An Introduction to Metamodelling and Graph Transformations

with eMoflon

Part VI: Miscellaneous

Version 0.1

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The eMoflon team
Darmstadt, Germany (October 2013)

Contents

Part VI:

And all that (eMoflon) jazz

Welcome to the miscellaneous part of our eMoflon handbook. You can consider this Part to be the 'bonus' or appendix area of the entire handbook series. Here we have collected and documented a series of advanced topics related to our tool. These include some tips and tricks you may find helpful while using the tool with Enterprise Architect (EA), a syntax reference table of our Moflon Specification Language (MOSL), and information about the protocol file generated with every Triple Graph Grammar (TGG) transformation which we were never able to explain in Parts IV or V. This entire part is kept rather compact, intended to be used mainly as a reference and consulted on demand.

Please note that if you're looking for instructions on how to properly export and import separate metamodels into the same project for work with TGG transformations, please refer to Part IV, Section 2.2 (visual/EAP files) and 2.3 (textual/Eclipse projects), where we included detailed steps in the context of an example.

If you feel anything is missing from this part, or if you have any other comments or suggestions about the handbook series and our tool, feel free to contact us anytime at contact@moflon.org.

1 Grokking Enterprise Architect

> Grok: "... to understand so thoroughly that the observer becomes a part of the observed."
>
> - Robert A. Heinlein, *Stranger in a Strange Land*

This section is a collection of a few of what we feel are the most important tips and tricks for working productively with Enterprise Architect (EA). We truly believe that spending the time to learn and practice these is necessary for a pleasant modelling experience.

1.1 Positioning elements

Layout is always an important factor when using a visual language: A well laid-out diagram is easiest to understand and, by centralizing important elements or clustering related elements, you can actually impart additional information.

- To select a group of elements, either drag a selection box around the items or hold `Ctrl` and select each element one-by-one.
- In the top right corner of the last selected element, a small colon-styled symbol will appear (Fig. 1). Click on this for a context list of different options you can simultaneously apply to all active elements. The same list appears on the toolbar above the diagram.
- Experiment to find out what effect each option has. The last symbol in the list opens a further drop-down menu with standard layout algorithms to organize your diagram automatically.
- Right-clicking any of the selected elements opens a different menu with a further set of layout options and their descriptions (Fig. 2). `Align Centers` or `Same Height and Width` can be especially useful.

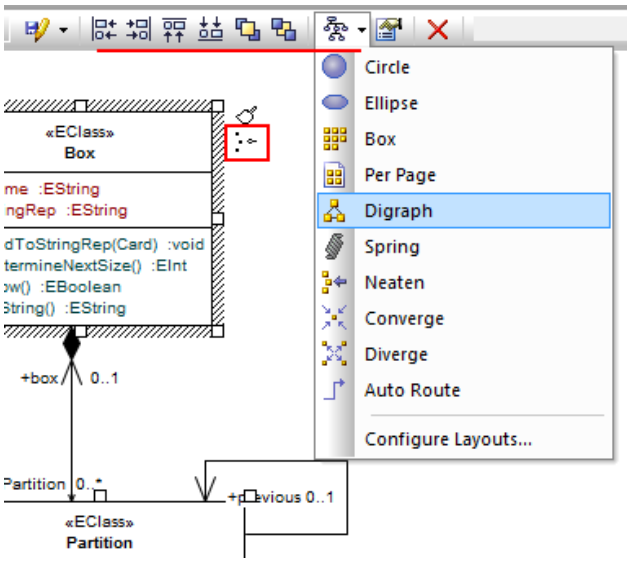

Figure 1: Setting the layout of multiple elements

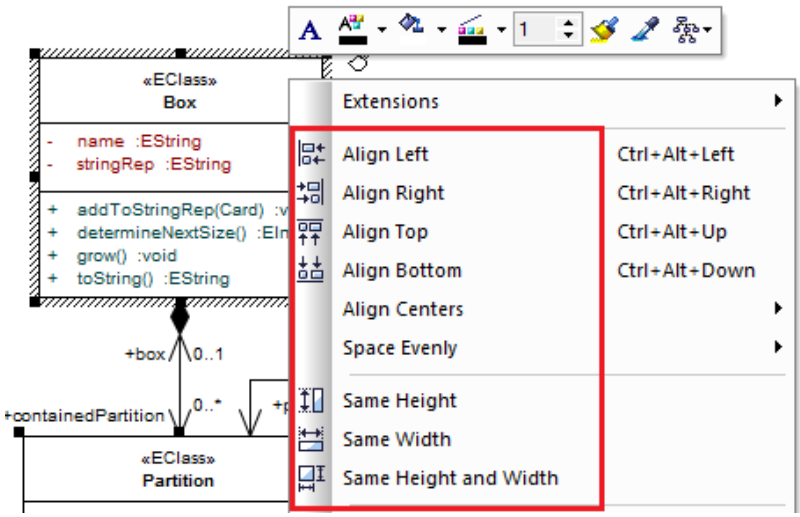

Figure 2: Further layout options

1.2 Bending lines to your will

Another important part of a good layout is getting lines to be just the way you want them to be. In EA you can add and remove bending points which can be used to control the appearance of a line.

- Hold down `Ctrl` and click on a line to create a bending point (Fig. 3). You can now pull the bending point and shift the line as you wish.

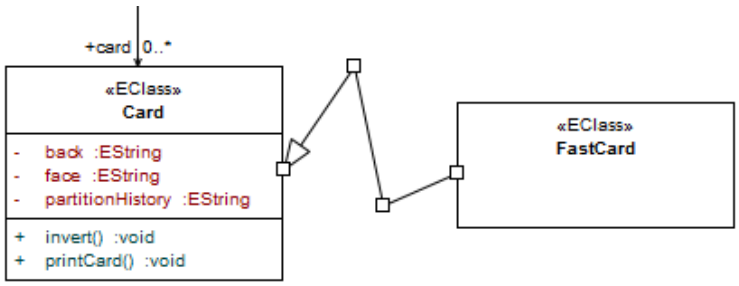

Figure 3: Adding bending points to a line

- You can create as many bending points as you wish, and you can *remove* them by holding down `Ctrl` and clicking once on the unwanted point.

1.3 Deleting vs. removing elements from diagrams

A central feature that new users should understand as soon as possible is the way EA handles diagrams. *A diagram is simply treated as a* view *of the complete model.* The complete model can always be browsed in its entirety via a tree view in the package browser. This space contains all elements that will be exported. The driving reason behind this setup is that diagrams typically do not contain all elements and one usually uses multiple (possibly redundant) diagrams to show the different parts of the model. Thinking in this frame is crucial and provides a pragmatic solution to the problem of having huge, unmaintainable diagrams.

A tricky consequence one must get used to is that removing an element from a diagram does *not* delete it from the model. We have added some support with the validation in the eMoflon add-in control panel, which can prompt a warning when an element cannot be found in any diagram,[1] but there's currently no way to recover a deleted element.

[1] Review Part II, Section 2.8 for an example

A common mistake new users make is to remove an element by pressing `del`, and expecting the element to be deleted from the model. As you can probably guess, this is not the case as evidenced in the package browser (Fig. 4).

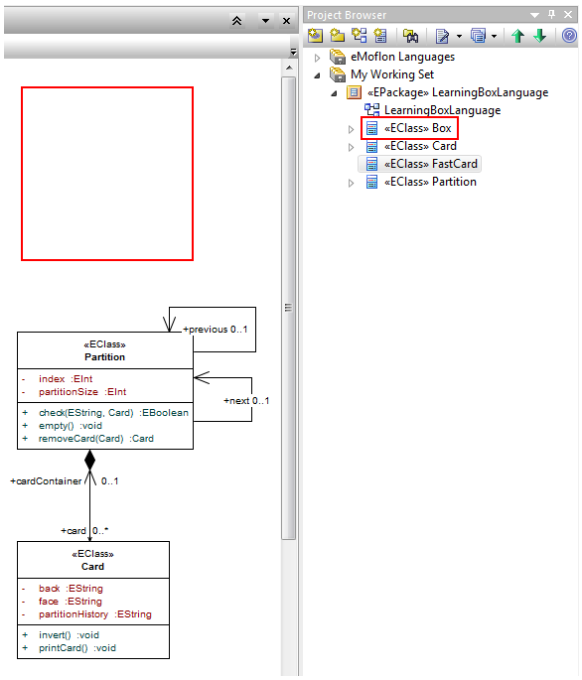

Figure 4: Removing an element from a diagram via pressing `Del` does not delete it from the model and it is still present in the package browser

- To fully delete an element from a model (not just a diagram), select it in the diagram and press `Ctrl + Del`. Confirm the action in the warning dialogue (Fig. 5), and the element should no longer be in the project browser.

- Alternatively, elements can be deleted directly from project browser by right-clicking the item and navigating to the large red 'x' at the bottom of the context menu

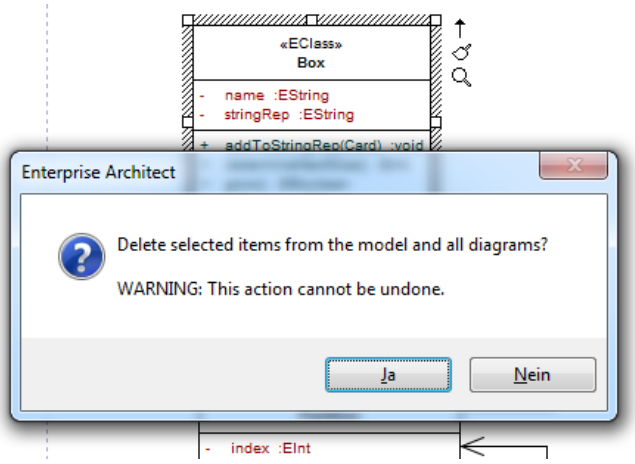

Figure 5: Deleting an element from a diagram and the model

1.4 Excluding certain projects from the export

You may find it sometimes necessary to exclude certain projects from your diagram export (such as the `MocaTree` model used in Part V). Some reasons for this could be (i) because the project is still a work in progress and simply not ready to be exported, (ii) because the complete project is present in the Eclipse workspace but has not been modelled completely in EA, and you wish to do this gradually on-demand, (iii) because the project is not meant to be present in your Eclipse workspace as generated code and is instead provided via a plugin (this is usually the case for standard metamodels like Ecore, UML etc.), or (iv) because the project is rather large and stable and you do not want to wait for EA to process a known, unchanging model. Whatever the reason, you can prevent unnecessary exports by setting a certain *tagged value* of the project.

- Open your project in EA, and navigate to "View/Tagged Values" from the menu bar (Fig. 6).
- The tagged value, *Moflon::Export*, should already be present and be set to a default `true` value (Fig. 7). If you want the project to be ignored by the eMoflon's validation and/or export functions, change the value to `false` (and conversely back to `true` to export it again).

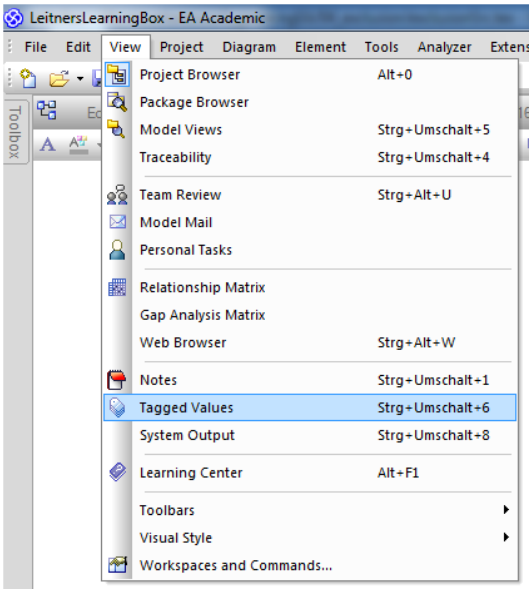

Figure 6: Opening the tagged values view

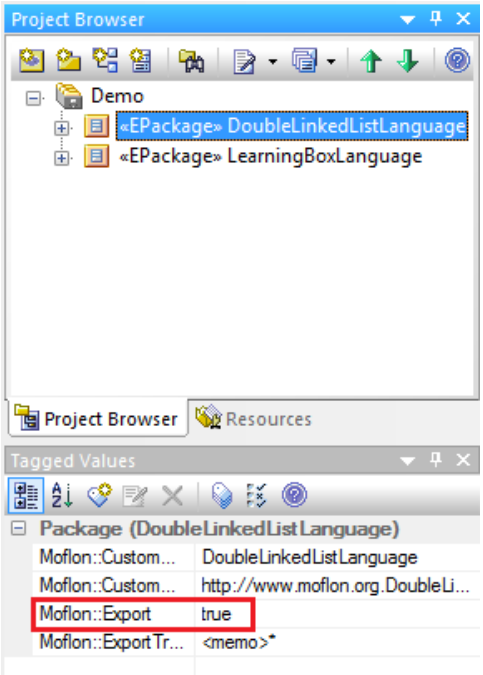

Figure 7: The `Moflon::Export` setting determines ignored projects

1.5 Getting verbose!

Although we use colours in SDMs to indicate when an element is to be matched (black), created (green), or destroyed (red), it sometimes makes sense to indicate these binding operators via explicit stereotypes (i.e., for black-and-white printouts of a model).

- Open the relevant diagram in the EA editor window and, depending on what type it is, press the `Verbose` button in either the `eMoflon SDM Functions` or `eMoflon TGG Functions` panel (Fig. 8).

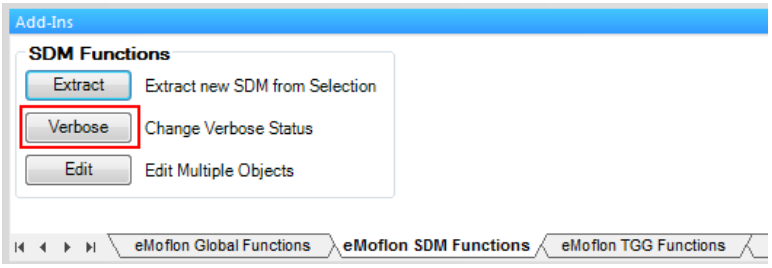

Figure 8: Add extra markup to colored links and objects in the current diagram

- This will add small `++` or `- -` symbols next to deleted and created elements in the current diagram (Fig. 9). Press the button again to deactivate these indicators.

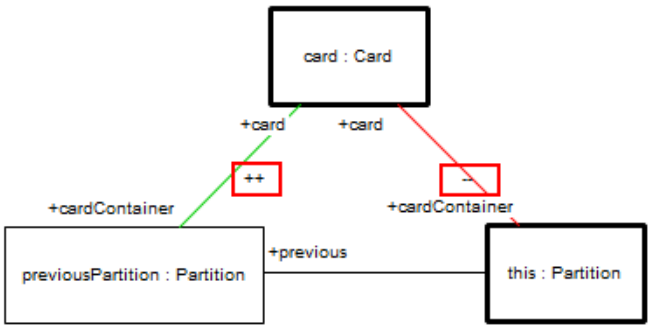

Figure 9: Diagram in verbose mode

1.6 Duplicating elements via drag-and-drop

Sometimes you'll have an element (or many) that are nearly identical, and life would be *so* much easier if you could copy and paste an existing one already. Suppose you want a copy of a `this` element, so you press `Ctrl + C`, followed by `Ctrl + V`. An error dialogue preventing the action will immediately raise, stating that the "... diagram already contains an instance of the element you are trying to paste." EA can only support unique objects, so you'll need to use the following process.

- In either a diagram or in the project browser, hold `Ctrl`, then drag the element you wish to duplicate. A confirmation-style dialogue will appear (Fig. 10), and a properties window will follow. You must assign a unique name to the new element, or else you'll receive an error when you try to export the project later.

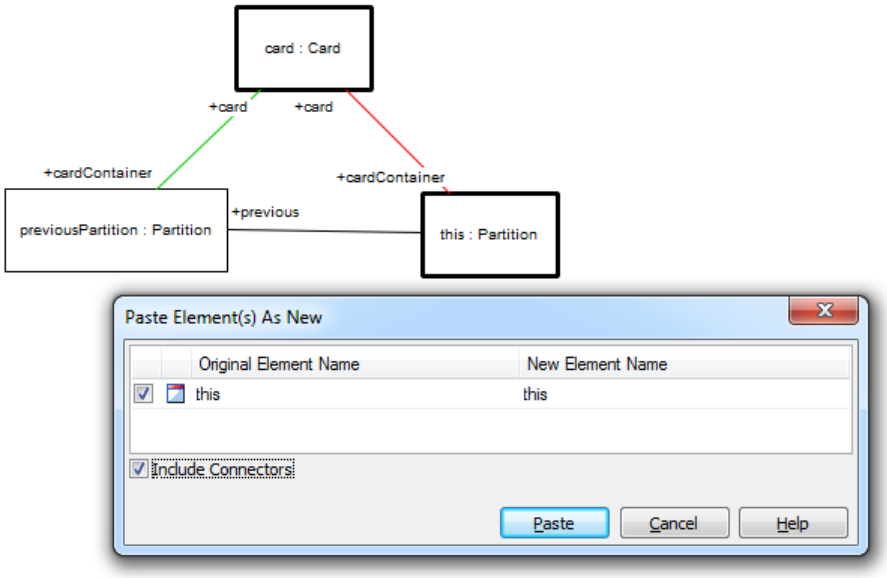

Figure 10: Copying elements

1.7 Seek, and ye shall find ...

EA has a model search function that can be quite handy for large models with thousands of elements and a brain that can't *quite* remember where something is.

- Select `Model Search Window` in the toolbar and enter the name of an element you wish to find (Fig. 11).[2]

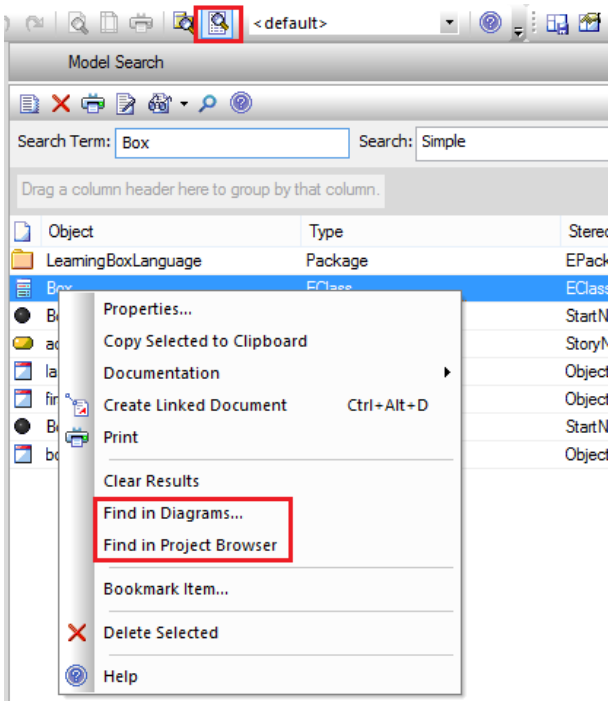

Figure 11: Model Search Window

- All elements that meet the search criteria are listed and you can right-click on each of the items and select one of the options above to locate the element.
- In a similar way, you can locate the corresponding class of an object by right clicking and selecting "Find/Locate Classifier in Project Browser."

[2] You can also access this window by pressing `Ctrl+Alt+A`

1.8 Advanced search

EA offers an even more advanced search capability using SQL.[3]

- To use this, first open the model search window via either the menu bar or by pressing `Ctrl + Alt + A`.
- Click the "Builder" button, and switch to the `SQL` tab (Fig. 12).

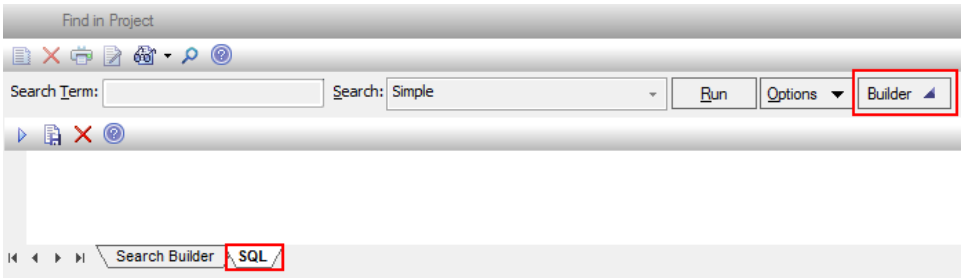

Figure 12: Advanced project search window

Here you can formulate any query on the underlying database. The SQL-editor helps you with syntax-highlighting and auto-completion. Here are some basic examples to get you started:

- To find all eClasses

```
SELECT * FROM t_object
WHERE Object_Type='Class' AND Stereotype='eclass';
```

- To find all associations

```
SELECT * FROM t_connector
WHERE Connector_Type='Association';
```

- To find all inheritance relations

```
SELECT * FROM t_connector
WHERE Connector_Type='Generalization';
```

- To find all connectors attaching a note to an element

```
SELECT * FROM t_connector
WHERE Connector_Type='NoteLink';
```

[3]For some detailed insights to the general database schema used by EA cf. `http://www.sparxsystems.com.au/downloads/corp/scripts/SQLServer_EASchema.sql`

- To find all control flow edges (used in SDMs)

```
SELECT * FROM t_connector
WHERE Connector_Type='ControlFlow';
```

- To find all associations connected to a class named “EClass”

```
SELECT t_object.Name, t_connector.* FROM t_connector,t_object
WHERE t_connector.Connector_Type='Association'
  AND (t_connector.Start_Object_ID=t_object.Object_ID
    OR t_connector.End_Object_ID=t_object.Object_ID)
  AND t_object.Name='EClass';
```

- To determine all subtypes of “EClassifier”

```
SELECT a.Name FROM t_connector,t_object a,t_object b
WHERE t_connector.Connector_Type='Generalization'
  AND t_connector.Start_Object_ID=a.Object_ID
  AND t_connector.End_Object_ID=b.Object_ID
  AND b.Name = 'EClassifier';
```

- To determine all supertypes of “EClassifier” (cf. above)

```
...
  AND t_connector.Start_Object_ID=b.Object_ID
  AND t_connector.End_Object_ID=a.Object_ID
...
```

To run the search, either hit the `Run SQL` button in the upper left corner of the editor toolbar (it shows a triangular shaped “play” icon), or press `F5` on your keyboard.

2 Using EA with subversion

The following steps are required to setup EA for use with Subversion. This is highly recommended when working in a group and sharing a single EA Project (EAP) file, which is otherwise a huge binary blob. This section assumes two things – you wish to use (i) Subversion and (ii) Windows. For other SCM and operating systems please consult the official documentation from EA.

2.1 Initial preparation and setup

Download and install **Slik SVN** (mandatory):

- x32: `http://www.sliksvn.com/pub/Slik-Subversion-1.8.9-win32.msi`
- x64: `http://www.sliksvn.com/pub/Slik-Subversion-1.8.9-x64.msi`
- You may also check for a more recent version at `https://www.sliksvn.com/en/download/`.

For public/private key authentication, you need **Tortoise SVN**:

- x32: `http://sourceforge.net/projects/tortoisesvn/files/1.7.9/Application/TortoiseSVN-1.7.9.23248-win32-svn-1.7.6.msi/download`
- x64: `http://downloads.sourceforge.net/project/tortoisesvn/1.7.9/Application/TortoiseSVN-1.7.9.23248-x64-svn-1.7.6.msi/download`
- You may check for a more recent version at `http://tortoisesvn.net/downloads.html`.

If you do not want to have your private key password in plain text in an SVN configuration file, then also download **Pageant**:

- `http://the.earth.li/~sgtatham/putty/latest/x86/pageant.exe`

With all of the tools installed, we now have to setup the SSH tunnel:

- Locate the file `%APPDATA%\Subversion\config` and open it with your favourite editor. Locate the `[tunnels]` section.

- If you do not want to install Pageant and do not mind entering your password in plain text enter the following command:
  `ssh = "<path/to/Tortoise/SVN>/bin/TortoisePlink.exe" -l <username> -pw <password for your private key> -i "<path to your private key>"`
- If you wish to use Pageant then the command can be simplified to:
  `ssh = "<path/to/Tortoise/SVN>/bin/TortoisePlink.exe" -l <username>` as you can add your private key to Pageant.

  Note: The connection to Pageant may sometimes fail, so additional steps may be necessary.
- It is **very important** that you use **forward slashes** for any filenames, otherwise SVN will not find the files.
- If you just use direct passwords for authentication then you can leave out the `-i` option in both cases.

2.2 How to setup a version-controlled EAP file

The following assumes an EAP file has already been placed under version control as instructed in the previous section, and that you wish to checkout this file and work with it. If our instructions do not work, the EAP file may have been placed under version control in a different manner. If this is the case, please contact whoever checked in the file, and setup the file for working with EA and SVN for further instructions.

- Check-out the project with the EAP file from the server using TortoiseSVN or Eclipse/Subclipse (or any SVN client of your choice). You should now have a *.svn* folder in the directory where you saved the revision.
- Open the EAP file. If the EAP file is already under version control *and* has been set-up correctly, a dialogue similar to Fig. 13 should immediately pop-up.
- Click "Yes" to open the "Version Control Settings" dialogue (Fig. 14).
- To work with the EAP file, you now have to *redefine* the SVN variable for the file in your EA workspace. To accomplish this, choose the local path to the folder which contains the EAP file in the "Working Copy Path" text-box, and correct the value in "Subversion Exe Path" if necessary (to fit your Slik installation location).

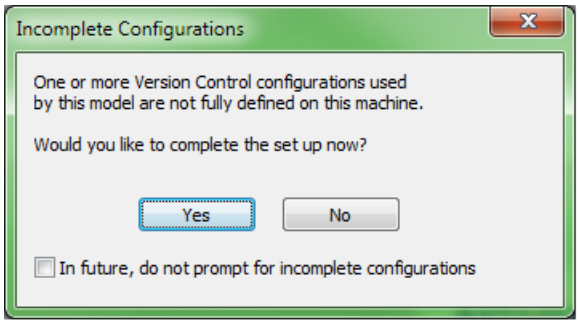

Figure 13: Configure an EAP file which is already under version control

2.3 Working with a version-controlled EAP file

- A `Check Out` retrieves the lock for a certain package and gives you exclusive access, i.e., no one else can change the package. Very important: if subpackages are also under version control, they are not affected by checking out the "super"-package and remain locked. A `Check Out` also updates the package to the latest version.
- A `Check In` commits your work to the server and gives up the lock on the package so others can work on it. If you do not want to commit your changes, you can just use `Undo Check Out...` to revert all local changes.
- The corresponding `..Branch` options perform the actions for the current package and all subpackages. Please note, this has nothing to do with "branching" in normal SVN lingo.
- `Get Latest/Get All Latest` retrieves the latest version of the selected package / all packages. This is basically an update but does not retrieve the lock for any package.
- Conversely, `Put Latest` saves all your changes without giving up any locks.
- `Compare with controlled version` can be used to review incoming changes. Green elements will be added, red will be deleted.
- `File History` gives you a summary of all commits made while you were lying on the beach. For a useful file history, always use meaningful commit statements when checking in! A date stamp is created automatically.

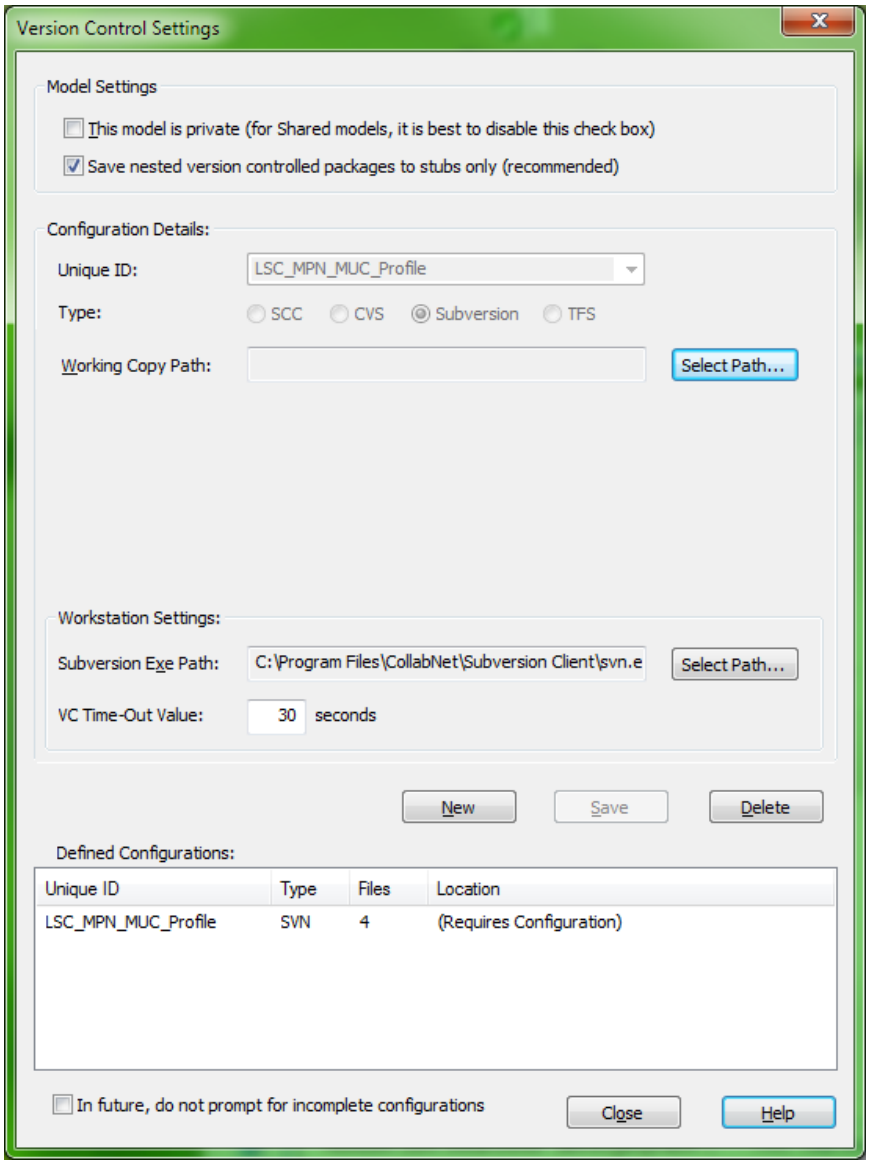

Figure 14: Update settings as required

2.4 Placing an EAP file under version control

If you already have an EAP file and would like to place it under version control, you first have to check it in as usual on the server using your favourite SVN client. Once the project is checked in, the required .svn folder should be in the folder containing the EAP file. The next step is to register an SVN-variable in EA:

- Open the EAP file, right click on a root folder and select "Package Control" and then "Version Control Settings..." (Fig. 15).

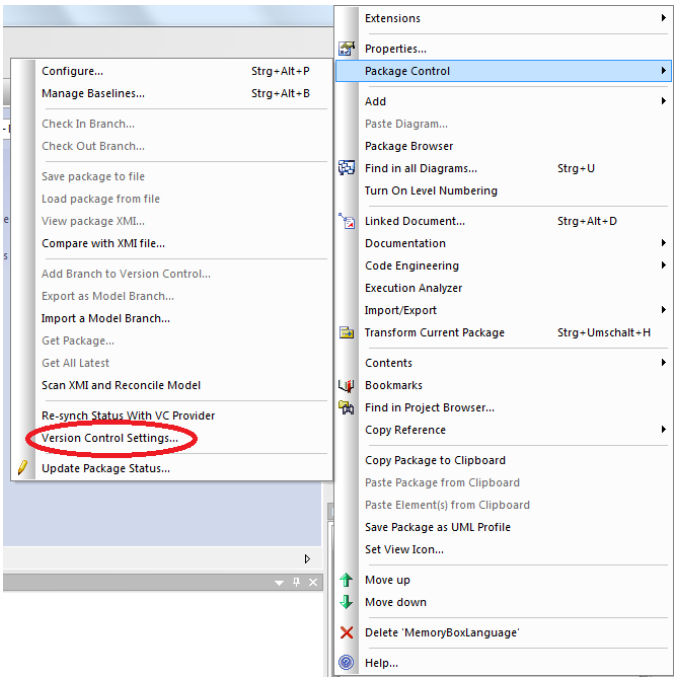

Figure 15: Select version control settings

- In the dialogue, choose a unique ID of your choice (we suggest you use the name of the EAP file) for the settings and activate the "Subversion" radio button below.
- Choose the local path to the folder which contains the EAP file in the "Working Copy Path" text-box.
- The field "Workstation Settings" must point to where you installed Sliksvn, i.e., `<path to SlikSVN>\bin\svn.exe"`). Press "Save" and close the dialogue (Fig. 16). If the dialogue closes without an error message, then you can be sure to have configured everything correctly.

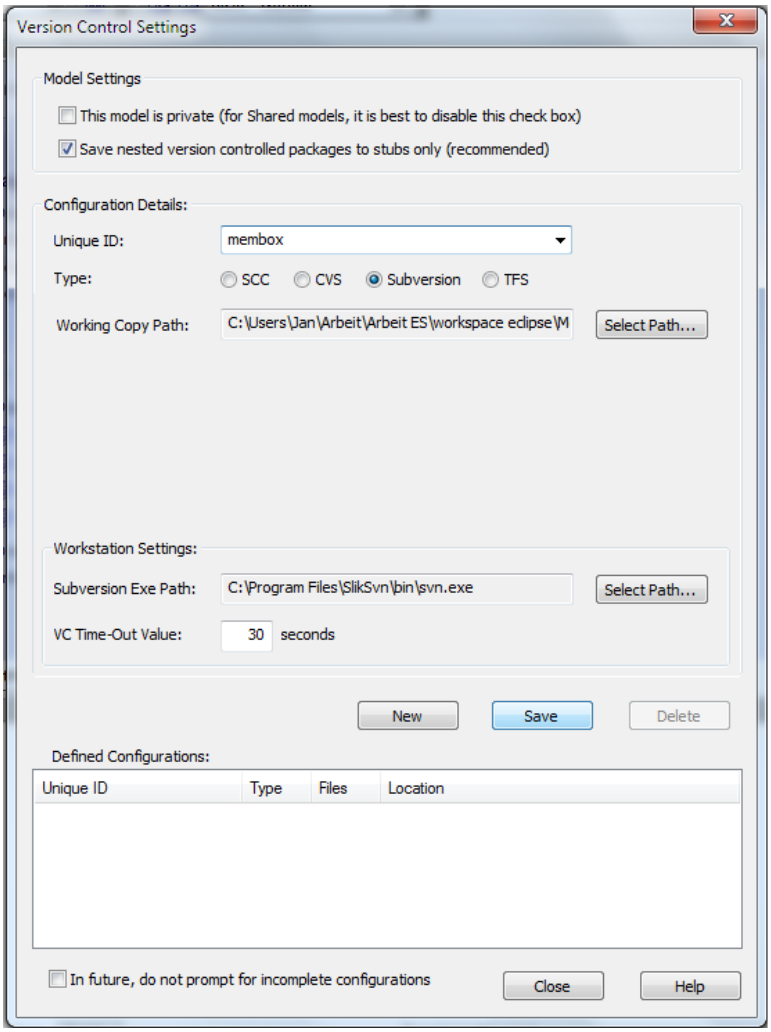

Figure 16: Register an SVN variable in EA

- In the EAP file, choose "Package Control\Configure..." for *each package* you wish to place under version control.

- In the ensuing dialogue, activate "Control Package" and select your previously defined SVN variable from the drop-down menu. Enter the path where the XML file for the project should be placed. Although this is not enforced in any way, we recommend you create a folder structure that mirrors the package structure in EA (Fig. 17). This process has to be repeated *for all sub-packages* as soon as their super-package has been placed under version control.

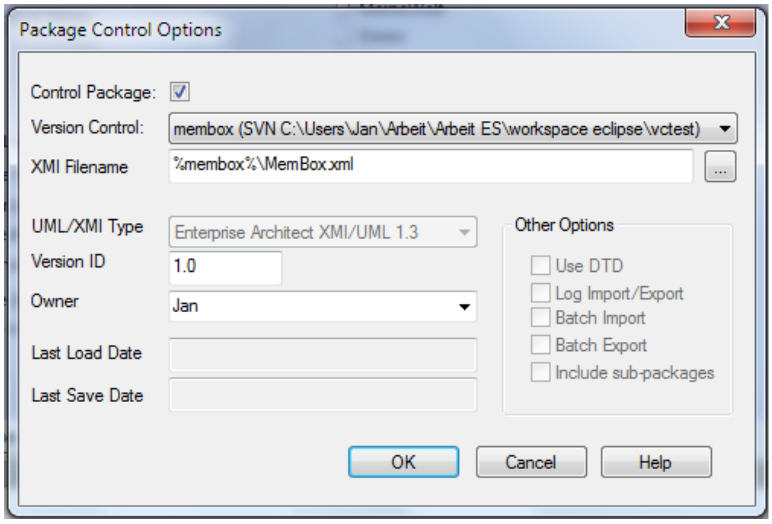

Figure 17: Placing a package under version control

- As a final step, check-in the current state of the EAP file directly with your SVN client. As from this point, the EAP file should not be checked-in anymore, and all versioning actions should be performed via EA (and not directly with your SVN client).

3 Using existing EMF projects in eMoflon

This chapter contains stepwise instructions on how to use existing EMF/Ecore projects with an eMoflon project specified using the visual syntax via EA. We will present an example of an existing metamodel which must be integrated with eMoflon before, for example, its transformation using SDMs can be specified. The basic workflow for using an existing EMF project in eMoflon is described in the following and may of course be similarly applied to a metamodel specified in the textual syntax via MOSL.

We will begin by implementing a small subset of the `Ecore -> GenModel` transformation, where `GenModel` is part of the EMF/Ecore standard. The *GenModel* for a given Ecore model can be viewed as a *wrapper* that contains additional generation-specific Java code details. These details are separated from the Ecore model to keep it free of such "low-level" information and settings.

3.1 Modelling relevant aspects in EA

The first step is to load an existing metamodel into EA. A complete and automatic import of existing Ecore files in EA is currently not possible and therefore, *relevant parts* of the existing metamodel (`GenModel`) have to be modelled manually. Although this might sound frightening (especially for large, complex metamodels), the emphasis here on *relevant* indicates that only elements that are needed for the transformation have to be present in EA, where more can be added iteratively as the transformation grows.

If you find this section challenging or unclear, refer to Part II: Ecore for a detailed review of metamodel construction.

- Open Eclipse and create a new metamodel project named `Ecore-ToGenModel`, selecting the `Add Demo Specification` option in the project wizard window.
- A new specifications folder with the project name should have loaded into the workspace, along with an `DemoTestSuite` JUnit test. You may choose to either delete or ignore this second project – it is used as the example in Part I and is irrelevant in this context.
- Double-click the generated `EcoreToGenModel.eap` file to open your project in EA. Explore the project browser and make of note of the packages already present in EA under `eMoflon Languages`, especially `Ecore` which we shall use in this transformation.

- Select either root note and create a new package named `GenModel-Language`.
- Add a new Ecore diagram and model the elements as depicted in Fig. 18. You'll need to create the three EClasses on the left, but `Ecore::EPackage` and `Ecore::EClass` can be drag-and-dropped and pasted as links from the project browser.

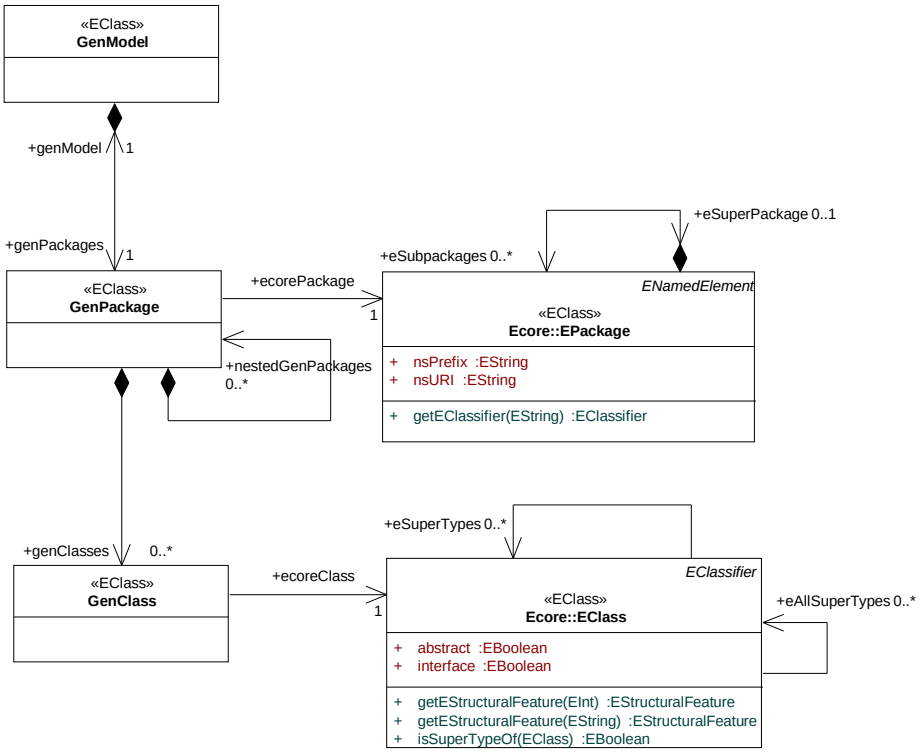

Figure 18: Metamodel of `GenModel`

- Please note that the actual `GenModel` metamodel contains many more elements, but this subset is sufficient for our task.
- Navigate to the project browser again and create another packaged named `Ecore2GenModel`. This will contain the `Transformer` class; Complete its diagram as depicted in Fig. 19.
- Carefully double-click each method to create and implement their SDMs as depicted in Figs. 20 and 21.

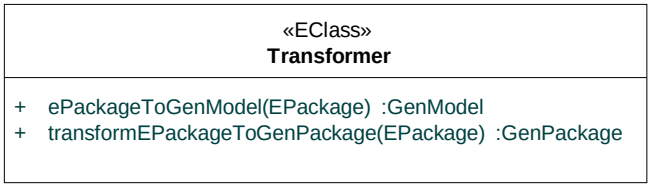

Figure 19: Methods in `Transformer`

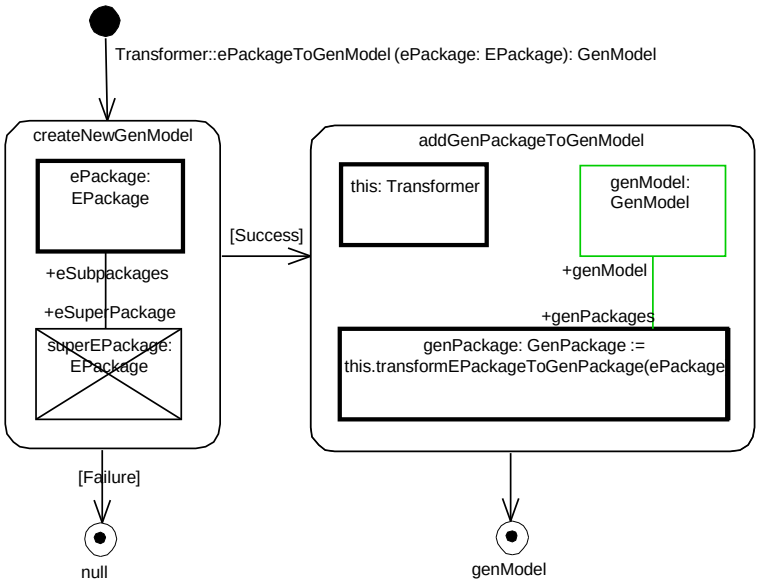

Figure 20: Main method for `EPackage` to `GenModel` transformation

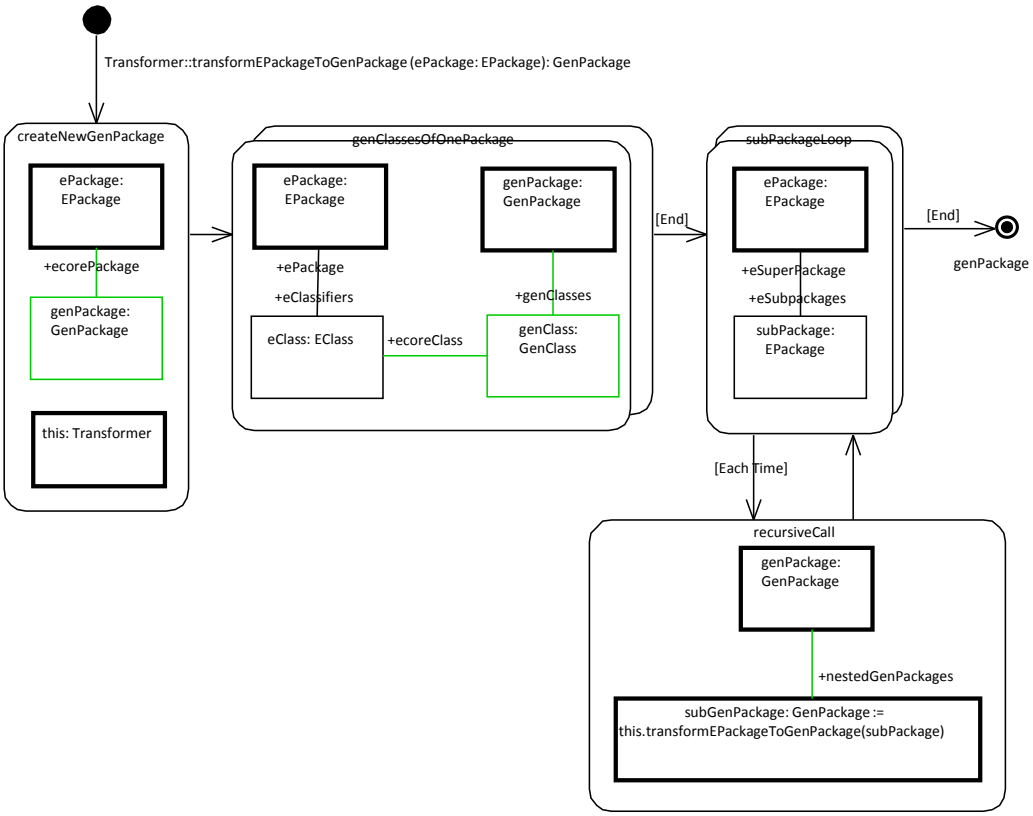

Figure 21: Helper function to transform all `EPackages` to `GenPackages`

3.2 Configuration for code generation in Eclipse

Since there is already generated code for the existing `GenModel` metamodel (provided via the Eclipse plugin), we do *not* want to export our incomplete subset of `GenModel` from EA. Instead, we need to configure Eclipse to access the elements specified in our partial metamodel from the complete metamodel.

- In EA, right-click your `GenModelLanguage` package and select "Properties..."
- Navigate to "Properties/Moflon" in the dialogue window and update the tagged `Moflon::Export` value to `false` (Fig. 22).

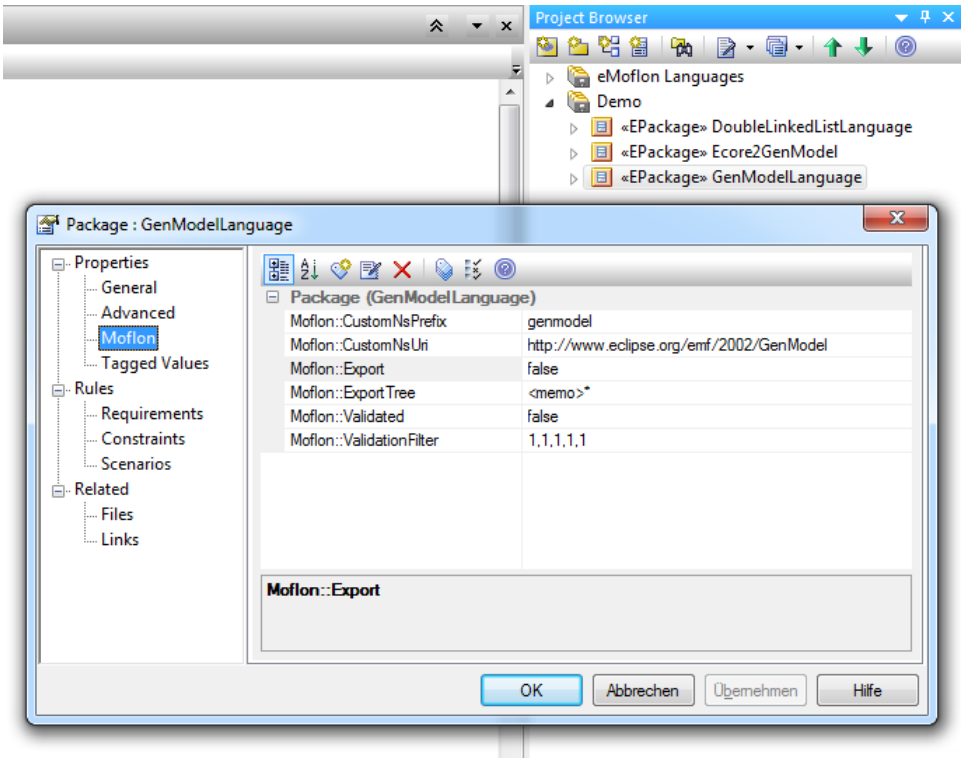

Figure 22: Update the `GenModel` export option and create custom tags

- Next we have to set the "real" name and URI of the project to be used in Eclipse so that the relevant references are exported properly. In the same window, create new tagged values `Moflon::CustomNsPrefix` and `Moflon::CustomNsUri`.
- Set their values to `genmodel` and `http://www.eclipse.org/emf/-2002/GenModel` respectively, as shown in Fig. 22. These values can be determined by inspecting the corresponding values in the existing .ecore file (i.e., the existing metamodel).
- Validate and export all projects as usual to your Eclipse workspace, and update the metamodel project by pressing `F5` in the package explorer.
- In order to simplify setting the required dependencies for code generation, convert the generated Eclipse project `Ecore2GenModel` to a *plug-in project* by right-clicking the project and selecting "Configure/-Convert to Plug-in Projects..."
- Right-click `Ecore2GenModel` once more and navigate to "Plug-in Tools/Open Manifest." The plug-in manager should have opened in the editor with a series of tabs at the bottom for each option.
- Switch to the `Dependencies` tab. Press `Add` and enter `org.eclipse.-emf.codegen.ecore`. This plug-in includes both the `Ecore` and `Gen-Model` libraries we require.

Although we have already specified the name and URI of the existing project (in this example, `GenModel`) as tagged project values, we now have to tell eMoflon where to find the correct implementation (generated code) of the existing project.

- Expand the `Ecore2GenModel` project folder and open the `moflon.-properties.xmi` file tree. Right-click the properties container, and create a new `Additional Dependencies` child. Double click the element to open its properties tab below the editor, and as shown in Fig. 23, update its `Value` to:

```
platform:/plugin/org.eclipse.emf.codegen.ecore/model/GenModel.ecore
```

- Similarly, add a second `Additional Used Gen Packages` child and set its value to:

```
platform:/plugin/org.eclipse.emf.codegen.ecore/model/GenModel.genmodel
```

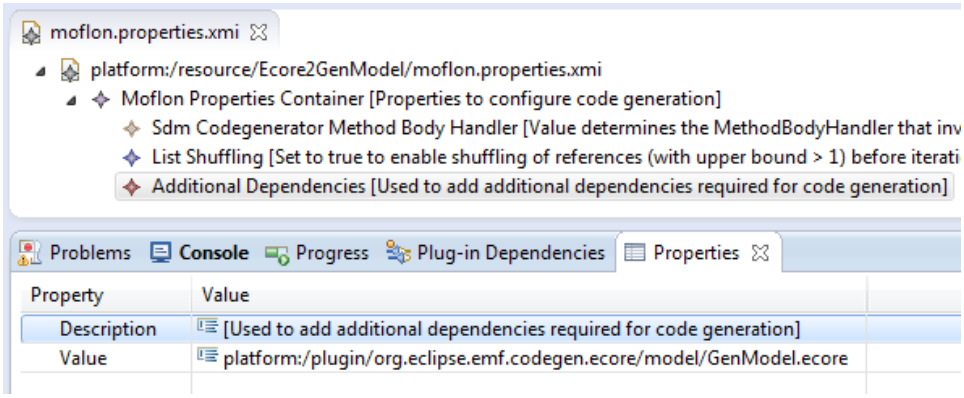

Figure 23: Setting properties for the correct implementation code

Finally, to compenstate for some cases where our naming conventions were violated, analogously add the following mapping as corrections:

- Add an *import mapping* child for correct generation of the required import, setting the key as `genmodel` (as depicted in Fig. 24) and value to:

  `org.eclipse.emf.codegen.ecore.genmodel`

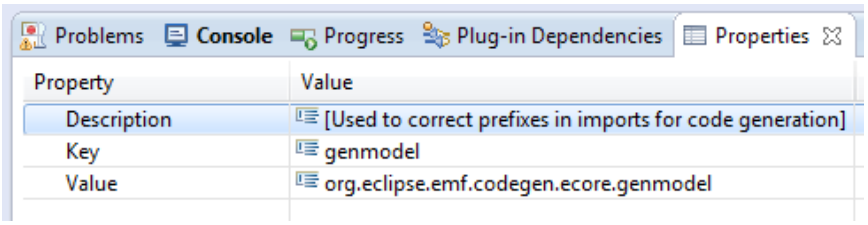

Figure 24: Mapping properties from our metamodel to the existing `GenModel`

- Finally, add a *factory mapping* to ensure that `GenModelFactory` is used as the factory for creating elements in the transformation instead of `GenmodelFactory`, which would be the default convention. Set its key as `genmodel`, and its value to: `GenModelFactory`.
- Your completed `moflon.properties.xmi` file should now closely resemble Fig. 25. Refresh your workspace one more time to generate code for the project and ensure that the transformation behaves as expected via a JUnit test.

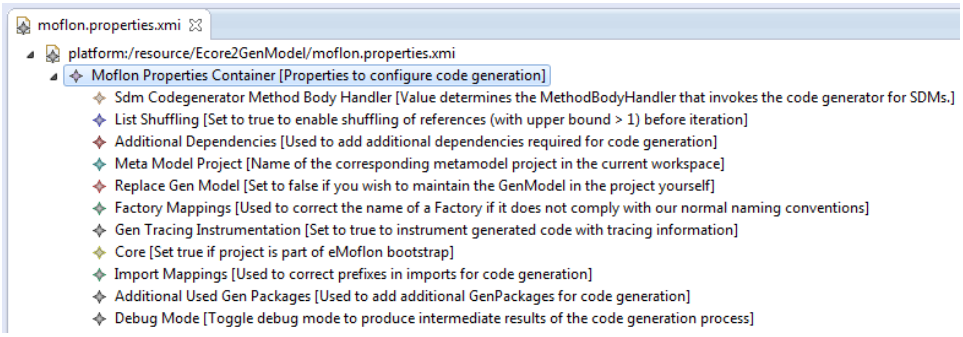

Figure 25: Additional properties for code generation

4 The TGG transformation protocol

If you worked through Part IV of the handbook, you'll remember that we introduced *bidirectional model transformations* via Triple Graph Grammars (TGGs). These take an instance input model and apply a series of rules to generate a transformed output model and correspondence (or link) metamodel. Together, these three files form the transformation's output *graph triple*. You might also remember that we introduced an integrator in Section 6, a visualizing tool that can help you trace a transformation via the correspondence model.

While the integrator's display structure is based on the entire graph triple, its purpose is to interpret the key parts of the transformation's co-generated `protocol` file, the detailed listing of every executed action. As you can imagine, examining this file directly provides much more detail than the integrator alone. While both list the current step, element, rule candidates, and their results, the protocol includes properties of each step such as the current element's full name, a listing of the created and/or translated elements, the reasons for a rule's success for failure, and other information.

To explain, let's revisit the running example as it was in Part IV, Section 7, where a fourth partition and card were added to a forward transformation only able to handle three partitions. Let's start by reviewing the integrator as shown in Fig. 26.

It begins the process by trying to translate the first node in the box, `partition0`. It checks for and applies the only valid rule, where each navigation step shows the operation being executed in the display window. The final message tells us the rule was successful! Remember, `BoxToDictionaryRule`[4] creates the primary container elements, `Box` and `Dictionary`, and translates up to three connected `partitions`.

[4]Refer to Part IV, Section 4, Fig. 28 (Visual) and Fig. 37 (Textual)

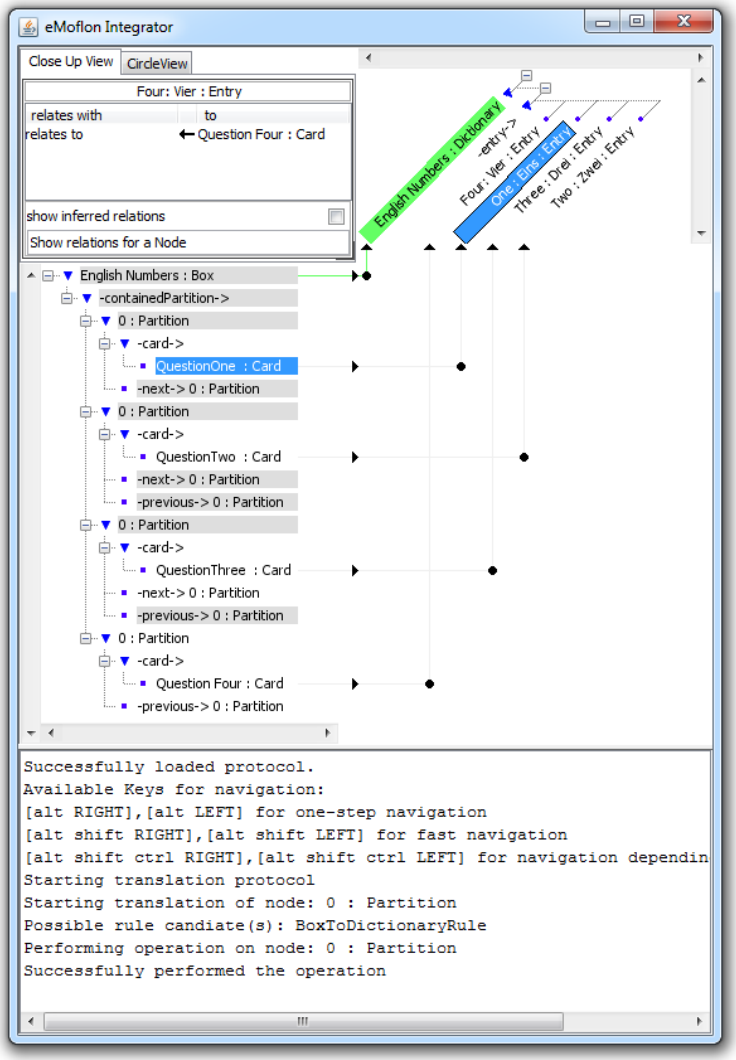

Figure 26: Integrator view of successful `BoxToDictionaryRule`

Now let's see the equivalent transformation in the protocol file as depicted in Fig. 27.

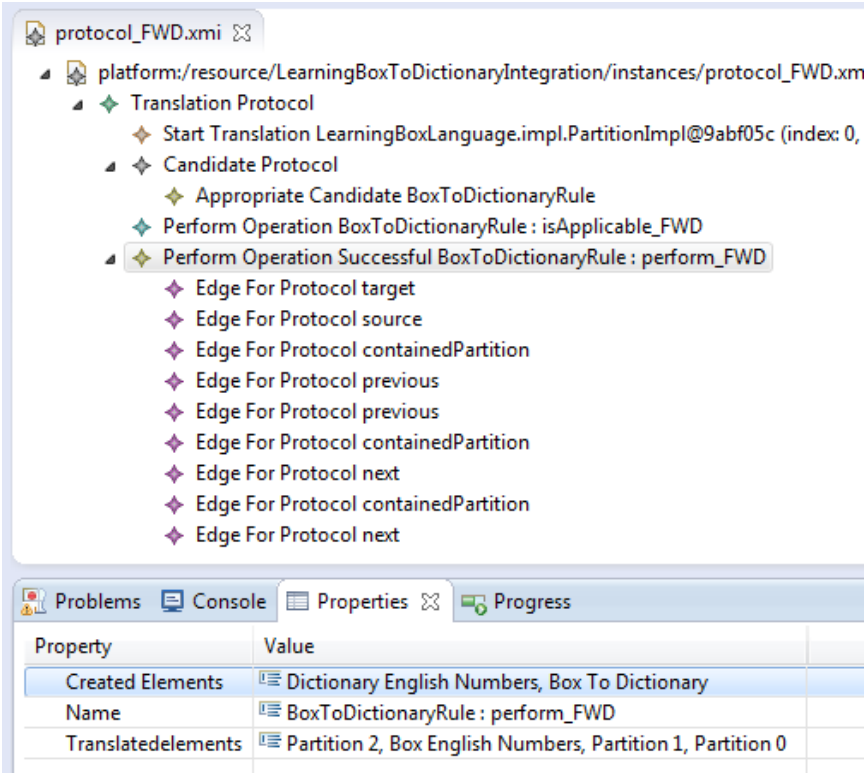

Figure 27: Protocol file showing successful `BoxToDictionaryRule`

Again, the translation starts with the zero node (identified by its `index`) and finds a valid rule. It performs the rule, and lists its final result. More information can be found however by double-clicking the success node, where the `Properties` window lists every element that was created and translated. Finally expanding this successful node, we can then see further details about every edge that needed to be handled which in turn include details such as their `name`, `Source`, and `Target` elements.

Let's skip ahead to something more interesting. Let's examine the place where the transformation starts trying to handle the erroneous fourth partition (Fig. 28).

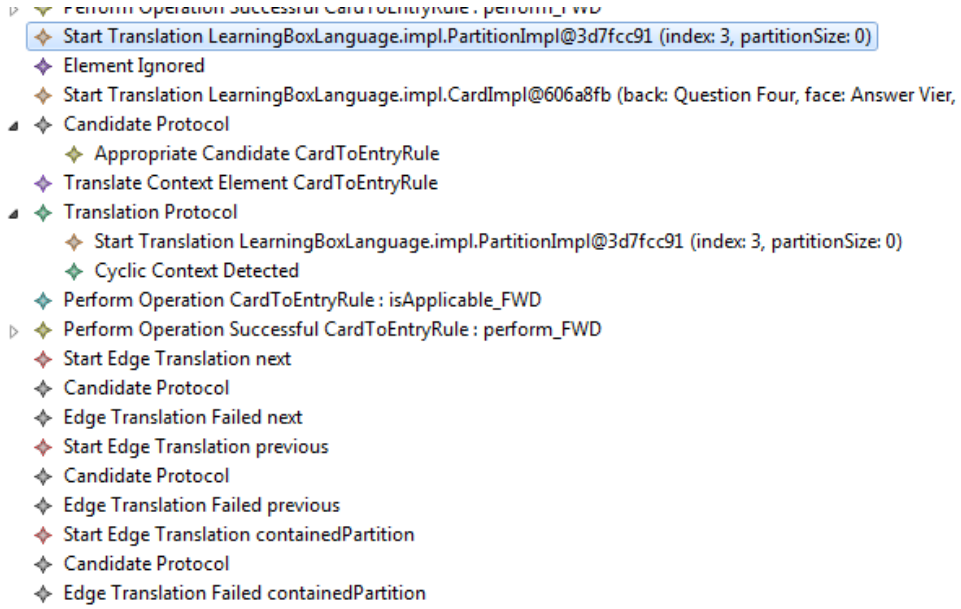

Figure 28: Examining how the transformation succeeded

If you ran the integrator up to this point and finished the transformation, all you would see are indications that something has gone wrong – the primary window will highlight problematic elements in yellow, failed ones in red, and the message window below will list each step attempted but offer no information. Examining the protocol however, we can see that the transformation isn't able to find any rule that can handle `partition3` (as indicated by the lack of a 'Candidate Protocol' beneath 'Start Translation'). It's designed to follow an optimistic approach however, so the translation chooses to simply ignore the element and try to translate its containing card first.

Sure enough, `CardToEntryRule`[5] is valid for `Question Four`, but this rule's protocol requires it to try and establish the context partition. Once again, it tries to find a rule for `partition3`. At this point, the transformation realizes it's doing the same thing over again (cyclic context detected) and chooses to ignore the partition a final time and proceeds to finish the rule, successfully creating `Entry Four: Vier`. Finally, it tries to establish the edges connected to the failed partition with no luck.

[5]Refer to Part IV, Section 4, Fig. 34 (Visual) and Fig. 41 (Textual)

5 MOSL syntax

We have created this sheet for you to keep handy while working on your own projects. It describes many key statements in context-free EBNF grammar that you'll need to use when building metamodels, SDM patterns, and TGG rules.

Please keep in mind that this has been designed as a quick-reference page, and is not intended to be a teaching tool. If you are unsure how to use any of the following statements, the best reference for you will be the explanations in Part II, III, IV, or V where they are introduced and described in the context of an example.

Basics

```
attribute_constraints := '==' | '!=' | '<=' | '>=' | '<' | '>'
binding_operator      := '++' | '--'
binding_semantics     := '!' | '?'
binding_state         := '@'
multiplicity          := '0..1' | '0..*' | '1' | ...
```

Metamodels

```
attribute   :=  attribute_name : type
link        :=  reference_name : target_type
operation   :=  operation_name'('param_list')' ':' return_type
opposites   :=  link '<->' link
parameter   :=  parameter_name : type
param_list  :=  parameter*
reference   :=  [binding_operator] ['<>'] '->' reference_name
                '('multiplicity')' ':' target_type

attribute_name, ov_name, parameter_name, reference_name, return_type,
  target_type, type := STRING
```

SDM Patterns and TGG Rules

```
assignment      := ov_name'.'attribute_name ':=' expression
statement_node  := '<'method_call'>'
link_variable   := [binding_operator] '->' reference_name ':' source_type
object_variable := [binding_semantics] [binding_operator] [binding_state]
                    ov_name ':' type_reference

AttributeValueExpression  := ov_name'.'attribute_name
LiteralExpression         := boolean_literal | integer_literal | any_literal
ObjectVariableExpression  := '@'ov_name
ParameterExpression       := '$'parameter_name
MethodCallExpression      := (objectVariableExpression | ParameterExpression)
                             '.'ID'('argument_list')'

boolean_literal := true, false
integer_literal := ['+' | '-'] ( '1' | ... | '9' )
any_literal     := STRING

attribute_name, method_call, ov_name, parameter_name,reference_name,
  source_type, type_reference := STRING
```

6 Useful shortcuts

This page is a simple list of special hotkeys you might find useful while working with eMoflon in either EA or Eclipse. Please note standard shortcuts, such as `Ctrl + S` and `Ctrl + Z`, are still applicable in most cases.

6.1 In Eclipse

Note: `I` indicates *in Integrator window*, and `GK` indicates *German keyboards only*

`Ctrl + Space`	Auto-type completion
`Ctrl + 1` (problems tab)	Quick-fix menu
`Alt + arrow` (I)	Proceed to next step
`Shift + Alt + arrow` (I)	Fast navigation
`Shift + Ctrl + Alt + arrow` (I)	Proceed to next breakpoint
`Shift + Ctrl + AltGr + arrow` (I, GK)	Proceed to next breakpoint

6.2 In EA

Note: `D` indicates *in Diagram*, and `PB` indicates *in Project Browser*

`Alt + Enter`	Selected element `Properties` dialogue
`F9 + EClass`	Class `Attribute` editor
`F10 + EClass`	Class `Operations` editor
`Space` (D)	Current toolbar menu
`Del + Ctrl + element` (D/PB)	Delete element from model
`Ctrl + element` (D/PB)	Duplicate and create new element
`Ctrl + Alt + A`	Open Model Search Window
`Alt + G + element` (D)	Highlight Element (PB)

7 Glossary

Abstract Syntax Defines the valid static structure of members of a language.

Activity Top-most element of an SDM.

Activity Edge A directed connection between activity nodes describing the control flow within an activity.

Activity Node Represents atomic steps in the control flow of an SDM. Can be either a story node or statement node.

Assignments Used to set attributes of object variables.

Attribute Constraint A non-structural constraint that must be satisfied for a story pattern to match. Can be either an assertion or assignment.

Bidirectional Model Transformation Consists of two unidirectional model transformations, which are consistent to each other. This requirement of consistency can be defined in many ways, including using a TGG.

Binding State Can be either *bound* or *unbound/free*. See *Bound vs Unbound*.

Binding operator Determine whether a variable is to be *checked*, *created*, or *destroyed* during pattern matching.

Binding Semantics Determines if an object variable *must* exist (*mandatory*), may not exist (*negative*; see *NAC*), or is *optional* during *pattern matching*.

Bound vs Unbound Bound variables are completely determined by the current context, whereas unbound (free) variables have to be determined by the *pattern matcher*. `this` and parameter values are always bound.

Concrete Syntax How members of a language are represented. This is often done textually or visually.

Constraint Language Typically used to specify complex constraints (as part of the static semantics of a language) that cannot be expressed in a metamodel.

Correspondence Types Connect classes of the source and target metamodels.

Dangling Edges An edge with no target or source. Graphs with dangling edges are invalid, which is why dangling edges are avoided and automatically deleted by the pattern matching engine.

Dynamic Semantics Defines the dynamic behaviour for members of a language.

EA Enterprise Architect; The UML visual modeling tool used as our visual frontend.

EBNF Extended Backus-Naur Form; Concrete syntax for specifying context-free string grammars, used to describe the context-free syntax of a string language.

Edge Guards Refine the control flow in an activity by guarding activity edges with a condition that must be satisfied for the activity edge to be taken.

Endogenous Transformations between models in the same language (i.e., same input/output metamodel).

Exogenous Transformations between models in different languages (i.e., unique metamodel instances).

Grammar A set of rules that can be used to generate a language.

Graph Grammar A grammar that describes a graph language. This can be used instead of a metamodel or type graph to define the abstract syntax of a language.

Graph Triples Consist of connected source, correspondence, and target components.

In-place Transformation Performs destructive changes directly to the input model, thus transforming it into the output model. Typically *endogenous*.

Link or correspondence Metamodel Comprised of all correspondence types.

Link Variable Placeholders for links between matched objects.

Literal Expression Represents literals such as true, false, 7, or "foo."

Meta-Language A language that can be used to define another language.

Meta-metamodel A *modeling language* for specifying metamodels.

Metamodel Defines the abstract syntax of a language including some aspects of the static semantics such as multiplicities.

MethodCallExpression Used to invoke any method.

Model Graphs which conform to some metamodel.

Modelling Language Used to specify languages. Typically contains concepts such as classes and connections between classes.

Monotonic In the context of TGGs, a non-deleting characteristic.

NAC Negative Application Condition; Used to specify structures that must not be present for a transformation rule to be applied.

Object Variable Place holders for actual objects in the current model to be determined during pattern matching.

ObjectVariableExpression Used to reference other object variables.

Operationalization The process of deriving step-by-step executable instructions from a declarative specification that just states what the outcome should be but not how to achieve it.

Out-place Transformation Source model is left intact by the transformation which creates the output model. Can be *endogenous* or *exogenous*.

Parameter Expression Used to refer to method parameters.

(Graph) Pattern Matching Process of assigning objects and links in a model to the object and link variables in a pattern in a type conform manner. This is also referred to as finding a match for the pattern in the given model.

Statement Nodes Used to invoke methods as part of the control flow in an activity.

Static Semantics Constraints members of a language must obey in addition to being conform to the abstract syntax of the language.

Story Node *Activity nodes* that contain *story pattern*s.

Story Pattern Specifies a structural change of the model.

Triple Graph Grammars (TGG) Declarative, rule-based technique of specifying the simultaneous evolution of three connected graphs.

Type Graph The graph that defines all types and relations that form a language. Equivalent to a metamodel but without any static semantics.

TGG Schema The metamodel triple consisting of the source, correspondence (link), and target metamodels.

Unification An extension of the object oriented "Everything is an object" principle, where everything is regarded as a model, even the metamodel which defines other models.

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