Correctness and Completeness for Incremental Model Synchronisation Based on TGGs

BANFF Bidirectional Transformations

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for Mathematical Innovation and Discovery

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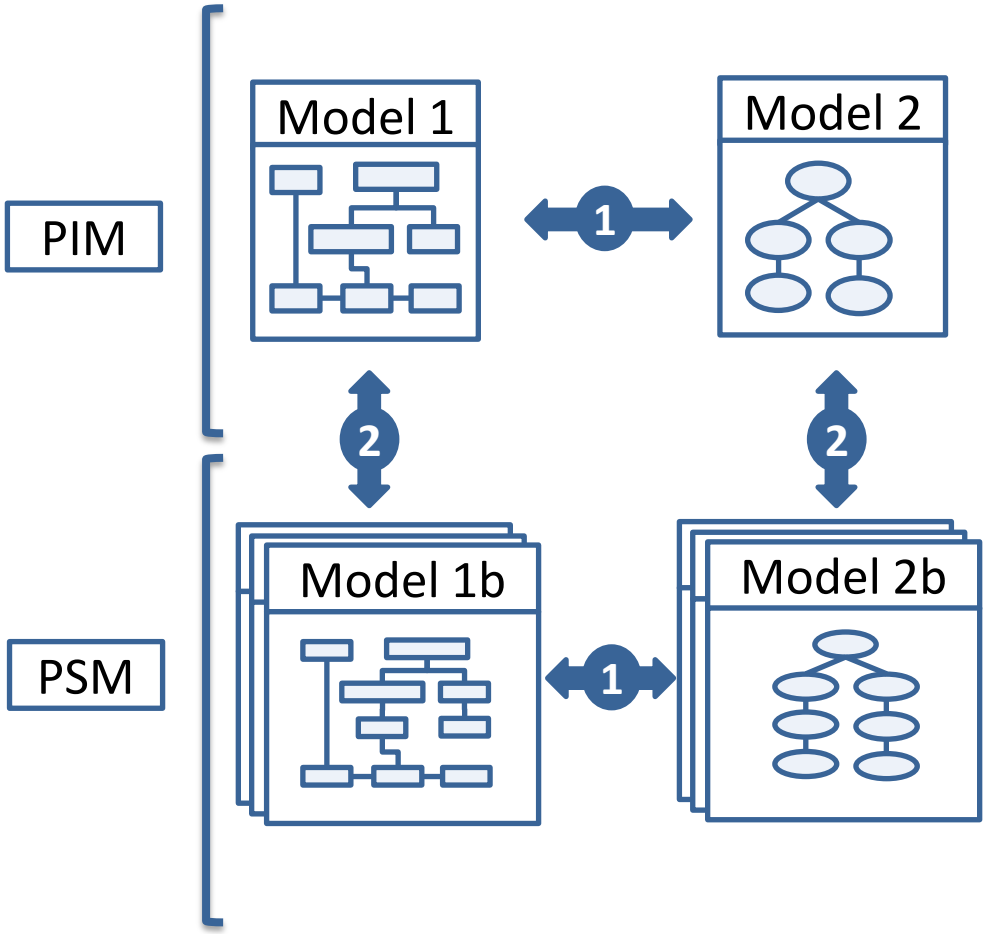
OVERVIEW

- **Formal results** for model synchronization via TGGs
- **Challenges** for **theory** and **tool support**
- Conclusion

Interrelated Models in Model Driven Engineering

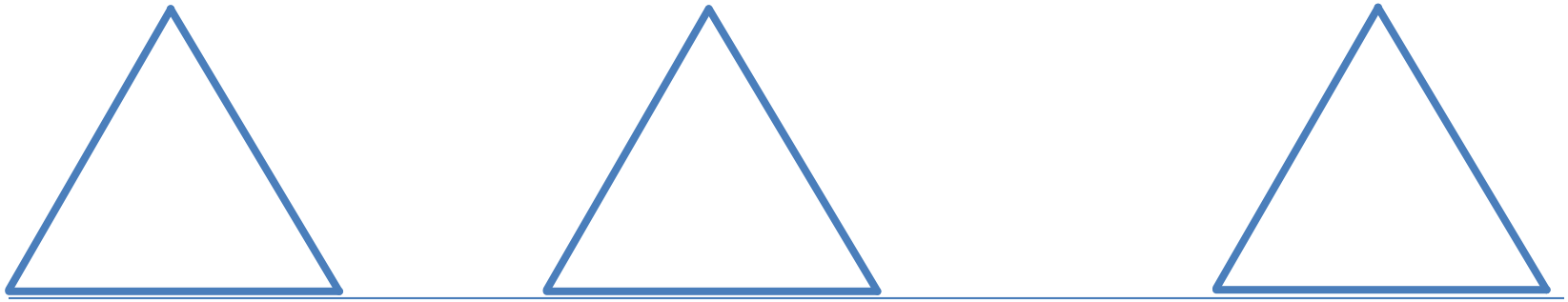


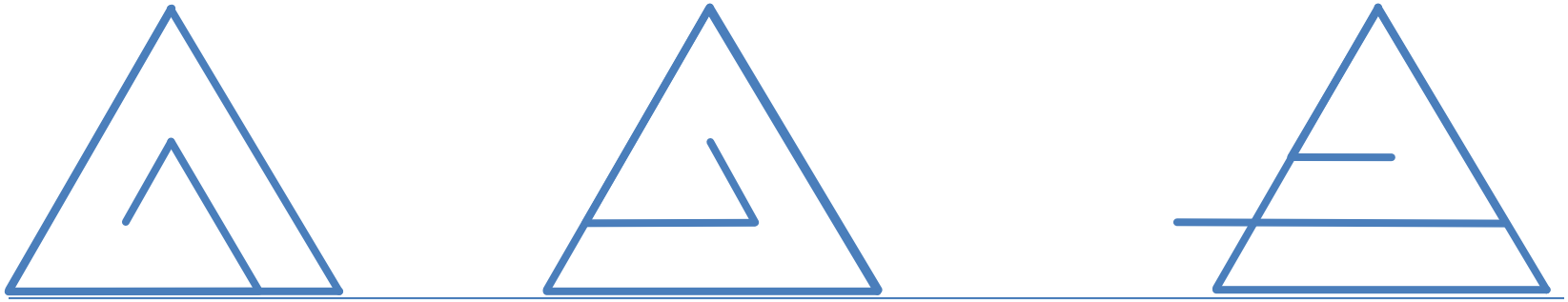
Model Transformations

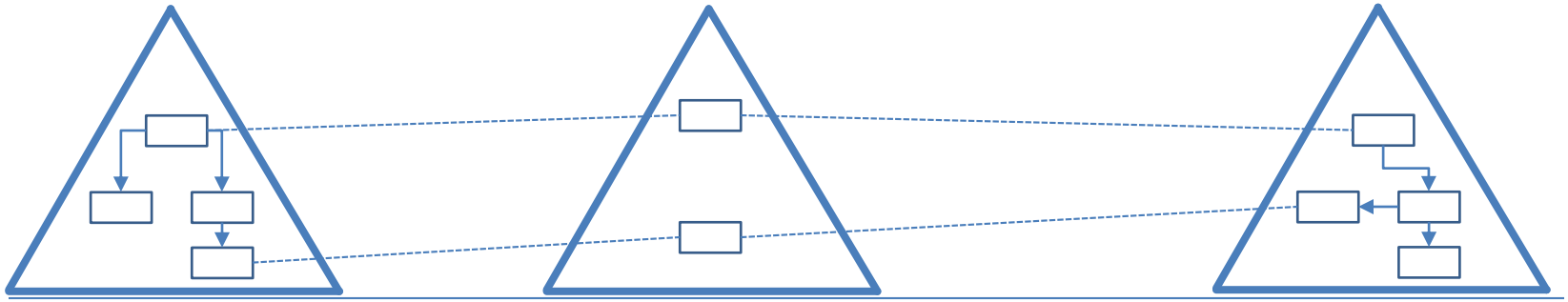
1 **PIM↔PIM (horizontal):**
DSL1↔DSL2,
Model Translation/ Integration/ Synchronisation, e.g.:
UML Class Diag.↔ RDBM
BPMN ↔ BPEL
Sequence Diag. ↔ St. Machines

2 **PIM↔PSM (vertical):**
Model/Code generation, reverse engineering, e.g.:
Class Diag.↔Class Diag.
Class Diag.↔Java

[HEO+13]

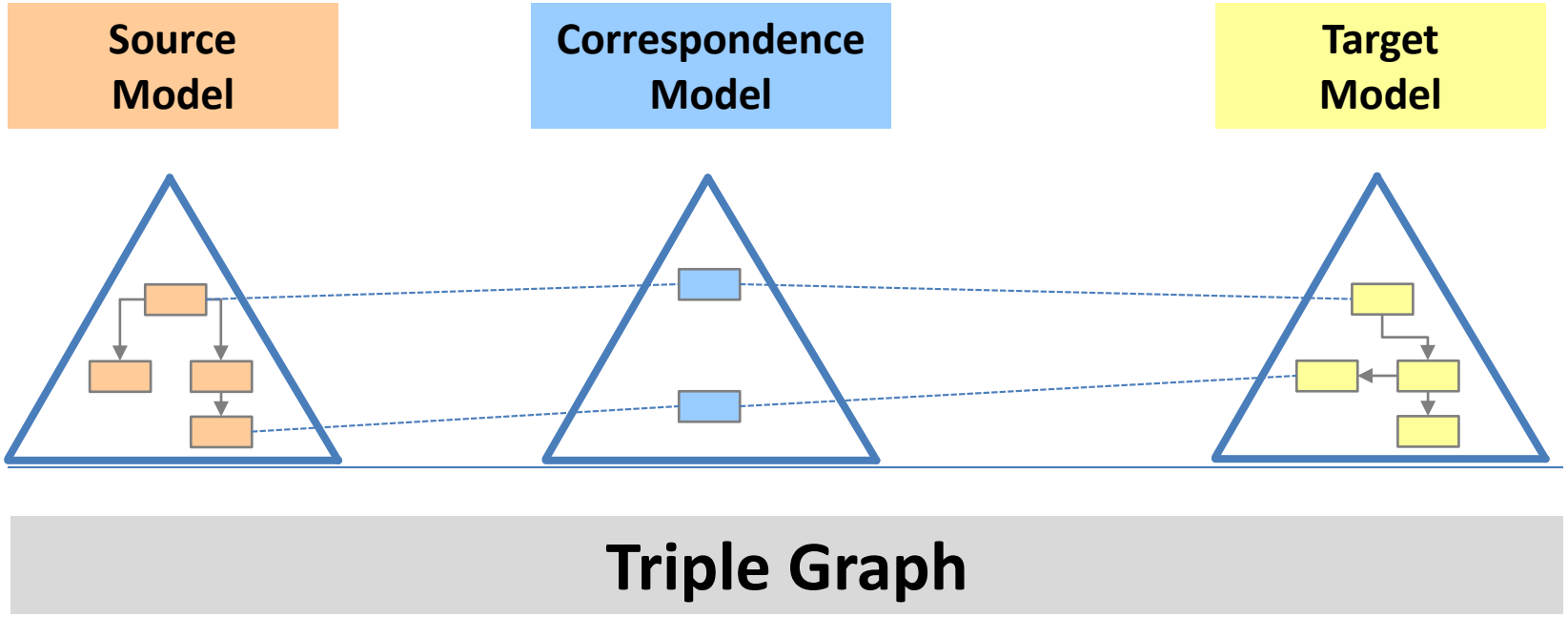






Key Idea of Triple Graph Grammars (TGGs)

- **Specify** pattern by pattern how **consistent integrated models** can be constructed **simultaneously**



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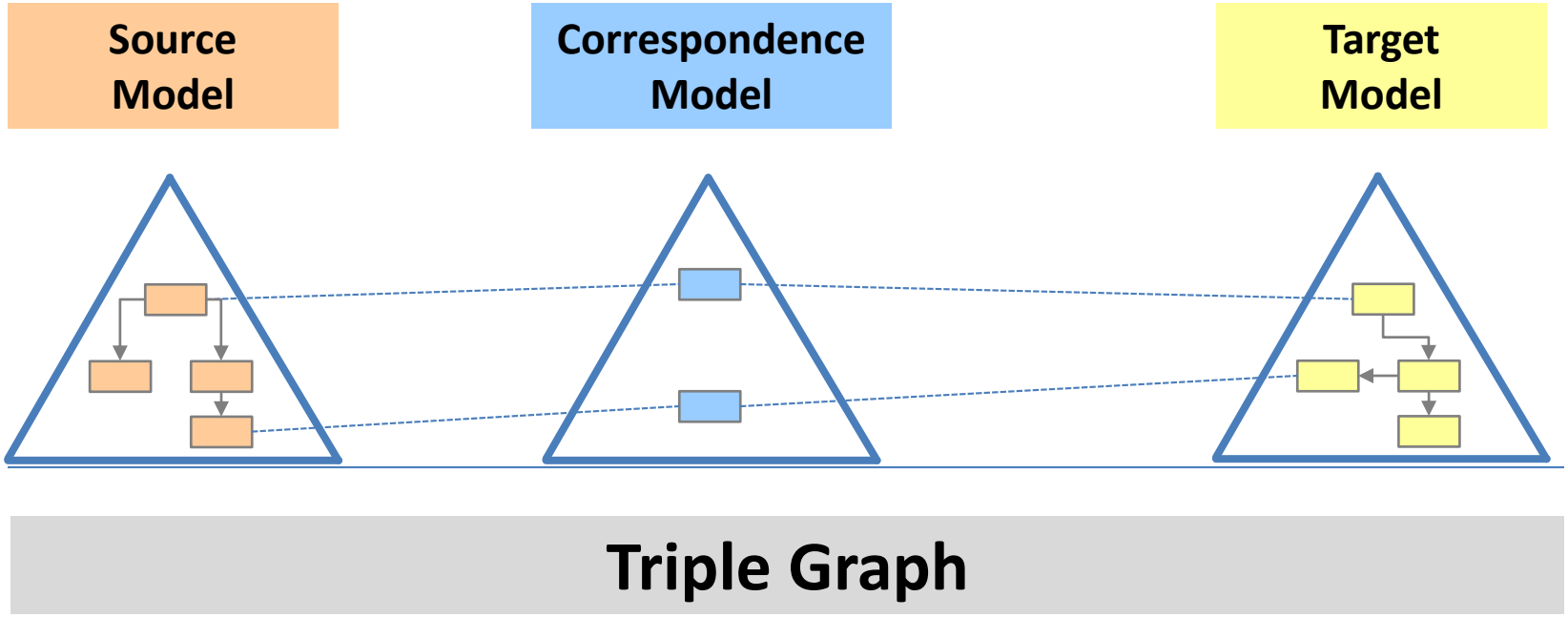

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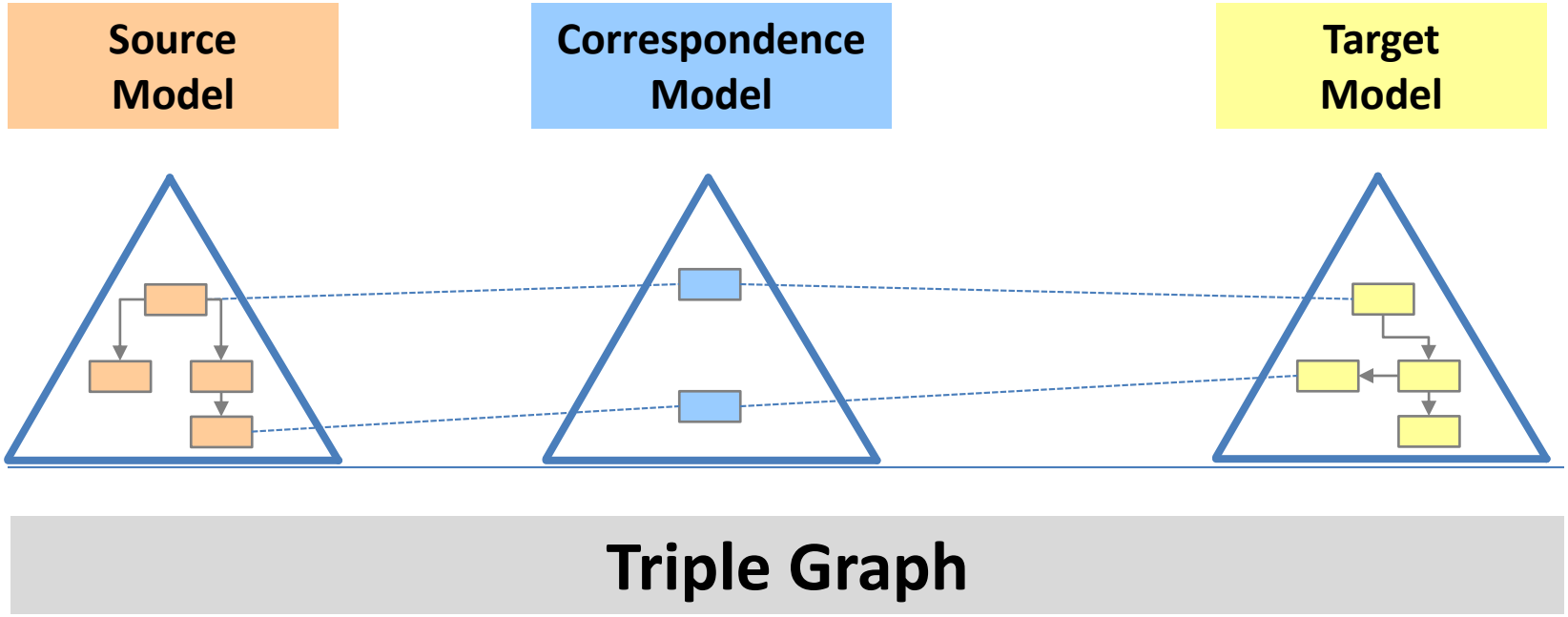
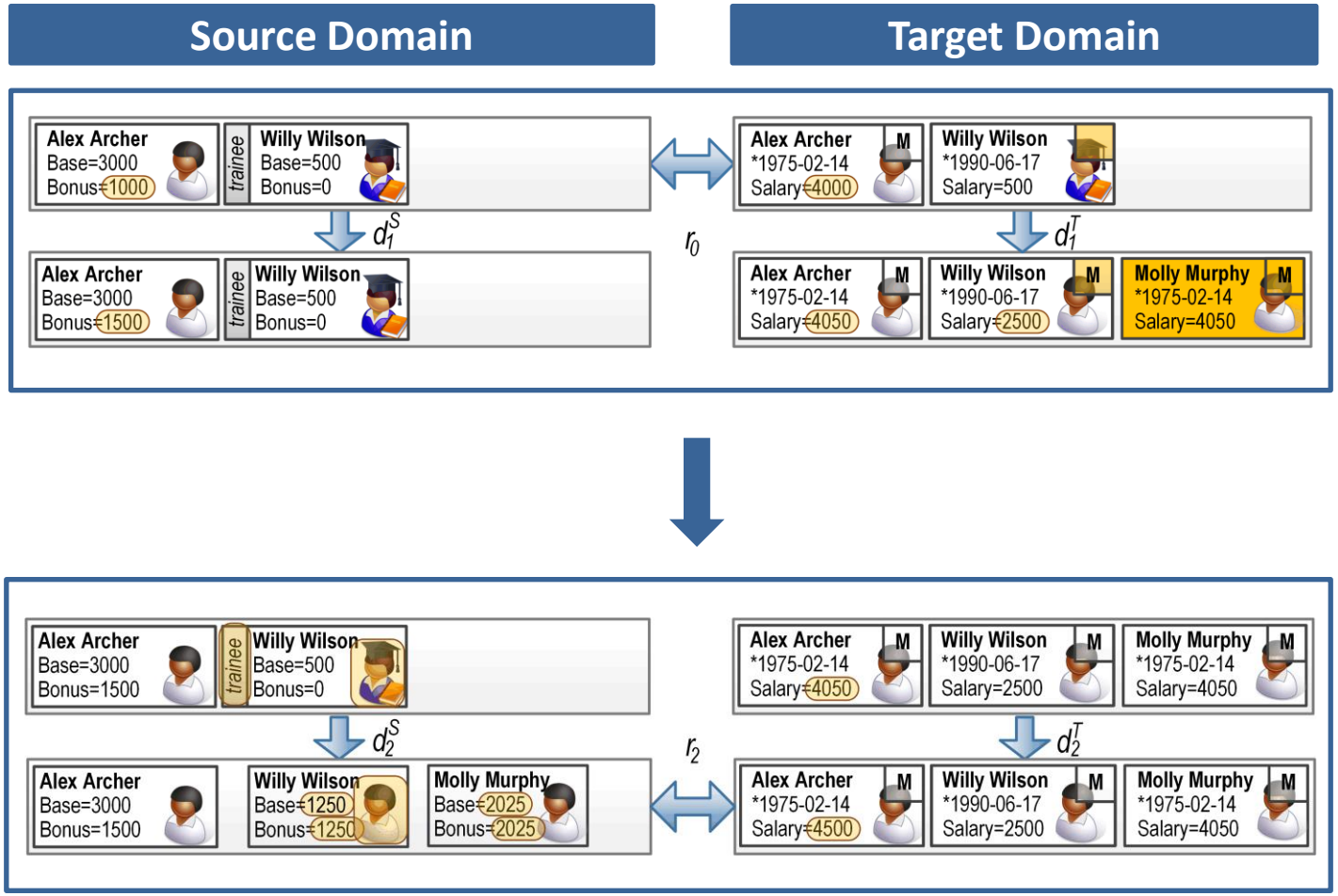
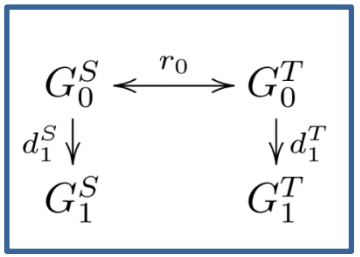


Concurrent Synchronization Problem





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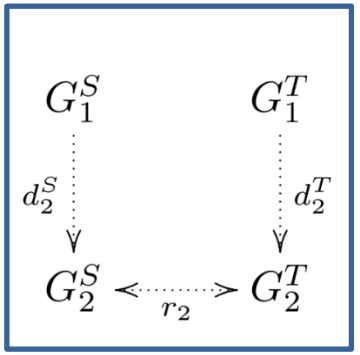
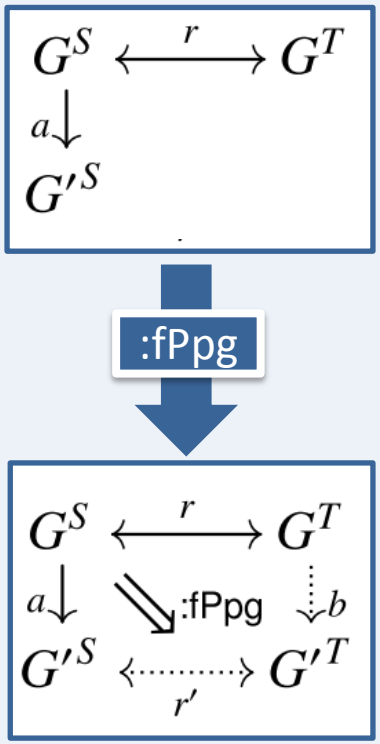
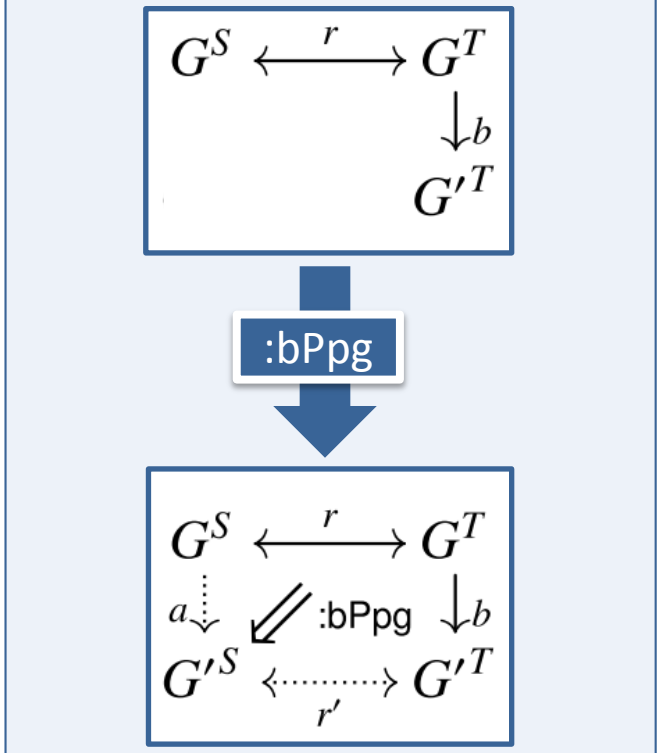


Propagation

Forward Propagation



Backward Propagation

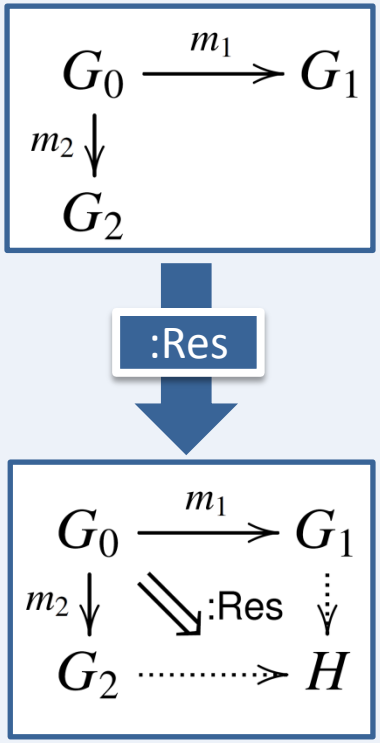


[HEO+11] F. Hermann, H. Ehrig, F. Orejas, K. Czarnecki, Z. Diskin, Y. Xiong: Correctness of Model Synchronization Based on Triple Graph Grammars. In: Proc. MoDELS'11. Springer (2011).

[HEO+13] F Hermann, H Ehrig, F Orejas, K Czarnecki, Z Diskin, Y Xiong, S Gottmann, T Engel: Model synchronization based on triple graph grammars: correctness, completeness and invertibility. In: Software & Systems Modeling, 1-29, Springer 2013.

Conflict Resolution

Conflict Resolution



Resolution Strategy

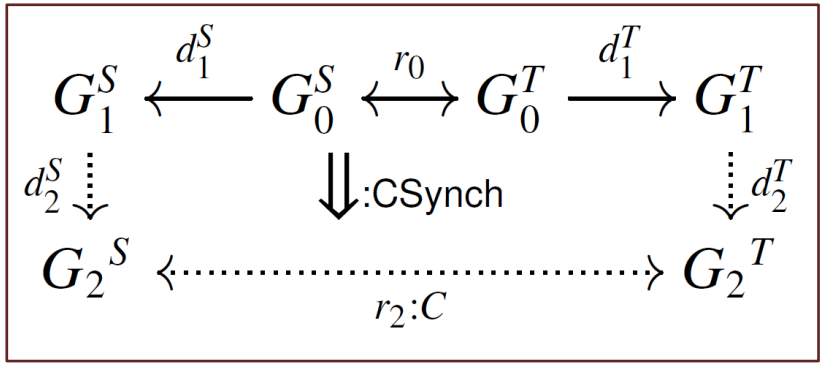
Preservation over deletion

- Elements are **preserved**, if
  - **not deleted** by any update or
  - **required** by one update
- Elements are **deleted**, if:
  - **deleted** by one update and **not required** by the other
  - **deleted** by **both** updates

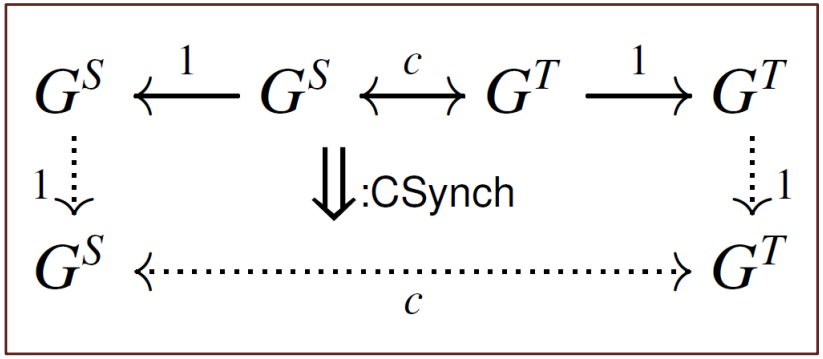
[EET11] H. Ehrig, C. Ermel, G. Taentzer: A Formal Resolution Strategy for Operation-Based Conflicts in Model Versioning Using Graph Modifications. In: Proc. FASE'11. Springer (2011).

Correctness

1. **Consistency Law:**
   result is always consistent



2. **Identity Law:**
   no change, if input is already consistent



Formal Result

Definition (Completeness)

Model synchronisation can be performed for **any input**.

Theorem (Correctness and Completeness)

The derived (non-) deterministic concurrent synchronisation framework CSync(TGG, CSync) is **correct** and **complete**.

[GHN+13] S Gottmann, F Hermann, N Nachtigall, B Braatz, C Ermel, H Ehrig, T Engel: Correctness and Completeness of Generalised Concurrent Model Synchronisation Based on Triple Graph Grammars. In: Proc. AMT'13, CEUR 2013.

[HEEO12] H. Ehrig, C. Ermel, G. Taentzer: Concurrent Model Synchronization with Conflict Resolution Based on Triple Graph Grammars. In: Proc. FASE'12. Springer (2012).

Existing Implementations

Achievement

Incremental synchronization – making it applicable in practice (non-invasive and efficient)

Restriction

Concurrency: no concurrent updates that could cause conflicts

Restriction

Types of TGGs: e.g., deterministic, node creating rules, rule dependencies

Key Challenges

Problem

Diversity: different concepts and implementations for incremental propagation

→

Challenge

Provide a **generalized notion** of incremental propagation (least change)

Problem

Gap: between formal results and implementations of incremental synchronisation

→

Challenge

Extend formal approaches to achieve a close relation to implementations

Challenge

Extend implementations to the **concurrent** case

Conclusion and next steps

SUMMARY

- Concurrent model synchronisation via TGGs
- Guarantees: syntactical correctness, completeness, termination

NEXT STEPS

- Closing the gap between formal theory and implementations by extending both

Further Reading

[EEE+07]	H. Ehrig, K. Ehrig, C. Ermel, F. Hermann, and G. Taentzer: **Information Preserving Bidirectional Model Transformations**. *Proc. FASE'07*. Springer (2007).
[EEPT06]	H. Ehrig, K. Ehrig, U. Prange, and G. Taentzer: **Fundamentals of Algebraic Graph Transformation.** EATCS Monographs in Theoretical Computer Science. Springer (2006).
[GHL12]	Giese, H., Hildebrandt, S., Lambers, L.: **Bridging the Gap Between Formal Semantics and Implementation of Triple Graph Grammars. Ensuring Conformance of Relational Model Transformation Specifications and Implementations.** *Software and Systems Modeling*, Springer (2012).
[GW09]	Giese, H., Wagner, R.: **From model transformation to incremental bidirectional model synchronization.** *Software and Systems Modeling* 8(1), Springer (2009).
[HEGO10]	F. Hermann, H. Ehrig, U. Golas, Fernando Orejas: **Efficient Analysis and Execution of Correct and Complete Model Transformations Based on Triple Graph Grammars**. *Proc. of MDI'10*, ACM (2010).
[HEOG10]	F. Hermann, H. Ehrig, F. Orejas, U. Golas: **Formal analysis of functional behaviour for model transformations based on triple graph grammars**. In: *Int. Conf. on Graph Transformations*, Springer (2010).

Further Reading

[HEO+13]	F. Hermann, H. Ehrig, F. Orejas, K. Czarnecki, Z. Diskin, Y. Xiong, S. Gottmann, T. Engel: **Model synchronization based on triple graph grammars: correctness, completeness and invertibility.** In: Software & Systems Modeling, Springer 2013.
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[LAVS12]	Lauder, M., Anjorin, A., Varró, G., Schürr, A.: Bidirectional model transformation with precedence triple graph grammars. In: *Proc. Eur. Conf. on Modelling Foundations and Applications (ECMFA'12)*, LNCS, vol. 7349. Springer (2012).
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[SK08]	Schürr, A., Klar, F.: 15 years of triple graph grammars. In: *Int. Conf. on Graph Transformations (ICGT 2008)*. LNCS, vol. 5214, Springer (2008).