

A VISUAL SPECIFICATION TOOL FOR EVENT-CONDITION-ACTION RULES SUPPORTING WEB-BASED DISTRIBUTED SYSTEM

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Abstract: Specifying Event-Condition-Action (ECA) rules is an important issue in the domain of active database. Current specification tools for ECA rules include visual specification tools and textual specification tools based on XML. Here, the visualization of ECA rules provides an easy-to-use interface in design/analysis tools for active database queries while the XML-based representation allows the exchange of ECA rules in a web-based distributed environment. Thus, a specification tool with advantages of both visual representation and XML-based representation is needed. In this paper we present and implement a new visual specification tool for ECA rules, called VSTE, to address this issue. We also use a web-based smart home system to evaluate our work.

1 INTRODUCTION

Event-condition-action (ECA) rules play very important roles in active databases since they define how active databases perform corresponding actions to response to the data and events. Visual languages have been considered to be good tools to specify ECA rules since they use the synthesis power of the eye (Matskin, 1996) and hide the irrelevant details behind users so as to make human understanding and following of rule execution and triggering easier. Several visual ECA rule languages have been presented in active database area. Some of them are based on the visualization of rules in modelling diagrams such as class diagrams (Calestam, 1999), state-chart diagrams (Berndtsson, 2003), ER diagrams (Navathe, 1992), or specific rule diagrams (Silva, 1996). Others are based on visualization of how rules behave and interact with each other and the underlying data model at run-time (Wagner, 2003).

Meanwhile, in web-based distributed environment, ECA rules need to be exchanged between different applications and platforms.

However, none of current visual specification tools/languages can support this kind of exchange of ECA rules. This makes applications on one site unable to understand graphical ECA rules specified on different sites.

In recent years, several ECA rule specification languages based on the form of XML have been presented to support the exchange of ECA rules between different applications and platforms (Boley, 2002, Cho, 2002, Seirio, 2005). However, this brings another problem: compared to visual ECA rule languages, textual specification languages are difficult to reveal structures of rules and follow the triggering relationship between rules. This hinders human understandings whereas to increase difficulties in rule execution and rule checking.

Therefore, the issue for combining the visualization of ECA rules and the XML-based representation as a single tool needs to be addressed in the domain of active databases and this paper presents an implemented solution.

The main idea of our solution is to compile visual ECA rules into XML to deal with the heterogeneity of ECA rules in web-based distributed environment. Specifically, we present and

implement a new visual specification tool for ECA rules, called VSTE. The core of this tool is a visual ECA rule language, called VECAS. It has a compatible syntax structure with XML. Once the user specifies ECA rules with VSTE, the graphical representations of VECAS will be automatically transformed in the form of XML in the background.

The rest of the paper is organized as follows: section 2 addresses a visual specification language for ECA rules, called VECAS; section 3 addresses the implementation of compiler; section 4 evaluates VSTE via a web-based smart home system. Conclusions and future works are stated in section 5.

2 VISUAL SPECIFICATION LANGUAGE

2.1 Modeling

The model behind the language constructs of VECAS can be represented as an augmented graph:

$$G = (V, E, Attr(V), M(E)) \quad (1)$$

V is a set of vertices. $V = V_E \cup V_C \cup V_A$, where V_E is a set of event vertices, V_C is a set of condition vertices and V_A is a set of action vertices. Each element in these three sets represents an event, a condition and an action respectively. The details of the events, conditions and actions supported by VECAS can be found in (Qiao, 2007) and are skipped due to size limit.

E is a set of edges. Each edge is a connection between different types of vertices. VECAS supports following three types of connections: *EC* connection (The relationship between an event and a condition; It means that once the event is detected, the condition will be examined.), *CA* connection (The link between a condition and an action; It means that once the condition is examined to be satisfied, the action will be executed.) and *RR* connection (The triggering relationship between two ECA rules; It means that execution of one rule may trigger execution of another.).

$Attr(V)$ is a set of attributes applied to each vertex to describe its critical characteristics. The attribute sets of each type of event, condition and action are addressed in (Qiao, 2007) and are skipped in this paper.

$M(E)$ is a set of constraints on each edge. It describes the characteristics of each connection.

These constraints represent coupling modes between events, conditions and actions (Paton, 1993).

2.2 Syntax Structure

Based on the model addressed in section 2.1, the syntax of VECAS can be graphically represented as Figure 1.

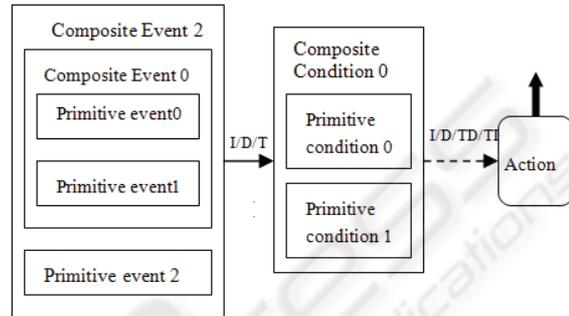


Figure 1: Syntax of VECAS.

In Figure 1, an event/condition is graphically represented by a square associated with a set of attributes. A single square is used for a primitive event/condition while nested squares are used for a composite event/condition. An action is represented as a rounded rectangle associated with corresponding attributes. The detailed graphical notations for events, conditions and actions can be found in our previous work (Qiao, 2007) and are skipped since they are not the emphases for this paper. The *EC* connection is graphically represented as a line with an arrow. The symbols “I”, “D” and “T” are constraints on the *EC* connection. They represent three coupling modes (Paton, 1993) between an event and a condition. The *CA* connection is graphically represented as a dash with an arrow. The symbols “I”, “D”, “TD” and “TI” are constraints imposed on the *CA* connection. They represent four coupling modes (Paton, 1993) between a condition and an action. Furthermore, the *RR* connection is graphically represented as a bold line with an arrow.

2.3 Editing Environment

VSTE provides a graphical rule editor for users to define ECA rules with VECAS. The Graphical User Interface (GUI) of the rule editor is shown in Figure 2.

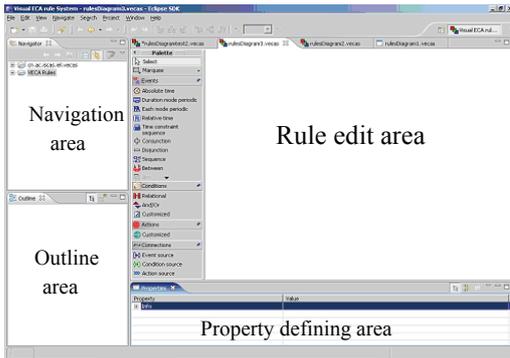


Figure 2: GUI for editing ECA rules.

The GUI includes four areas, i.e., navigator area, outline area, rule edit area, and property define area. In the navigator area, the name of project and the files contained in this project are listed. When the user defines a group of rules, a project containing several files is created. A group of dependent rules are saved into one file under this project. The outline area is responsible to display the overall picture of selected group of ECA rules defined by the user. A set of graphical components is provided in the rule edit area. Users can drag corresponding graphical components into the edit area to draw ECA rules according to the syntax of VECAS addressed in section 2.2. There are four types of graphical components, i.e., event components, condition components, action components and connection components. The detailed graphical notations for each graphical component can be found in our previous work (Qiao, 2007). In the property defining area, the user can define the attributes associated with each graphical block in defined ECA rules.

3 COMPILER

Compiler is a key infrastructure of VSTE, which is responsible to convert VECAS representations of ECA rules into corresponding XML-based representations. Via the compiling, a corresponding XML file is created for VECAS codes of a specific set of dependent ECA rules. This XML file has a root element. The name of the root is defined as “VECAS” indicating the file is compiled from VECAS codes. There are two main sections in the file, i.e., Module section and Rule section. The Module section is used to define reused elements in XML descriptions. The Rule section is used to define a set of dependent ECA rules. The framework of this XML file is shown in Figure 3.

```
<VECAS>
  <module>
  ...
  </module>
  <Rules>
  ...
  </Rules>
</VECAS>
```

Figure 3: Framework of compiled XML file.

The core of a compiler is a mapping mechanism which is used to create the Rule section in the compiled XML file. It includes two aspects, i.e., component mapping and attribute mapping.

In component mapping, the compiler identifies each single ECA rule among a group of dependent graphical ECA rules and creates a sub-element called “ruleitem” for each identified ECA rule in the Rule section. Then, the compiler will search all graphical blocks in each ECA rule and convert graphical blocks representing events, conditions and actions into corresponding event sub-element, condition sub-element and action sub-element of each “ruleitem” element. Figure 4 shows the framework of the Rule section in a compiled XML file created via the component mapping.

```
<Rules>
  <Rule>
    <Ruleitem name="yyy"; priority=1; executable= True>
      <event>
      ...
      </event>
      <condition>
      ...
      </condition>
      <action>
      ...
      </action>
    </Ruleitem>
  </Rule>
  <Rule>
    <Ruleitem name="zzz"; priority=2; executable= True>
      <event>
      ...
      </event>
      <condition>
      ...
      </condition>
      <action>
      ...
      </action>
    </Ruleitem>
  </Rule>
  ...
</Rules>
```

Figure 4: Framework of Rule section.

In attribute mapping, the compiler examines attributes associated with each graphical block in a graphical ECA rule and maps them into the attributes with the same names for corresponding event sub-element, condition sub-element and action

sub-element of a “ruleitem” element in the Rule section.

4 CASE STUDY

Smart home is the home environment that can proactively change to provide services that promote independent living (Augusto, 2005). Assume a web-based smart home system has two local smart home systems S1 and S2. Each computer-based smart home system consists of a group of sensors and an active database. In this context, a group of sensors are used to collect the data about the person’s movements throughout the house, the status of person’s health and the various home appliances and facilities. These data are sent to an active database which holds a set of ECA rules. With ECA rules, the active database has the enhanced capabilities to detect complex events and contexts in order to anticipate potential or actual hazardous situations and intelligently discern how to best advise medical staffs. Figure 5 shows the architecture of the web-based smart home system. The detailed requirements for ECA rules in local smart home system S1 and S2 are shown in Table 1.

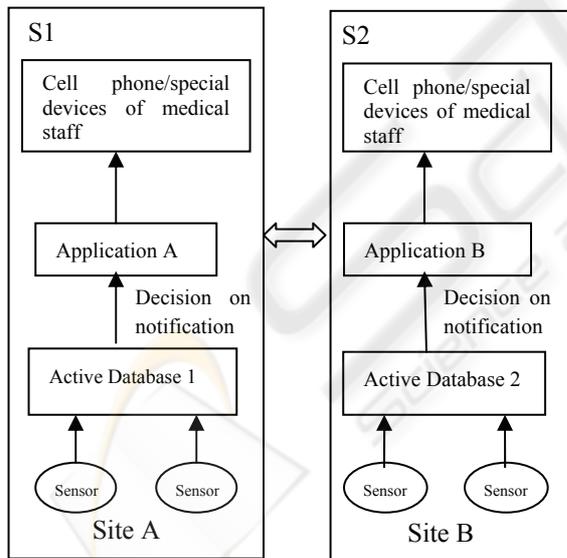


Figure 5: Architecture of web-based smart home system.

Table 1: Requirements for ECA rules.

ECA rules in S1	
Req1: On “At 10:00AM”	If “the person’s blood pressure is higher than 200/175” Do “Notify the medical staff”
Req2: On “ Monitor blood pressure every 2 hours”	If “ the Blood pressure higher than 200/175 for more than two times in past 8 hours” Do “Notify the medical staff”
Req3: On “the person is in bed during [T1, T2]”	If “ the person is active during [D1, D2]” and “[T1, T2] is included in [D1, D2] and “Duration [T1, T2] is longer than 2 hours” Do “Report the context abnormal”
Req4: On “ Monitor blood pressure every 2 hours” and “blood pressure higher than 200/175 for more than two successive samples”	Do “ Notify the medical staff”
Req5: On “ Blood pressure higher than 200/175” after “the heart beat is higher than 150” within 5 minutes	Do “ Notify the medical staff”
ECA rules in S2	
Req6: On “1 hour after the cooker is on”	If “the cooker is still on” Do “Trigger alarm”
Req7: On “ 15 minutes after the door is open”	If “the door is still not locked” Do “Trigger alarm”
Req8: On “1 minutes after leaving the bath room”	If “the light leaving on” or “the water leaving on” Do “Create a reminder”
Req9: On “ the person does not pass” after “the door is open” during [12:00Am, 7:00AM]	Do “ Create reminder”
Req10: On “leaving a room”	If “monitored key is on the desk” Do “trigger alarm process”

To evaluate VSTE’s capability to support the exchange of ECA rules, we use VSTE and four typical visual specification tools for ECA rules, i.e. OMT-A(Calestam, 1999), UML-A(Berndtsson, 2003), ECA² nets(Navathe, 1992) and A/OODBMT(Silva, 1996) to specify the ECA rules in local smart home system S1 and S2 based on the requirements in Table 1 and analyze if the system S1 and S2 can access each other’s ECA rules in different cases of visual specification tool usages. Table 2 gives evaluation results. (Here, we do not show the detailed graphical representations of ECA rules specified by VSTE and four selected visual specification tools since they are not emphases for the evaluations.)

Table 2: Evaluation results.

Visual specific ation tool used by S1	Visual specific ation tool used by S2	Same platforms		Different platforms	
		S1 access ECA rules in S2	S2 access ECA rules in S1	S1 access ECA rules in S2	S2 access ECA rules in S1
OMT-A	OMT-A	Yes	Yes	No	No
UML-A	UML-A	Yes	Yes	No	No
ECA ²	ECA ²	Yes	Yes	No	No
A/OOD BMT	A/OOD BMT	Yes	Yes	No	No
VSTE	VSTE	Yes	Yes	Yes	Yes
OMT-A	UML-A	No	No	No	No
OMT-A	ECA ²	No	No	No	No
OMT-A	A/OOD BMT	No	No	No	No
OMT-A	VSTE	Yes	No	Yes	No
UML-A	OMT-A	No	No	No	No
UML-A	ECA ²	No	No	No	No
UML-A	A/OOD BMT	No	No	No	No
UML-A	VSTE	Yes	No	Yes	No
ECA ²	OMT-A	No	No	No	No
ECA ²	UML-A	No	No	No	No
ECA ²	A/OOD BMT	No	No	No	No
ECA ²	VSTE	Yes	No	Yes	No
A/OOD BMT	OMT-A	No	No	No	No
A/OOD BMT	UML-A	No	No	No	No
A/OOD BMT	ECA ²	No	No	No	No
A/OOD BMT	VSTE	Yes	No	Yes	No
VSTE	OMT-A	No	Yes	No	Yes
VSTE	UML-A	No	Yes	No	Yes
VSTE	ECA ²	No	Yes	No	Yes
VSTE	A/OOD BMT	No	Yes	No	Yes

From Table 2, we can observe four cases:

- Case 1: When system S1 and S2 have same platforms and they use same visual specification tools, they can access each other's ECA rules and the exchange of ECA rules is allowed.

- Case 2: When system S1 and S2 have same platforms and they use different visual specification tools, there are following three sub-cases:

- (1) When S1 and S2 use different selected visual specification tools, they cannot access each other's ECA rules and the exchange of ECA rules is not allowed.

- (2) When S1 uses one of selected visual specification tools and S2 uses VSTE, the exchange of ECA rules is not allowed. In this case, S1 can access ECA rules in S2, but S2 cannot access ECA rules in S1.

- (3) When S1 uses VSTE and S2 uses one of selected visual specification tools, the exchange of ECA rules is not allowed. In this case, S2 can access ECA rules in S1, but S1 cannot access ECA rules in S2.

- Case 3: When system S1 and S2 have different platforms but they use same visual specification tools, there are following two sub-cases:

- (1) When S1 and S2 use selected visual specification tools, they cannot access each other's ECA rules and the exchange of ECA rules is not allowed.

- (2) When S1 and S2 use VSTE, they can access each other's ECA rules and the exchange of ECA rules is allowed.

- Case 4: When system S1 and S2 have different platforms and they use different visual specification tools, there are following three sub-cases:

- (1) When S1 and S2 use different selected visual specification tools, they cannot access each other's ECA rules and the exchange of ECA rules is not allowed.

- (2) When S1 uses one of selected visual specification tools and S2 uses VSTE, the exchange of ECA rules is not allowed. In this case, S1 can access ECA rules in S2, but S2 cannot access ECA rules in S1.

- (3) When S1 uses VSTE and S2 uses one of selected visual specification tools, the exchange of ECA rules is not allowed. In this case, S2 can access ECA rules in S1, but S1 cannot access ECA rules in S2.

Here, Case 1 is rare since the local smart home systems are usually independently developed before they are connected to create a web-based smart home system. Case2, Case 3 and Case 4 are very popular for a web-based smart home system. Thus,

based on above analysis, we can make following conclusions:

- (1) Compared to current typical visual specification tools, our specification tool VSTE has much stronger capability to support the exchange of ECA rules in web-based distributed environment.
- (2) In web-based distributed environment, the exchange of ECA rules between different applications and platforms can be achieved when the active databases in local systems use our specification tool VSTE to specify their ECA rules.

5 CONCLUSIONS

Although many works have been done on visual specification tools for ECA rules, none of them is able to support the exchange of ECA rules in web-based distributed environment. Meanwhile, textual specification tools based on XML provide an efficient way to deal with the exchange of ECA rules between different applications and platforms. However, these textual specification tools are hard to be used by the user who lacks of professional skills. To solve above problems, we integrate visualization of ECA rules and the XML-based representation as a single tool by developing a new visual specification tool for ECA rules called VSTE. It provides a visual specification language for users to specify ECA rules and the defined graphical representations can be automatically converted into the form of XML, which makes ECA rule specifications suitable to support the exchange of ECA rules between different platforms and applications. Furthermore, we use a web-based smart home system to evaluate our work. The evaluation results show that compared to selected visual specification tools, VSTE has much stronger capability to support the exchange of ECA rules in web-based distributed environment.

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