Automated co-evolution of GMF editor models

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Abstract. The Eclipse Graphical Modeling (GMF) Framework provides the major approach for implementing visual languages on top of the Eclipse platform. GMF relies on a family of modeling languages to describe different aspects of the visual language and its implementation in an editor. GMF uses a model-driven approach to map the different GMF models to Java code. The framework, as it stands, provides very little support for evolution. In particular, there is no support for propagating changes from say the domain model (i.e., the abstract syntax of the visual language) to other models. We analyze the resulting co-evolution challenge, and we provide a transformation-based solution, say GMF model adapters, that serve the propagation of abstract-syntax changes based on the interpretation of difference models.

1 Introduction

“The Eclipse Graphical Modeling Project (GMP) provides a set of generative components and runtime infrastructures for developing graphical editors based on EMF and GEF” [11]. Arguably, GMF defines the mainstream approach to graphical editor development within the Eclipse platform. The approach heavily relies on metamodeling (based on EMF [72]), model-to-model and model-to-code transformations, and even some forms of code customization, subject to round-tripping considerations.

Fig. 1. Snapshot of a simple editor with indications of underlying models.

The present paper describes research on the co-evolution of GMF editors. In particular, we are concerned with the question what and how GMF models need to be co-changed in reply to changes of the domain model (say, metamodel, or abstract syntax definition) of the editor. Consider, for example, the simple mind-map editor in Fig. 1.
We have annotated the different panes of the editor with the associated GMF models underneath, and also added mentioning of the mapping model which connects the various models. (We will describe the architecture of the editor in more detail later.) The co-evolution challenge at hand is to “unbreak” the editor upon changes to the domain model. The GMF framework does not support such co-evolution. In particular, there are no semi-automatic means to unbreak the editor.

Such lack of co-evolution support somewhat diminishes the original goal of GMF to aggressively simplify the development of graphical editors. That is, while it is reasonable simple to draft and connect all GMF models from scratch, it is notably difficult to evolve an editor through changes of specific GMF models. A recurring focus for evolution is the domain model of the editor. Upon domain model changes, the user may notice that the editor is broken through unsuccessful runs of some generator, the compiler, or the editor itself, and in all cases, subject error messages at a low level of abstraction. However, the editor’s unsoundness may also go unnoticed for some time. Alternatively, the user may attempt to regenerate some models through the available wizards (model-to-model transformations of GMF), which however means that the original, possibly customized models are lost.

Contributions

– We analyze GMF’s characteristics in terms of the co-evolution of the various models that contribute to a GMF editor. Starting from conceived domain-model changes, their implications for the editor itself and other GMF models are identified.

– We address the resulting co-evolution challenge by complementing GMF’s wizard-and generator-biased architecture with model-to-model transformations that propagate changes of the domain model to other models.

Limitations The existing GMF infrastructure is obviously rather complicated: it is a conglomeration of metamodels, libraries, generators, model transformations of industrial scale. We cannot claim to provide a full-fledged solution to the co-evolution challenge of GMF—this would require full coverage of Ecore, and full understanding of the implicit semantics of GMF model dependencies and tools. Nevertheless, we are confident that our transformational approach can be scaled incrementally over time to cover an increasing number of concrete evolution scenarios. We make available some reusable elements of our development publicly (scenarios, transformations, difference models, etc.)

The most critical omission in our methodology is that we do not cover currently co-evolution of customization code. This is a very intricate problem by itself, to which we hope to contribute through future work.

Road-map In §2 we briefly recall the basics of the GMF approach to graphical editor development. In §3 we study a detailed evolution scenario to systematically reveal the co-evolution challenge of GMF. In §4 we develop an initial list of domain model changes and derive a methodology of co-evolution based on propagating changes to all relevant GMF models. In §5 we describe the realization of model-to-model transformations that are driven by difference models for the domain-model changes. Related work is described in §6 and the paper is concluded in §7.

1 http://www.emfemigrate.org/gmfevolution
2 GMF in a nutshell

GMF consists of a generative component (GMF Tooling) and runtime infrastructure (GMF Runtime) for developing graphical editors based on the Eclipse Modeling Framework (EMF) and the Graphical Editing Framework (GEF). The GMF Tooling supports a model-driven process for generating a fully functional graphical editor based on the GMF Runtime starting from the following models:

- The **domain model** is the Ecore-based metamodel (say, abstract syntax) of the language for which representation and editing have to be provided.
- The **graphical definition model** contains part of the concrete syntax; it identifies graphical elements that may, in fact, be reused for different editors.
- The **tooling definition model** contains another part of the concrete syntax; it contributes to palettes, menus, toolbars, and other periphery of the editor.
- Conceptually, the aforementioned models are reusable; they do not contain references to each other. It is the **mapping model** that establishes all links.

Consider again Fig. 1 which illustrates the role of these models for a simple mind-map editor. Fig. 3 shows all the models involved in the definition and implementation of the mind-map editor. In addition to the aforementioned models, two generator models are mentioned; they will be explained in a second.

The domain model of the mind-map editor contains all the concepts and relationships which have to be implemented in the editor. In the example, the class **Mindmap** is introduced as a container of instances of the classes **Topic** and **Relation**.

Once a domain model is defined, it is possible to automatically produce Java code to manage models (instances), say mind maps in our example. To this end an additional model, the **EMF generator model**, is required to control the execution of the EMF generator. A uniform version of the extra model can be generated by EMF tooling. The model contains the mere list of classes and properties to be considered as well as low-level details, e.g., the package prefix for the generated code.

The graphical definition model consists of a figure gallery including shapes, labels, lines, etc., and canvas elements to define nodes, connections, compartments, and diagram labels. For instance, in the graphical model in Fig. 3 a rectangle named **TopicFigure** is defined, and it is referred to by the node **Topic**. A diagram label named

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2 A mind map is a diagram used to represent words, ideas, tasks, or other items linked to and arranged around a central keyword or idea. The initial mind-map editor suffices with “topics” and “relations”, but some extensions will be applied eventually.
Fig. 3. The GMF models and model dependencies for the editor of Fig. 1. We highlight contributions that are related to a selected domain concept: topics. In this manner, we show how information about domain concepts is scattered over the various models. It is important to notice that most of these recurrences are not actual references; the correspondences are name-based. Strong links are only to be found in the mapping and the generator models.

TopicName is also defined. Such graphical elements will be used to specify the graphical representations for Topic instances and their names.

The tooling definition model defines toolbars and other periphery to facilitate the management of diagram content. In Fig. 3, the sample model consists of the Topic and Relation tools for creating the Topic and Relation elements.

The mapping model links together the various models. For instance, according to the mapping model in Figure 3, Topic elements are created by means of the Creation Tool Topic and the graphical representation for them is Node Topic. For each topic the corresponding name is also visualized because of the specified Feature Label Mapping.
which relates the attribute name of the class Topic with the diagram label TopicName defined in the graphical definition model.

Once the mapping model is obtained, the GMF Tooling generates (by means of a model-to-model transformation) the GMF generator model that is used by a code generator to produce the real code of the modeled graphical editor.

3 GMF’s co-evolution challenge

Using a compound change scenario, we will now demonstrate GMF’s co-evolution challenge. Overall, the objective is to clarify that domain model changes imply changes of other GMF models. Such change propagation is not supported currently by GMF, and it is labor-intensive and error-prone, when carried out manually. Conceptually, it turns out to be difficult to precisely predict when and how co-changes must be performed.

Consider the enhanced mind-map editor of Fig. 4. Compared to the initial version of Fig. 1, scientific vs. literature topics are distinguished, and topics have a duration property in addition to the name property.

Now consider Fig. 5, it shows the evolved metamodel at the top, and the status of the, as yet, unamended mapping model at the bottom. We actually show the mapping model as it would appear to the user if it was inspected in Eclipse. Some of the links in the mapping model are no longer valid; in fact, they are dangling (c.f., “null”). Through extra edges, we show what the links are supposed to be like.

We get deeper insight into the situation if we comprehend the evolved domain model through a series of simple, potentially atomic changes. i) The Topic class was renamed to ScientificTopic. ii) The new abstract class NamedElement was added. iii) The attribute name of the old Topic class was pulled up to the new NamedElement class. iv) The attribute duration was added to the NamedElement class. v) The new class LiteratureTopic was added as a further specialization of NamedElement.

In practice, these changes would have been carried out in an ad-hoc manner through free-wheeling editing capabilities of the Ecore editor of Eclipse. Because of these changes, the existing mapping model is no longer valid—as shown in Fig. 5. In particular, references to Topic or the attribute name thereof are dangling. The other GMF models are equally out-of-sync after these domain model changes.
Incomplete or unsuccessful editor evolution may be signaled in different ways, or may, in fact, remain hidden for some time—depending on the specific domain model change as well as the usage of GMF tooling. We list obvious and hidden symptoms of broken or unsound editors:

1. The EMF generator or the GMF generator fails (with an error).
2. The EMF generator or the GMF generator completes with a warning.
3. The generator for the GMF generator model fails.
4. The compiler fails on the generated EMF or GMF code.
5. The editor plugin fails at runtime, e.g., at launch-time.
6. A GMF model editor reports an error upon opening a GMF model.
7. The editor plugin apparently executes but misses concepts of the domain.
8. The editor plugin apparently executes but there are GUI events without handlers.

Let us consider two specific examples. First, the addition of a new class to the domain model, e.g., LiteratureTopic, should probably imply a capability of the editor to create instances of the new class. However, such a creation tool would need to be added in the mapping and tooling models. Second, the renaming of a class, e.g., the renaming of Topic to ScientificTopic, may lead to an editor with certain functionality not having any effect because elements are referenced that changed or do not exist anymore in the domain model. Both examples are particularly interesting in so far that the editor apparently still works. i.e., it is not broken in a straightforward sense. However, we say that the editor is unsound; the editor does not meet some obvious expectations.
Such a distinction of broken vs. not broken but nevertheless unsound also naturally relates to a spectrum of strategies for co-changes. A minimalistic strategy would focus on unbreaking the editor. That is, co-changes are supposed to bring the editor models to a state where no issues are reported at generation, compile or runtime. A best-effort strategy would try to bring the editor to a sound state, or as close to it as possible with a general (perhaps automated) strategy.

Consider again the example of adding a new class $C$:

**Minimalistic strategy**  The execution of the EMF generator emits a warning, which we take to mean that the editor is broken. Hence, we would add the new class $C$ to the EMF generator model. This small co-change would be sufficient to re-execute all generators without further errors or warnings, and to build and run the editor successfully. The editor would be agnostic to the new class though because the mapping and tooling models were not co-changed.

**Best-effort strategy**  Let us make further assumptions about the added class $C$. In fact, let us assume that $C$ is a concrete class, and it has a superclass $S$ with at least one existing concrete subclass $D$. In such a case, we may co-change the other GMF models by providing management for $C$ based on the replication of the management for $D$.

Here we assume that a best-effort strategy may be amenable to an automated transformation approach in that it does not require any domain-specific insight. The modeler will still need to perform additional changes to complete the evolution, i.e., to obtain a sound editor.

### 4 Changes and co-changes

Let us discuss and assess a catalog of domain-model changes and associated co-changes of other editor models. Obviously, we can depart from catalogs of metamodel changes as they are available in the literature, e.g., [19][13], and previous work by the authors [3].

Due to space constraints, a selection must be made: it covers atomic changes that are needed for the compound scenario of the previous section, completed by a few additional ones. Many of the missing changes would refer to technical aspects of the EMF implementation, and as such, they do not contribute to the discussion.

| Level | Description |
|-------|-------------|
| 1     | Unsound in the sense of being broken; there are reported issues (errors, warnings). |
| 2     | Unsound in the sense that the editor “obviously” lacks capabilities. |
| 3     | Sound as far as it can be achieved through automated transformations. |
| 4     | Sound; established by human evaluation. |

**Table 1.** Levels of editor soundness along evolution.

In continuation of the soundness discussion from the previous section, Table 1 identifies different levels of soundness for an evolving editor. The idea is here that we assess the level of the editor before and after all (automated) co-changes were applied. The proposed transformations can never reach Level 4 because it requires genuine evaluation by the modeler.

However, we are not just interested in the overall level of the editor, but we also want to blame one or more editor models for the editor’s unsoundness. In Table 2, we list atomic changes with the soundness levels for the editor before and after co-changes,
and all the indications as to what models are to blame. We use “×” to blame a model for causing the editor to be broken, i.e., to be at Level 1. We use “◦” and “•” likewise for Level 2 and Level 3.

The EMFGen model is frequently to blame for a broken editor before the co-changes; the Graph model is never to blame for a broken editor; the remaining models are to blame occasionally for a broken editor. Obviously, there is trend towards less blame after the co-changes: no occurrences of “×”, more occurrences of “•”. In different terms, for all domain-model changes, all other models can be co-changed so that the editor is no longer broken. In several cases, we reach Level 3 for the editor.

There are clearly constellations for which changes cannot be propagated in an automated manner that resolves all Level 2 blame. For instance, the metamodel change add concrete class does not require a co-changed Graph model as long as some existing graphical element can be reused. However, avoidance of Level 2 blame would require a manual designation of a new element or genuine selection of a specific element as opposed to an automatically chosen element.

Fig. 6 describes some changes and co-changes in detail.

### 5 Automated transformation of GMF models

We have developed a process for GMF co-evolution which involves automated transformations in an essential manner. We describe this process here. We also provide some insight into the implementation of the involved transformations, which is based on model transformations specified in ATL [14]. (The implementation is available publicly—as described in the introduction of the paper.)

Fig. 7 summarizes the approach: given two subsequent versions of the same domain model their differences are calculated and then represented in a difference model. Such differences are then taken as input by different adapters each devoted to the co-change of a specific GMF model. Interestingly, the GMFMap and the GMFTool adapters take
Add empty, concrete class  Apart from the EMFGen model, the other ones are not affected; the editor simply does not take into account the added class. Thus, modelers cannot create or edit instances of the new class. The co-change may replicate the model from existing classes as discussed in Fig. 3. Ultimately, the modeler may need to manually complete the management of the new class.

Add empty, abstract class  In comparison to the previous case, the co-change of the EMFGen model is fully sufficient since abstract classes cannot be instantiated, and hence, no additional functionality is needed in the editor.

Add specialization  The change consists of modifying an existing class by specifying it as specialization of another one. In particular, in the simple case of the superclass being empty, this modification does not affect any model; thus, no co-changes are required.

Delete concrete class  Deleting an existing class is more problematic since all the GMF models except the Graph model are affected. Especially the Mapping model has to be fixed to solve possible dangling references to the deleted class. The Tooling model is also co-changed by removing the creation tool used to create instances of the deleted class. Even if the model is not adapted, the generator model can be generated—even though the palette will contain a useless tool without associated functionality. The Graph model can be left unchanged. The graphical elements which were used for representing instances of the deleted class, may be re-used in the future.

Rename class  Renaming a class requires co-change of the Mapping model which can have, as in the case of class deletion, invalid references which have to be fixed by considering the new class name. The Graph model does not require any co-change since the graphical elements used for the old class can be used even after the rename operation. The Tooling model can be left untouched, or alternatively the label and the description of the tool related to the renamed class can be modified to reflect the same name. However, even with the same Tooling model, a working editor will be generated.

Add property  The strategy for co-change is similar to the addition of new classes.

Delete property  Deleting a property which has a diagrammatic representation requires a co-change of the Mapping model in order to fix occurred dangling references. Moreover if some tools were available to manage the deleted property, also the Tooling model has to be co-changed. As in the case of class removals, the graphical model can be left unchanged.

Rename property  The strategy for co-change is similar to the renaming of classes.

Move property  When a property is moved from one class to another, then dangling references may need to be resolved in the Mapping model. If the moved property is managed by means of some tools, the Tooling model require co-changes, too. We only offer a simple, generic strategy for co-changes: the repaired editor does not consider the moved property.

Pull up property  Given a class hierarchy, a given property is moved from an extended to a base class. This modification is similar to the previous one—even though an automatic resolution can be provided to co-change Tooling and Mapping models in a satisfactory manner.

Change property type  The EMFGen model is not affected. However, by changing the type of a property some dangling references can occur in the Mapping model; their resolution cannot be fully automated. Also, if the affected property is managed by some tool, then the Tooling model must be co-changed as well.

Fig. 6. Detailed descriptions of selected changes and co-changes.
as input both the GMFMap model and the GMFTool model since the dependencies between these two models have to be updated simultaneously. No adapter is provided for the Graph model; the discussion of the previous sections suggested that we can always reasonable continue with the old model.

Model-based representation of domain model differences

We seek the adoption of standard model-driven techniques and tools for their management and to derive in an automatic way the co-changes of the GMF models. To this end, the difference metamodel concept, presented by the authors in [4], and already adopted in different scenarios including the management of the coupled evolution of metamodels and models [3], is leveraged.

The approach is summarized in Fig. 8: given two Ecore metamodels, their difference conforms to a difference metamodel \( \text{MMD} \) derived from Ecore by means of the \( \text{MM2MMD} \) transformation. For each class \( \text{MC} \) of the Ecore metamodel, the additional classes \( \text{AddedMC} \), \( \text{DeletedMC} \), and \( \text{ChangedMC} \) are generated in the extended Ecore metamodel by enabling the representation of the possible modifications that can occur on domain models and that can be grouped as follows:

– additions, new elements are added in the initial metamodel;
– deletions, some of the existing elements are deleted;
– changes, some of the existing elements are updated.
In Fig. 9, a fragment of the difference model representing the changes between the domain models in Fig. 3 and Fig. 5 is shown. For some of the reported differences, the corresponding properties are shown. For instance, the renaming of the Topic class is represented by means of a ChangedEClass instance which has as updated element an instance of EClass named LiteratureTopic (see the updatedElement property of the changed class Topic shown on the right-hand side of Fig. 9). The addition of the class NamedElement is represented by means of an AddedEClass instance. The move operation of the attribute name from the class Topic to the added class NamedElement is represented by means of a ChangedEAttribute instance which has one EAttribute instance as updated element with a different value for the eContainingClass property. In fact, in the initial version it was Topic (see the second property window) whereas in the last one, it is NamedElement (as specified in the third property window).

**ATL-based implementation of GMF model adapters**

Our prototypical implementation of the GMF model adapters leverages ATL, a QVT compliant language which contains a mixture of declarative and imperative constructs. In particular, the implementation of the GMF adapters consists of transformation rules which copy the given source model to a target one; during this operation they evaluate if changes are needed. A number of helpers have been defined; they navigate models and perform complex queries on them. Many of the helpers are common to all the adapters, and hence, they are available through a library gmfAdaptationLib. Table describes some of these helpers.

Small excerpts of the GMFMap and GMFTool adapters are shown in Listing 1.1 and Listing 1.2 respectively. For instance, the AddedSpecializationClassTo... transformation rules manage new classes which have been added in the domain model as specializations of an existing one. The code excerpts involve the replication strategy that we have described in previous sections. More specifically, the AddedSpecializationClassToNodeMapping rule in Listing 1.1 is executed for each match of the source pattern in lines 4-14 which describes situations like the one we had in the sample scenario where the LiteratureTopic class (see s1) is added as specialization of an abstract class (see s2) which is specialized by another class (see s3). In this case, the Mapping model...
| Helper name                      | Context        | Return type | Description                                                                 |
|---------------------------------|----------------|-------------|-----------------------------------------------------------------------------|
| getEClassInNewMetamodel         | EClass         | EClass      | Given a class of the old metamodel, it returns the corresponding one in the new metamodel. |
| getNewContainer                 | EAttribute     | EClass      | Given an EAttribute in the old metamodel, the corresponding container in the new one is retrieved. To this end, the helper checks if the EAttribute has been moved to a new added class, if not an existing class is returned. |
| isMoved                         | EAttribute     | Boolean     | It checks if the considered EAttribute has been moved to another container |
| isMovedToAddedEClass            | EAttribute     | Boolean     | It checks if the considered EAttribute has been moved to a new added EClass. |
| isRenamed                       | EAttribute     | Boolean     | It checks if the given EAttribute has been renamed. |

Table 3. Some helpers of the gmfAdaptationLib

is updated by adding a new `TopNodeReference` and its contained elements (see lines 20-34) which are copies of those already existing for `s3`.

```plaintext
... rule AddedSpecializationClassToNodeMapping {  
  from  
s1: DELTAMM!AddedEClass, s2: DELTAMM!AddedEClass,  
s3: DELTAMM!ChangedEClass, s4: DELTAMM!ChangedEAttribute,  
s5: DELTAMM!EAttribute  
((not s1.abstract)  
  and s1.eSuperTypes->first() = s2  
  and s2.abstract  
  and s3.updatedElement->first().eSuperTypes->first() = s2  
  and s4.updatedElement->first() = s5  
  and s4.eContainingClass = s3  
  and s5.eContainingClass = s2 ))  
using {  
siblingFeatureLabelMapping : GMFMAPMM!FeatureLabelMapping = s3.  
  getNodeMappingFromChangedClass().labelMappings  
    ->select(e | e.oclIsTypeOf(GMFMAPMM!FeatureLabelMapping))->first(); }  
to  
t1 : GMFMAPMM!TopNodeReference {  
  containmentFeature <- s3.getNodeReferenceFromChangedClass().  
    containmentFeature.getFeatureInNewMetamodel(),  
  ownedChild <- t2  
},  
t2 : GMFMAPMM!NodeMapping {  
  domainMetaElement <- s1.getAddedClassInNewMetamodel(),  
  relatedDiagrams <- s3.getNodeMappingFromChangedClass().relatedDiagrams,  
  tool <- s1.name.getNewToolFromTitle(),  
  diagramNode <- s3.getNodeMappingFromChangedClass().diagramNode  
},  
t3 : GMFMAPMM!FeatureLabelMapping {  
  diagramLabel <- siblingFeatureLabelMapping.diagramLabel,  
  features <- siblingFeatureLabelMapping.features->collect(e | e.  
    getFeatureInNewMetamodel())  
},  
...  
...  
...  
...  
```
Listing 1.1. Fragment of the GMFMap Adapter

A similar source pattern is used in the rule of Listing 1.2 (lines 4-9) in order to add a creation tool for the new added class \texttt{s1} to the Tooling model (see lines 15-19).

Listing 1.2. Sample transformation rule of the GMFTool Adapter

6 Related work

Graphical model editors In [1], a number of technologies for the development of domain-specific modeling languages (DSMLs) are evaluated; Eclipse (EMF with GEF) is covered, but not GMF. The evaluation criteria include language evolution to mean the ability to co-evolve models when the domain model changes, and Eclipse receives a medium grade here. There is no criterion though that relates to GMF’s particular characteristics of using multiple editor models.

Other GMF- or GEF-based frameworks have been proposed. For instance, the Mu-vitorKit framework [16] is based on EMF and GEF and specifically meant as an alternative to GMF for the benefit of additional editor capabilities (e.g., multiple panes) as well as additional modeling capabilities, thereby requiring less customization of generated code. There is also the EuGENia framework [15] which raises the level of abstraction in GMF-based development by using annotations on the domain model, thereby feeding into code generation. We are not aware of any prior effort to propagate changes across GMF models.

The ViautraDSM framework [17] replaces GMF in that it allows for versatile mappings between abstract and concrete syntax. Live transformations are leveraged to maintain the coherence of the two models. Our uni-directional, difference-driven transformations propagate domain-model changes elsewhere. Our work is specifically targeted at the mainstream GMF-based approach with its various models.
Model consistency  The status of GMF models being out-of-sync can be compared to the notion of model inconsistency in (UML-based) modeling where different models providing different views may require synchronization. For instance, in [6], inconsistencies between the different diagrammatic forms in UML models are considered, and possible fixes are proposed in the form of value changes. In [10], the dependencies between models are modeled through triple graph grammars in a manner that enables incremental model synchronization. Our specific contribution is one of reverse engineering: discovering the GMF model dependencies, and making them operational through automated transformations.

Co-evolution of metamodels and models  The techniques and the methodology of our work are inspired by research on co-evolution in model-driven engineering [8,18]. Much of this work is concerned with co-transforming models in reply to metamodel changes. In our work, the focus is on the domain models (metamodels), too, and changes are to be propagated to other editor models. Our soundness levels for evolved editors relate to transformation properties of [12,19]. Our change scenarios are inspired by considerations in [19,13] for MOF and EMF. We leverage difference representations of our previous work [3,5].

7 Concluding remarks

We have described the challenge of sound evolution for graphical editors based on model-driven development with GMF in particular, and we have addressed this challenge by a system of co-transformations that propagate changes from domain models to the other editor models.

We have identified a range of options for evolved editors to be unsound, and we have described corresponding resolution strategies. Our work is the first attempt to come to a similar level of understanding as with the established problem of metamodel/model co-evolution, in which case the situation is more clear-cut: models either are not broken, or they are broken and can be reasonably resolved in an automated manner, or a well-understood problem-specific contribution to the resolution must be provided manually or through a heuristic. In the case of co-evolution for editor models, each of the various models calls for a designated analysis, and there are intricate inter-model dependencies.

In our ongoing research, we try to better understand the co-evolution issues and associated strategies for the code level of GMF where generated code has been possibly customized. Based on preliminary research, we can already report that customization is used by some GMF projects extensively, and hence designated co-evolution support may provide significant help with real-world editor development.

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