Model Transformation with Triple Graph Grammars and Non-terminal Symbols

William da Silva, Max Bureck, Ina Schieferdecker, and
Christian Hein

Fraunhofer Fokus, Berlin, Germany
william.bombardelli.da.silva@fokus.fraunhofer.de
Technische Universität Berlin, Berlin, Germany

November 2, 2018

Organization

Introduction

- Model-driven software development as a technique to enhance quality of software

Background

- Model-driven software development as a technique to enhance quality of software
- Models as formal specifications of safety-critical systems

Background

- Model-driven software development as a technique to enhance quality of software
- Models as formal specifications of safety-critical systems
- Transformation between models (e.g. from a formal specification to high-level source-code and vice-versa)

W. da Silva et al.
Model Transformation with TGG and Non-terminal Symbols
Fraunhofer Fokus

- Model-driven software development as a technique to enhance quality of software
- Models as formal specifications of safety-critical systems
- Transformation between models (e.g. from a formal specification to high-level source-code and vice-versa)

- **Goal:** Comprehensible and reliable transformations
  - Efficient representation of abstract concepts
 - Small size

The Model Transformation Problem

Source Models — G ~ T — *Target Models*
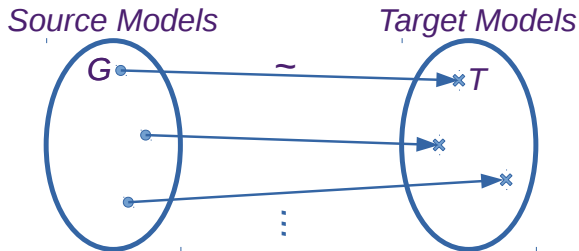
- $G \sim T$ iff G is correctly transformed into T
- $\sim$ is the *correctly-transformed relation* between source and target models
- **Batch forward transformation:**
  Given G, find a T, such that $G \sim T$
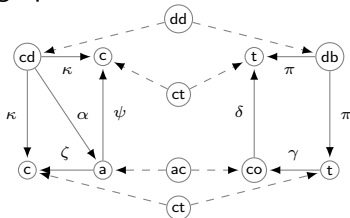
- Models are graphs

The Triple Graph Grammar Approach

- Models are graphs
- Two correctly-transformed graphs G and T are in a triple graph $G \leftarrow C \rightarrow T$
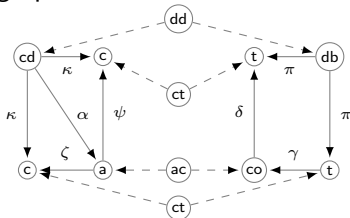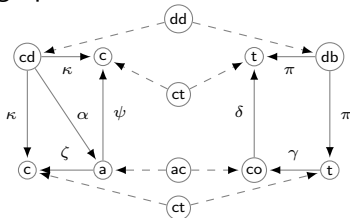
The Triple Graph Grammar Approach

- Models are graphs
- Two correctly-transformed graphs G and T are in a triple graph $G \leftarrow C \rightarrow T$

- A triple graph grammar TGG is a generator of a set of triple graphs $L(TGG)$

The Triple Graph Grammar Approach

- Models are graphs
- Two correctly-transformed graphs G and T are in a triple graph $G \leftarrow C \rightarrow T$
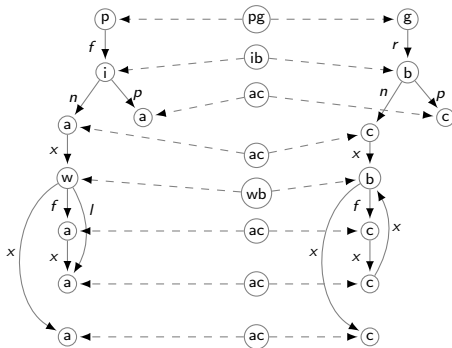

- A triple graph grammar TGG is a generator of a set of triple graphs $L(TGG)$
- The correctly-transformed relation $\sim$ between graphs is described in terms of a triple graph grammar TGG
  - $G \sim T$ iff $(G \leftarrow C \rightarrow T) \in L(TGG)$
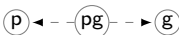
TGG – An Example

- *Pseudocode* to *Controlflow*


```
program main(n)
if  n < 0 then
    return Nothing
else
    f ← 1
    while n > 0 do
        f ← f * n
        n ← n - 1
    end while
    return Just f
end if
```

TGG - An Example

- *Pseudocode* to *Controlflow*
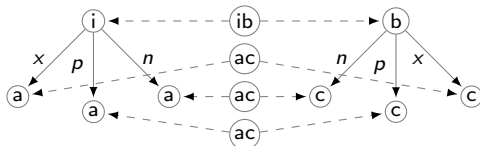
Triple Graph Grammars with Non-terminal Symbols

Our Contribution – NCE TGG

- New formalism: NCE TGG
  - *Graph Grammar with Neighborhood-controlled Embedding* (NCE) [Janssens and Rozenberg(1982)]
  - *Triple Graph Grammar* (TGG) [Schürr(1994)]
- Non-terminal symbols
- Context-free

- *Pseudocode* to *Controlflow*

Transformation
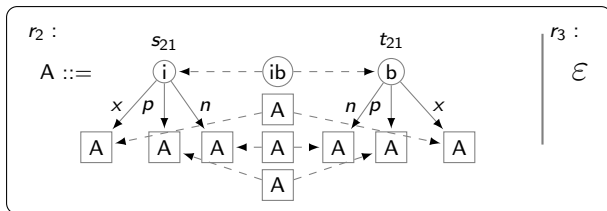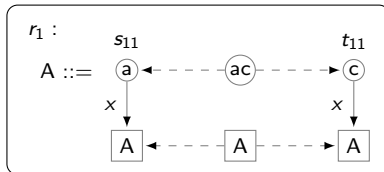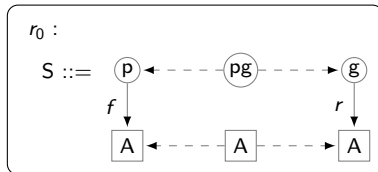
- Parsing and production
- Bottom-up parser, analogous to CYK, from [Rozenberg and Welzl(1986)]
- Polynomial worst-case time complexity, but not linear
- Performance not practicable (yet)

Evaluation

	Standard TGG		BNCE TGG	
Transformation	Rules	Elements	Rules	Elements
Pseudocode2Controlflow	47	1085	**7**	**185**
BTree2XBTree	**4**	**50**	5	80
Star2Wheel	-	-	**6**	**89**
Class2Database	**5**	**80**	-	-

Table: Results of the usability evaluation of the BNCE TGG formalism in comparison with the standard TGG for the model transformation problem

Conclusion

Conclusion

- New context-free TGG formalism
  - Used to specify model transformations
  - Outperforms standard TGG in 2 evaluated cases
  - Special potential for code-generation
  - Cannot model important transformations (e.g. Class Diagrams)

Conclusion

- New context-free TGG formalism
    - Used to specify model transformations
    - Outperforms standard TGG in 2 evaluated cases
    - Special potential for code-generation
    - Cannot model important transformations (e.g. Class Diagrams)
- Future Work
    - Efficient transformer: Top-down parser
    - Application conditions: Positive experimental results
    - Broader evaluation including empirical assessment with engineers and performance reports
    - Model synchronization

References

References

Dirk Janssens and Grzegorz Rozenberg.
Graph grammars with neighbourhood-controlled embedding.
Theoretical Computer Science, 21(1):55–74, 1982.

Grzegorz Rozenberg and Emo Welzl.
Boundary NLC graph grammarsbasic definitions, normal forms, and complexity.
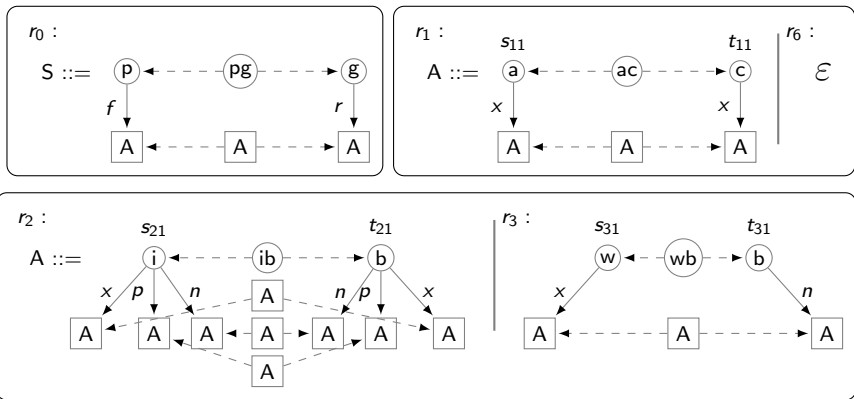*Information and Control*, 69(1-3):136–167, 1986.

Andy Schürr.
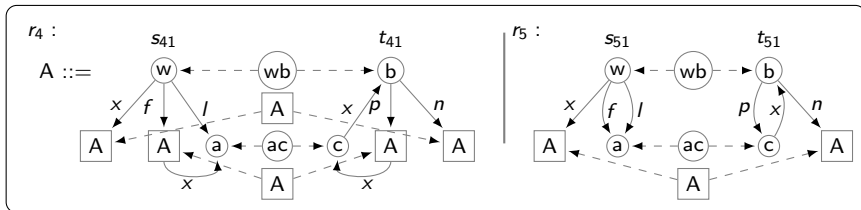Specification of graph translators with triple graph grammars.
In *International Workshop on Graph-Theoretic Concepts in Computer Science*, pages 151–163. Springer, 1994.

Appendix

Pseudocode to Controlflow – Full

Pseudocode to Controlflow – Full

Pseudocode to Controlflow – Derivation