during a document presentation. Events of presentation and attribution types also have an attribute named *repetitions*, which counts how many times the event shall be automatically restarted (transited from sleeping to occurring states). This attribute may contain the "indefinite" value, leading to an endless loop of the event occurrences until some external interruption.

Link conditions can be simple or compound. Simple conditions are associated to event state transitions defined in

Table 3 Reserved condition values associated to event state machines

Role Value	Transition Value	Event Type
OnBegin	Starts	Presentation
OnEnd	Stops	Presentation
OnAbort	Aborts	Presentation
OnPause	Pauses	Presentation
OnResume	Resumes	Presentation
OnSelection	Stops	Selection
OnBeginSelection	Starts	Selection
OnEndSelection	Stops	Selection
OnBeginAttribution	Starts	Attribution
OnEndAttribution	Stops	Attribution
OnAbortAttribution	Aborts	Attribution
OnPauseAttribution	Pauses	Attribution
OnResumeAttribution	Resumes	Attribution

Table 3. Compound conditions are logical expression (using "and" or "or" operators) between simple and compound conditions.

Link actions can also be simple or compound. Simple actions are shown in Table 4. Compound actions are made up by simple and compound actions associated by parallel ("||") or sequential (";") operators.

Some examples can help understanding how relationships are defined. If one would like to define a relationship between two media objects "A" and "B", in which the end of "A" starts the exhibition of "B", we would have "onEnd

Table 4 Reserved action role values associated to event state machines

Role value	Action type	Event type
Start	Start	Presentation/attribution
Stop	Stop	Presentation/attribution
Abort	Sbort	Presentation/attribution
Pause	Pause	Presentation/attribution
Resume	Resume	Presentation/attribution
Set	Start	Attribution

A then start B end”. In another example, if an author would like to mute the audio of an audiovisual object “V” when it is resized (property *bounds*), we would have “onEndAttribution V.bounds then set V.soundLevel = ‘0’ end”.

Taking back to the “Button-Text-Image” template of Listing 2, lines 14 to 22 specify a relationship among types of components. Since the relationship starts with the <forEach> element, it is translated into several NCL links, when processed targeting the NCL language. These link conditions are given in line 16, in which the selection of any component of “button” type triggers the actions stopping all images and text presentations (line 17 to 19) and starting, in sequence, the presentation of the text and the image corresponding to the selected button (line 20).

4 Extending and nesting templates

This section describes two further features of TAL. In Sect. 4.1 we illustrate the extension mechanism for templates, using a slide show as example. In Sect. 4.2 we show how templates can define component types that follow other template definitions. This template nesting feature is exemplified by replacing the “image” component type of the Button-Text-Image template of Sect. 3, by a component type that follows the “slideshow” template of Sect. 4.1.

4.1 Slide show

Figure 7 shows an open-composition describing a slide show, a classical example of document family. During the slide show, a background audio is played. The open-composition can be defined by a template with two component types. One is the audio type, which is constrained to have only one instance. The other is the photo type, which is constrained to have at least one instance, but without limit of instances. Two resources establish the audio component and the first instance of the photo component as starting points of the composition. Two relationships are defined in the template. The first one establishes that the end of the audio instance must stop the presentation of all photo instances, thus ending the slide show. The second one determines that when the presentation of any photo ends the next photo presentation must start.

Next we use this simple example to illustrate how templates can be extended to generate new templates. So, let us first define a basic TAL template for slide shows specified using NCL language. This template is similar to the one of Fig. 7, but without the background audio. In this basic TAL template whose identifier is “slideSequence”, as shown in line 3 of Listing 3, the presentation begins starting the first photo component instance, as defined by the NCL <port> resource of line 4. Line 5 defines the photo component type that selects each padding (document) <media> element with *class* attribute equal to “photo”. Every instance of the photo component inherits the defined *explicityDur* attribute that must be translated by the TAL processor to an attribute of the targeting language that determines 6 seconds for each photo instance exhibition. Lines 12 to 14 establish that there must be at least one photo instance. The basic template has only one relationship (“changingPhotos”) defined in lines 7 to 11. The relationship determines that the end of each photo instance presentation must start the following, with the end of the last instance starting the first one. This circular behavior is created by the line 9 (“i%#photo+1”). The % symbol denotes the binary operator that calculates the remainder of the division of first operand (i) by the second operand (#photo). This is necessary in order to index the first instance after the last one.

The template of Listing 3 can now be extended by the template “slideshow” (line 4 in Listing 4) to define the desired template of Fig. 7. Line 3 of Listing 4 shows how this new template imports the previous one to be extended. The importing template will inherit the vocabulary, relationships, resources and constraints of the imported one.

In the “slideshow” template, a new audio component type is defined (line 6) with only one instance (constraint in line 14 to 16). A <media> element of the padding document shall refer to this component through its *class* attribute having “audio” as value. Another NCL <port> resource is also added (line 5) to start the audio component instance when the template starts its presentation. The relationship of lines 7 to 13 establishes that the end of the presentation of the audio instance must stop the presentation of all photo component instances.

Let us now extend the “slideshow” template giving rise to the “controlledSlideshow” template of Listing 5. NCL documents following this template allows for moving forward and backward in the slide sequence using the navigational “RIGHT” and “LEFT” keys, respectively, without waiting for the 6 seconds duration of each slide.

In Listing 5, the “slideshow” template is imported with the “doc” alias (line 3). The new template is defined in line 4

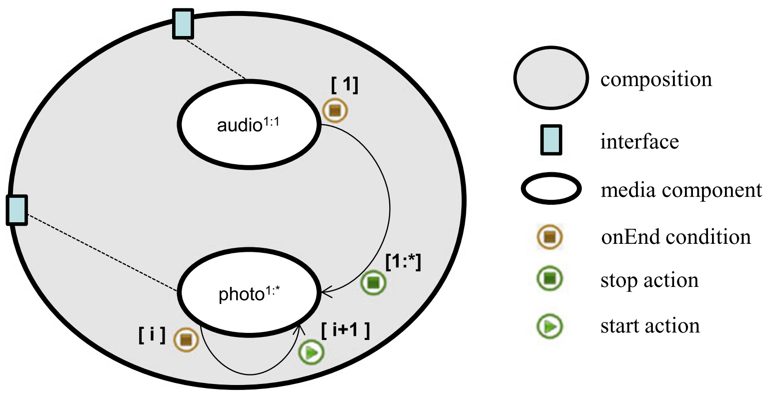


Figure 7 *slideshow* template

Listing 3 slideSequence.xml document file: basic slide show

```
1:  <?xml version="1.0" encoding="UTF-8"?>
2:  <tal:tal id="templateDocument1">
3:     <tal:template id="slideSequence">
4:        <port id="pPhoto1" component="photo [1]"/>
5:        <tal:component id="photo"
               selects="media[class=photo]" explicityDur="6s"/>
6:        <!-- circular slideshow -->
7:        <tal:link id="changingPhotos">
8:           <tal:forEach instanceOf="photo" iterator="i">
9:             onEnd photo[i] then start photo[i\%\#photo+1] end
10:          </tal:forEach>
11:       </tal:link>
12:       <tal:assert test="\#photo>0">
13:          There must be at least one PHOTO component.
14:       </tal:assert>
15:    </tal:template>
16: </tal:tal>
```

Listing 4 slideshow.xml document file: slideshow with background audio

```
1:  <?xml version="1.0" encoding="UTF-8"?>
2:  <tal:tal id="templateDocument2">
3:     <tal:importBase documentURI="slideSequence.xml"
                       alias="doc"/>
4:     <tal:template id="slideshow"
                   extends="doc\#slideshow">
5:       <port id="pAudio" component="audio\cite{1}"/>
6:       <tal:component id="audio" selects="media[class=audio]"/>
7:       <tal:link id="stopPresentation">
8:          onEnd audio[1] then
9:             <tal:forEach instanceOf="photo" iterator="i">
10:              stop photo[i],
11:          </tal:forEach>
12:          end
13:      </tal:link>
14:      <tal:assert test="\#audio==1">
15:       There must just one AUDIO component.
16:      </tal:assert>
17:    </tal:template>
18: </tal:templateBase
```

as an extension to the previous template. Three new relationships are added. The first defines the navigation to the next photo exhibition by using the "RIGHT" key (lines 6 to 11). The last two define the circular navigation to the previous photo exhibition by using the "LEFT" key (lines 13 to 22). Note that the "abort" command is used instead of "stop", since "abort" does not generate notification (onEnd) to trigger the link "changingPhotos" inherited from the template of Listing 3.

4.2 Button-Text-Slideshow Template

The template we present in this section is similar to the Button-Text-Image template of Sect. 3. However, instead of presenting an image when a button is selected, a slideshow is exhibited. This new template example also targets the NCL language. It illustrates how TAL allows authors to define a template that contains a composition (a component type) that is defined in agreement with another referenced template.

Listing 5 controlledSlideshow.xml document file: including key navigation in a slide show

```
<?xml version="1.0" encoding="UTF-8"?>
<tal:tal id="templateDocument3">
   <tal:importBase documentURI="slideshow.xml" alias="doc"/>
   <tal:template id="controlledSlideshow"
                              extends="doc\#slideshow">
      <!-- RIGHT button -->
      <tal:link id="nextPhoto">
         <tal:forEach instanceOf="photo" iterator="i">
            onSelection photo[i] with {key="RIGHT"} then
            abort photo[i], start photo[i\%\#photo+1] end
         </tal:forEach>
      </tal:link>
      <!-- LEFT button -->
      <tal:link id="previousPhoto">
         <tal:forEach instanceOf="photo" iterator="i">
            onSelection photo[i] with {key="LEFT"} then
            abort photo[i], start photo[i-1] end
         </tal:forEach>
      </tal:link>
      <tal:link id="circularPreviousPhoto">
         onSelection photo [1] with {key="LEFT"} then
         abort photo [1], start photo[\#photo] end
      </tal:link>
   </tal:template>
</tal:tal>
```

Listing 6 buttontextslideshow.xml document file: template “Button-Text-Slideshow”

```
<?xml version="1.0" encoding="ISO-8859-1"?>
<tal:tal id="butttontextslideshowTemplateBase">
   <!-- importing slideshow template base -->
   <tal:importBase documentURI="temporalSlideshow.xml"
                                                alias="base"/>
   <tal:template id="ButtonTextSlideshow">
      <tal:interface id="pButton" selects="port[class=pButton]">
          <tal:forEach instanceOf="pButton" iterator="i">
                                             component="button[i]"
          </tal:forEach>
      </tal:interface>
      <tal:component id="button" selects="media[class=button]"/>
      <tal:component id="text" selects="media[class=text]"/>
      <tal:component id="slideshow"
                              selects="context[class=slideshow]"
                             template="base\#slideshow"/>
    <tal:link id="buttonSelection">
      <tal:forEach instanceOf="button" iterator="i">
         onSelection button[i] then
         <tal:forEach instanceOf="text" iterator="j">
            stop text[j], abort slideshow[j],
         </tal:forEach>
         start text[i], start slideshow[i] end
      </tal:forEach>
    </tal:link>
    <tal:assert test="\#logo<2">
     It must be only one LOGO element.
    </tal:assert>
    <tal:assert test="\#button==\#pButton">
     The cardinality of BUTTON and the template’s interface
     must be the same.
    </tal:assert>
    <tal:assert test="\#button>0">
     It must be at least one BUTTON element.
    </tal:assert>
    <tal:assert test="\#text>0">
     It must be at least one TEXT element.
    </tal:assert>
    <tal:assert test="\#slideshow>0">
     It must be at least one SLIDESHOW element.
    </tal:assert>
    <tal:assert test="\#button==\#text">
     The cardinality of BUTTON and TEXT must be the same.
    </tal:assert>
    <tal:assert test="\#button==\#slideshow">
     The cardinality of BUTTON and SLIDESHOW must be the same.
    </tal:assert>
  </tal:template>
</tal:tal>
```

Listing 6 presents this new template in TAL. The single difference with regards to the template of Sect. 3 is related with the previous "slideshow" template, which is imported in line 4. In this new template, instead of having the definition of the "image" component type, we define the "slideshow" component (line 13). This component represents an imported template referred in the *template* attribute. From line 14 on of Listing 6, the template definition is identical to lines 14 to 45 of Listing 2, except from replacing "image" by "slideshow" in all occurrences.

Finishing this section, we should stress that template nesting enhances TAL expressiveness and makes easier the modeling of several scenarios.

5 Conclusions

Templates specified using TAL can be instantiated generating new final documents. As aforementioned, these documents are actually the output of a TAL *processor*. In order to do so, a TAL processor takes a template specification along with a *padding document* as its input data. This kind of approach enables "expert" authors to create TAL templates to be used by less skilled multimedia document creators (see Listing 2). All the latter have to do is to define how features that are specific to the particular document they are about to produce must be *filled in*. In other words, less skilled authors simply produce a padding document for a particular TAL template (see Listing 1 for a padding document targeting the NCL language). We should emphasize that this strategy promotes reuse of all the semantic structure associated to a template.

The paradigm used to create applications promoted by TAL seems to appropriately answer to the requirements imposed by emerging interactive digital TV applications. It allows for authors to establish and follow a particular *format* (or *pattern*) of presentation, which may be associated to branding, among other things.

A side effect of using TAL, which may come as a handy feature, is that it allows authors to specify explicitly the semantics of a given composition type. That is, as we define a template as *an open hypermedia composition*, new compositions are created as specializations of high-level specification. Seen from this perspective, a template can be taken as the description of semantic constrains that apply to all relationships pertaining to a given composition type, regardless of the actual compositions that are eventually instantiated by *end authors*.

The TAL processor for NCL was developed in Lua language and it is freely distributed in http://www.telemidia.puc-rio.br/tal.

We are currently working on providing use of templates in authoring tools such as NCL Composer [5, 7]. Since this particular tool provides support for plug-ins that may define different authoring *views* for a document specification (textual, layout, structural, outline, and temporal views, among others), we are working on adding views to help authors creating new documents using TAL templates. This should promote the use of Composer, helping novice authors to create new documents based on pre-existing templates.

As future work we are planning to do empirical tests with (potential) TAL users, in an attempt to understand what is the actual contribution of TAL to the overall usability of NCL-based authoring resources, especially in comparison with other existing template-specification languages (in the same domain). One of the factors that are of particular interest and relevance for this research is to assess the scalability of TAL in actual contexts of use.

As another future work we are planning to use ontologies in describing TAL templates. This would bring about better reasoners to check the consistency of templates, subtemplates and instances. Moreover, users could use conventional ontology readers and editors in using TAL.

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