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A Dialog Engine Metamodel for the Transformation-Driven Architecture[1]

Sergejs Kozlovics
University of Latvia, Faculty of Computing, Raina bulv. 19, Riga, LV-1586, Latvia
Institute of Mathematics and Computer Science, University of Latvia
Raina bulv. 29, Riga, LV-1459, Latvia
sergejs.kozlovics@lumii.lv

Many metamodel-based tools provide only limited features for specifying dialog windows by means of the metamodel. Is there a way of specifying complex dialogs while still using the metamodel-based ap-proach? The metamodel proposed in this paper permits specifying rather complex dialogs in a simple and intuitive way. It has been successfully used within the context of the transformation-driven architecture (TDA).

Keywords: dialogs, GUI, dialog engine, TDA, transformation-driven architecture.

1 Introduction

It is hard to imagine a graphical tool without a graphical user interface (GUI). Classical dialog boxes with input fields and buttons are well-known and accus-tomed. We will not invent the wheel in this paper; we concentrate on already familiar dialog windows. We present a simple yet expressive metamodel for describing such dialogs and comment on the corresponding engine for handling dialogs specified by means of that metamodel. Since this is a metamodel, it may be used in the world of model transformations. Our metamodel has already been successfully used with the transformation-driven architecture [1], which is a system-building approach that incorporates model transformations and metamodels with their engines.

The above mentioned dialog metamodel is the main contribution of this paper. The metamodel has been developed in such a way that, given an instance of it, the dialog engine is able to automatically create the real dialog box at runtime and to show it to the user. One of the important features of the metamodel is the possibility to specify the layout of dialog elements. If we sketch a dialog box on a sheet of paper, we usually do not bother about exact coordinates, but we think about the layout and grouping of components and aesthetics. The same kind of layout information is expected in instances of the proposed metamodel.

One may be interested whether the metamodel uses exact sizes and/or co-ordinates for components. A dilemma arises: on the one hand, exact coordinates may guide the dialog engine on the desired sizes of components in case the components with the default (or in some way calculated) sizes are not aesthetic. On the other hand, the system font

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and depth-per-inch (DPI) settings may differ from one computer to another; thus, it is preferable to avoid exact sizes and coordinates. The features of our metamodel may help to deal with this dilemma.

– The metamodel permits specifying absolute sizes, including minimal, preferred and maximal. Yet all these sizes are optional, and when they are not specified, the dialog engine selects the values itself. These values are suitable for the specific platform and widget toolkit to provide nice look and feel and to allow resizable components to be resized. When applicable, the DPI settings and the size of the font used are taken into account.
– The metamodel also permits specifying relative sizes of components. One may require that the input field has to be two times wider than the button B or that the aspect ratio of the dialog form should be 4 : 3.

Another question that arises is whether the proposed metamodel is bound to some specific widget toolkit. Basic components such as buttons, input fields and check boxes can be found in a wide variety of widget toolkits. We include these basic components as well as other more complex but also popular components like the table and the tree in the metamodel. There should be no problem to use those toolkits for handling instances of our metamodel. The metamodel certainly can be augmented to support other components as well. We will show how that can be done in this paper.

We try to explain the semantics of the proposed metamodel by means of graphical images in this paper, which is an interesting feature, but textual explanations are also used.

Our metamodel utilizes the event/command mechanism of the transformation-driven architecture. We start with a brief explanation of TDA (Section 2) before presenting and explaining the dialog metamodel with its semantics (Section 3). Then we explain how additional components may be included in the metamodel and present two non-trivial metamodels for the tree component and the table component (Section 4). Before the conclusion, we reference some related work (Sections 5–7).

2 The Transformation-Driven Architecture as the Context

The transformation-driven architecture (TDA) [1] is an approach to building systems in general and tools in particular (Fig. 1). The idea of the TDA is very simple. There is a system metamodel (the largest bubble in Fig. 1) which merges interface metamodels and the core metamodel and optional domain meta-model. Interface metamodels are processed by the corresponding engines. While processing instances of interface metamodels, engines, for example, may create a graphical presentation of the data represented by these instances. The data are stored in the Repository, which is accessed through the Repository Proxy that provides the UNDO/REDO functionality. All this is brought to life by model transformations.

Transformations can communicate with engines by means of the event/command mechanism. The Core Metamodel served by the Head Engine provides classes *Event* and *Command* as well as the class *Engine*. We will not describe the Core Metamodel in detail. However, let us look at the design pattern which uses the above mentioned classes to define events and commands in engine metamodels.

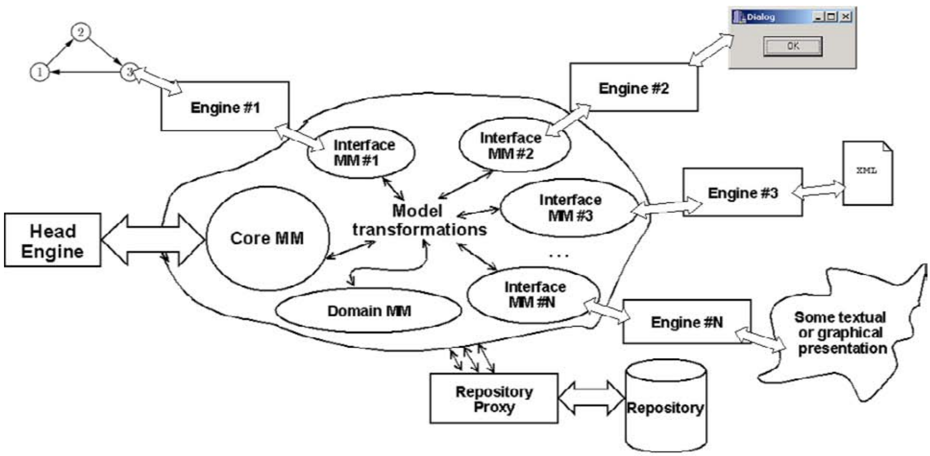

Fig. 1. The essence of transformation-driven architecture

When some event (e.g., a mouse click) occurs in the engine, it may be useful to notify the transformation about that event. For all such events, the engine's metamodel should contain some class derived from the Event class (Fig. 2 (a)). When an event occurs, the engine should create an instance of the corresponding *Event* subclass, set its attributes (if needed), create links from the event object to other object(s) (if needed), and ask the Head Engine to call the corresponding transformation for handling that event.

However, we may wonder how does the Head Engine know what transformation to call? If the event has one or more objects associated with it (the context), one of these objects (event source) may have an attribute called *on<EventName>*, whose value would be the name of the transformation to be called. If the event does not have a context, this attribute may be defined in the corresponding engine's class (Fig. 2 (b)). The values for the *on<EventName>* attributes are supposed to be specified by transformations and/or by the trans-formation programmer to handle the required events in suitable way.

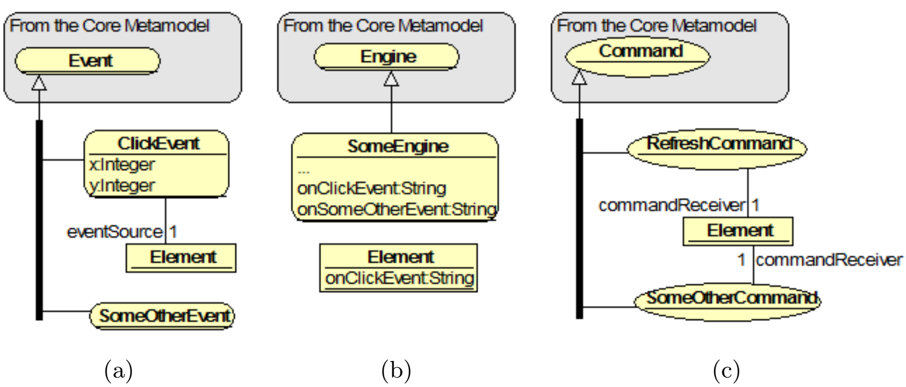

Fig. 2. (a) Defining events as *Event* subclasses; (b) defining attributes to specify event handling transformations; (c) defining commands as *Command* subclasses

If more than one class contains the *on<EventName>* attribute, the search order for finding the valid transformation name should be defined. As shown in Fig. 2 (b), the *onClickEvent* attribute of the event source element has to be checked first. If the value is not set, the attribute of the *SomeEngine* instance should be checked. This permits handling the *ClickEvent* for different elements differently by specifying transformations in the *Elements onClickEvent* attributes, while also permitting handling the *ClickEvent* by the same transformation for all elements by specifying the value for *onClickEvent* in the *SomeEngine* instance and leaving such attributes empty for the elements.

While events serve as a communication bridge in the direction from engines to transformations, commands serve communication in the opposite direction. Commands are derived from the *Command* class in the Core Metamodel (Fig. 2 (c)). The transformation may create command instances (the context may also be specified), and leave them in the repository. When the transformation finishes, the commands are being sent to the corresponding engines. What exactly has to be called may be considered internal information; thus, there are no attributes in the metamodel for storing the name of the function to execute commands.

Having in mind the approach to defining events and commands just described, let us take a look at the dialog metamodel.

Dialog metamodel instances are usually created by transformations. The data may be collected from the domain model or from interface models of engines and then presented as a dialog window. After the dialog window is closed, the transformation brings the data entered or modified by the user from the dialog window to the corresponding places in the system model. The transformation may also handle inputs in the dialog window, not waiting for the dialog window to be closed.

3 The Dialog Engine Metamodel and Its Semantics

3.1 At the First Glance

Perhaps the main notion in the Dialog Engine Metamodel (Fig. 3) is the notion of the component (see the abstract class *Component*). Components are graphical elements such as the *Label*, *CheckBox*, *InputField*, and so on (see direct *Component* subclasses on the left in Fig. 3).

Another important notion in the metamodel is the notion of the container (see the abstract class *Container*). Containers are special components which may contain other components (see the generalization and the composition between the *Component* and the *Container*). Familiar containers that can be found in the metamodel are the *Form, GroupBox*, *TabContainer,* and *Tab*. Such containers are used to group components visually. However, there are other containers in the rounded rectangle on the right. The types of those containers specify how the components are laid out inside them. This will be discussed in more detail below.

[1] In order not to overload Fig. 3, we do not show generalizations for subclasses of *DialogEngineCommand* and *DialogEngineEvent*. Instead, we use rounded rectangles and ellipses to show which classes are events and which are commands.

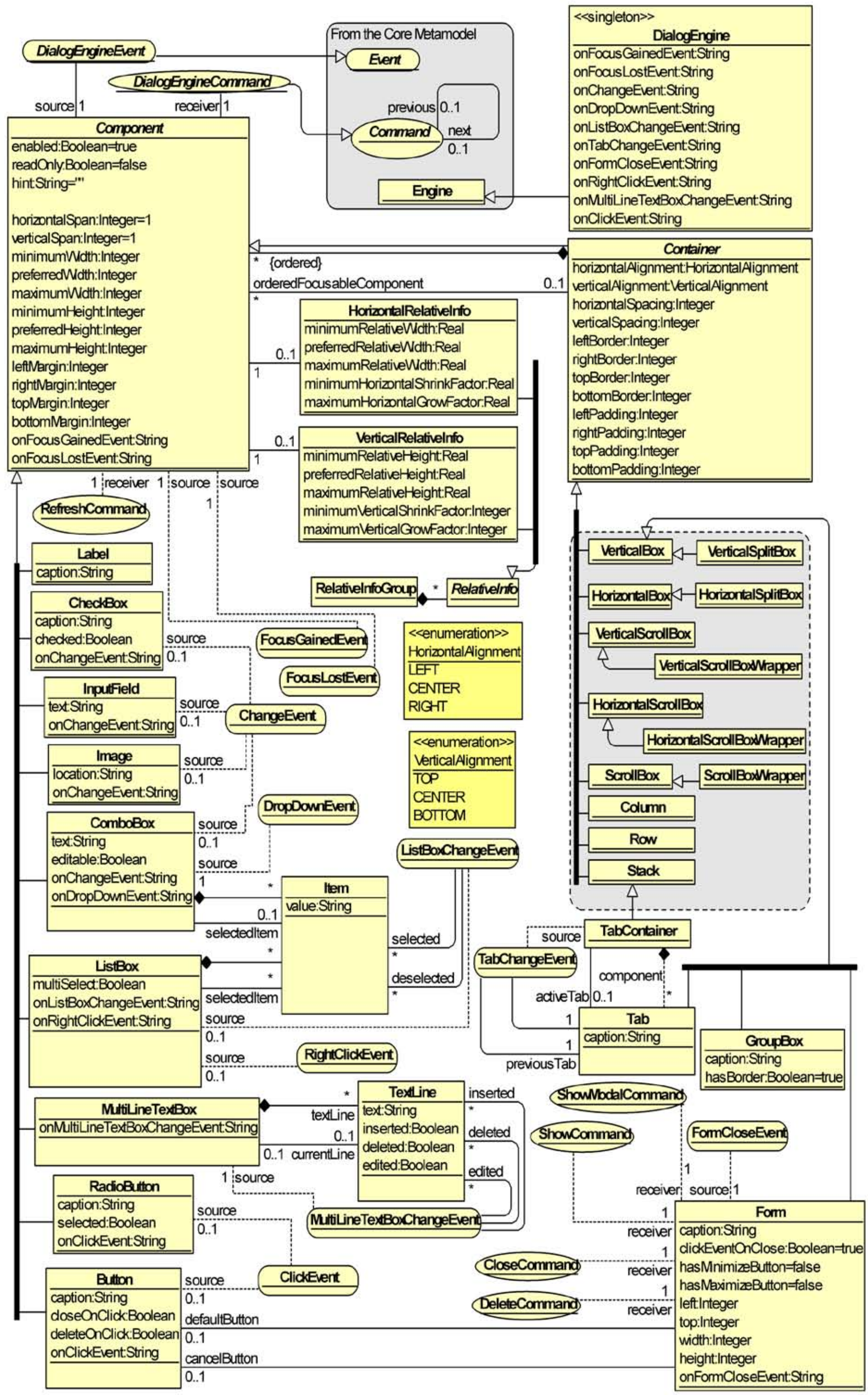

Fig. 3. The Dialog Engine Metamodel

There are certain events and commands that may be assigned to components. As we can see at the top of Fig. 3, the Dialog Engine Metamodel follows the design pattern mentioned in Sect. 2. Each *DialogEngineCommand* and *DialogEngineEvent*[1] has a context which must include a component to which the command/event refers to; see roles *source* and *receiver* of the class *Component*. For instance, a *ClickEvent* may be linked to a *Button* or to a *RadioButton*.

The class *DialogEngine* contains *on<EventName>* attributes for specifying event handling transformations. Note that components also have such attributes for the events they may refer to; see, for example, the *Button*'s *onClick-Event* attribute.

After the first glance at the metamodel, let us look closer at the basic components and the layout specification.

3.2 The Basic Components with Their Events and Commands

We start from the features common to all components.

There is a *readOnly* attribute in the *Component* class. Different components may implement their semantics differently, but the main meaning is that if *readOnly*= **true**, the user is not able to change the value of the component.

The *readOnly* attribute is recursive, i.e., its value applies to the component itself, and, in case the component is a container, to the child components, and so on. In case another value is specified for some child/descendant, that new value is propagated recursively. Such recursive semantics of the *readOnly* attribute may be useful when a non-editable form has to be shown, for instance, in read-only mode, or when the user does not have access to change the values in the form. It suffices to specify *readOnly*= **true** only for the *Form* instance, leaving *readOnly* undefined for all other components in that form.

The *Component* class also has two events: the *FocusGainedEvent* and the *FocusLostEvent*. These events occur when the component gains or loses the input focus. Not all components may produce such events (e.g., the *Label* does not).

Furthermore, a *RefreshCommand* may be associated with the component. The semantics of this command is to re-read value(s) for the component from the repository.[2] If the component is a container, then, besides refreshing the component itself, the *RefreshCommand* reloads its descendants — one may think of it as if the previous descendants have been deleted, and the current descendants have been added.

Now we are going to look at the semantics of basic dialog components. Let us explain the semantics graphically. We use the following notation: the names of properties (attributes or roles) in angular brackets and the arrow points to the graphical presentation of the value of that property (the <*caption*>, <*text*> and <*value*> attributes are present at places without a pointing arrow; one or more asterisks may be added to denote that the values correspond to different instances). Events are shown as instances in rectangles, and the lines point to user actions that generate these events.[3]

Figures 4 and 5 illustrate the semantics of the visual components that can be found in the metamodel.

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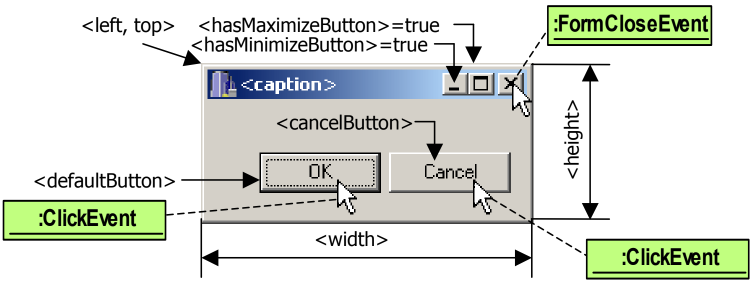
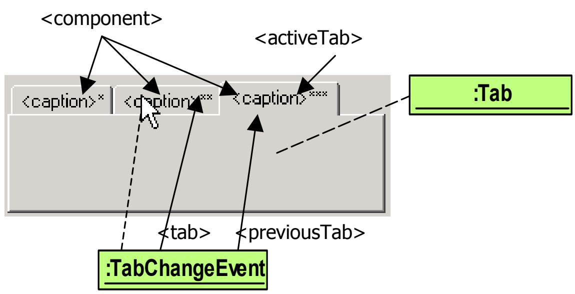
[2] Internally this action may be performed either on the same graphical control or on a new control that replaces the previous one.

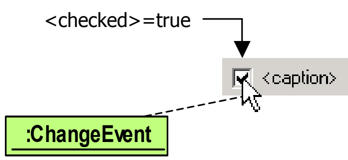
[3] We show only mouse actions.



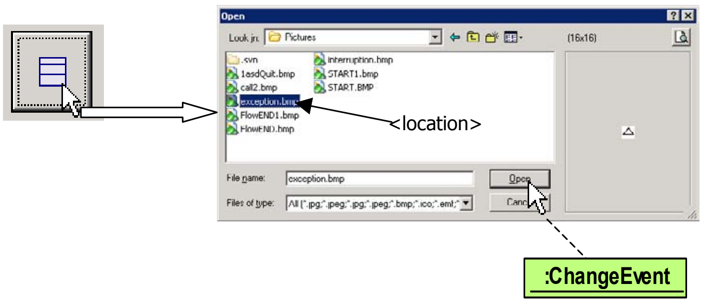
(a)



(b)



(c) (d) (e)



(f)

Fig. 4. The semantics for the (a) *Form*, (b) *TabContainer* and Tab, (c) *Label*, (d) *CheckBox*, (e) *InputField* and (f) *Image* classes

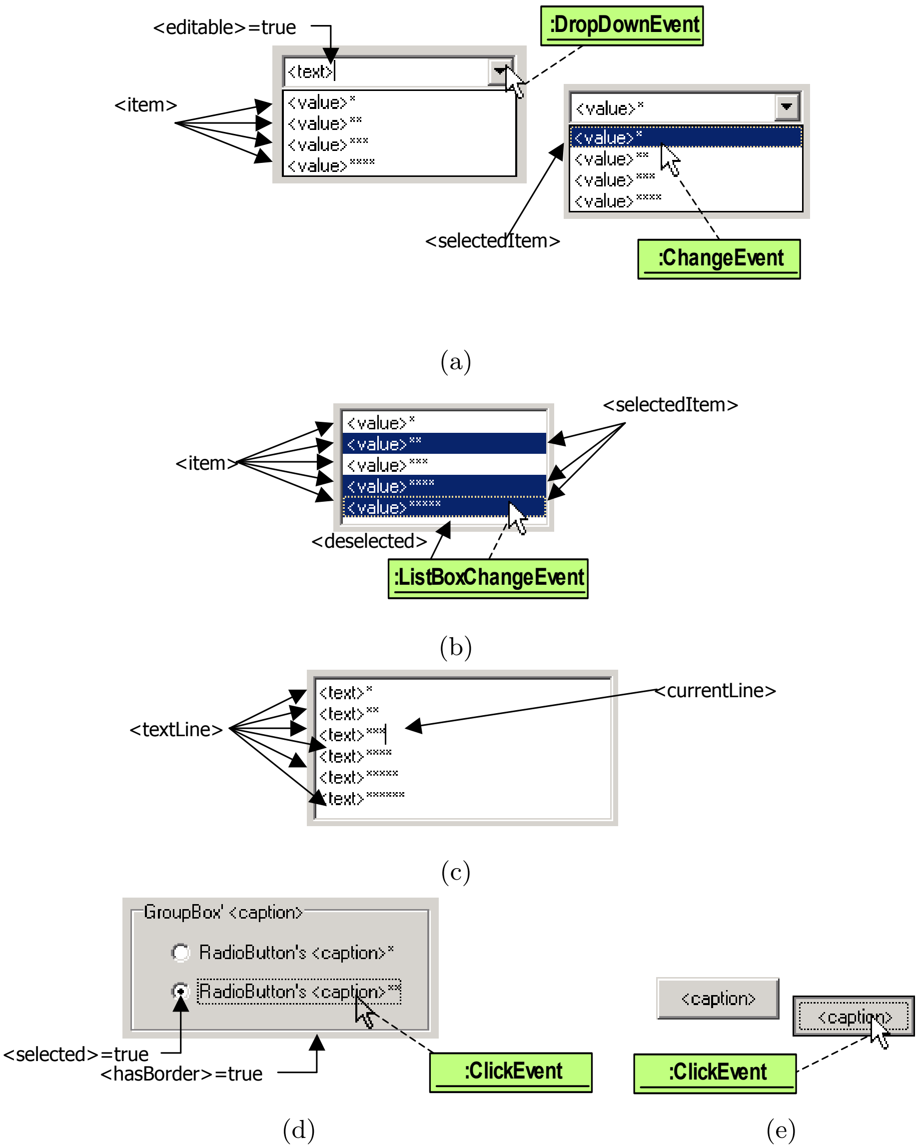


Fig. 5. The semantics for the (a) *ComboBox*, (b) *ListBox*, (c) *MultiLineTextBox*, (d) *GroupBox* and *RadioButton*, and (e) *Button* classes

Let us explain some aspects not explicitly shown in Fig. 4 and 5.

– The semantics for the event produced when the user clicks the “close” ("X") button of the form (Fig. 4 (a)) is as follows: if <*clickEventOnClose*> = **false** or there is neither the “cancel”, nor “default” button[4], the *FormCloseEvent* is generated. Otherwise, a *ClickEvent* for the “cancel” button is generated. In case there is no “cancel” button, a *ClickEvent* is attached to the “default” button (this is useful when the form contains only one "OK" button).

– The *MultiLineTextBox* (Fig. 5 (c)) continues to be linked to those *TextLine*s which have already been deleted from the screen and have *deleted* = **true**. This may be useful when some actions have to be performed after some *TextLine*s have been deleted, but these *TextLine*s are linked to other objects.

– *RadioButtons* (Fig. 5 (d)) usually are grouped together. Only one of the radio buttons in the group may be selected at the same time. We assume that the group consists of the radio buttons that are in the same visible container.[5]

– In case *readOnly* = **true**[6], the values of the following properties are blocked and the user is not able to change them as normally (when *readOnly* = **false**).

Component	**Property**
CheckBox	*checked*
InputField	*text*
ComboBox	*text* and *selectedItem*
ListBox	*selectedItem*
MultiLineTextBox	*textLine* (also the *text* property of *TextLines)*
RadioButton	*selected*

– There are the following commands for the *Form:*

- *ShowCommand* is used to show the modeless form; after the command is executed, the form remains on the screen;
- *ShowModalCommand* is used to show the modal form; the command is being executed until the form is closed (see *CloseCommand* below);
- *CloseCommand* is used to close the dialog window;
- *DeleteCommand* is used to cascade delete the form with its containers and components from the repository.

3.3 Laying Out the Components

In this sub-section, we first describe the classes contained within the rounded rectangle in Fig. 3. Then we describe how absolute and relative sizes may be specified.

Container types. When imaging a dialog box, we assume that all begins with the form which is the top-level (root) container. This container can be logically divided into several parts or cells. Each cell may be divided again, and so on, recursively. Some

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[4] The “default” button is the button which is automatically clicked when the user presses the "Enter" key; the “cancel” button is automatically clicked when the user presses the "Esc" key.

[5] Invisible containers which are "skipped" when forming a group of radio buttons are *VerticalBox, HorizontalBox, Column, Row, Stack,* see Sect. 3.3.

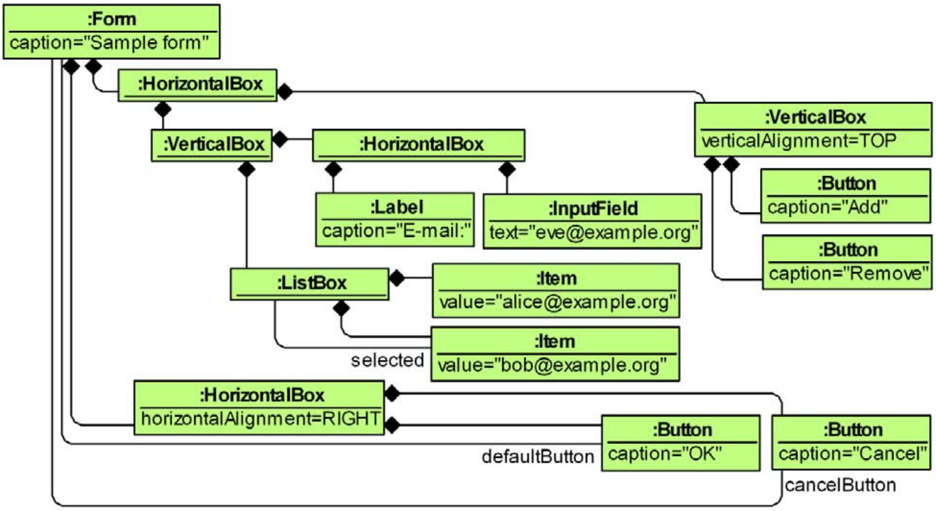
[6] The attribute *readOnly* is defined for all components in the common superclass *Component.*

cells are occupied by visible components or containers, while other are simple invisible "frames" or "borders".

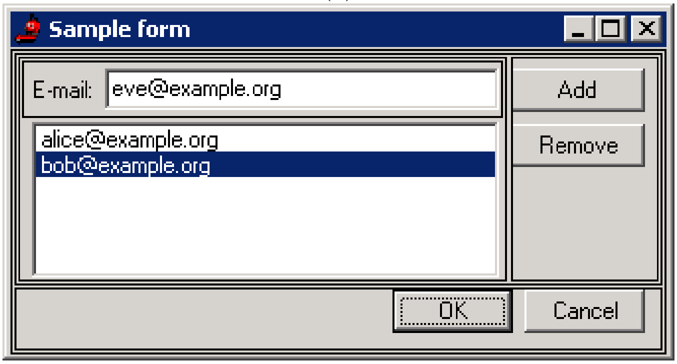
Each cell has its width and height. However, if the cell is occupied by a (visible) scrollable container, there are also interior width and interior height that correspond to the scrollable area where the child components are placed.

In the metamodel, the notion of the cell is represented by the *Container* class. The way the cell (or the container) is divided into other cells determines the type of the container.

Two obvious ways of dividing a cell is dividing it into horizontal and vertical boxes. In the first case horizontal child cells are placed vertically one on another; thus, we call the parent cell the *VerticalBox*. In the second case child cells are placed horizontally from left to right; thus, we call the parent cell the *HorizontalBox*. Fig. 6 shows a sample

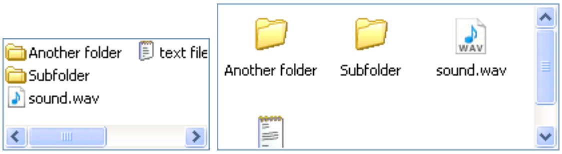


(a)



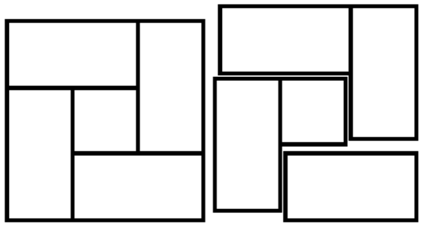
(b)

Fig. 6. (a) An instance of the Dialog Engine Metamodel for the sample form; (b) the sample form: the rectangles (in reality invisible, but shown here) outline horizontal and vertical boxes



(a) (b)

Fig. 7. Examples of (a) a horizontally scrollable box and (b) a vertically scrollable box



(a) (b)

Fig. 8. (a) An example of five containers that cannot be laid out using horizontal and vertical boxes only; (b) the arrangement of the same five containers using rows – the first row contains two components: the first one spans two columns (horizontally) and the second spans two rows (vertically). The first component of the second row spans two rows; neither rows nor columns are spanned by the second component (this is the default behavior). The third row has only one component that spans two columns.

form which uses horizontal and vertical boxes for the layout.[7] The form itself is a vertical box as well. A container of some other type may be placed on the form when needed, thus converting the form from a vertical box to the other container type.

However, one of the scrollbars adds the possibility for the children to move to the second line (in a vertically scrollable box, *VerticalScrollBox,* Fig. 7 (a)) or to the second column (in a horizontally scrollable box, *HorizontalScrollBox,* Fig. 7 (b)) and so on. In the case of the horizontally scrollable box, the children are laid out as text in newspaper columns.

When there are both horizontal and vertical scrollbars, we call such a container the *ScrollBoxContainer.* It is similar to the *VerticalBox,* but in case the internal area of the *ScrollBoxContainer* is scrolled out of the visible area, one or both scrollbars appear, and the internal area can be scrolled. We use one scroll box container (vertical) instead of two (horizontal and vertical) since a horizontal box may be put inside the scroll box when needed.

The container types mentioned above, however, do not permit creating such structures as in Fig. 8 (a). Moreover, they do not provide a way of creating a grid-like structure to be able to align components to grid. Thus, we add the following two container types: the *Row* and the *Column.* Rows and columns are for creating a grid-like layout; they are not for scrolling, but they may be put into a scroll box if needed.

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[7] This figure also shows an example of how to specify dialog boxes by means of the metamodel from Fig. 3.

We do not add the container for representing the table. We assume that neighboring rows (or columns) form the necessary grid-like structure, i.e., the compo-nents of neighboring rows (or columns) are aligned to grid. Thus, their parent container may be considered to be a container representing the table.

However, having a grid, we should allow the components to be able to span several rows and/or columns (see attributes *horizontalSpan* and *verticalSpan* of the *Component* class). This permits creating layout structures such as in Fig. 8.

One more container type is needed to implement the tabs. Since tabs occupy the same space, we think that the components are put one over another like cards. We introduce the *Stack* container, where all the children occupy the same space.

Table 1 summarizes the types of the containers we described and tells which containers are visible and which are invisible. In case a visible analog for an invisible container is required, a *GroupBox* can be used as a visible parent of the invisible container.

Table 1

Container types

Invisible container types	Visible container types
VerticalBox	*VerticalSplitBox*
HirizontalBox	*HorizontalSpllitBox*
Column	*VerticalScrollBox*
Row	*VerticalScrollBoxWrapper*
Stack	*HorizontalScrollBox*
	HorizontalScrollBoxWrapper
	ScrollBox
	ScrollBoxWrapper

We find that the container types listed in Table 1 permit laying out components in many ways and cover not only simple layouts, but also layouts that are complex enough.

Absolute Sizes. The meaning for the six attributes from *minimumWidth* to *maximumHeight* of the *Component* class is obvious. The *maximumWidth* and *maximumHeight* values are allowed to increase (minimally) to satisfy other constraints. Thus, if a component has *maximumWidth* = 0, then its real width would be as small as possible.

The *Container*'s attributes *horizontalAlignment* and *verticalAlignment* refer to the children. If a child is resizable, it is attached to the border of the parent container. However, if the child reaches its maximum width (or height), it is aligned according to the *horizontalAlignment* value (or *verticalAlignment* value). If there are several children in a horizontal box, *horizontalAlignment* refers to all of them as one component. The same is true for the vertical box and the *verticalAlignment* attribute.

The meaning of attributes for specifying margins (in the *Component* class) as well as for specifying borders, padding and spacing (in *Container* class) is revealed in Fig. 9. The margins specify the extra space outside the component (i.e., this space is not considered to be part of component's width or height). The borders in the Container class specify the size of the border (e.g., bevel). These values are parts of the component's width and height. Padding is like a margin but inside the area it is bounded by the border. In non-scrollable containers the notions of padding and border are the same. However, in scrollable containers, the border is outside the scrollable area, while the padding is inside.

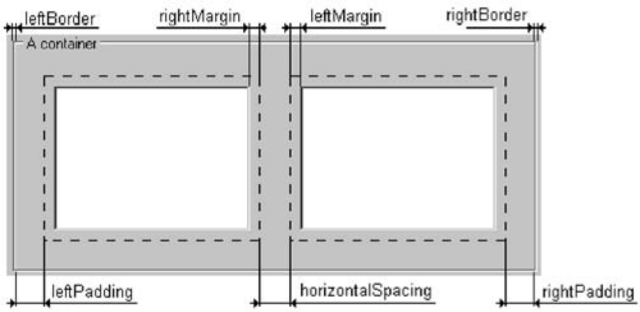

Fig. 9. An example illustrating what values for margins, borders, paddings and spacings mean

Relative sizes. Relative dimensions are related to the notion of the relative information group (see class *RelativeInfoGroup).* The group consists of widths and/or heights which relatively depend on each other. For example, we may group the widths of three components to specify the ratio for the widths as 2 : 3 : 4. There is no need for a particular width or height of some component to be in several groups, since in this case the groups depend on each other and may be replaced by one group by adjusting the ratio.

To specify the relative width ratio 2 : 3 : 4 between three components, we attach a *HorizontalRelativeInfo* instance to each of these components and set the values of the *preferredRelativeWidth* to 2, 3 and 4, respectively. Finally, the three *HorizontalRelativeInfo* instances are linked to the *RelativeInfoGroup* instance to form a group. The relative heights are specified in the same way.

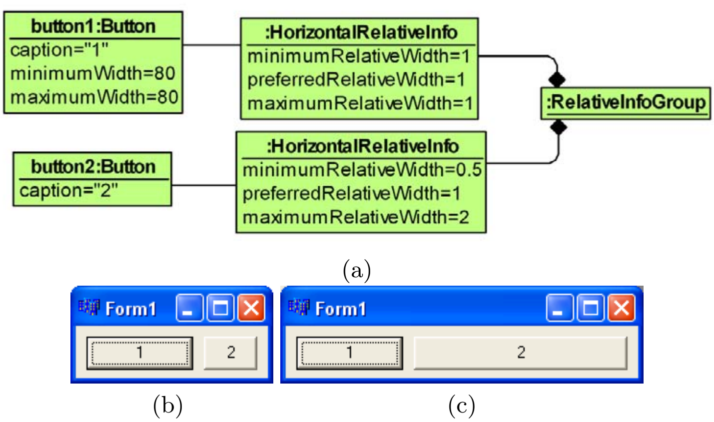

Fig. 10. An instance (a) demonstrating the usage of minimum and maximum relative sizes; the minimum (b) and the maximum (c) sizes of Button 2

The minimum and maximum relative width and height are useful in resizing. An example is given in Fig. 10. Button 1 is not resizable, and the width of Button 2 is preferred to be the same as of Button 1. However, if the preferred ratio cannot be achieved, Button 2 is allowed to be up to 2 times wider or shorter than Button 1.

4 Adding Components: the Tree and the Table

In order to add a component to the Dialog Engine, two steps have to be performed.

1. Developing a metamodel for the component for which the component class is a direct or indirect subclass of *Component.*
2. Implementing a certain interface for the new component so that the Dialog Engine could use the new component.

Let us see the examples of the first step for the *Tree* and the *VerticalTable* components. We outline the interface that has to be implemented to be able to use the new components within the dialog engine.

4.1 The *Tree* and the *VerticalTable* Metamodels

Figure 11 and 12 depict the syntax and semantics for the *Tree* and *VerticalTable* components. Note that these components are descendants of the *Component* class of the main dialog engine metamodel and events are descendants of the *DialogEngineEvent* (and thus also of *Event)* class. Some comments on the *Tree* metamodel follow.

- The *TreeNodeSelectEvent* may have a *previous* link which denotes which tree node was selected last.
- The *TreeNodeMoveEvent* occurs only when *movableNodes* attribute value of the *Tree* instance is **true.** The event is produced when the user drags one node over another (non-descendant) node (as in Fig. 11 (b)) or before or after some (non-descendant) node (in this case the position is shown as a line before or after the node). The links *previousParent, previousSiblingBefore* and *previousSiblingAfter* are created when necessary.

Some comments on the *VerticalTable* metamodel follow.

- The *lazyLoadRows* attribute means that the table rows should not be loaded all at once. Only visible rows have to be loaded first. Then, when the user scrolls the table, other rows may be loaded. Although this may speed up the table, not all cells are taken into consideration when preferred widths for the columns are calculated.
- The *insertButtonCaption* and *deleteButtonCaption* are useful only for non-read-only tables (i.e., when the superclass *Component* attribute *readOnly* value = **false**). These are captions for the buttons to insert and delete rows.
- Similarly to the *MultiLineTextBox TextLine*s, the *VerticalTableRow* also has the *inserted, edited* and *deleted* attributes. The rows are not deleted from the repository automatically, but only marked by setting *deleted* = **true**.
- The *hasCells* association is derived since it may be calculated. The order of *VerticalTableCell*s in a *VerticalTableRow* corresponds to the order of the *VerticalTableColumnType* of the *VerticalTable.*

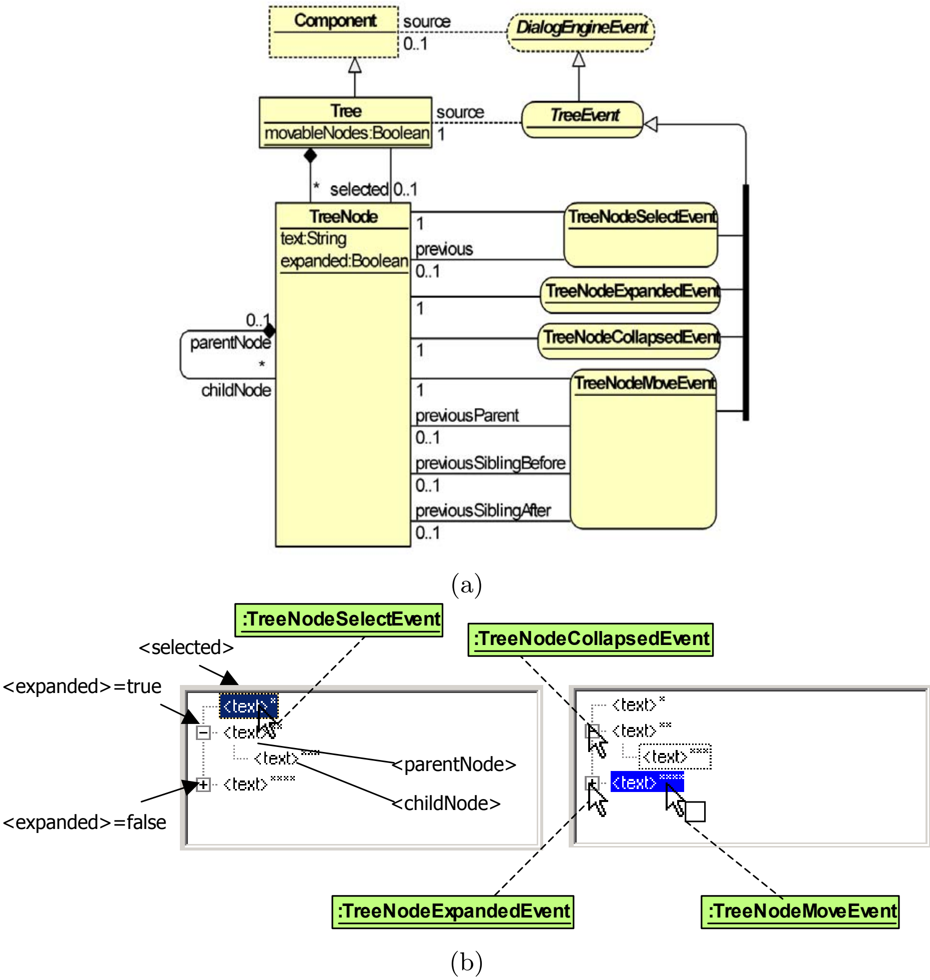

Fig. 11. (a) A metamodel and (b) its semantics for the Tree component

– The *defaultValue* attribute values are used for the corresponding cells when a new row is added.

– The *VerticalTableComponent* can be linked either to a *VerticalTableColumnType* or to a *VerticalTableCell*. In case there is no component linked to a cell, it is considered that the cell is occupied by the component linked to the corresponding *VerticalTableColumnType*. This component is also used as a default component for new rows.

– Since a component linked to the *VerticalTableColumnType* may correspond to several cells in the same column, the input value of that component should be taken from the *value* attribute of the cells. For the *ComboBox*, there is also a *selected* link from the cell to the item that should be used instead of the original *selectedItem* link from the *CombobBox* to the *Item*.

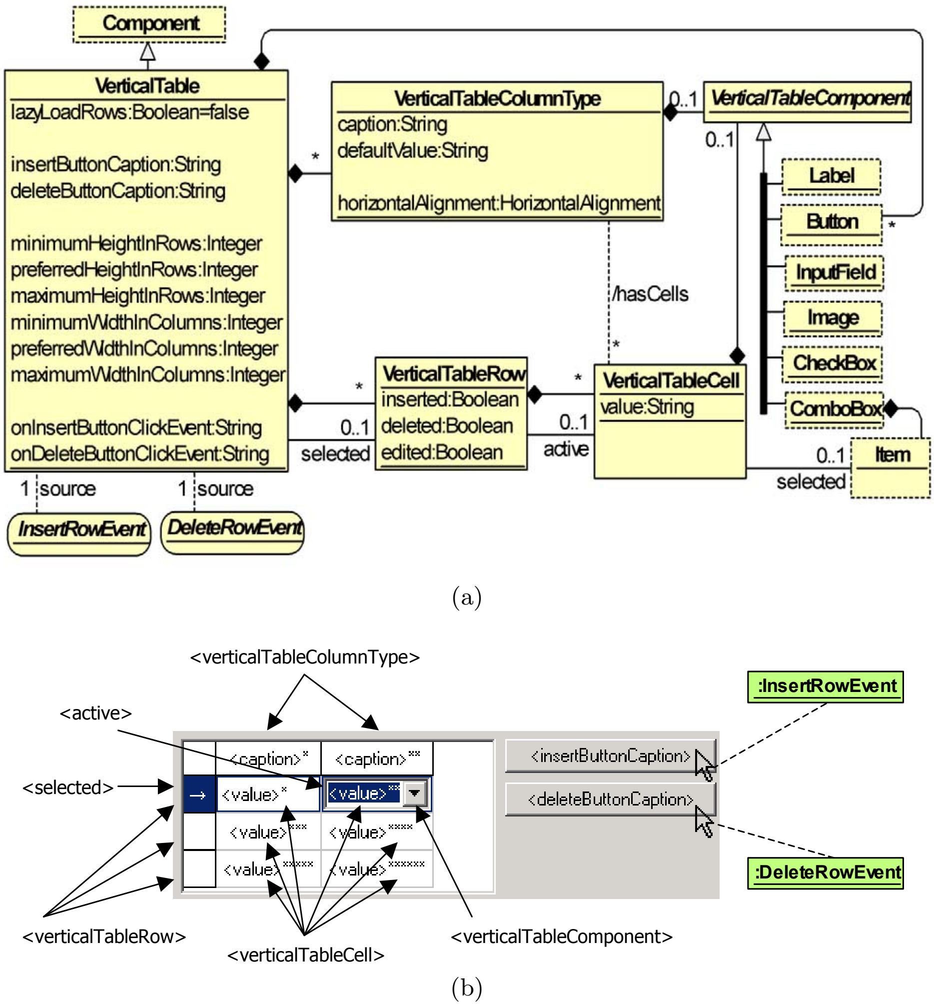

Fig. 12. (a) A metamodel and (b) its semantics for the *VerticalTable* component

4.2 The Communication Interface between Components and the Dialog Engine

In addition to the type *Component* that corresponds to the *Component* class from the Dialog Engine Metamodel, we use the following types:

– *Node*, used for internal description of a component including layout information[8];

– *Handle*, used for window handles that can be used by the dialog engine and by implementations of additional components;

[8] We will not describe that structure in detail here.

– *Control*, used as a pointer to a control (for example, to an object of the class implementing the component). The dialog engine passes this pointer back to the implementation of the component, for example, to lay out the control.

The interface is as follows.

Control, Handle – LOAD(*Component* component, *Node* node)

Called by the dialog engine when the given component has to be loaded from the repository and the corresponding graphical control created. The layout information stored in node is already loaded by the dialog engine, but that information may be adjusted here. Returns the control and the corresponding window handle. (The window handle is used to specify parent container for that window. Since the dialog engine is not related to the internal implementation of the control and obtaining of the handle, the LOAD function has to return that handle specifically.)

AFTERSHOW(*Control* control, *Component* component) // optional

Called by the dialog engine before the form becomes visible. May be useful if some initialization has to be performed when the control becomes visible.

BEFOREHIDE(*Control* control) // optional

Called by the dialog engine after the form becomes invisible. May be useful if some finalization has to be performed while the control is still visible.

FREE(*Control* control)

Called when the control should be deleted.

LAYOUT(*Control* control, *Integer* left, *Integer* top, *Integer* width, *Integer* height, *Integer* interiorWidth, *Integer* interiorHeight)

Called when the control has to be laid out. The (left; top) coordinates denote the position relative to the parent container. The interiorWidth and interiorHeight are only needed for scrollable controls.

Boolean, Control, Handle — LOADCHILD(*Control* parent, *Component* child, *Node* childNode) // optional

Called for containers when the child component has to be loaded. If the child component has been loaded, LOADCHILD should return TRUE as well as a control and a handle for the child component (like in the LOAD function). Otherwise, if the child has not been loaded or has to be skipped, the function should return FALSE as the first value.

This function can, for example, manage the situation when the children components have to be of certain type(s) only, or when some additional steps have to be performed to attach the children to the control.

If not implemented, then the LOAD(child, childNode) is called by the dialog engine and the returned control and handle are used.

5 Related Work

There are several ways of specifying dialog boxes. One is to use graphical designers that can be stand-alone programs (like GLADE [3]), or incor-porated into the IDE (Integrated Design Environment) such as Borland C++ Builder, Microsoft Visual Studio and Java NetBeans. Such designers are usually developed for a specific widget toolkit or library (e.g., GLADE is developed for GTK+ library, Borland C++ Builder uses VCL (Visual Component Library), Microsoft Visual Studio uses Windows::Forms library, and Java NetBeans uses Swing library).

There are also user interface (UI) libraries that do not have designers. In this case dialog boxes are specified in the program code that uses the routines of the particular library. Of course, such a code can also be written for the libraries that do have graphical designers.

Another way for specifying dialogs is using textual languages. HTML (Hyper Text Markup Language) is an example of such language since it allows graphical user interface components to be placed on the web pages. Other examples include User Interface Markup Language (UIML) [4] and UsiXML [5].

Along with the specification, there is the problem of laying out the dialog components. Many toolkits permit specifying absolute coordinates (like coordinates of the left-top corner) and dimensions (i.e., width and height) for each component. Several tools avoid specifying coordinates by using tables (HTML), boxes (GLADE) or other mechanisms (Java NetBeans UI designer uses horizontal and vertical groups to lay out the components by means of the *GroupLayout* manager [6]).

Java *Swing* library contains several layout managers for laying out and resiz-ing GUI components [7]. A layout manager is associated with a container, so the elements inside that container are laid out depending on the layout manager.

As of specifying resizable components, some tools (Borland C++ Builder and Delphi, Microsoft Visual Studio) permit to set up *anchors*, i.e., to fix the distance between the component and one or several window borders.

Thus, when the window is resized, the component is relocated or resized to keep these distances constant. This is useful when there is one large component that has to be resized along with the window. However, if several components have to be resized simultaneously, anchors may be a not-so-good solution, as can be seen in Fig. 13: when the form is resized, the buttons overlap.

(a) (b)

Fig. 13. (a) A form with two buttons where left and right anchors are set; (b) the form after resizing

The Windows Presentation Foundation (WPF) [8] is a platform allowing to build rich user interfaces in Windows applications. WPF uses *panels* to lay out child components (panels are similar to our containers). Also, WPF uses alignments (similar to our *horizontalAlignment* and *verticalAlignment* properties), padding (similar to our borders and padding) and margins (similar to our margins). The difference is in stretching the components: we use maximal sizes to bound streching, while WPF uses special alignment constant "Stretch".

An interesting idea for specifying both absolute and relative sizes is based on the usage of linear constraints [9].[9] Using the constraints permits specifying the layout and behaviour of components in a more flexible way. However, defining the constraints explicitly by means of equations and inequalities is not a natural way to specify the properties of UI components. Moreover, the question arises, what to do if the constraints are unsatisfiable. UI may be generated at runtime, and the components should be laid out despite inconsistent constraints. As it was told before, we solve this problem by allowing the maximum sizes to be increased when needed.[10]

Several web-based techniques with multiple opportunities for creating user interfaces are available for developers today. AJAX is an approach where several web technologies are used to provide fast responses to the user [10]. If the client-side AJAX engine can handle the user request by its own, it does so. Otherwise, a request (usually, asynchronous) to the server is performed. Google Web Toolkit (GWT) [11] is an AJAX-type framework, which provides solutions to many AJAX problems. With GWT, web-based applications are developed in Java. However, at runtime, web-based technologies such as JavaScript and HTML are used.

Microsoft Silverlight [12] and Adobe Flash [13] are two other platforms for providing enhanced user interface experience including interactivity and anima-tions.

The XForms XML format can be used for specifying user interfaces along with data processing on the client's side. XForms is "the next generation of forms technology for the world wide web" [14]. The Apogee project [15] is aimed to provide the XForms engine (and other features) for the Eclipse environment [16].

6 Conclusion

The dialog engine that uses the proposed dialog engine metamodel has been successfully implemented, although with minor differences, in the graphical tool-building platform GrTP [2] that now uses the principles of the transformation-driven architecture [1]. The implementation of the layout of graphical dialog components is based on the quadratic optimization technique [17].

The GrTP tool contains the universal transformation which allows for common functionality to create graphical modeling tools. Universal transformation can create tool-specific dialog boxes on the fly. However, such generated dialogs do not use all the opportunities the Dialog Engine provides. For example, dialog boxes have the same row-by-row layout. To be able to adjust generated dialog windows, a graphical dialog designer may be added to GrTP.

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[9] Java also allows for creating layout managers that support constraints.

[10] A maximum size bound can also be set for the components in order not to allow them to become very large.

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