*Electronic Notes in Theoretical Computer Science 50 No. 3 (2001) { Proc. GT-VMT 2001 URL:* [*http://www.elsevier.nl/locate/entcs/volume50.html*](http://www.elsevier.nl/locate/entcs/volume50.html) *6 pages*

*Visual Language Parsing in GenGEd 1*

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*Abstract*

*GenGEd supports the visual speci cation of visual languages and the generation of syntax-directed editors. However, syntax-directed editing is not always desired by the user. Therefore we extended GenGEd by parsing facilities which allow for free editing as well.*

# *1 Introduction*

*Syntactical de nition of visual languages (VLs) and VL-parsing are diÆcult* problems due to the absence of an easy to use and eÆciently parsable stan- dard syntax de nition formalism. Most proposals published up to now rely on context-free grammar rules, i.e., they allow replacement of a single non- terminal in the left-hand side. Using these approaches it is not always possible to de ne the VL in mind. Therefore, context-sensitive graph grammars have been proposed, e.g., in the form of Layered Graph Grammars (LGG) [11]. LGG rules are allowed to delete and create several elements and relations, represented as vertices and edges.

*Unfortunately, LGGs are still not convenient enough to de ne a VL in gen-* eral because of at least missing Negative Application Conditions (NACs) and further conditions for rules. Therefore, a new form of LGGs, called Contextual Layered Graph Grammars (CLGGs) was developed [2] which support vertex embedding, NACs, and complex predicates. This approach includes the de - nition of layering conditions guaranteeing termination of the parsing process. Furthermore, static analysis techniques like critical pair analysis [10,9,12] are available which can be exploited to identify a maximum set of rules which may be parsed without any need for backtracking.

*VLCC [3] and DiaGen [8] use restricted context-sensitive rules to parse* VLs. This kind of rules is successfully applied to rather simple languages but

*1 Research partially supported by the German Research Council (DFG), and the projects APPLIGRAPH (ESPRIT Basic Research WG) and GRAPHIT (CNPq and DLR).*

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*might be tricky to use in more complex cases. CLGGs are related to Reserved* Graph Grammars (RGGs), another restricted and modi ed form of LGGs [13]. RGGs o er some kind of embedding mechanism, too, but do not support the de nition of predicates (however, not used in GenGEd) and NACs. Their rules have to be locally con uent, so that the polynomial naive LGG parsing algorithm in [11] works. Backtracking for handling recognized critical rule pairs is not supported.

*In Section 2 we brie y review the GenGEd environment for the visual* speci cation of VLs. The parsing facilities and their usage in GenGEd are proposed in Section 3, and illustrated by a small example (a subset of the well- known UML class diagrams). Although this example is not very expressive, it is suitable for illustrating the concepts. In Section 4 we conclude.

*2 The GenGEd Environment*

*The GenGEd environment implements concepts for the visual speci cation* of VLs [1]. A VL-speci cation is given by a visual alphabet and a visual grammar. In the visual alphabet the types of symbols and links occurring in a VL are speci ed. The visual grammar consists of a start expression and a set of context-sensitive grammar rules. Originally the grammar rules de ne the syntax-directed editing commands of a language-speci c graphical editor, i.e., the visual grammar does not only comprise language-generating rules but a convenient set of editing rules as well. In the following we show that the concepts of VL-speci cations can be easily extended by the speci cation of parsing.

*GenGEd is based on algebraic graph transformation [4] and graphical* constraint solving [7]. A visual alphabet is represented by an attributed graph structure signature 2 and a constraint satisfaction problem de ning positions and sizes of visual elements. Correspondingly, a visual grammar is represented by an attributed graph structure grammar where the constraint satisfaction problem of each visual expression is satis ed. Moreover, we distinguish two syntactical levels, namely the abstract syntax describing the logical part of a VL, and the concrete syntax denoting the layout.

*According to the constituents of a VL-speci cation, the GenGEd envi-* ronment comprises an alphabet editor and a grammar editor. The speci ed alphabet is the input of the grammar editor, where so-called alphabet rules are generated de ning the editing commands of this editor. In this way it is guaranteed that only correct visual expressions can be de ned by a lan- guage designer. For the transformation of visual expressions according to the abstract syntax the Agg system [6] is used. The graphical constraints are solved by the constraint solver ParCon [7].

*2 A graph structure signature is an algebraic signature according to [5] with unary operation symbols.*

*The parsing algorithm proposed in [2] (which is based on Contextual Lay-* ered Graph Grammars (CLGG) and critical pair analysis) is now implemented using the Agg system, hence we call it Agg graph parser. In GenGEd we in- tegrated the Agg graph parser such that we yield a parser for visual languages. In this sense, not only syntax-directed editing but also free editing is available in speci c graphical editors generated by GenGEd, similar to [8]. As before, the alphabet editor supports the de nition of visual alphabets comprising the types for symbols and links. Based on a visual alphabet, the grammar editor may be used in two ways: for the de nition of comprehensive syntax-directed editing rules as well as for the de nition of a parse speci cation. The latter one is explained in the following.

# *3 Parsing of Class Diagrams*

*As already mentioned before, a visual alphabet describes the types of symbols* (vertices) and links (edges) of a VL. Figure 1 illustrates the visual alphabet for a subset of UML class diagrams. It comprises the symbols needed and explains how these symbols are linked. In the top the abstract syntax is shown where the lexical symbols Package, Class and Assoc (association) are framed by rectangles, and the attribute symbol CN (class name) of type String by rounded rectangles. The arrows indicate the links between the symbols. The symbol's layouts are connected with the abstract syntax by so-called layout operations illustrated by dashed arrows. The constraints which have to be de ned for each (abstract) link are illustrated by dotted arrows between the symbol layouts.



String

at\_CN

in

CN

a\_CN

begin

end

12pt, Helv.

*Concrete Syntax*

Assoc

Class

Package

*Abstract Syntax*

*Fig. 1. Visual alphabet of the class diagram language.*

*A visual alphabet is the basis to de ne a parse speci cation using the* GenGEd grammar editor. Based on the Agg graph parser, a parse speci - cation consists of a parse grammar (which can be de ned using the means of the VL), a layer function, and critical pairs.

*Graph rules occurring in a parse grammar consist of a left-hand side (L)* and a right-hand side (R) over typed (labeled) graphs. Parts of both rule sides are related to each others. The related parts are preserved during a graph transformation. All non-related graph objects of L are deleted, all non- related objects of R are created. Moreover, a rule may contain a set of NACs specifying exactly those fractions of matching situations that must not exist for a rule to be applicable.

*Assigning rules as well as vertex and edge types to layers such that a* certain layering condition is satis ed (cf. [2]), the layer-wise application of rules (according to the rule layer) toa given terminal graph always terminates. Roughly speaking, the layering condition is ful lled if each rule deletes at least one vertex or edge coming from a lower level (deletion layer) and creates graph objects of a higher level (creation layer).

*Critical pair analysis [10,9,12] can be used to make parsing by graph trans-* formation more eÆcient: decisions between con icting rule applications are delayed as far as possible. This means to apply non-con icting rules rst and to reduce the graph as much as possible. Afterwards, rule application con icts are handled by creating decision points for the backtracking part of the pars- ing algorithm. For critical pair analysis of CLGG rules, a layer-wise analysis is suÆcient, since a rule of an upper layer is not applied as long as rules of lower layers are still applicable.

*In the GenGEd grammar editor, the critical pairs are generated automat-* ically from the Agg graph parser, but the remaining constituents the language designer has to de ne. For our example of simpli ed UML class diagrams, the parse rules express the deletion of visual symbols such that for each lexical symbol of the visual alphabet there is one parse rule. These rules and the layer function are proposed in the following.

*Figure 2 (a) illustrates the parse rule for packages. Packages can be deleted* if they are empty. If the package where the rule should be applied to, is not empty, the dangling condition prohibits the application of this rule. The rule allowing for the deletion of association symbols is illustrated by Figure 2 (b). Here we consider only classes of the same package to be related by association symbols.



**L**

**Delete**

**Package()**

**R**

x:Package



**L**

**R**

**Delete**

**Assoc()**

z1:Package

x:Class y:Class

x:Class z:Assoc y:Class

z1:Package

**(a) (b)**

*Fig. 2. Parse rule for package symbols (a) and for association symbols (b).*

*The rule supporting the deletion of class symbols is shown in Figure* *3.*

*According to the visual alphabet, a class symbol always has to be linked to a* package which is expressed by the left-hand side L of the rule. Moreover, we expect that the user always inserts a class symbol together with a class name represented by the node x':CN holding the value represented by the variable cn. The NAC states that the class name has to be unique in one package.



cn

z1:Package

cn

x’:CN

y’:CN

**NAC**

**L**

**Delete**

**R**

**Class()**

z1:Package

z1:Package

cn x’:CN

x:Class

y:Class

x:Class

*Fig. 3. Parse rule for class symbols and class names.*

*The layer function for our small example is given below. Thereby we use* the abbreviations dl for deletion layer, cl for creation layer, and rl for rule layer. Note that the rule layer supports the ordering of rule application, whereas the deletion and the creation layer are necessary for the termination of the parsing algorithm. Note that the language designer must not de ne creation nor deletion layers for links; those are generated automatically in dependence of the symbols the links have in their domain, i.e., the source vertices of the corresponding link edges.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| *Type* | *dep* | *endent layers* | | | *Rule layer* | | |
| *dl(Assoc)* | *=* | *cl(Assoc)* | *=* | *0* | *rl(DeleteAssoc())* | *=* | *0* |
| *dl(Class)* | *=* | *cl(Class)* | *=* | *1* | *rl(DeleteClass())* | *=* | *1* |
| *dl(Package)* | *=* | *cl(Package)* | *=* | *2* | *rl(DeletePackage())* | *=* | *2* |

*For the critical pair analysis which must be done only once, the Agg graph* parser is called with the parse grammar and the layer function. The resulting parse speci cation and the visual alphabet is the input of the graphical editor where the user can manipulate visual expressions (diagrams) in a free editing style. In order to check the visual expression against the visual syntax, the Agg graph parser gets the parse speci cation together with the visual expres- sion as input and checks whether the expression is correct or not. The result will be illustrated in the graphical editor.

# *4 Conclusion*

*Graph parsing based on critical pair analysis can be used for eÆcient VL* parsing. The VL parser integrated in GenGEd is based on a new graph parsing component of Agg. First experiences on free editing of class diagrams have been made. We are going to consider more sophisticated VLs in the future as, e.g. Statecharts. Furthermore, the implemented parsing algorithm has to be compared with related approaches concerning eÆciency.

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