MIA 91-40: Mjolner Integrated Development Tool - Tutorial

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Mjølner Informatics Report
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Source Browser

How to Get Started

The Mjolner tool is activated by writing

mjolner
on the command line (UNIX or Windows) or by double-clicking on the mjolner icon (Windows or Macintosh):

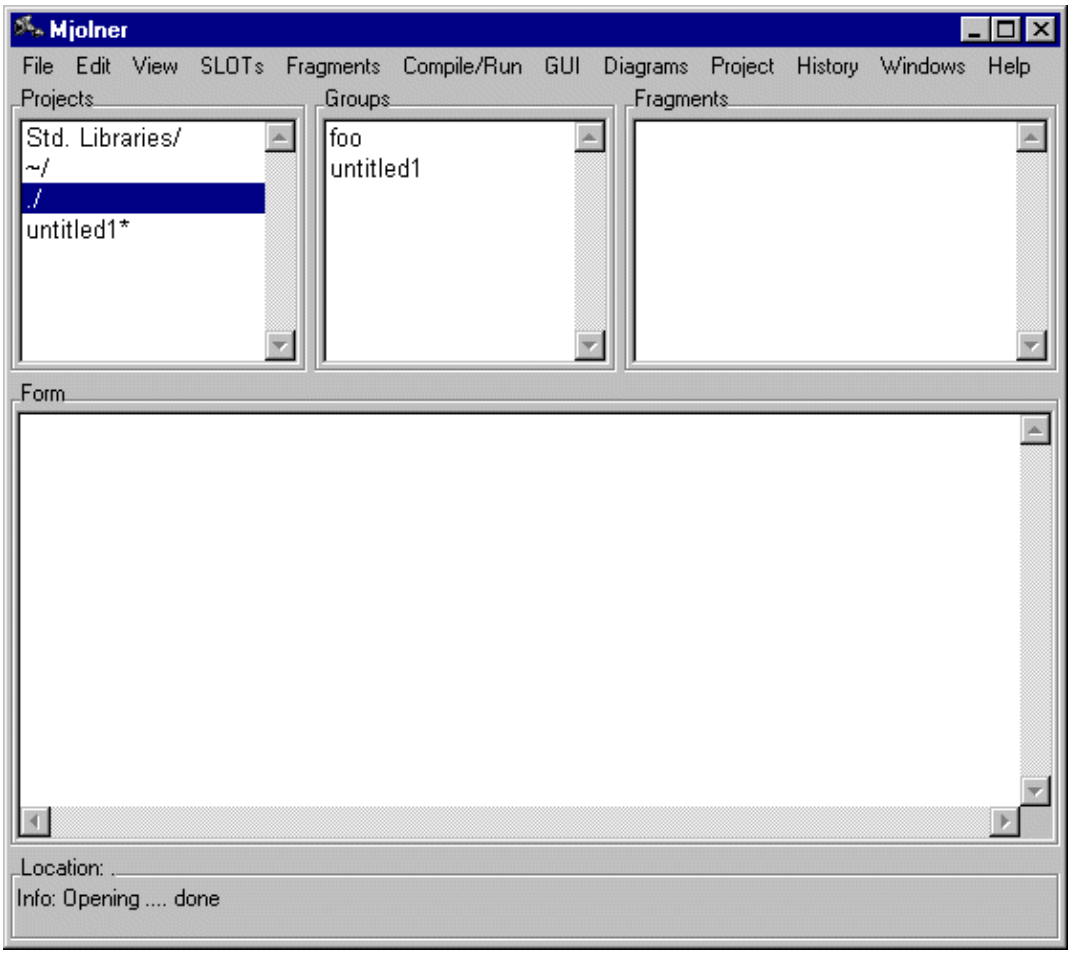

Figure 1: Start window

Source Browser

Browsing at Project Level

Double-clicking on the Std. Libraries project in the project list pane will give the following result:

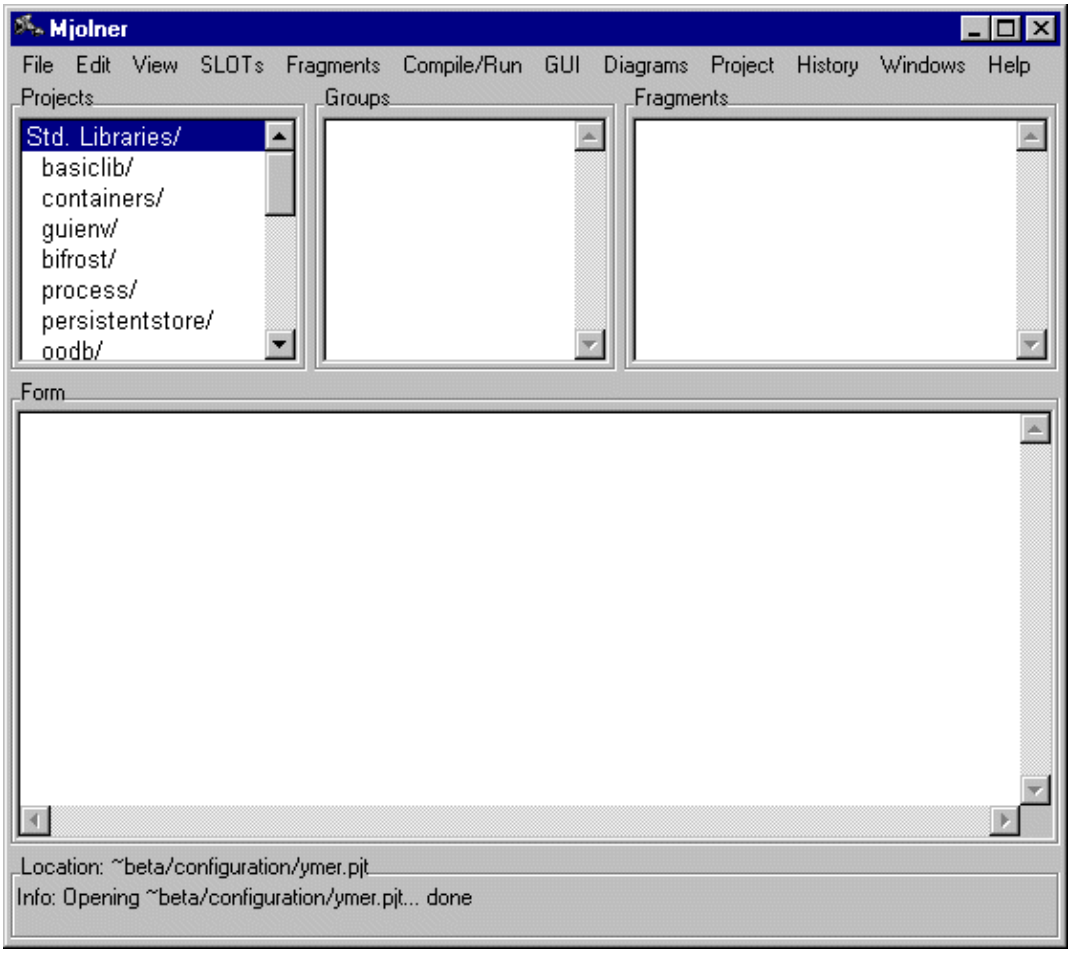

Figure 2

Std. Libraries is the standard project that contains the basic libraries of the Mjølner BETA System. The contents of the Std. Libraries project is a list of file directories. By selecting the container directory its files (fragment groups) will be shown in the group list pane:

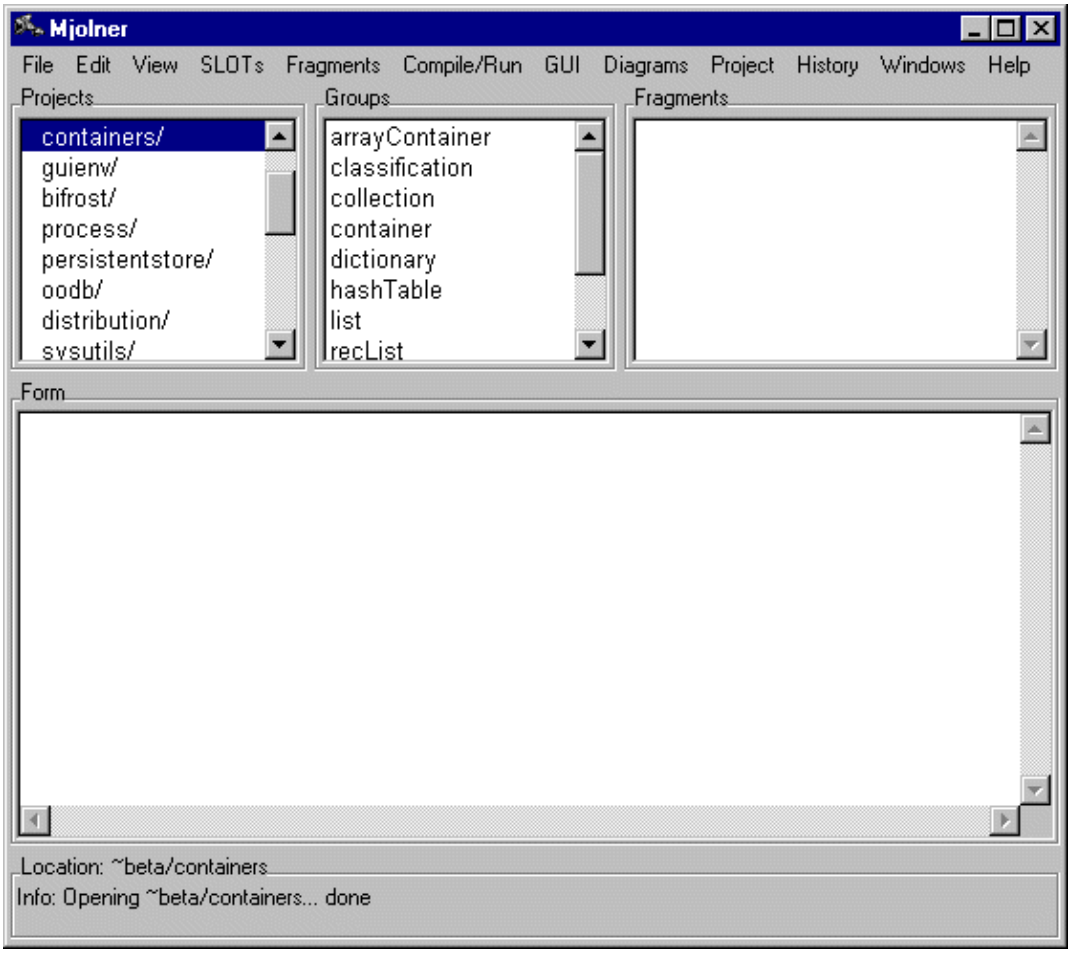

Figure 3

Now by selecting the classification fragment group its properties and fragment forms will be presented in the group viewer. Since classification only contains 1 fragment form it is automatically presented in the code viewer:

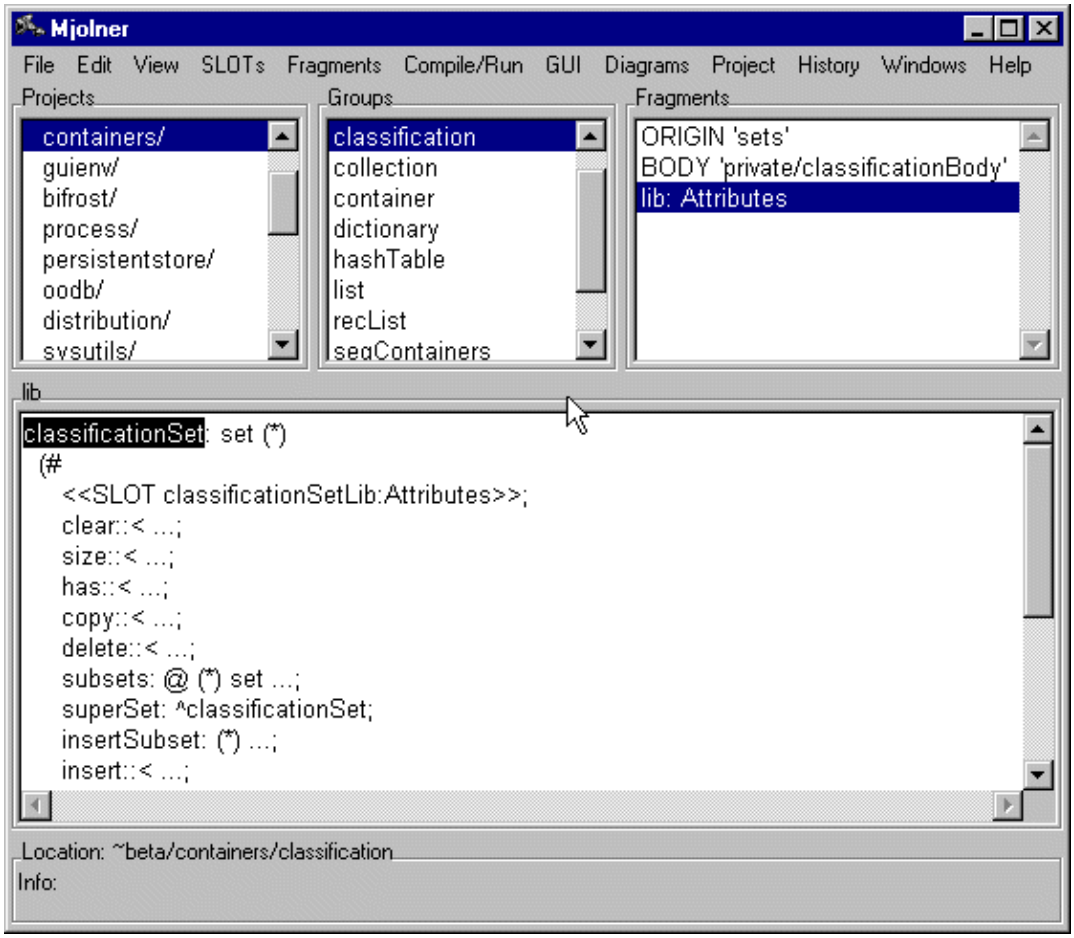

Figure 4

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Source Browser

Browsing at Group Level

Browsing at the group level is provided in the following way:

1. If an ORIGIN, BODY, MDBODY or INCLUDE entry is selected in a group viewer, the link to the specified group can be followed by double-clicking on it. The contents of the group viewer is replaced with the specified fragment group (if it exists). Shift-double-click gives a separate source browser.
2. If a fragment group presented in the group viewer only contains one fragment form it is automatically presented in the code viewer. When a fragment form is selected in the group viewer (by just clicking at it) it will be presented in the code viewer. Shift-double click gives a separate code viewer/editor.
3. The way links between SLOTs and fragment forms can be followed (is described separately under Fragment and SLOT Links)

The screen dump below is the result of double-clicking on the ORIGIN property in the group viewer of Fig. 4.

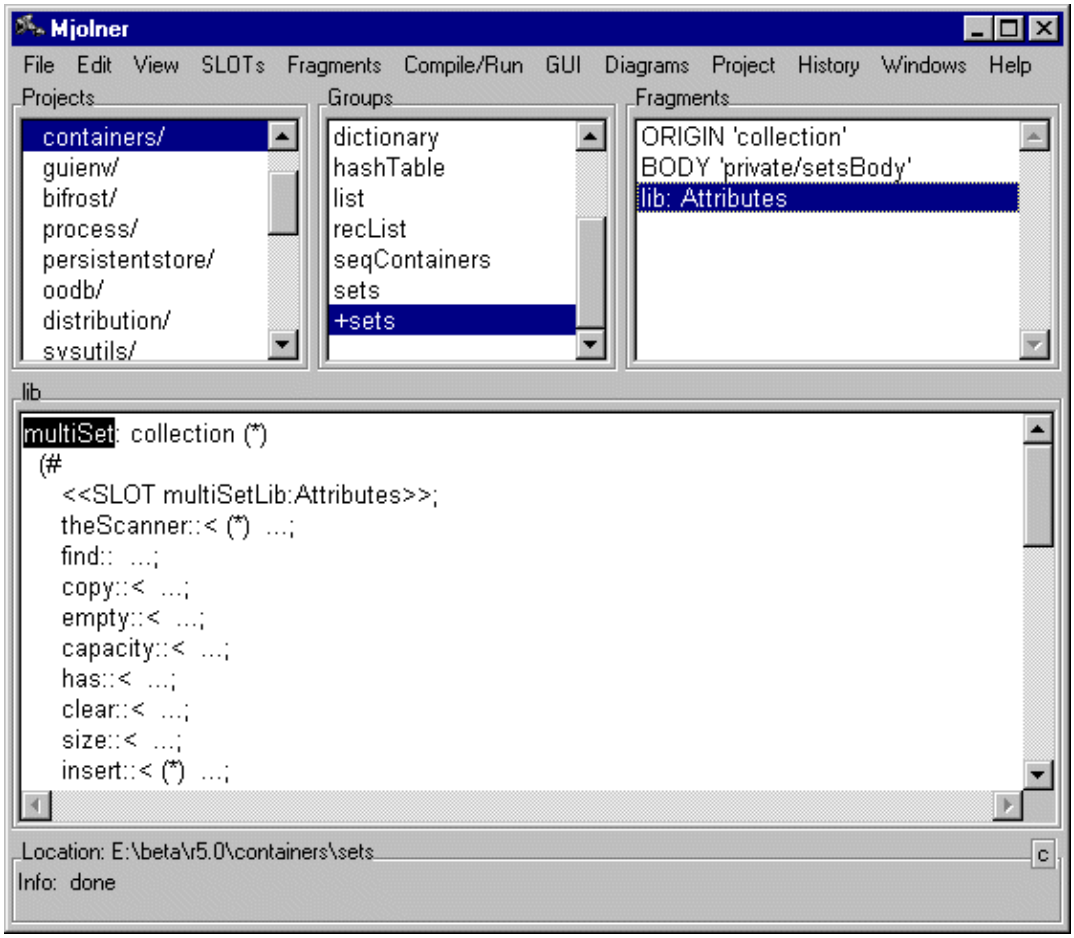

Figure 5

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Source Browser

Browsing at Code Level

Abstract Presentation

When a fragment is shown in the code viewer, i.abstract presentation; is used. Instead of showing the program in full detail, 3 dots (...) are shown for certain syntactic categories. In the presentation of BETA programs these syntactic categories are Descriptor, Attributes and Imperatives.

These 3 dots are called a contraction. By double-clicking on a contraction the next level of detail is shown. E.g. when double-clicking on the 3 dots belonging to insertSubset in Fig. 4, the result will be:

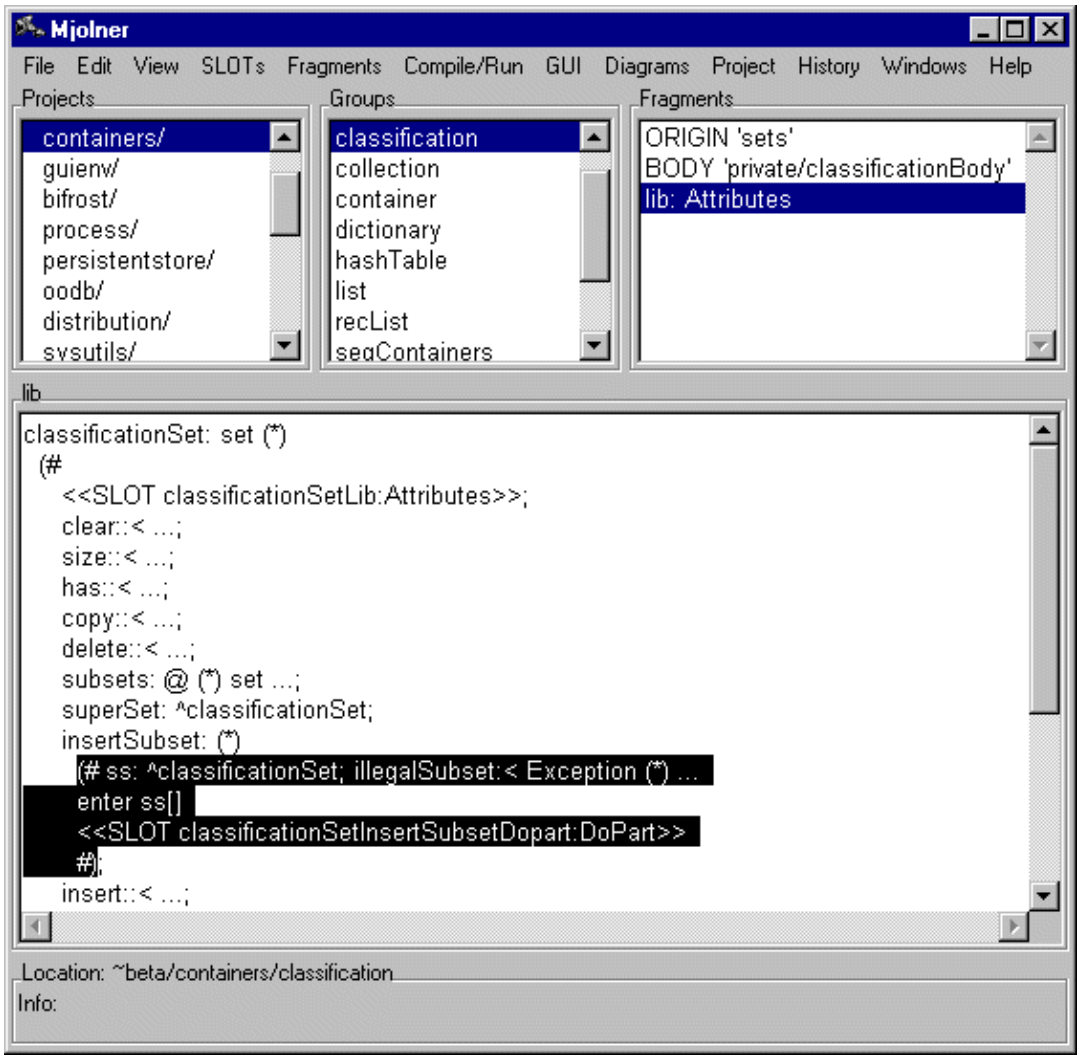


Figure 6

Abstract presentation can be used to browse around in the program or to produce documentation. By means of the commands in the View menu or by double-clicking an appropriate abstraction level can be chosen. This presentation can then be written on a text file by means of the Save Abstract... command in the Group menu.

Semantic Links

This facility is only relevant for BETA programs. If the program has been checked it is possible to browse around in the semantic structure of the program. If, for example, a name application is selected in the code viewer, the corresponding name definition can be found using the Follow Semantic Links command of the View menu or by simple double-clicking on the name application.

If the definition is in another fragment, a code viewer is opened on that fragment. Fig. 7 is the result of double-clicking on set in the first line of the code viewer in Fig. 6.

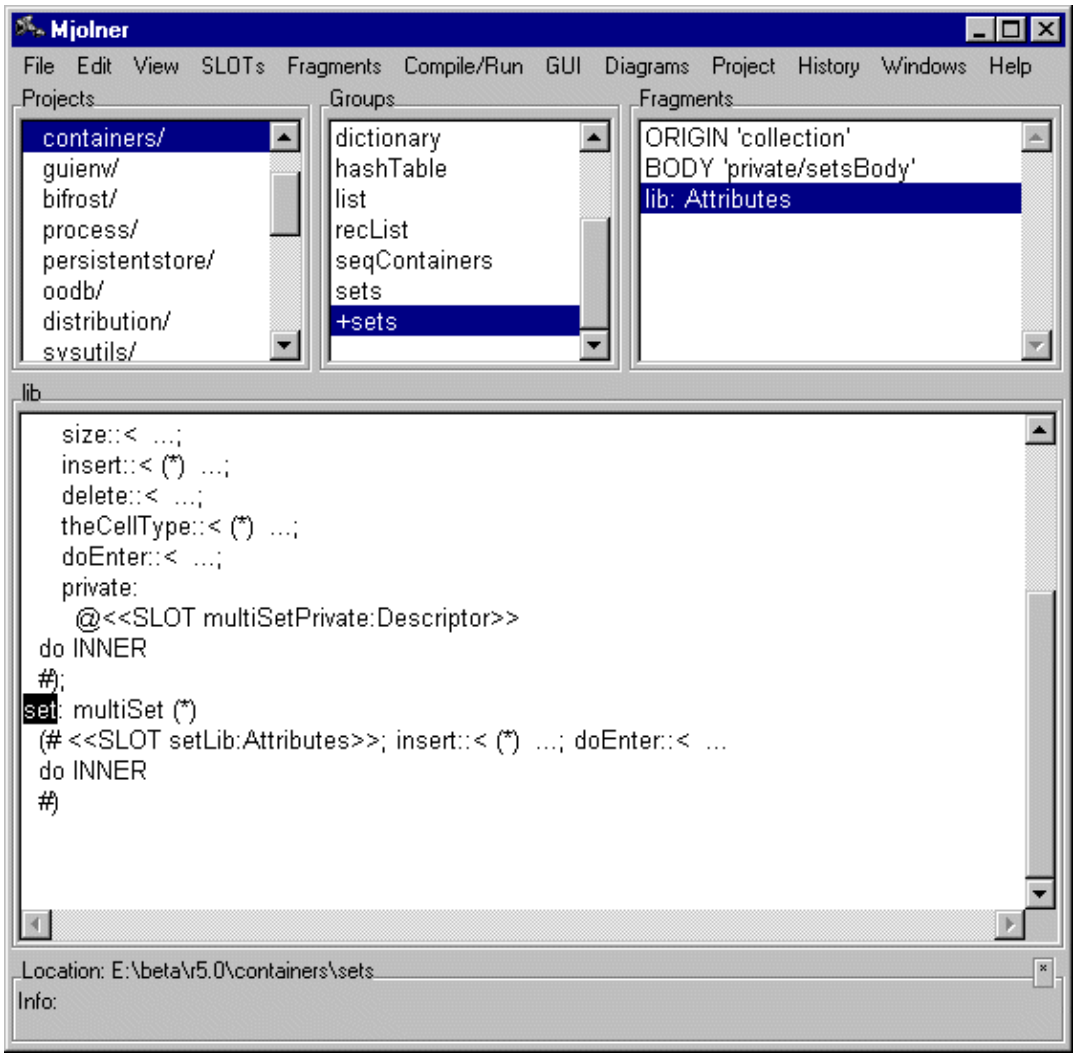


Figure 7

If the program has not been checked, no semantic links are available. Or if the program has been modified, the semantic links may become inconsistent and the program then has to be re-checked. If this command is used and the program needs to be re-checked and a dialog box, that offers re-checking, is popped up.

Comments

In order to compress information in the windows, comments are not shown in the code viewer window, but instead a so-called comment mark (*) is shown. By double-clicking on such a comment mark, the comment mark is expanded and the whole comment is shown. Fig. 8 is the result of double-clicking on the comment mark after multiSet in Fig. 7:

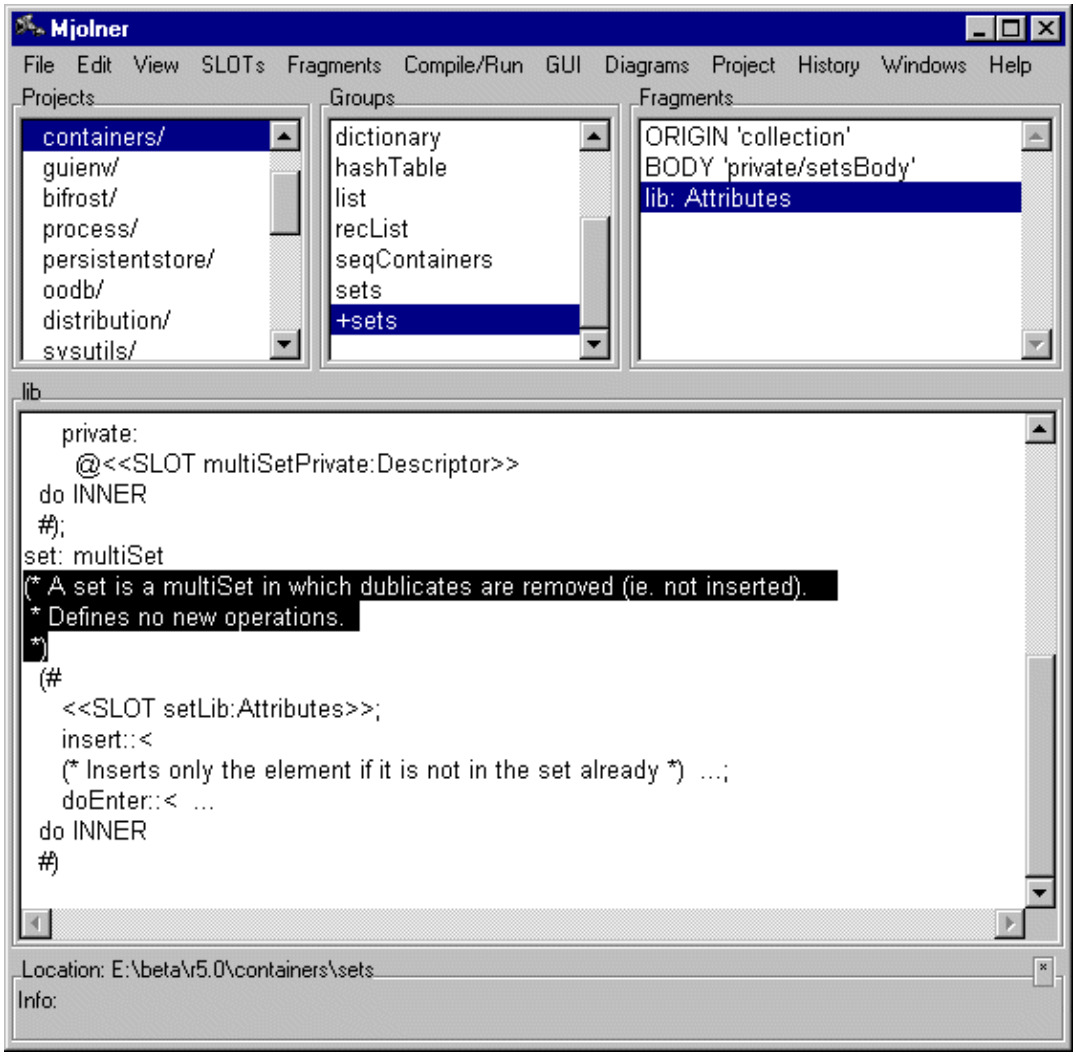


Figure 8

Likewise the expanded comment can be collapsed to a comment mark again by double-clicking on it.

By shift-double-clicking on the comment mark the comment will be shown in a separate text editor window. The following window shows the comment associated with the multiSet pattern:

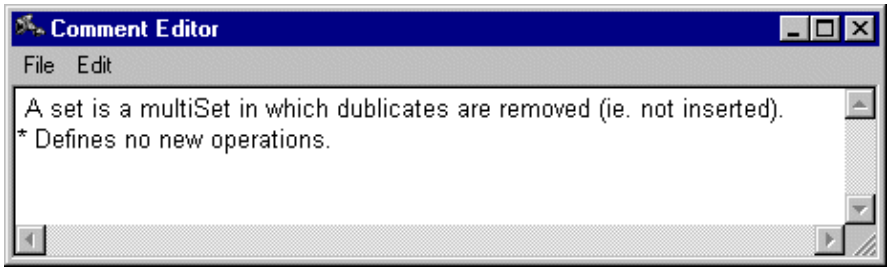


Figure 9

The Show Node command in the Edit Menu of the comment window makes it possible to 'find back', i.e. navigate to the node this comment is associated with.

Fragment and SLOT Links

Follow link to fragment form

Given a SLOT definition, the link to the binding of the definition (i.e. a fragment form with the same name and type) can be followed.

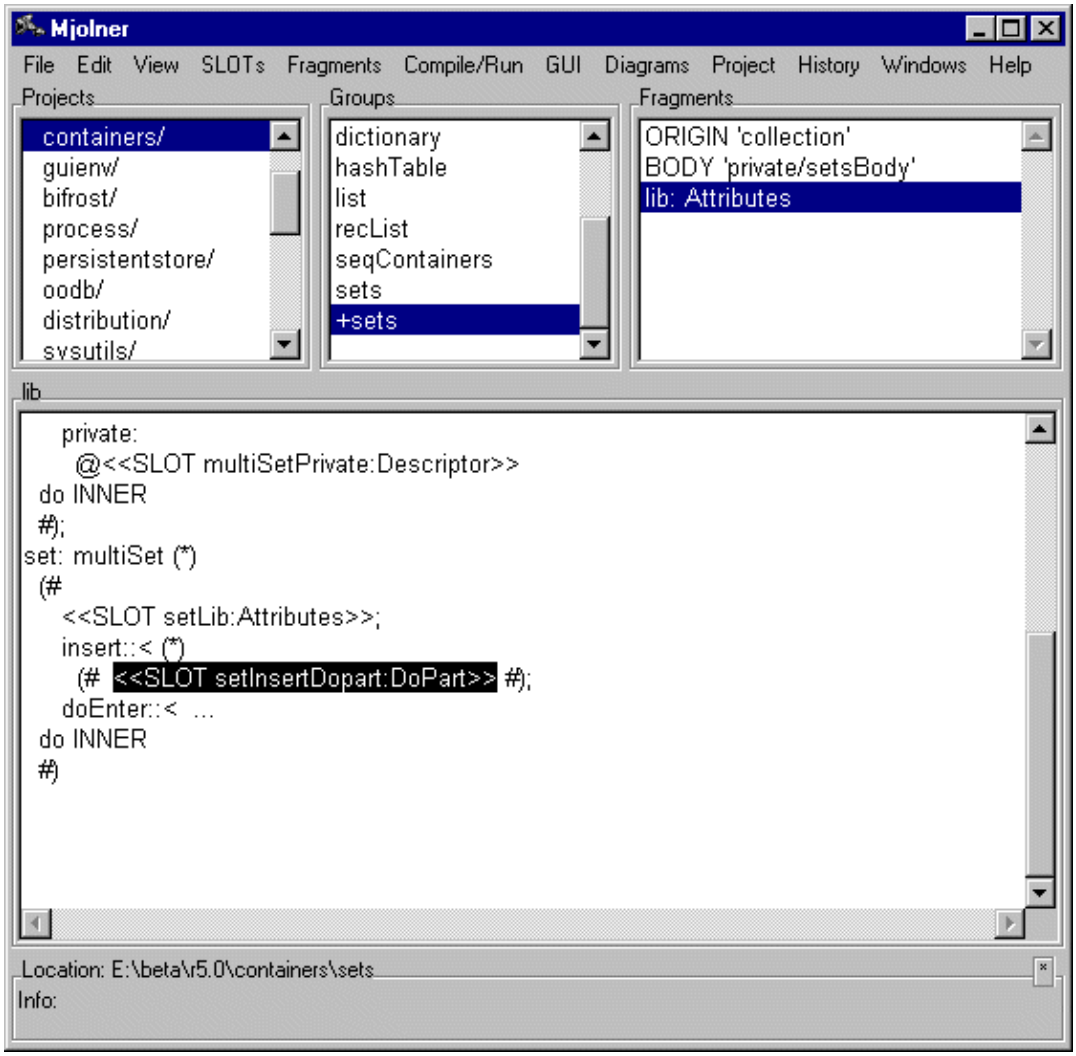


Figure 10

This is done either by selecting the SLOT definition in a code viewer and the Follow Fragment Link command in the View menu or simply by double-clicking on the SLOT definition. The editor will now search for a fragment form with the same name in the BODY and MDBODY hierarchy of the group that the current fragment is part of. Doing this in the example above will result in the fragment shown in Fig. 11. If Shift-double-click is used a separate code viewer window is shown.

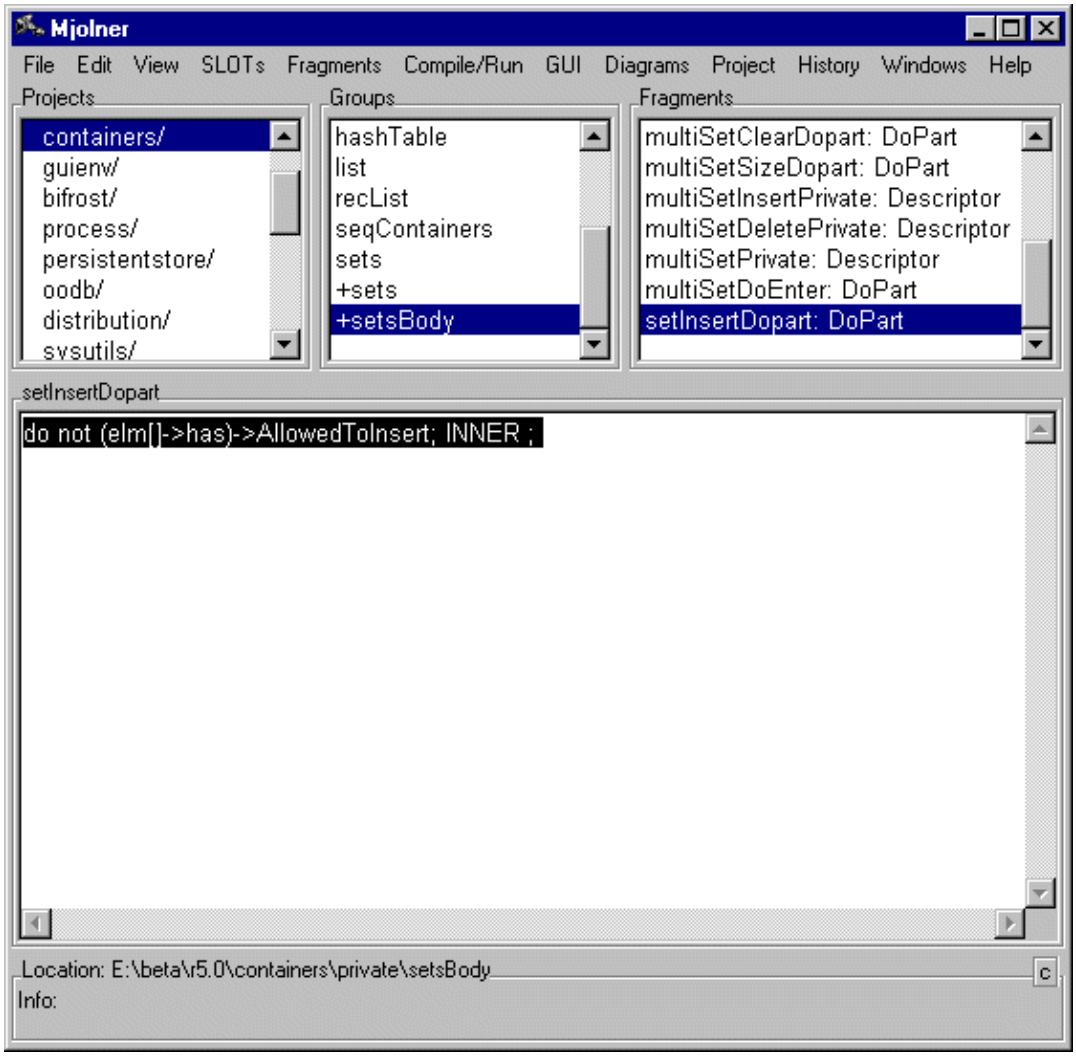


Figure 11

Notice that during an editing session the fragment form may not be found since the program may be incomplete. Another restriction is that binding of Attributes SLOTs only can be found in this way if they are bound in the BODY and MDBODY hierarchy. If not, there is no automatic way of finding the bindings.

Follow link to SLOT definition

Given a fragment form, the link (possibly dangling) to the SLOT definition with the same name can be followed. This is done by selecting a fragment form and using the Follow Link to SLOT command in the View menu. The editor searches after a SLOT definition along the ORIGIN chain until it finds it or reaches the top, i.e. betaenv.

Searching

By means of the Search command in the Edit menu it is possible to search for a substring of a lexem, i.e. a name definition, a name application or a string in a codeviewer.

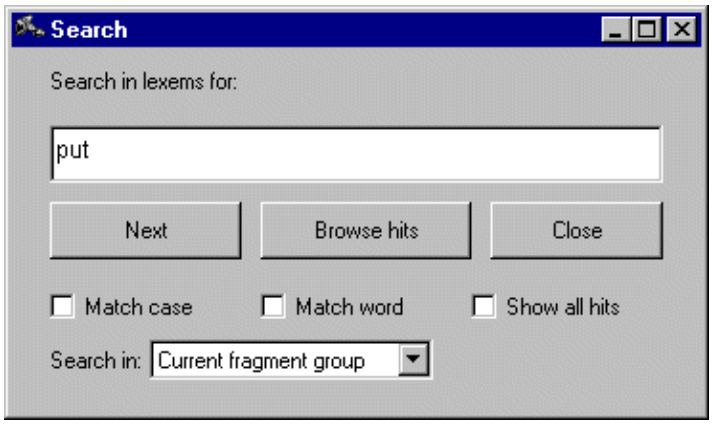
A more advanced lexem search is possible using Search in the Fragment Menu. This search command makes possible to search in

- the current fragment form of the source browser, i.e. the fragment form currently presented in the codeviewer of the source browser
- the current fragment group of the source browser
- the current project in the source browser e.g. also in the domain and extent of the current fragment group

An especiallly useful facility is the browser of search hits, that collects all the search hits for easy overview and access.

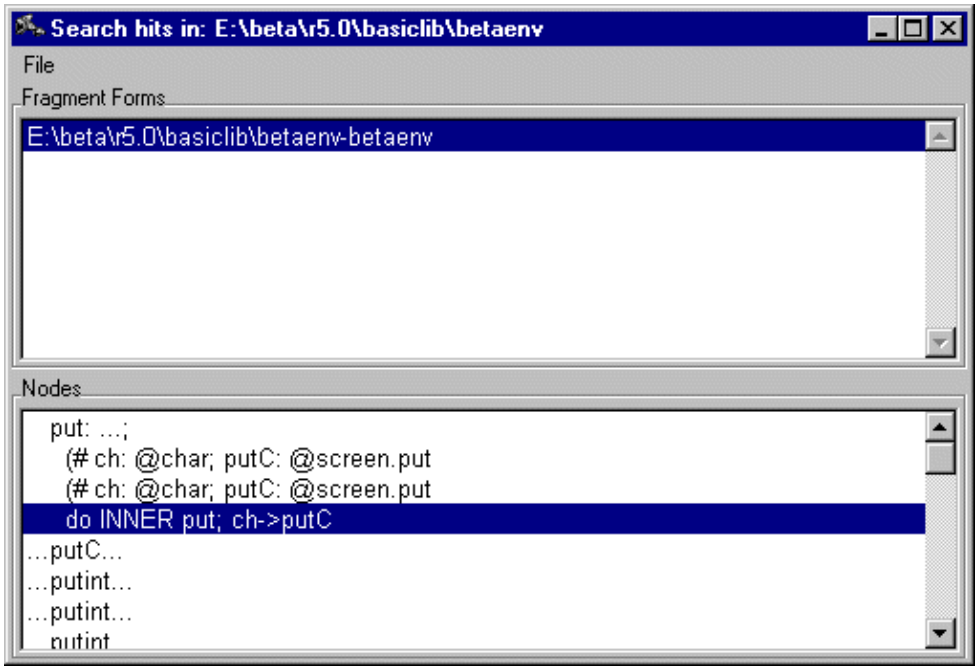
In the following two examples of advanced search will be demonstrated. First we will search for a text in a fragment group and then we will search for a all applications of a certain name.

An example of searching in a fragment group will now be shown. We want to find all occurrences of the text 'put' in 'basiclib/betaenv'. First we open 'basiclib/betaenv' in mjolner. When using the search command the search window pops up:



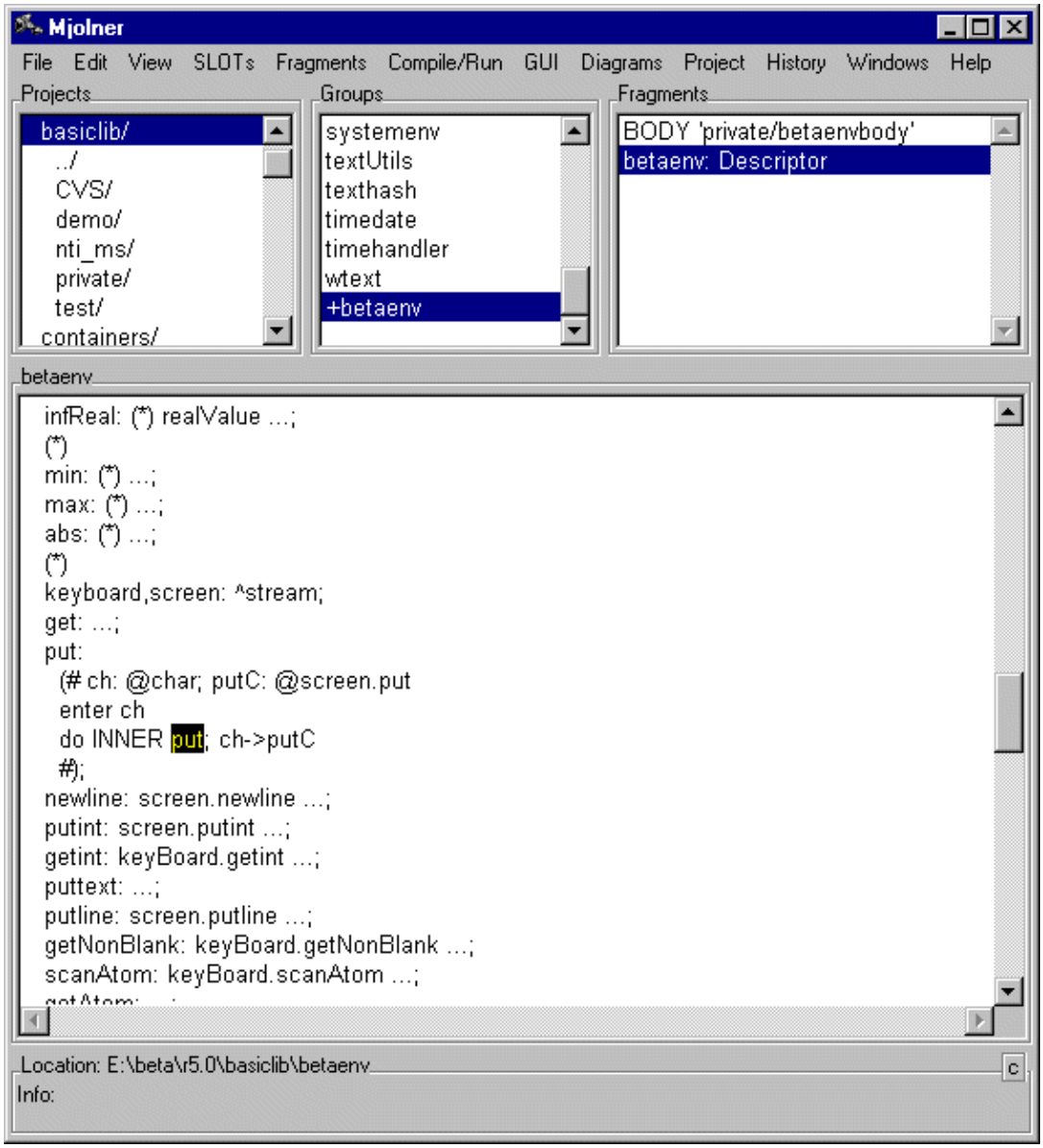
Search window

If we enter 'put' and click on the 'Browse hits' button the current fragment group i.e. 'betaenv' will be searched for occurrences of the text 'put'. I.e. all lexems (name declarations, name applications and strings) will be searched. The search hits are then presented in the search hit browser:



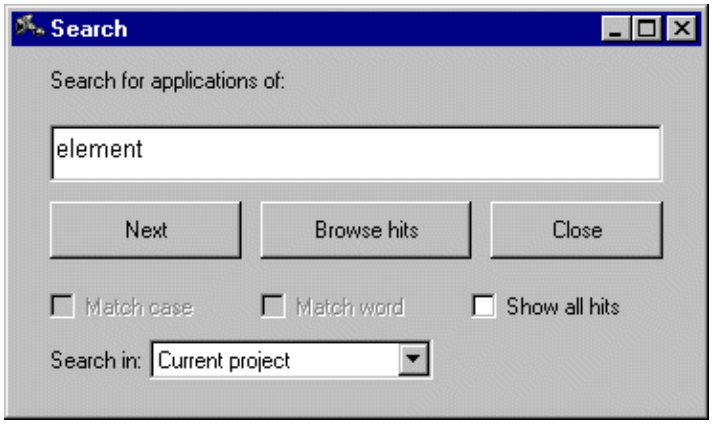
Search hits browser

This search hit browser can be used to select some of the search hits. The Return key can be used to browse quickly through the search hits. An example of a selected search hit:



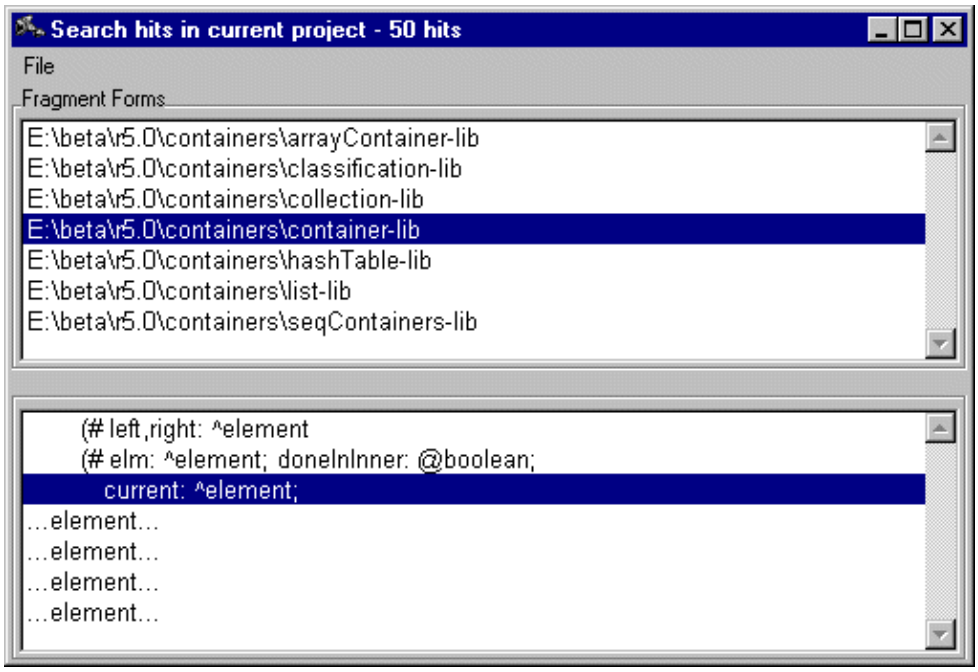
A search hit

An example of searching for all applications of a certain name in a project will now be shown. If the current selection in the source browser is a name declaration the Search command will provide the possibility of searching for applications of that name declaration. In this case we want to search not only in a file (fragment group) but in the whole 'containers' directory. We want to find all occurrences of the name 'element' as declared in the 'containers/container' file. If we select the 'element' declaration in 'containers/container' and activate the Search command, the Search window will appear as:



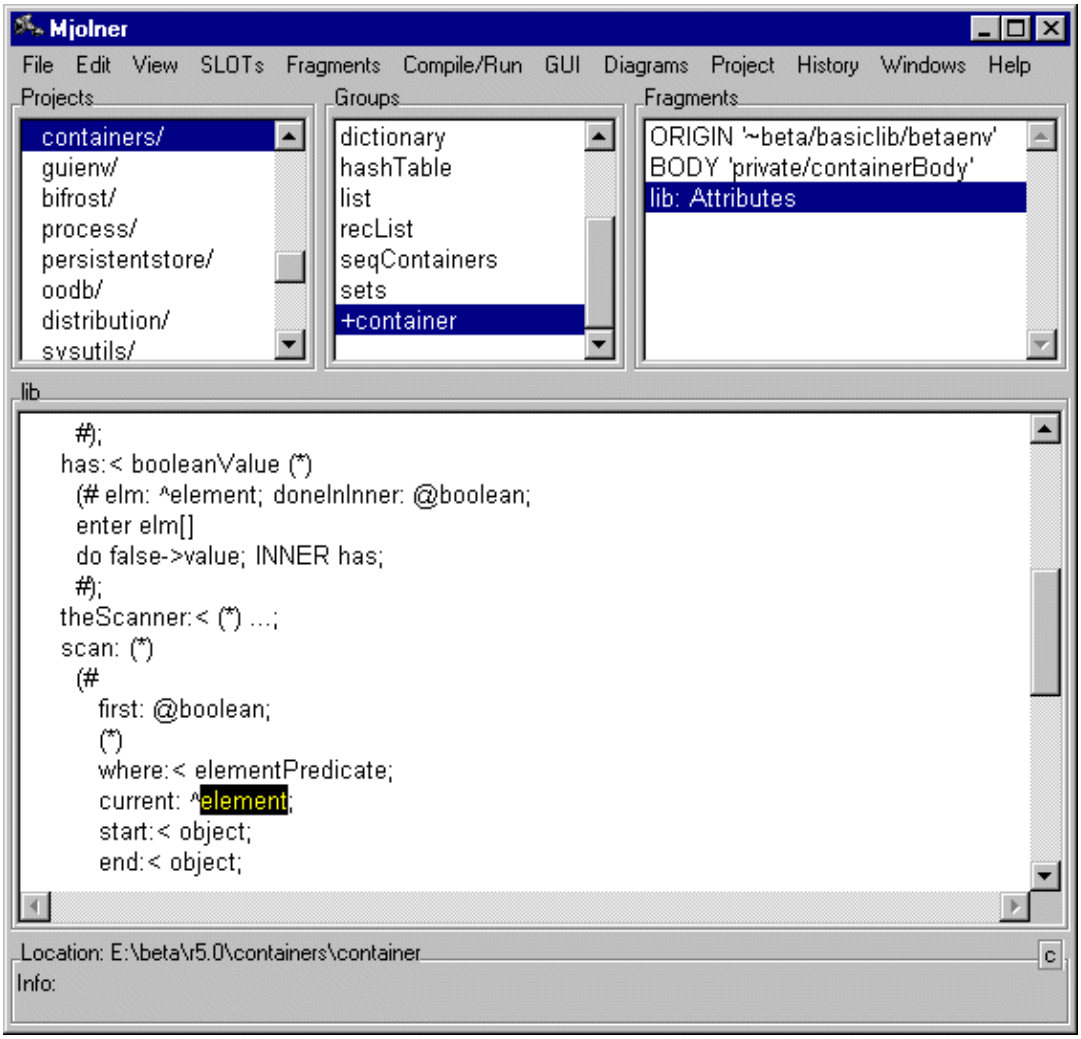
Search for applications window

We have changed the search area to be the current project. In this case the current project is the 'containers' directory. Pressing the 'Show all hits' button the 'Search hit browser' will appear as:



Search for applications hits browser

An example of a selected search hit:



An application search hit

It is also possible to search for all applications of a name in the whole dependency graph. See Domain and Extent Projects

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Editor - Tutorial

Code Editor

The editor consists of basically two types of editors: a group editor and a code editor.

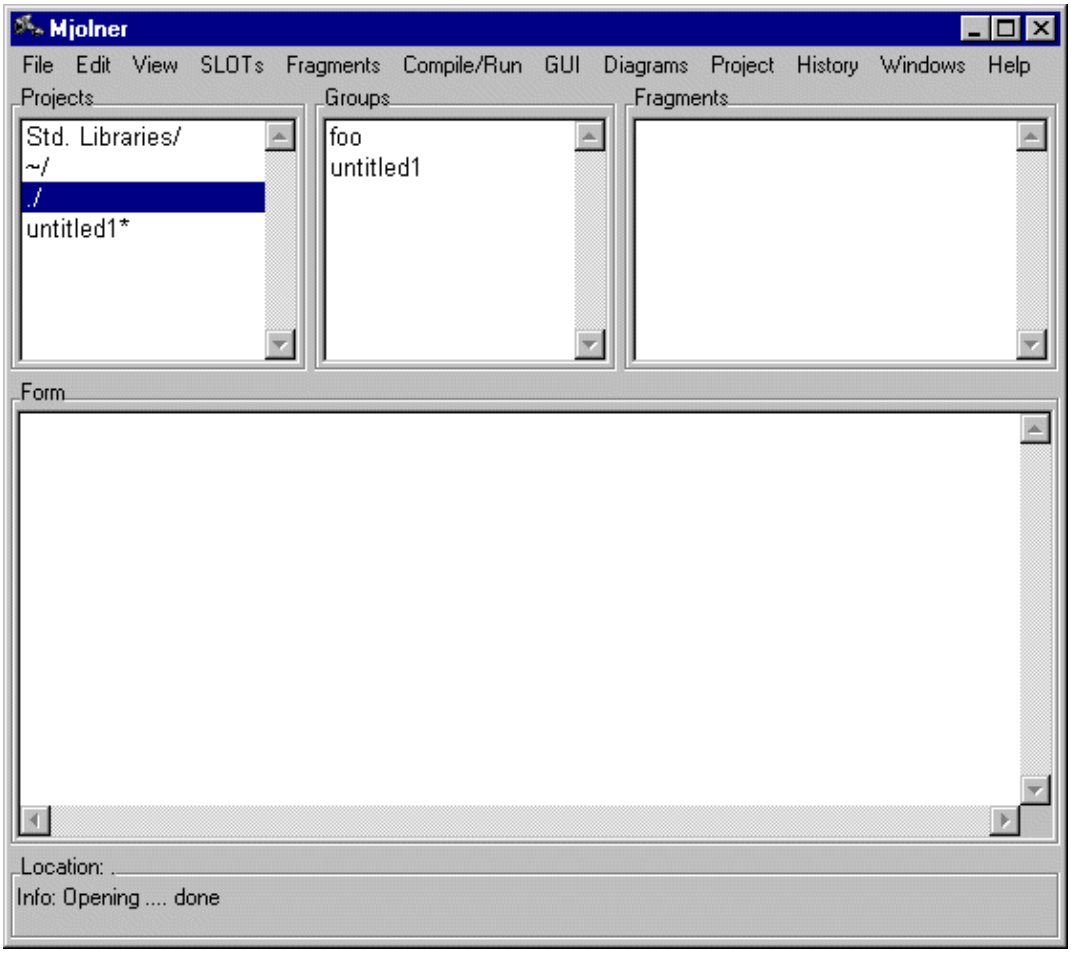

Figure 12

The Group editor

The group editor is only relevant if the language in question is BETA. It is used for browsing or editing BETA programs. It is used to present and modify the structure of a group, i.e. the properties (ORIGIN, BODY, MDBODY, INCLUDE etc.) and fragments (Descriptor forms, DoPart forms or Attributes forms).

The Code editor

The code editor provides structure editing on each fragment form.

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Code Editor

Creating a New Program

When mjolner is started without arguments a template for a BETA program is automatically created.

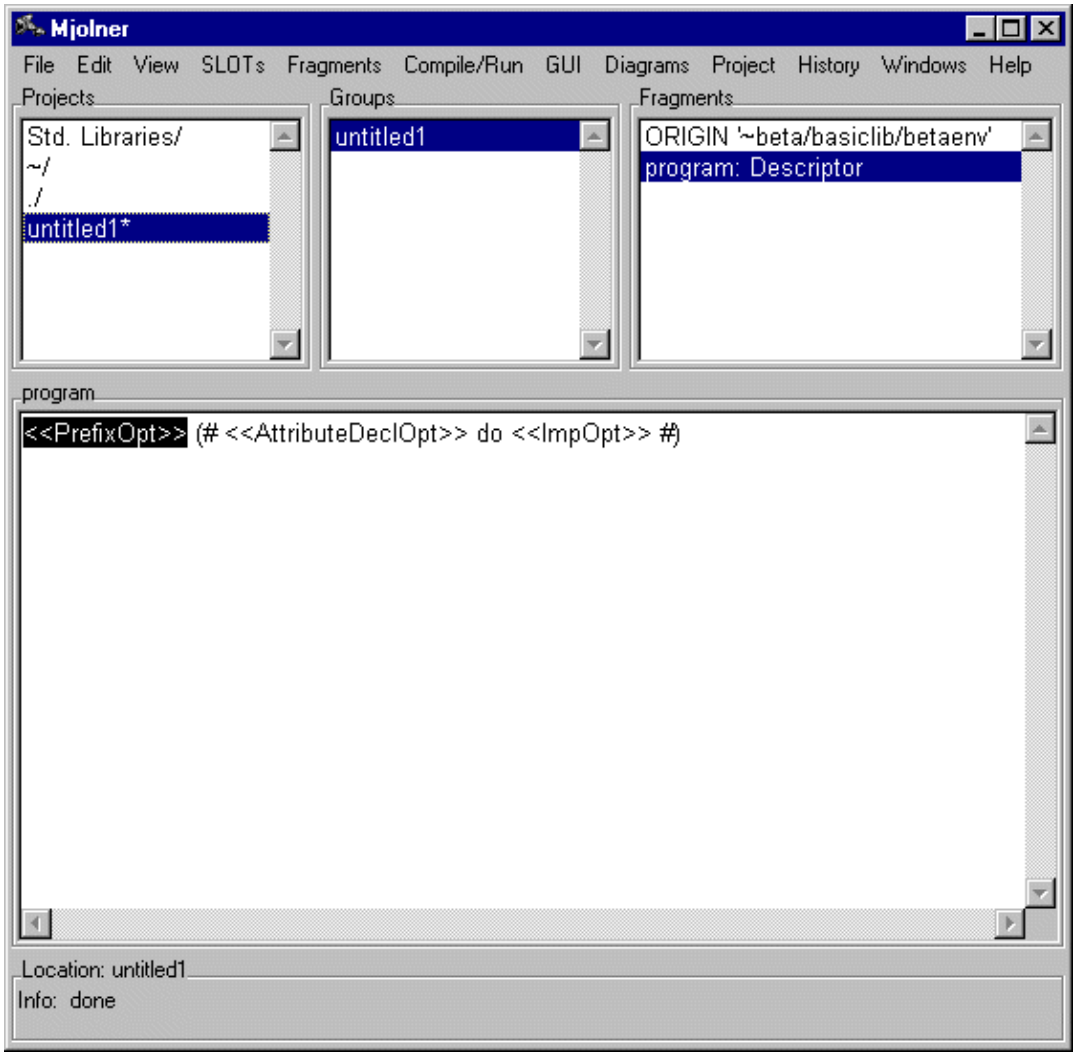

Figure 13

This program is called untitled1.

Alternatively the 'New BETA Program...' command of the File menu can be used.

Code Editor

Editing at Code Level

Code editor

The code editor provides structure editing on each fragment form. In the following a separate code editor is chosen by shift-double-clicking on the program fragment form in the group editor (or using the pop-up menu in the code editor) of Fig. 13.

Structure Editing

The basic idea of structure editing is that the program is manipulated in terms of its logical structure rather than the textual elements such as characters, words and lines. The advantage of this approach is that only logically coherent parts can be inserted or deleted and thereby preserving the syntactical rules of the language at any time.

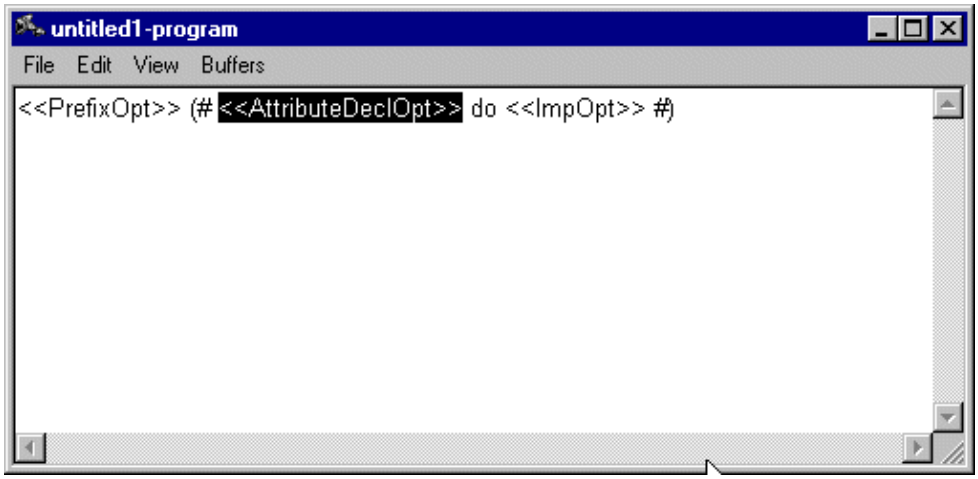

Figure 14

The window above shows an example where a template for a BETA program has been derived. The template includes placeholders (nonterminals) and keywords (terminals). If a nonterminal is selected the mouse pointer is changed to an icon that indicates that the rightmost button of the mouse must be pushed to pop-up a menu (only Unix version, in general the Pop-up Menu Button;.;; is used, see Basic User interface principles). In the example, the <<AttributeDeclOpt>> placeholder has been selected and the legal declarations (according to the BETA grammar) is shown in the pop-up menu.

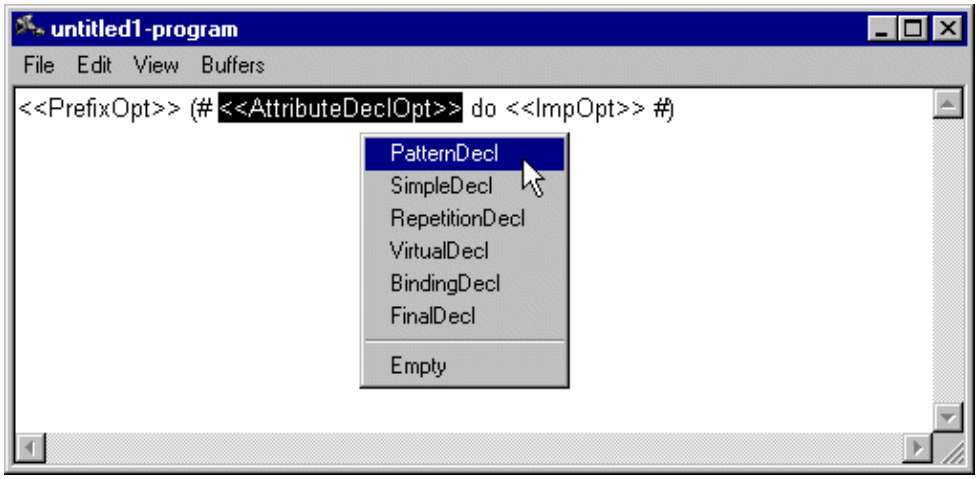

Figure 15

The PatternDecl entry is selected and the result is:

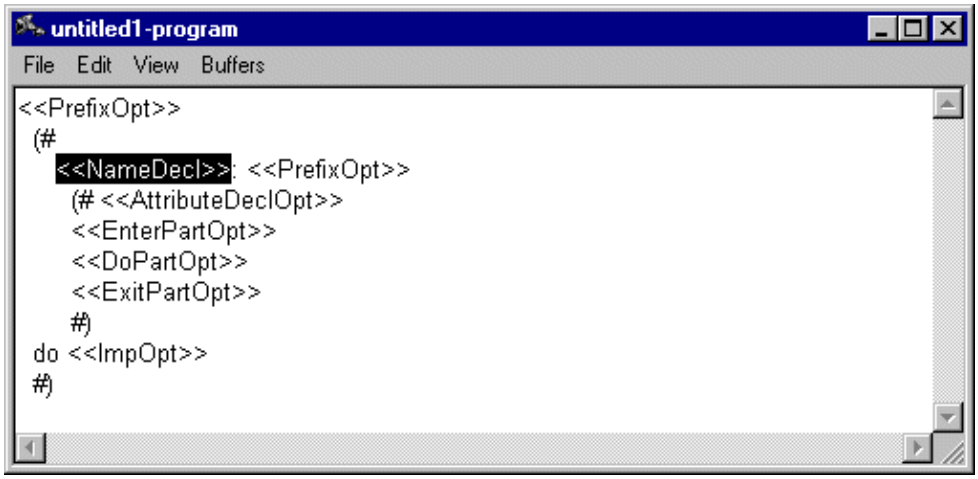

Figure 16

Text Editing and Parsing

Structure editing has its greatest force at the higher levels of editing, i.e. for creating the overall structure of the program or for moving around large chunks of code. At the detailed level the textediting technique is more useful.

Text editing can at any time be used as an alternative to structure editing. Text editing is activated either by just starting to type or by selecting the Textedit command in the Edit menu. If you start typing at the keyboard, the typed characters will replace the current selection in the code editor window. Text editing mode may alternatively be entered without deleting the current selection, by means of the Textedit command or by pressing the <space> key. In that case the text cursor will be positioned in the start of the current selection.

Text editing mode can be terminated by selecting the Parse Text command in the Edit menu, or by one of the short-cuts: Ctrl t or Ctrl <spaceThe possibly modified text will immediately be parsed and any parse errors will be reported (but only one at a time). Note that semantic checking is not done by the editor. In this example a parse error is detected.

In Fig. 17 the placeholder <<NameDecl>> is selected and the name hello is typed. After that the <<DoPartOpt>> is selected and the text

```
'hello world -> putline
```

is typed. When textediting is exited the syntax error is immediately reported:

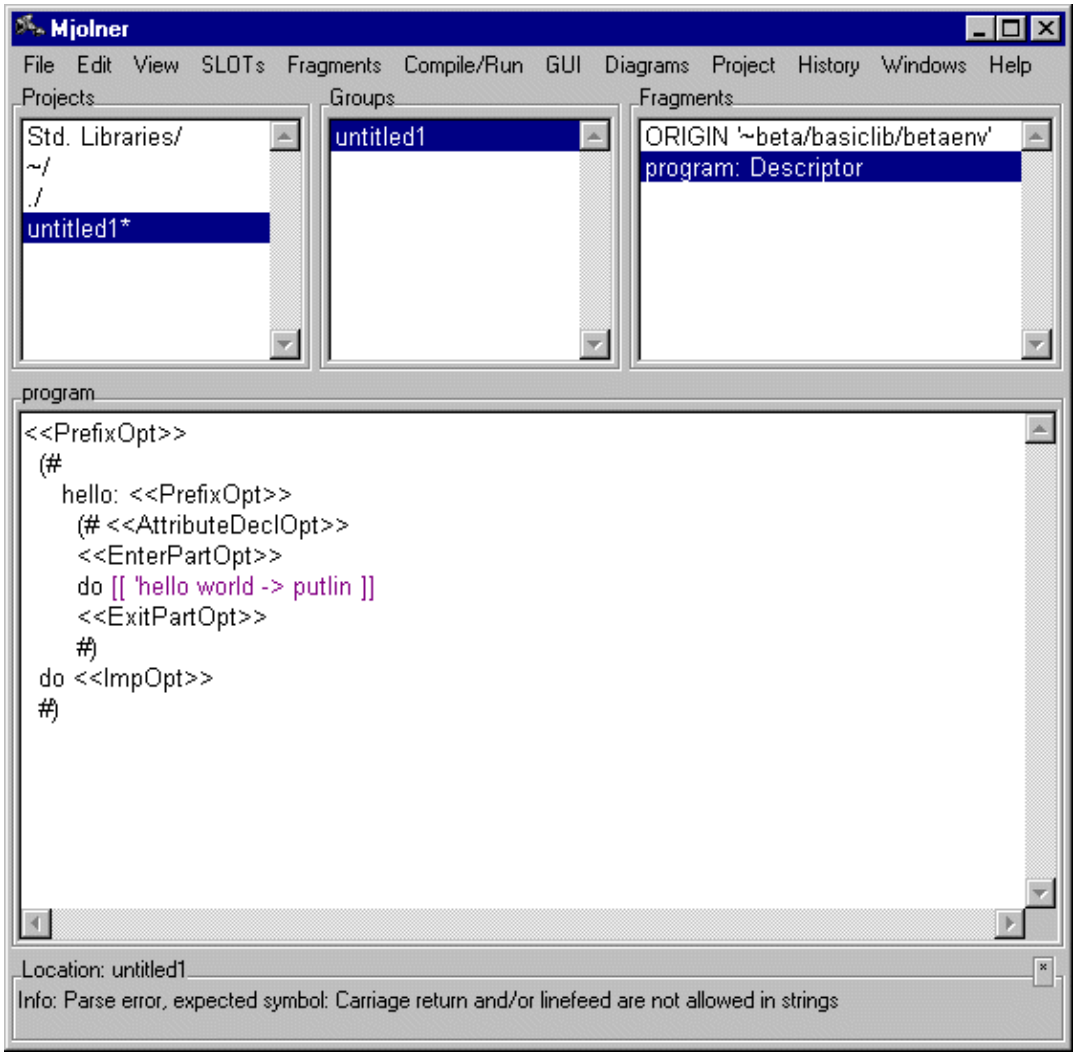
Mjolner
File Edit View SLOTs Fragments Compile/Run GUI Diagrams Project History Windows Help
Projects
Std. Libraries/
~/
./
untitled1*
Groups
untitled1
Fragments
ORIGIN '~beta/basiclib/betaenv'
program: Descriptor
program
<<PrefixOpt>>
(#
hello: <<PrefixOpt>>
(# <<AttributeDeclOpt>>
<<EnterPartOpt>>
do [['hello world -> putlin]]
<<ExitPartOpt>>
#)
do <<ImpOpt>>
#)
Location: untitled1
Info: Parse error, expected symbol: Carriage return and/or linefeed are not allowed in strings

Figure 17

Checking

After correcting the syntax error the program looks like below:

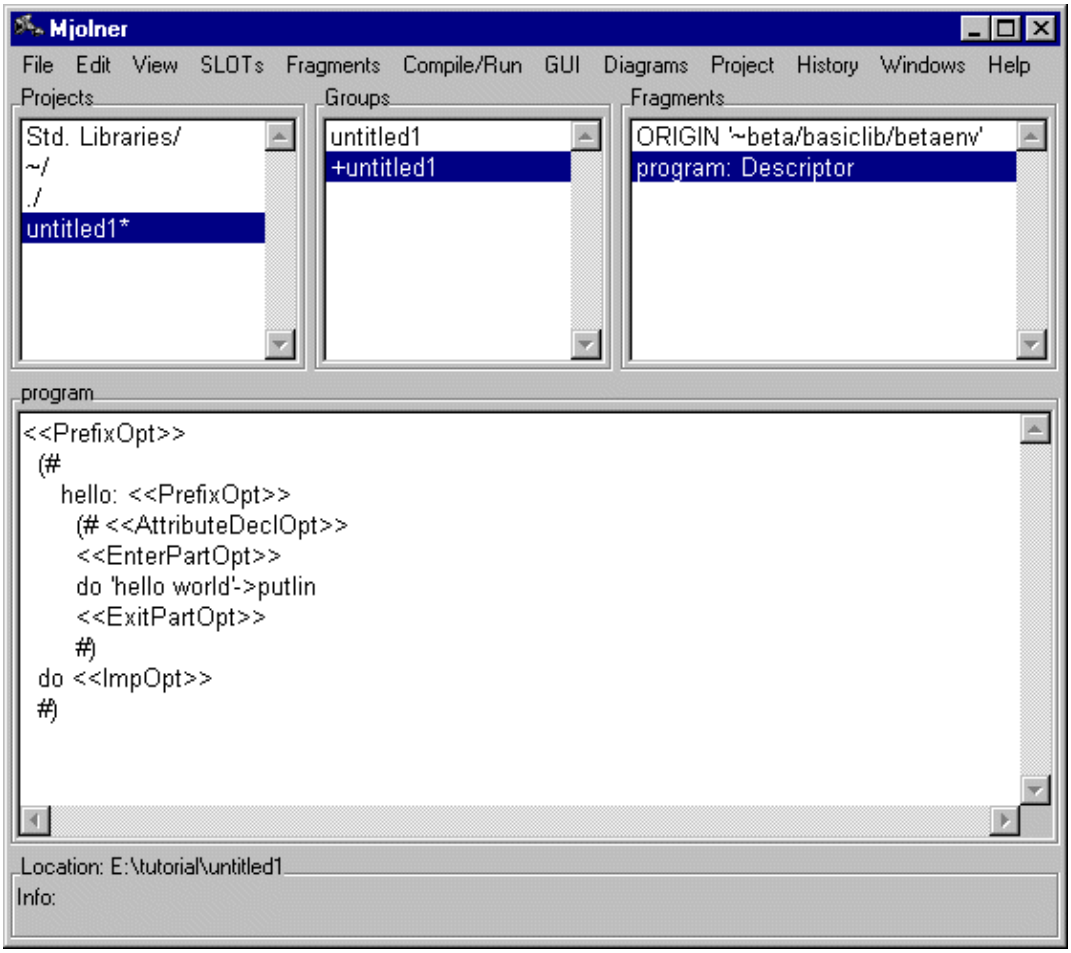

Figure 18

Now we want to call the checker. This is done by means of the Check Current command in the Tools menu. But the compiler does not accept unexpanded nonterminals. Therefore the following dialog is popped up:

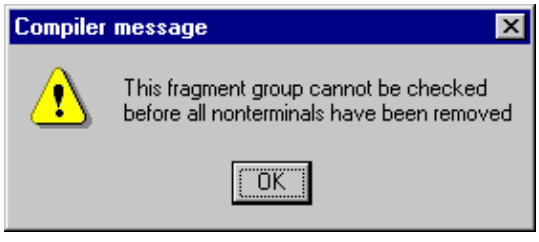

Figure 19

Notice that in this example all nonterminals are optionals (is indicated by the Opt suffix). An easy way to remove unexpanded optionals is to select the whole program and use the Remove Optionals in the Edit menu. The result is:

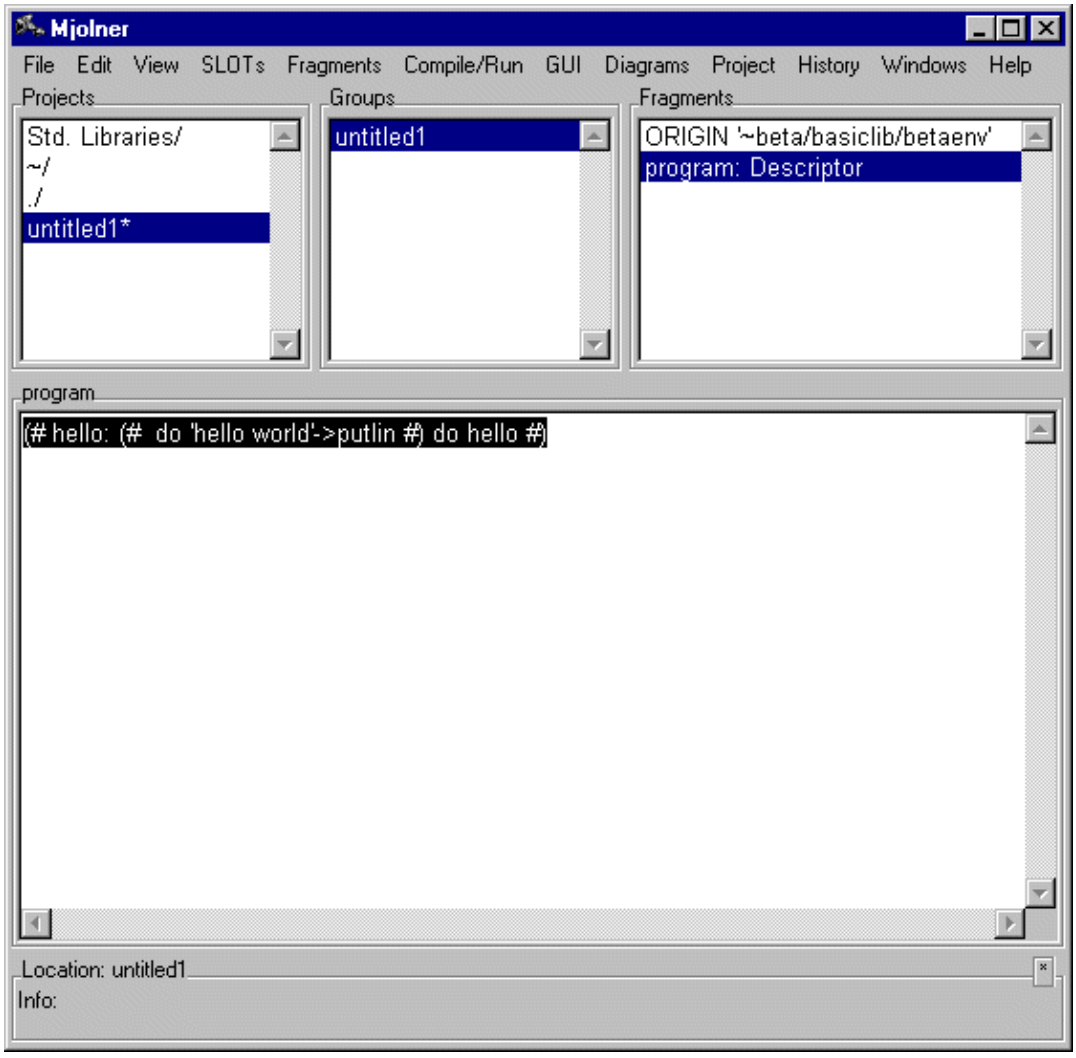

Figure 20

Now the checker is called again and the semantic error is detected and shown by means of the semantic error viewer:

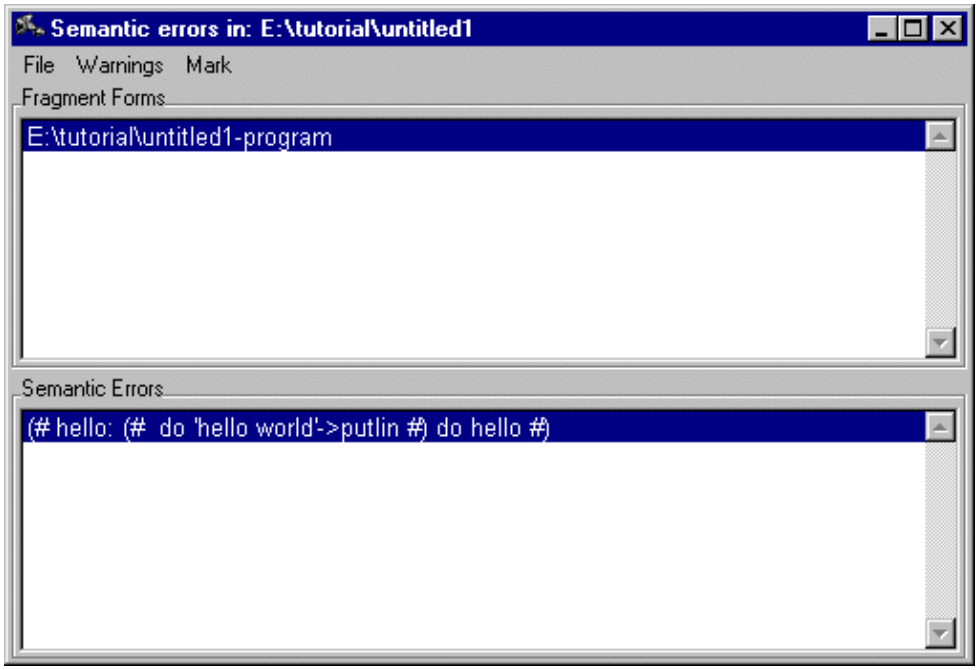

Figure 21

In this case there is only one semantic error, but in general the Fragment Forms pane will contain a list of fragment forms with semantic errors and the Semantic Errors pane will for each fragment form in the upper pane show a list of semantic errors. By selecting in the two panes the different semantic errors can be inspected. By clicking in the Semantic Errors pane the code editor will select the corresponding structure. The first semantic error will always be selected automatically. In the example the following selection is made:

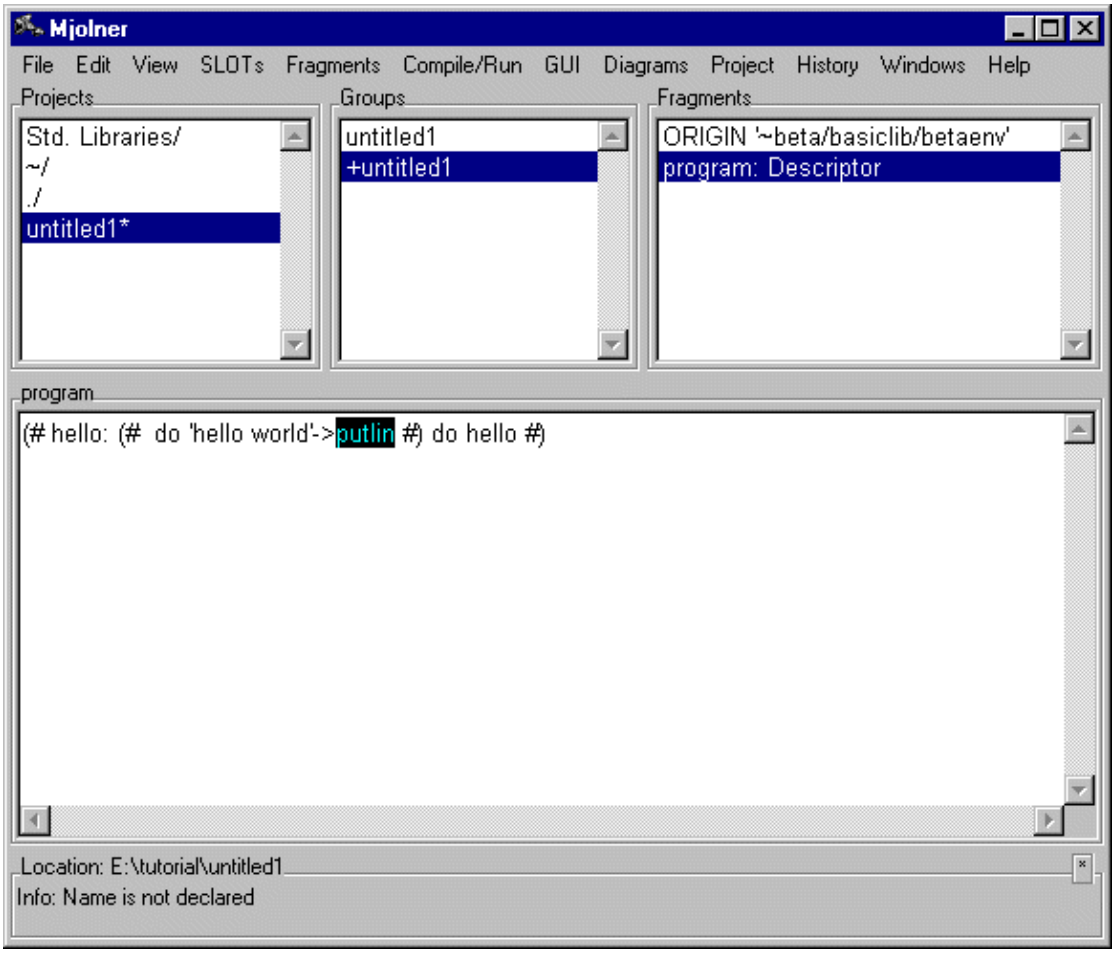

Figure 22

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Code Editor

Modifying a Program

Consider the program of Fig. 22. We now want to add an enter part that should enter a text to be printed after the 'Hello world' string. To add an enter part you can either select for example the descriptor of the hello pattern and type the enter part using text editing.

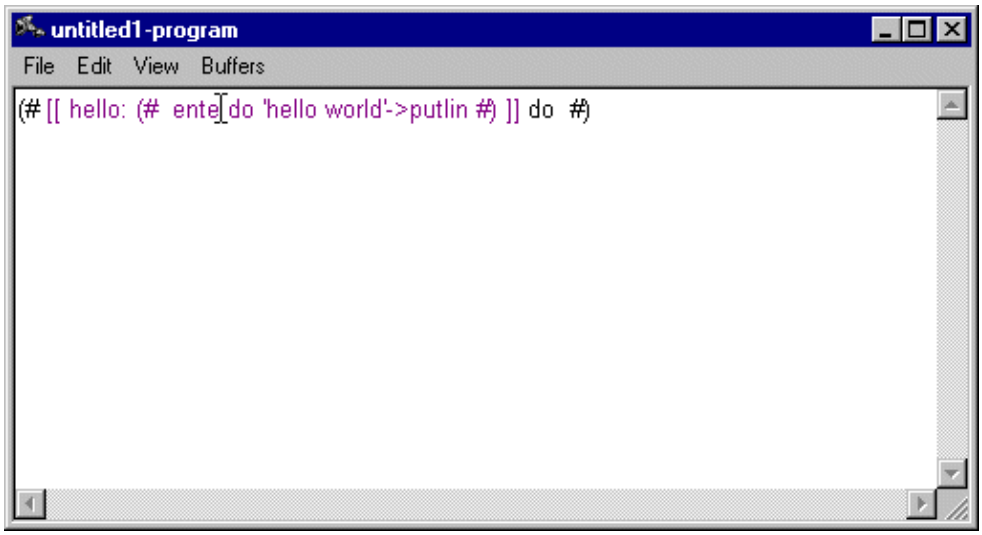

Figure 23

Another technique is to select the whole pattern declaration and use the Show optionals command in the Edit menu. The latter has been done below:

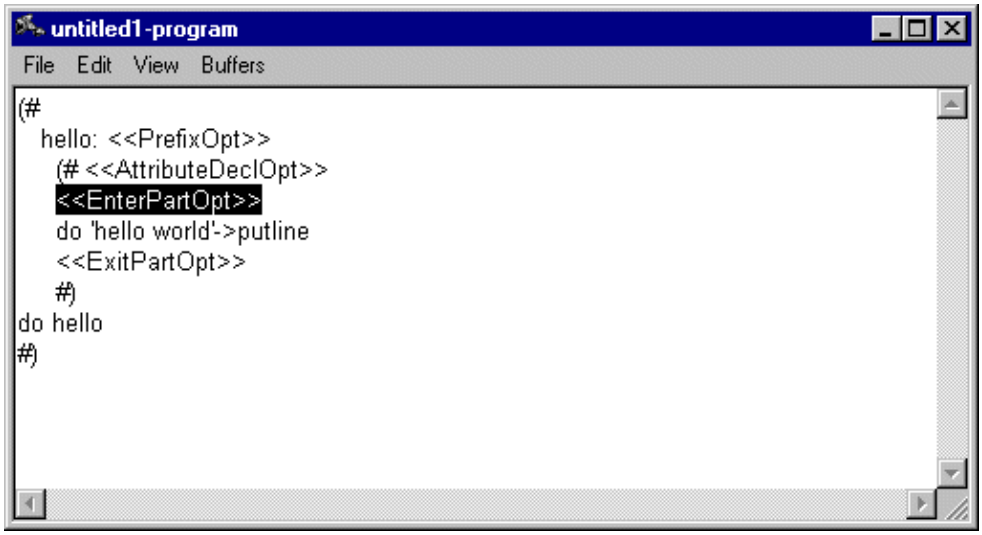

Figure 24

We select the EnterPartOpt nonterminal and via the pop-up menu we choose 'EnterPart' which gives the result: enter >. Then we select > and 't' is typed. Likewise we select the AttributeDeclOpt nonterminal and type: t: @text. Now we want to add an imperative after the putline. To insert a new list element in a list element is selected and the Insert After or Insert Before command of the Edit menu is used. An alternative to Insert After is to press the <cr> key.

In Fig. 23 the imperative 'hello world'->putline is selected e.g. by clicking on the arrow (->). Then the <cr> key is pressed and the result is:

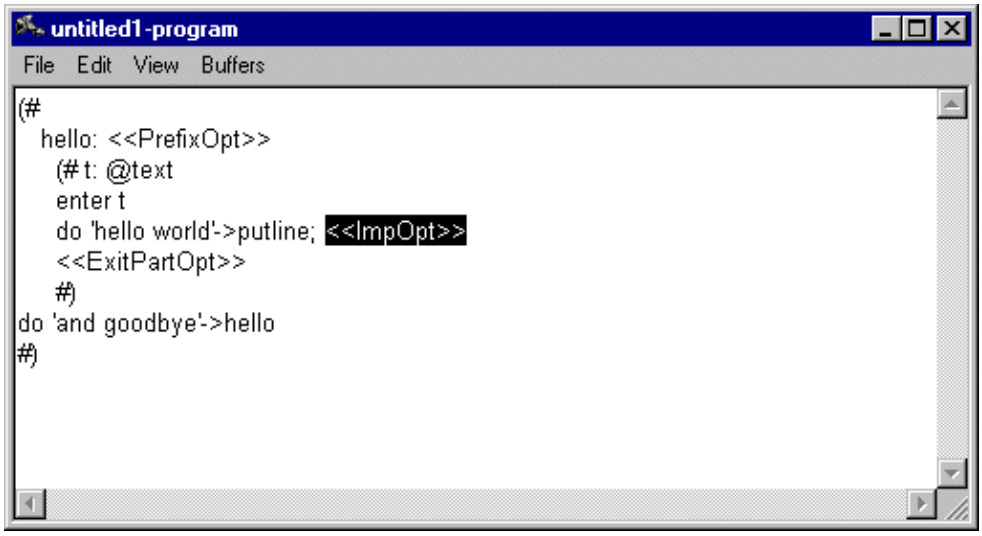

Figure 25

The final result is:

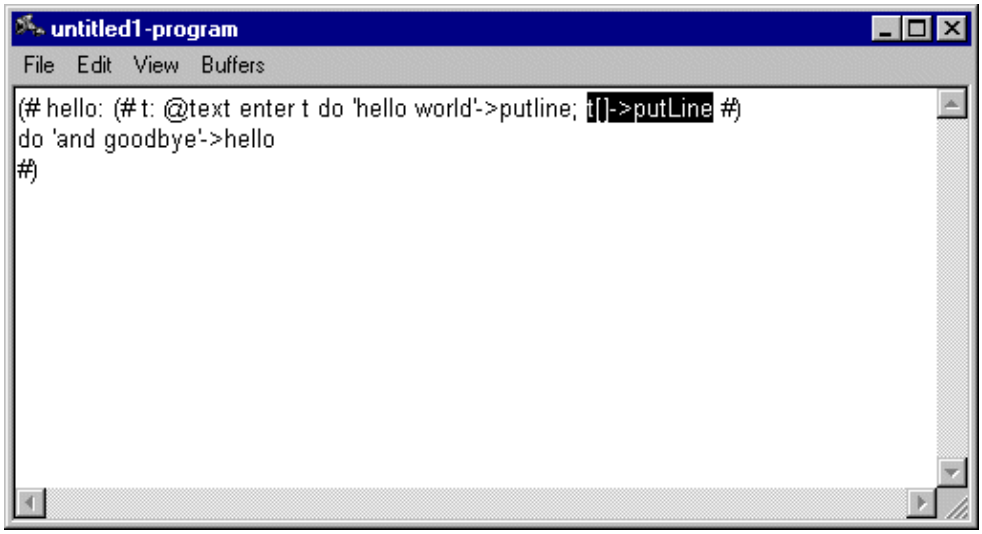

Figure 26

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Code Editor

Editing at Group Level

Group Editing

Manipulation of the fragment group structure is done in the group editor. It is possible to insert or delete fragment forms, modify the names of the fragment forms, or edit the properties of the fragment group e.g. the ORIGIN, INCLUDE and BODY properties. Editing of properties is done using a property editor that is a structure editor on the properties. This editor is activated by means of the 'Fragments:Edit ORIGIN, INCLUDEs etc...' command.

Fragmenting

The fragment system provides facilities for splitting a BETA program into several parts in order to support separation of interface and implementation, variant configuration or separate compilation. The code editor supports this kind of fragmenting.

If, for example, a fragment form is going to be divided into an interface part and an implementation part the, SLOTs menu is very useful. Consider the small program hello:

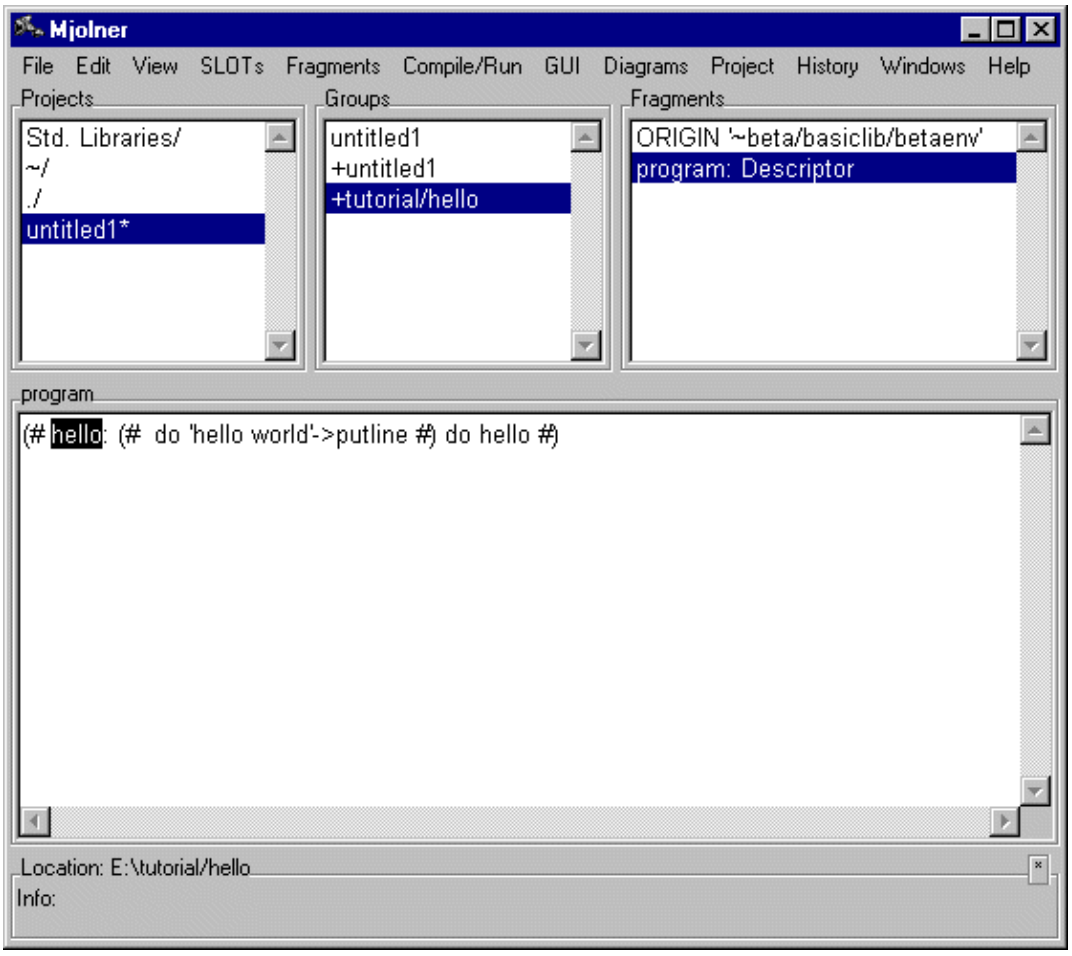

Figure 27

Let say we want to create a BODY file called 'hellobody' that contains the DoPart of the hello pattern. First we create the BODY file using the 'SLOTs:Create Implementation File...'.

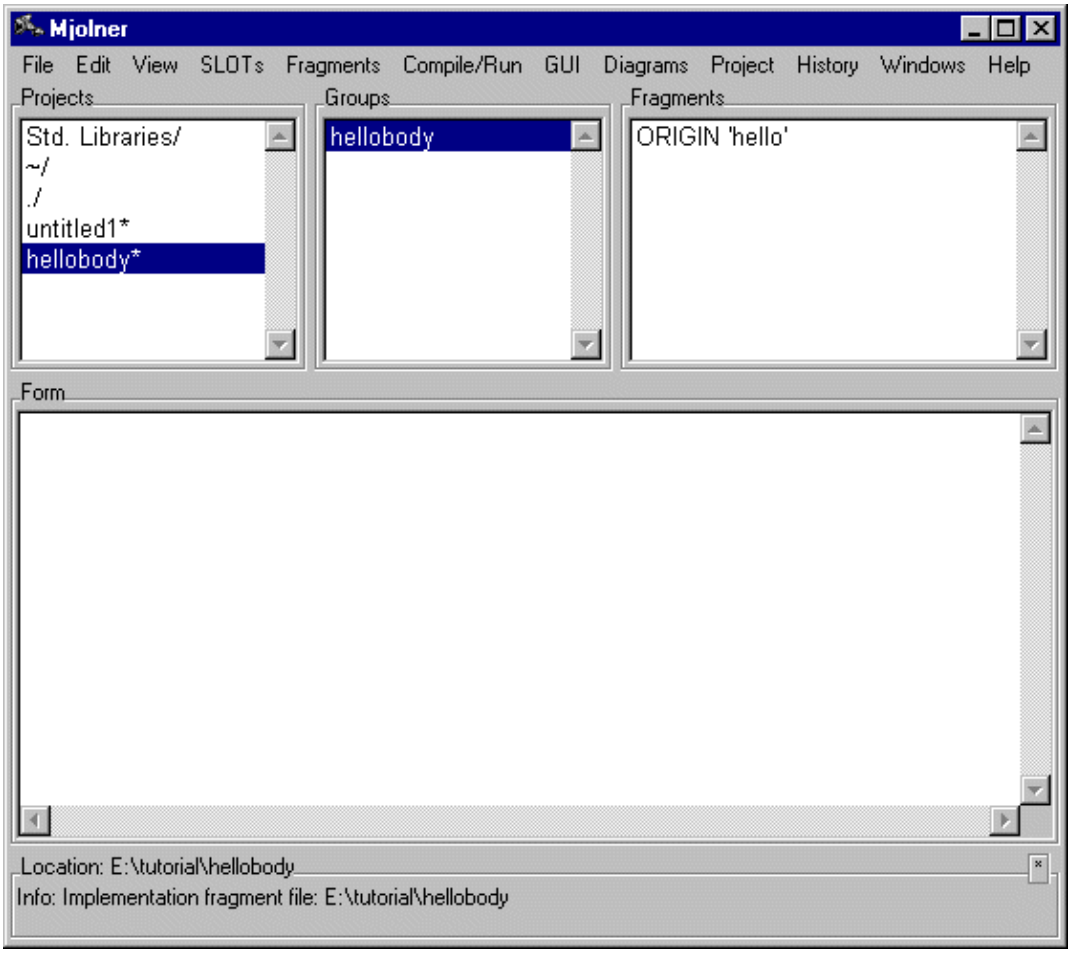

Figure 28

Notice that this new file has ORIGIN in hello. If we double-click on this ORIGIN, we return to the hello file, and we see that the property: 'BODY hellobody' has been inserted.

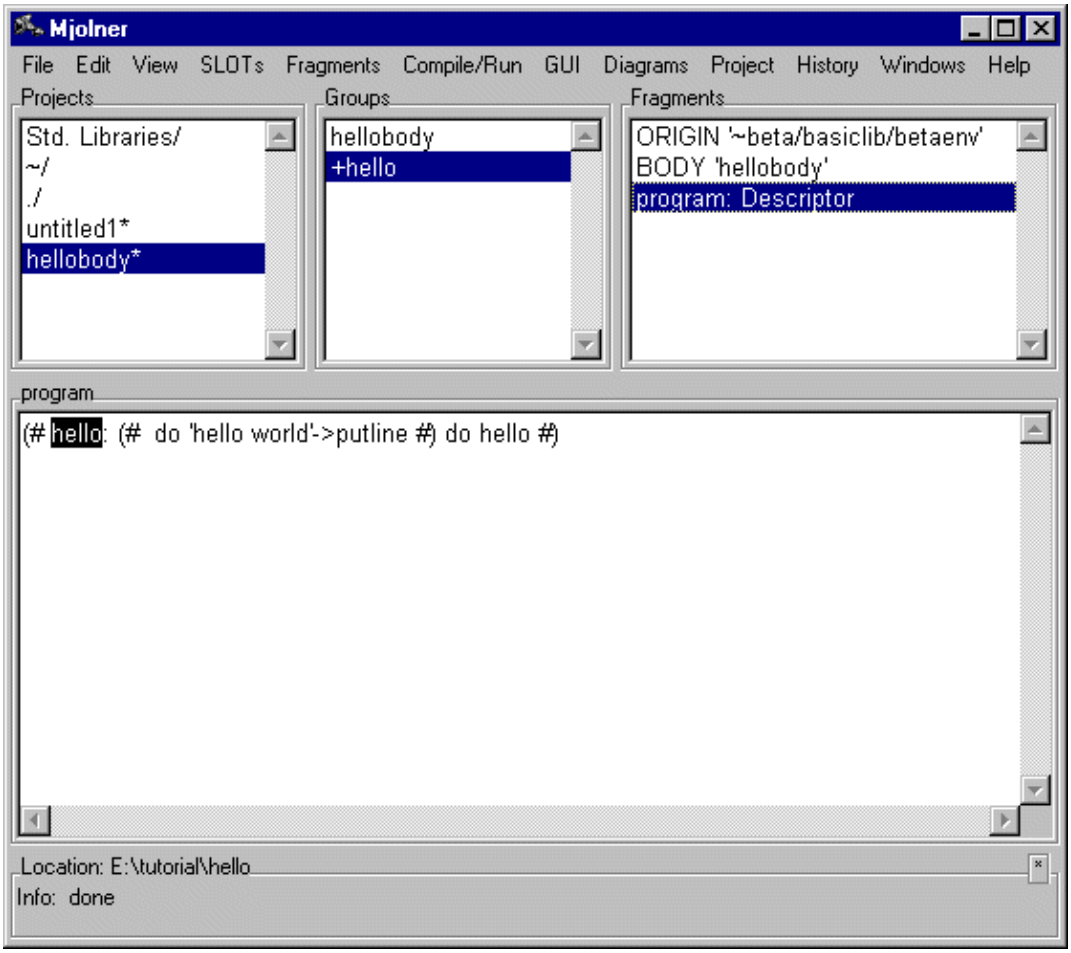

Figure 29

Now we are ready to hide the implementation of the hello pattern. This is done by means of the 'SLOTs:Hide Implementation...' command. For each DoPart in the selection you are asked whether to create a DoPart SLOT and move it to the BODY file.

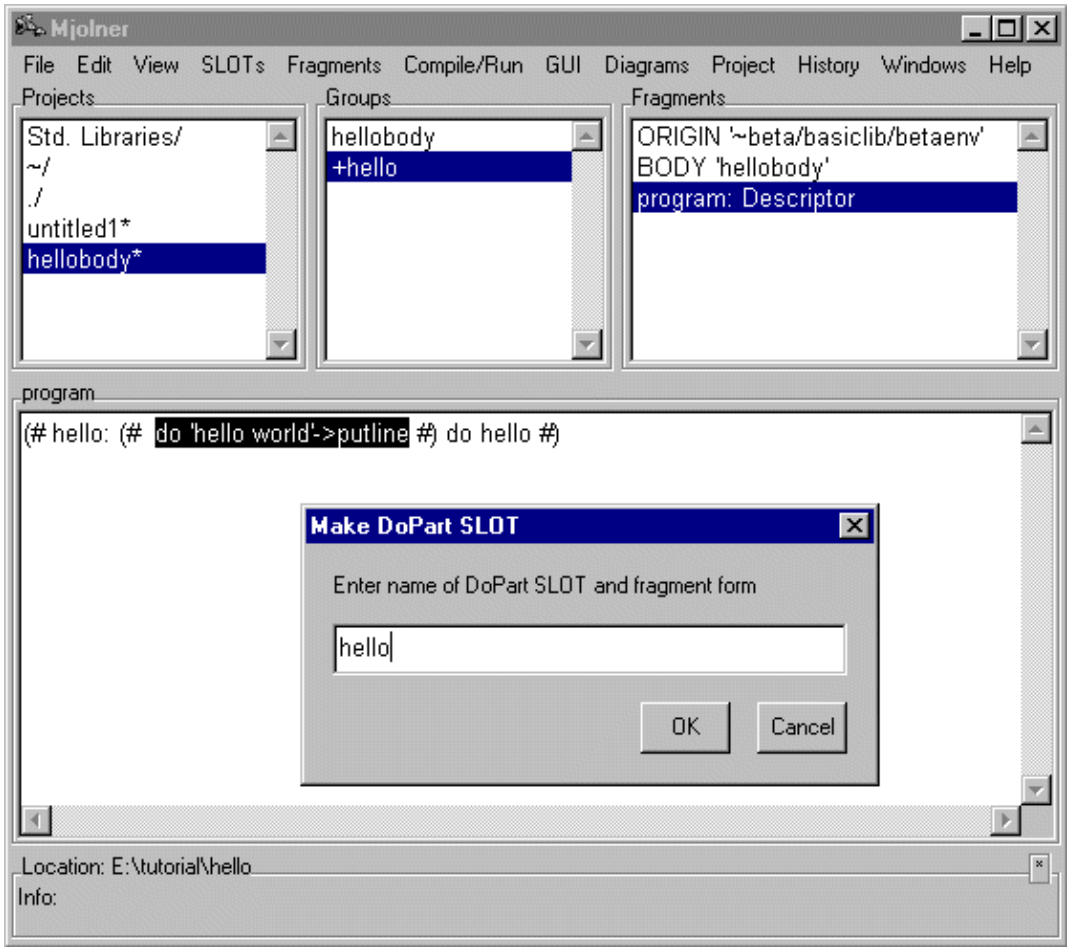

Figure 30

We accept and the result is:

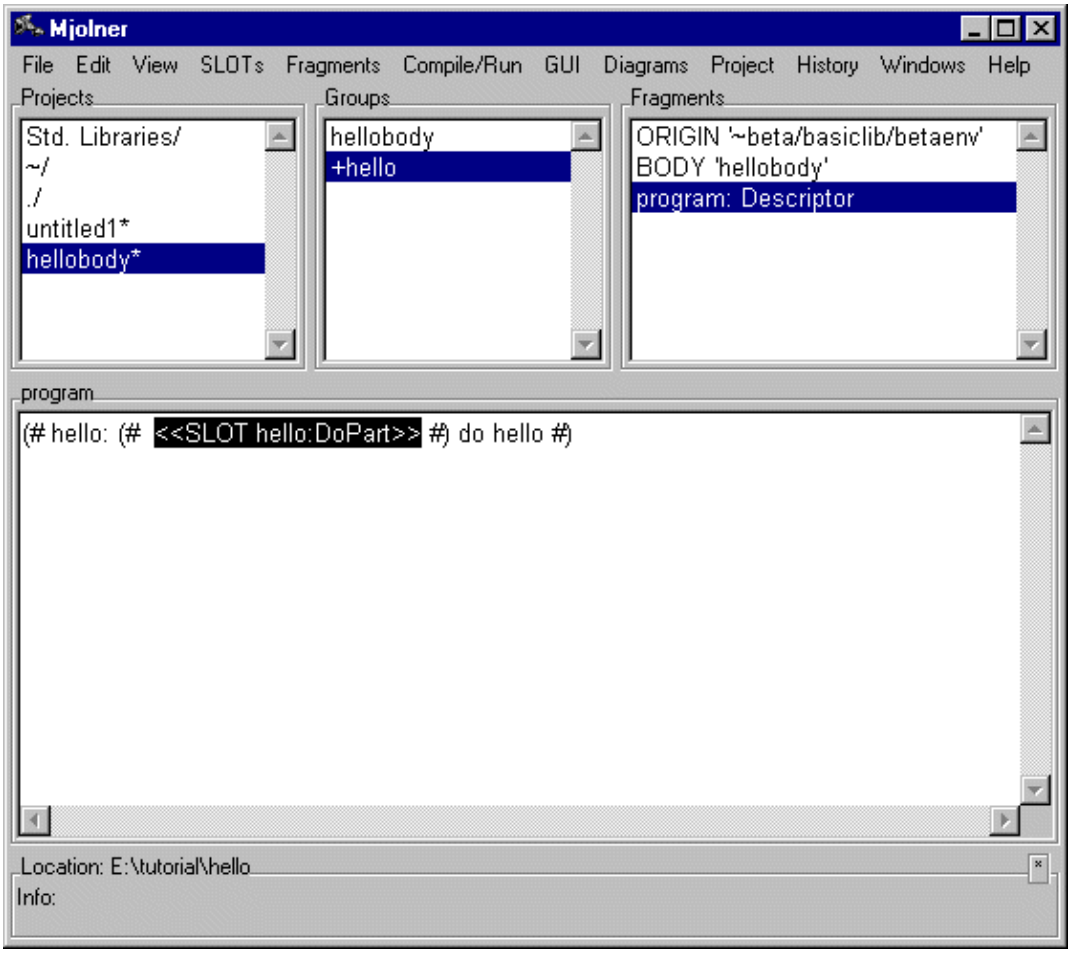

Figure 31

and the BODY file looks like:

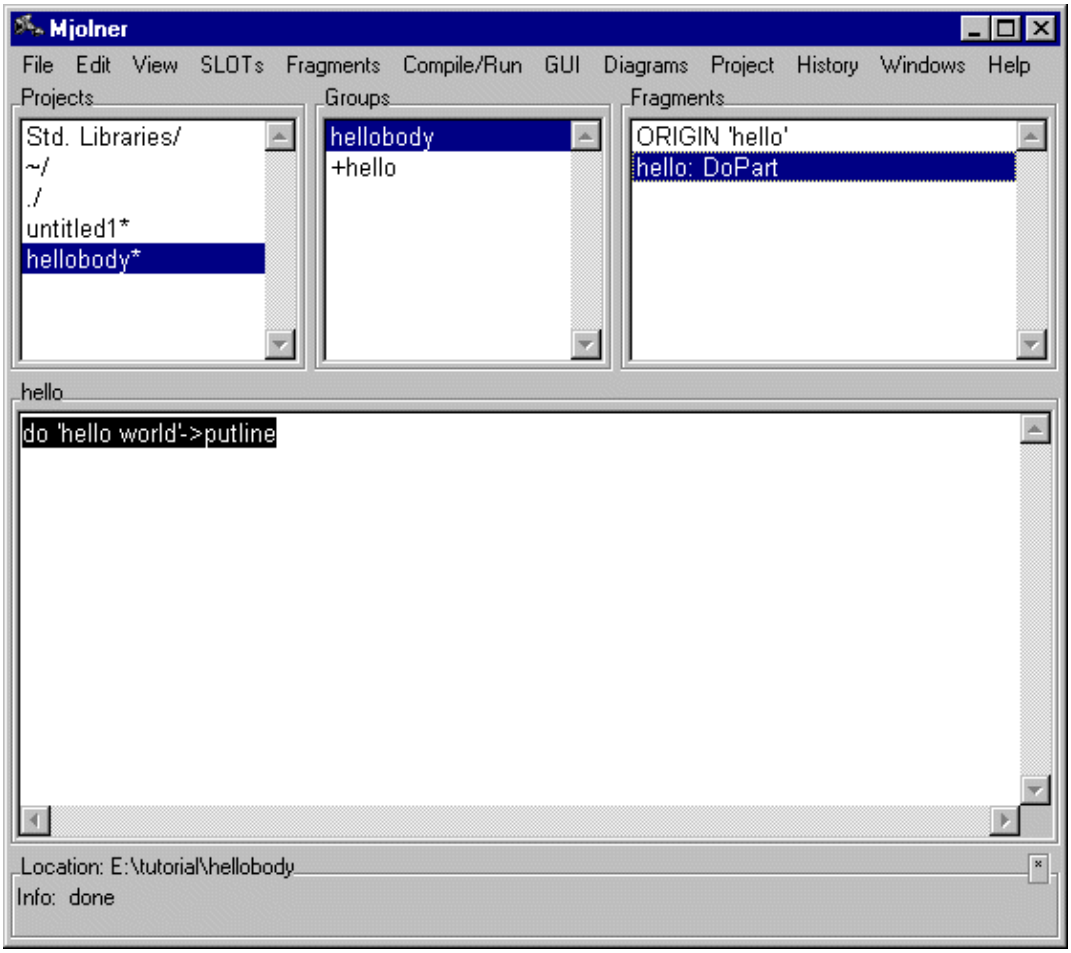

Figure 32

There are alternative ways to fragmentize BETA programs in mjolner.

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Code Editor

Work Space

Consider the following interface file:

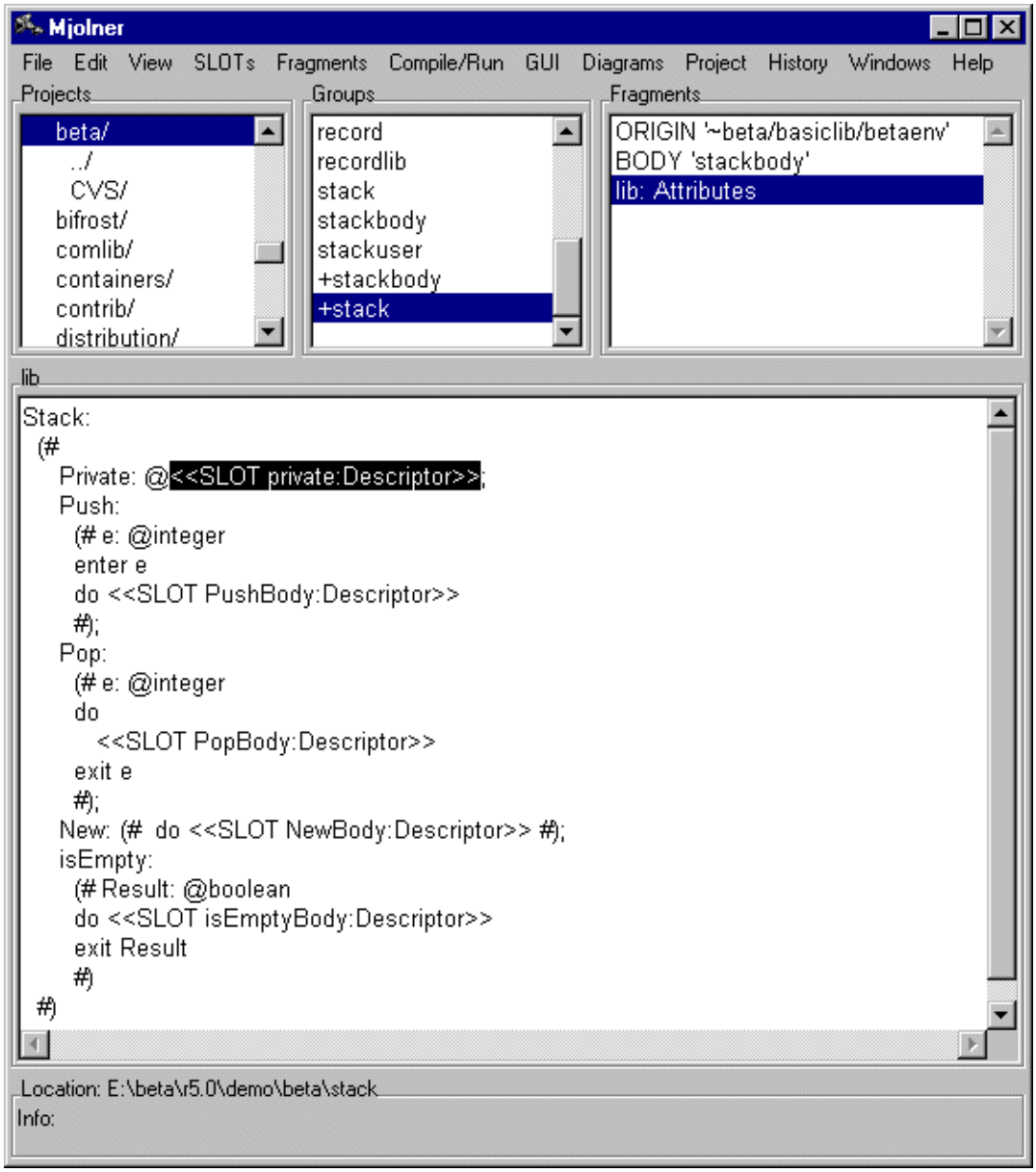

Figure 33

Each fragment form in the implementation file can be shown one at a time in the browser either by double-clicking on the SLOTs or by double-clicking on the BODY property in the group editor window to get the implementation file and then selecting them one at a time:

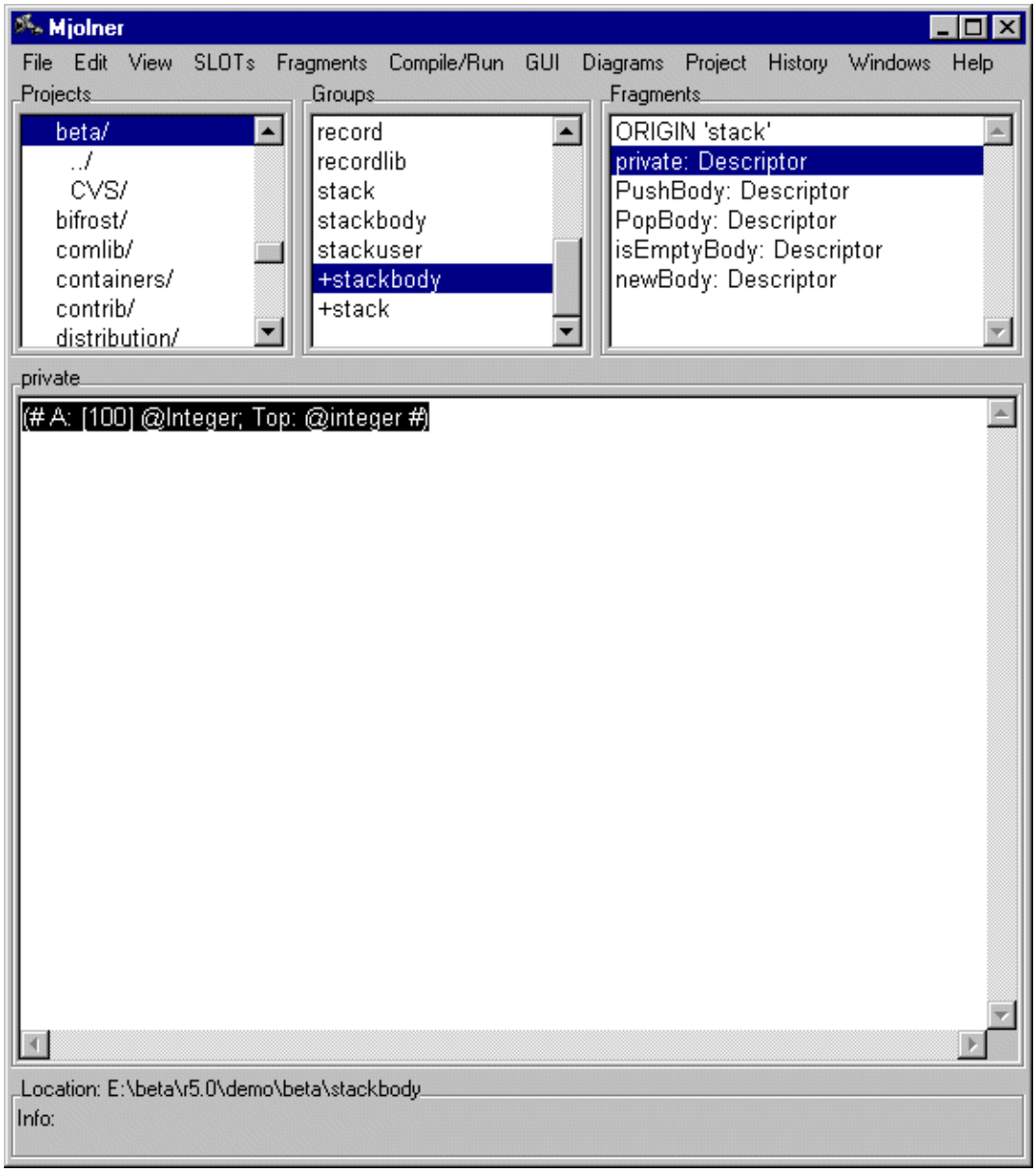

Figure 34

but an easier way is to get all or a subset of the fragment forms in a so-called work space window by using the Workspace command of the Windows menu. The Import menu is used to open a code editor on all or a subset of the fragment forms in the workspace window:

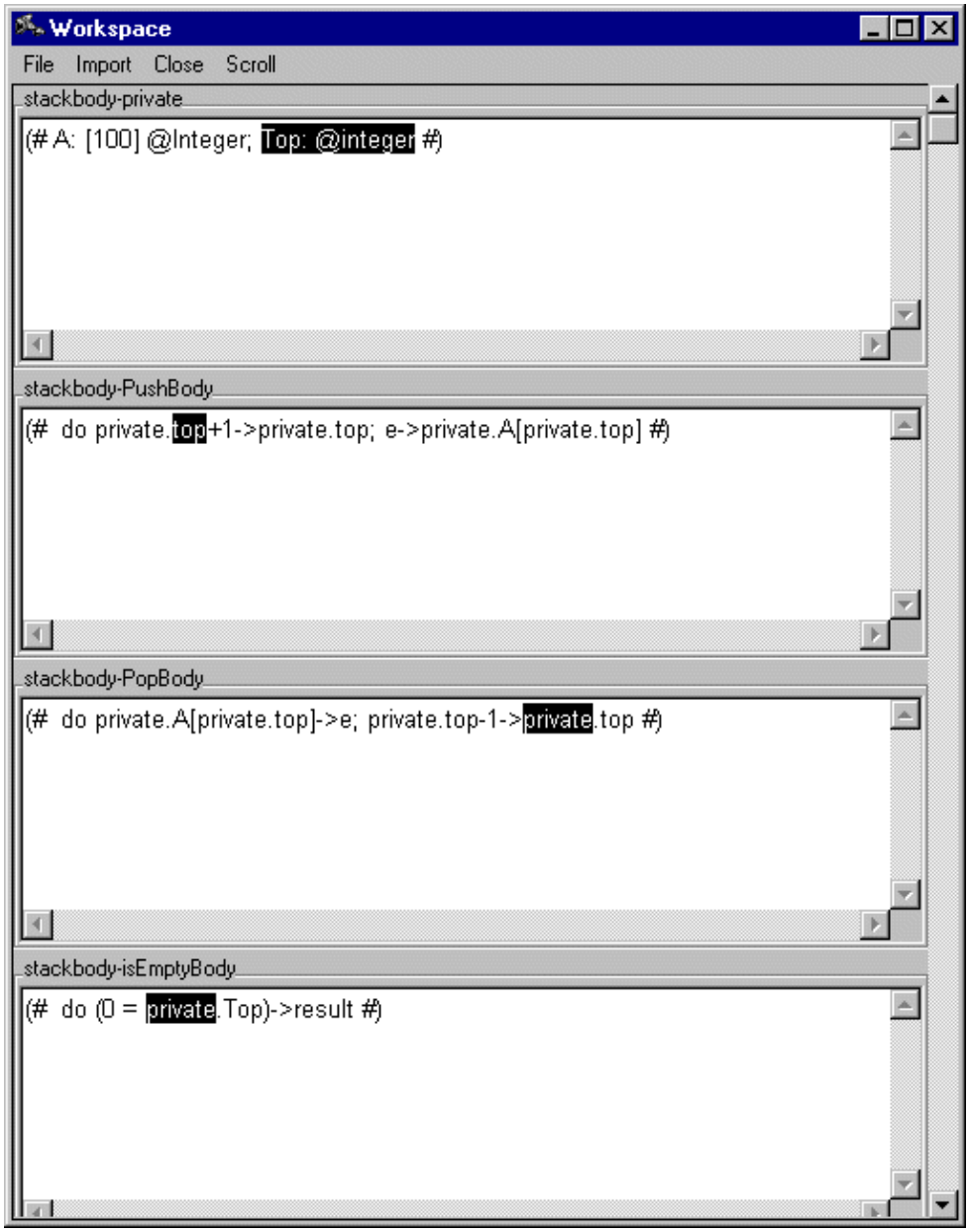
Workspace
File Import Close Scroll
stackbody-private
(# A: [100] @Integer; Top: @integer #)
stackbody-PushBody
(# do private.top+1->private.top; e->private.A[private.top] #)
stackbody-PopBody
(# do private.A[private.top]->e; private.top-1->private.top #)
stackbody-isEmptyBody
(# do (0 = private.Top)->result #)

Figure 34

CASE Tool

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CASE Tool

How to Get Started

Freja is launched from within the Mjølner tool one of the following ways:

- In the source browser select *Diagram:New Diagram...* to create a new diagram and corresponding source code.
- In the source browser open a BETA fragment form. Select *Diagram:Show Diagram* to display a reverse engineered diagram of the code in the fragment form. Note that relations, like specializations and associations, will only be reverse engineered if the fragment has been checked (e.g. using *Compile/Run:Check*). Also note that if a diagram already exists for the selected fragment this will be opened and possibly be updated.
- In the source browser open a BETA fragment form. Right-click anywhere in the code editor and select *Show Diagram* from the popup menu. This will have the same effects as mentioned above.
- In the source browser select *Diagram:Open Diagram...*. An *Open File* dialog is launched. From here select either a diagram file (with .diag extension) or select a BETA fragment file (.ast, astL or .bet extension).

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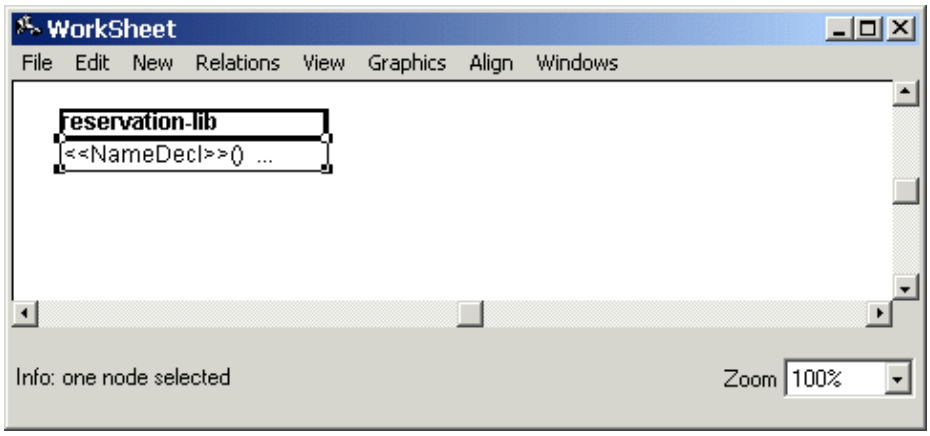
CASE Tool

Editing

Creating a New Diagram

To create a new diagram use *Diagrams:New Diagram...* in the source browser. Below the command New BETA program has been used:

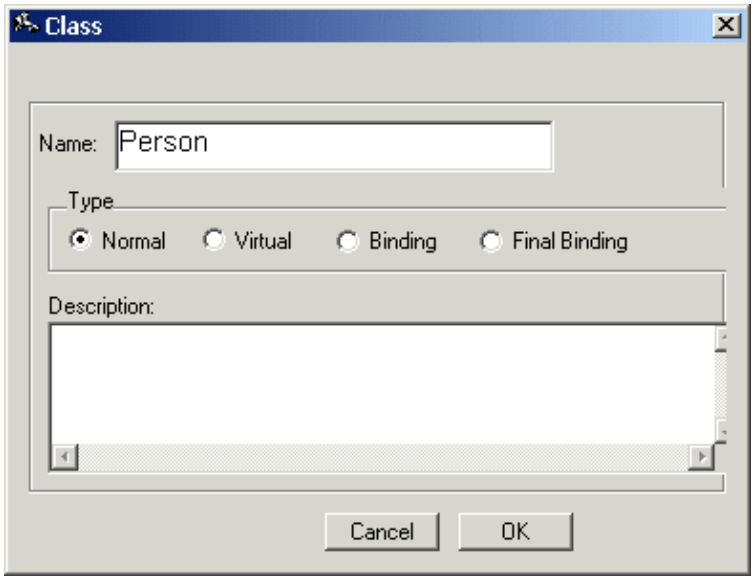


The title of the diagram corresponds to the name and the category (attributes) of the new BETA fragment:

```
ORIGIN '~beta/basiclib/betaenv';
INCLUDE '~beta/freja/associations';
-- lib: Attributes --
<ltNameDecl>gt: (#  #)
```

Creating a New Class

When an attribute or a title of a diagram is selected it is possible to create a new class using the Class command in the *New* menu [**tip:** you may also right-click the class or attribute and select *New:Local Class...* from a popup-menu]. Doing this you get a dialog where the name of the new class can be typed in.

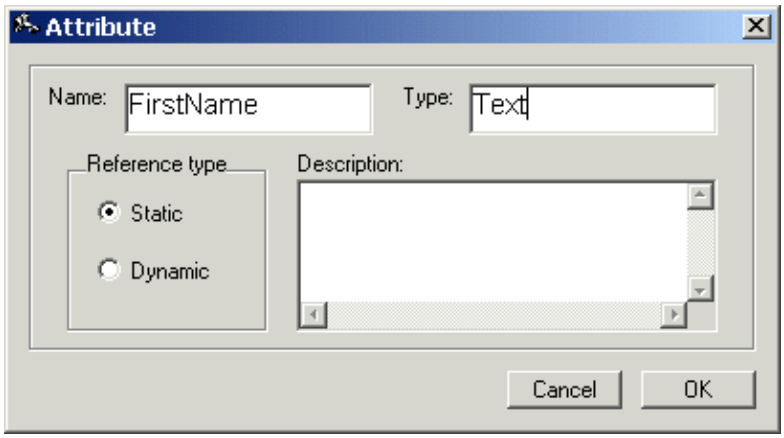


The BETA code corresponding to new class looks like this:

```
Person:(# #)
```

Adding Attributes and Operations

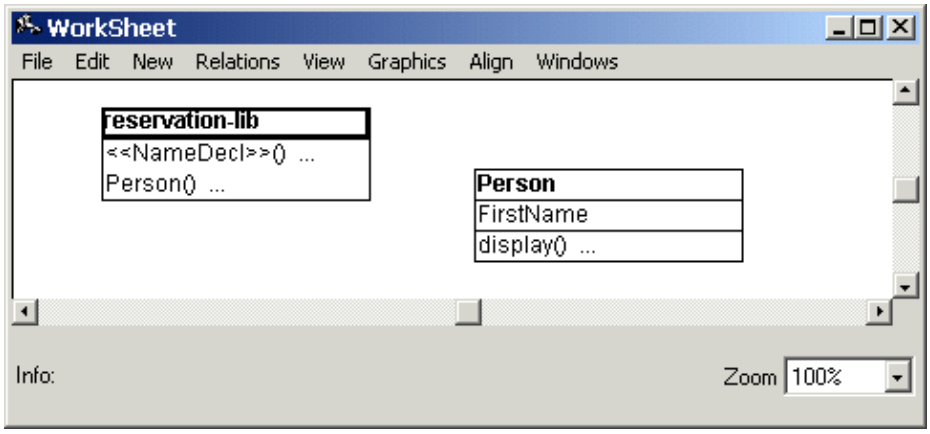
To add an attribute to a class, select the class and use *New:Attribute...* [**tip:** you may also right-click the class and select *New:Attribute...* from a popup-menu]. As above a dialog is presented and you can now type in the name of the new attribute.



The corresponding BETA code looks like this:

```
Person(# FirstName: @Text #)
```

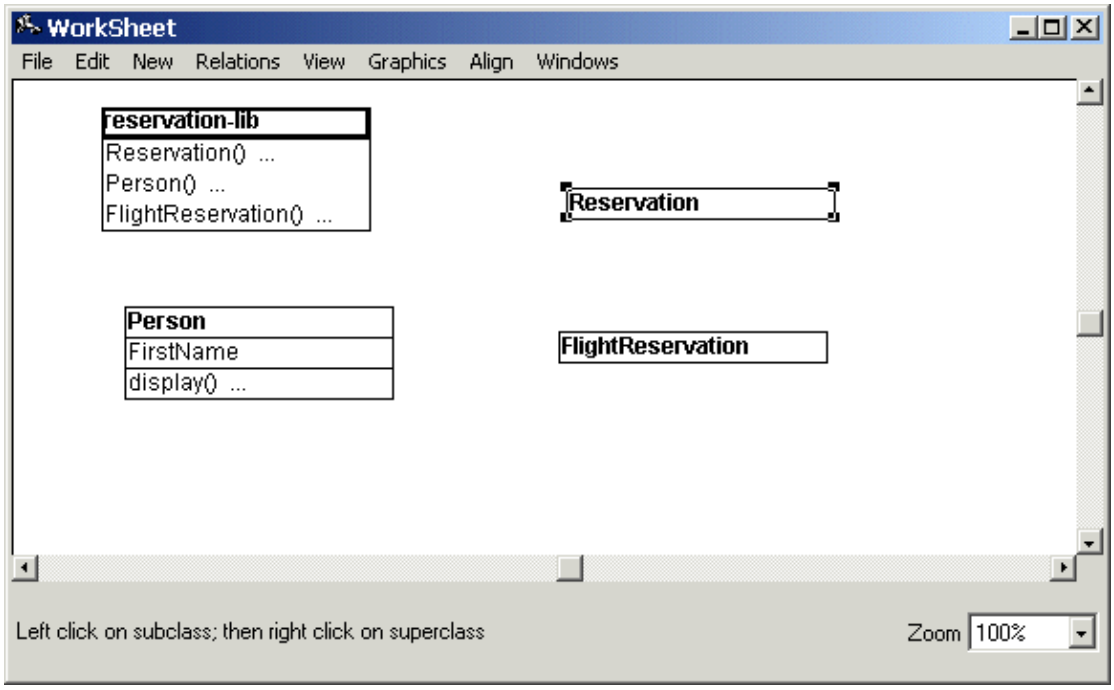
In the same manner as with attributes a new operation "display" can be added to the class using *New:Operation...*. This makes the diagram appear as follows:



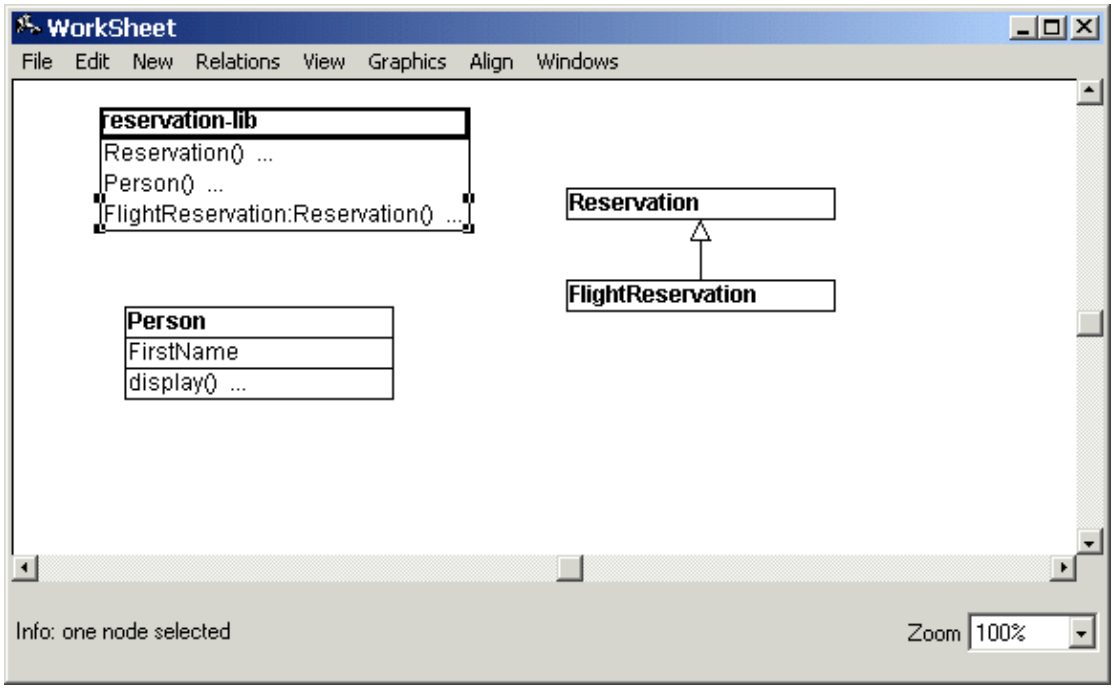
Notice the first item in the diagram, ..., is still there. This is meant as first template for a new class (the >part is a placeholder for the name of the class). In this case, where we have already created a new class using *New:Class...*, we could just delete this first item by selecting it and using *Edit:Clear*. However, we can also choose to use it as a template for a new class. To do this, select it and use the *Edit...* entry of the right-click popup-menu to replace "with the name "Reservation".

Specifying Specialization

In the following situation one class further, FlightReservation, has been added to the diagram. To specify that FlightReservation is a subclass of Reservation the *Specialization* command of the *Relations* menu is used. As the status message of the menubar states in the example below it is now possible to create a specilization by clicking the left mouse button on the subclass and hereafter clicking the right mouse button on to the superclass.



The result will look like this:



The code correspondingly changes from:

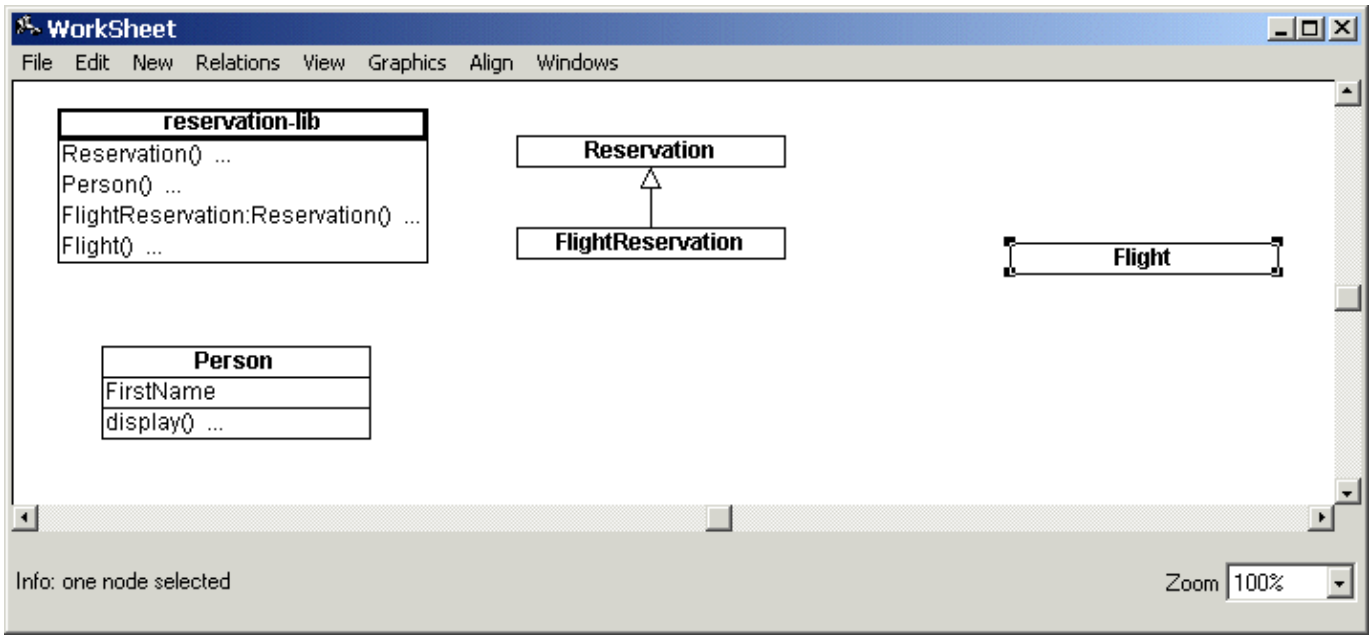
```
Reservation: (# ... #);
FlightReservation: (# ... #);
```

to:

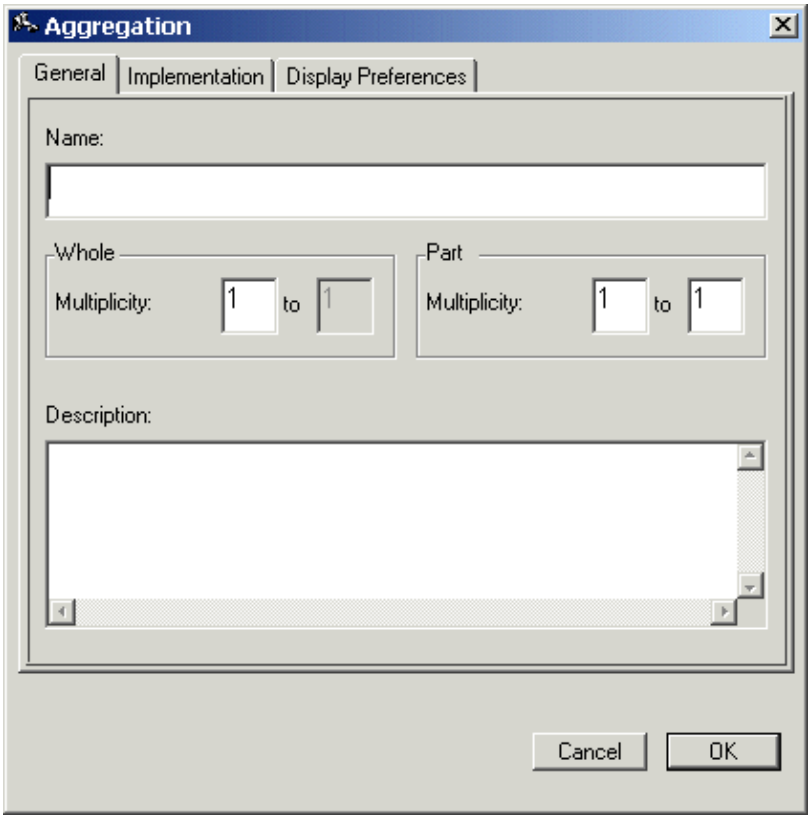
```
Reservation: (# ... #);
FlightReservation: Reservation(# ... #);
```

Specifying Aggregation

Below the class Flight has been added to the diagram.



We wish to specifify a by-reference aggregation between FlightReservation and Flight. To do this select *Aggregation* in the *Relations* menu. This brings up the following dialog:

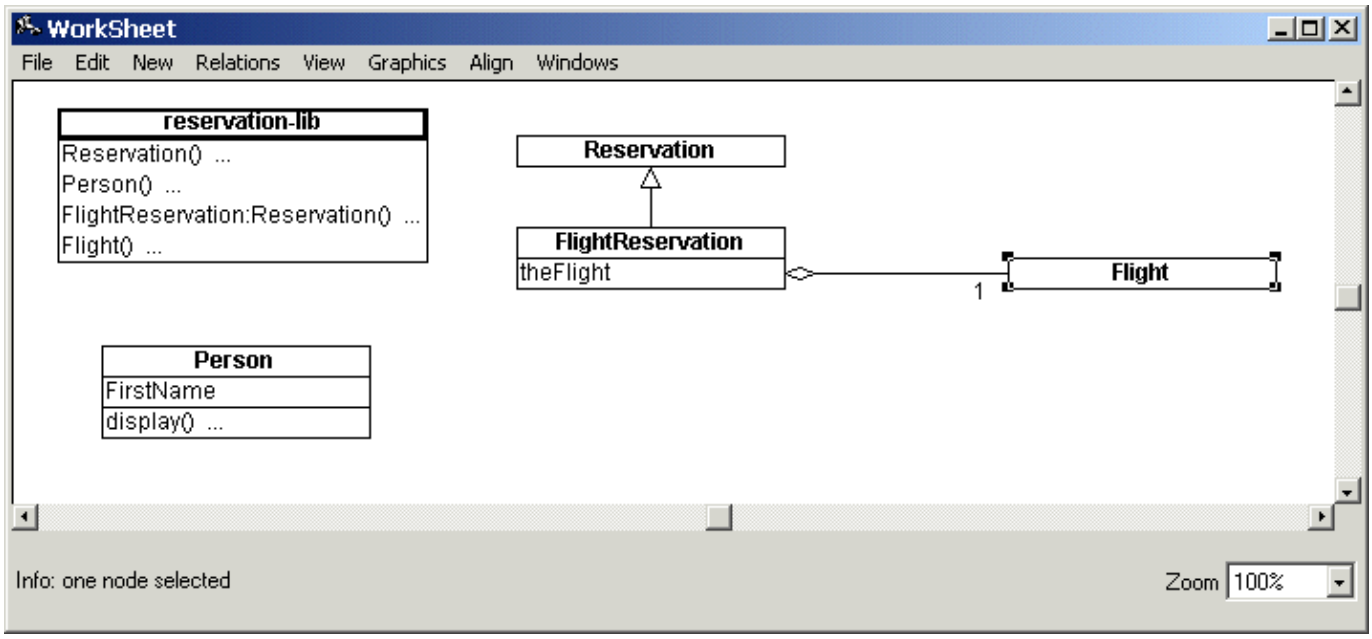


The aggregation dialog makes it possible to:

- give the aggregation a name
- specifify the multiplicities of the whole and the part
- specify the implementation of a one-to-many[1] aggregation; that is to specify if a repetition or one of the basic container classes should be used in the resulting code (using the *Implementation* tab)
- specify if the aggregation is to be implemented by-reference or by-value (using the *Implementation* tab)
- give a textual description of the aggregation
- set a number of preferences for the visual presentation of the aggregation (using the *Display Preferences* tab)

In this example we only specify the name of the aggregation (defaults are such that we get a one-to-one by-reference aggregation).

After choosing *Ok* in the dialog left click on the class designating the whole (FlightReservation) and, after that, right click on the class designating the part (Flight).



The BETA code correspondingly changes from:

```
Flight: (# #);
FlightReservation: Reservation(#  #)
```

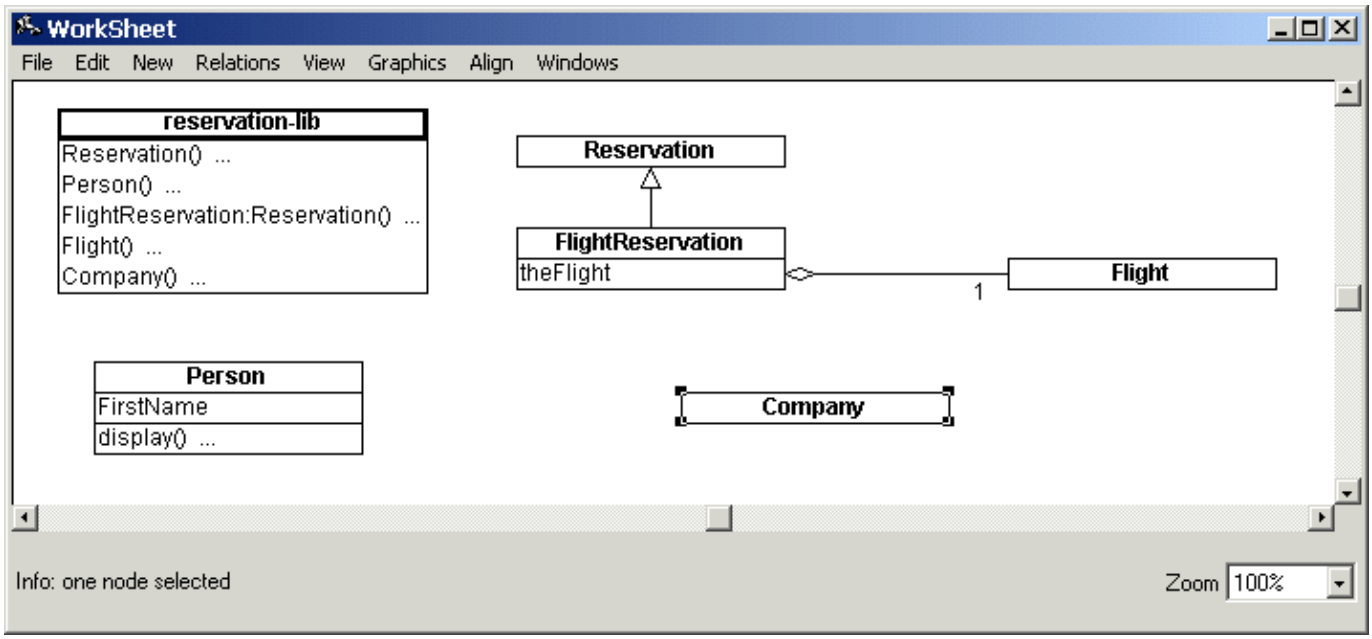
to:

```
Flight: (# ... #);
FlightReservation: Reservation(# theFlight: ^Flight #)
```

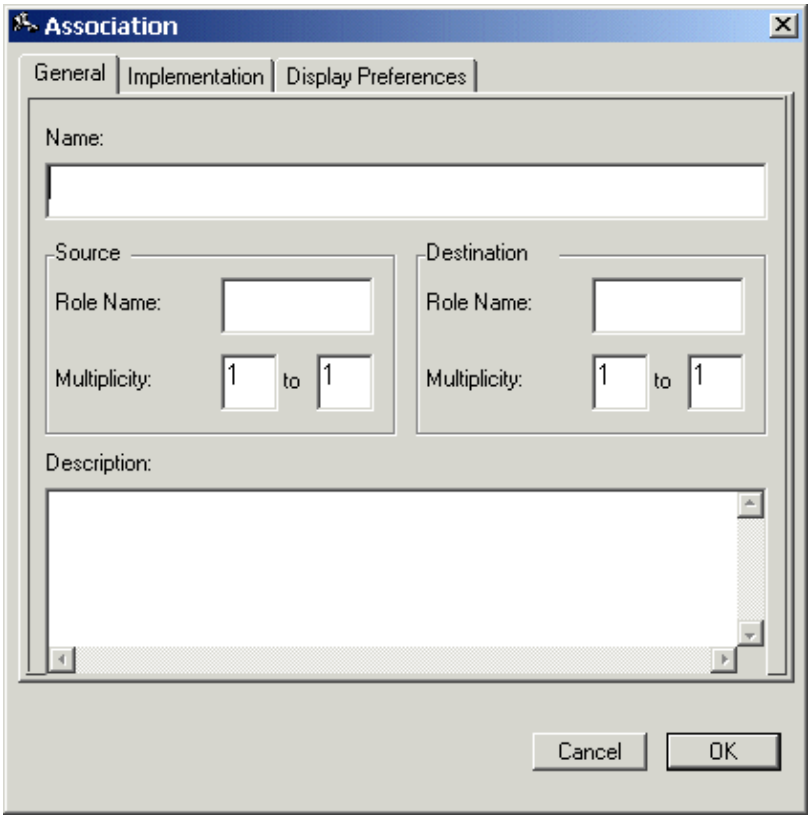
As can be seen the name of the aggregation is reused in the code and the fact that we created a by-reference aggregation is reflected by the dynamic reference implementation of the new declaration (had we instead chosen by-value a static reference would have been declared).

Specifying Association

Below a new class Company has been added to the diagram.



We wish to specify a one-to-many association between Company and Person. To do this select *Association* in the *Relations* menu. This brings up the following dialog:

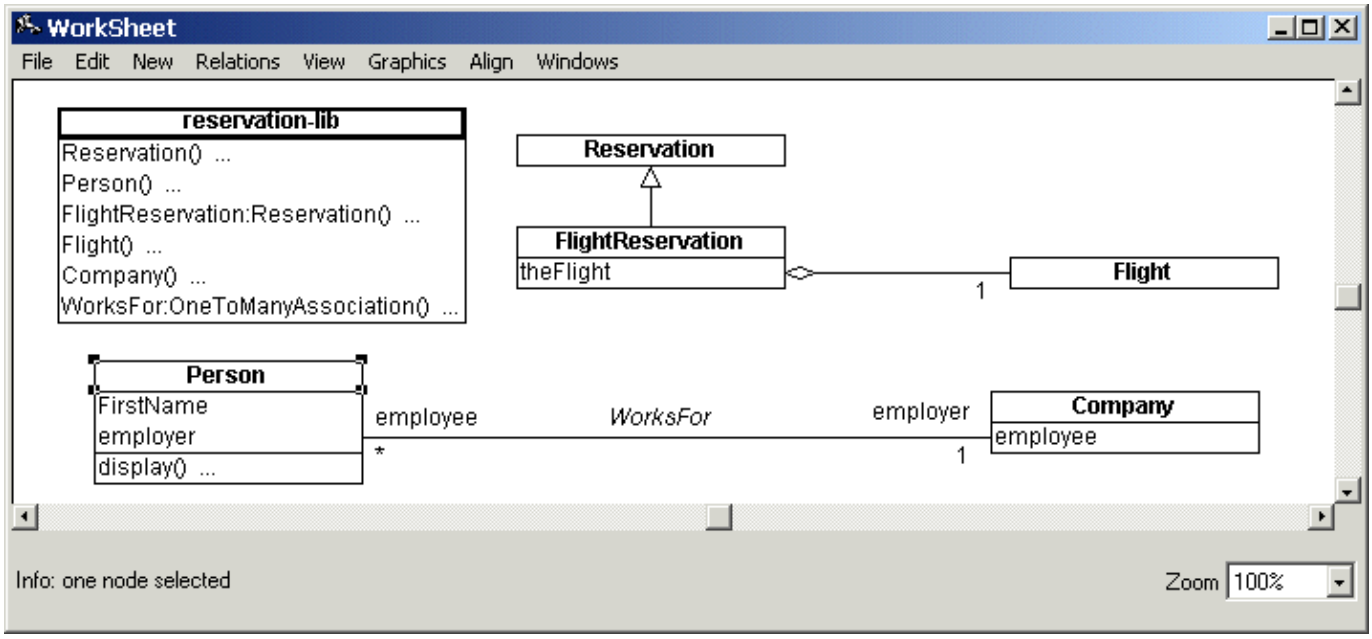


The Association dialog makes it possible to:

- give the association a name
- specify role names for both sides of the association
- specify multiplicities for both sides of the association
- specify if the association should be embeded or not; that is to specify if the generated code is to result in a separate association class or if it is to be embedded in the source and destination classes (using the *Implementation* tab) (see below)
- give a textual description of the association
- set a number of preferences for the visual presentation of the association (using the *Display Preferences* tab)

In this example we specify the name of the association, WorksFor, the name of the source role, employee, the name of the destination role, employer, and the multiplicities. Specifying that the multiplicity of the employee end of the association is more than one (in this case '*') automatically sets the implementation to the default, List.

After choosing *Ok* in the dialog left click on the class designating the source (Person) and right click on the class designating the destination (Company).



The resulting code looks like this:

```
Person: (# ...; employer: ^WorksFor #);
Company: (# employee: ^WorksFor #);
WorksFor: OneToManyAssociation
  (# oneType:: Company; manyElmType:: Person #)
```

Where the things added to code are the employer and employee declarations and the WorksFor class.

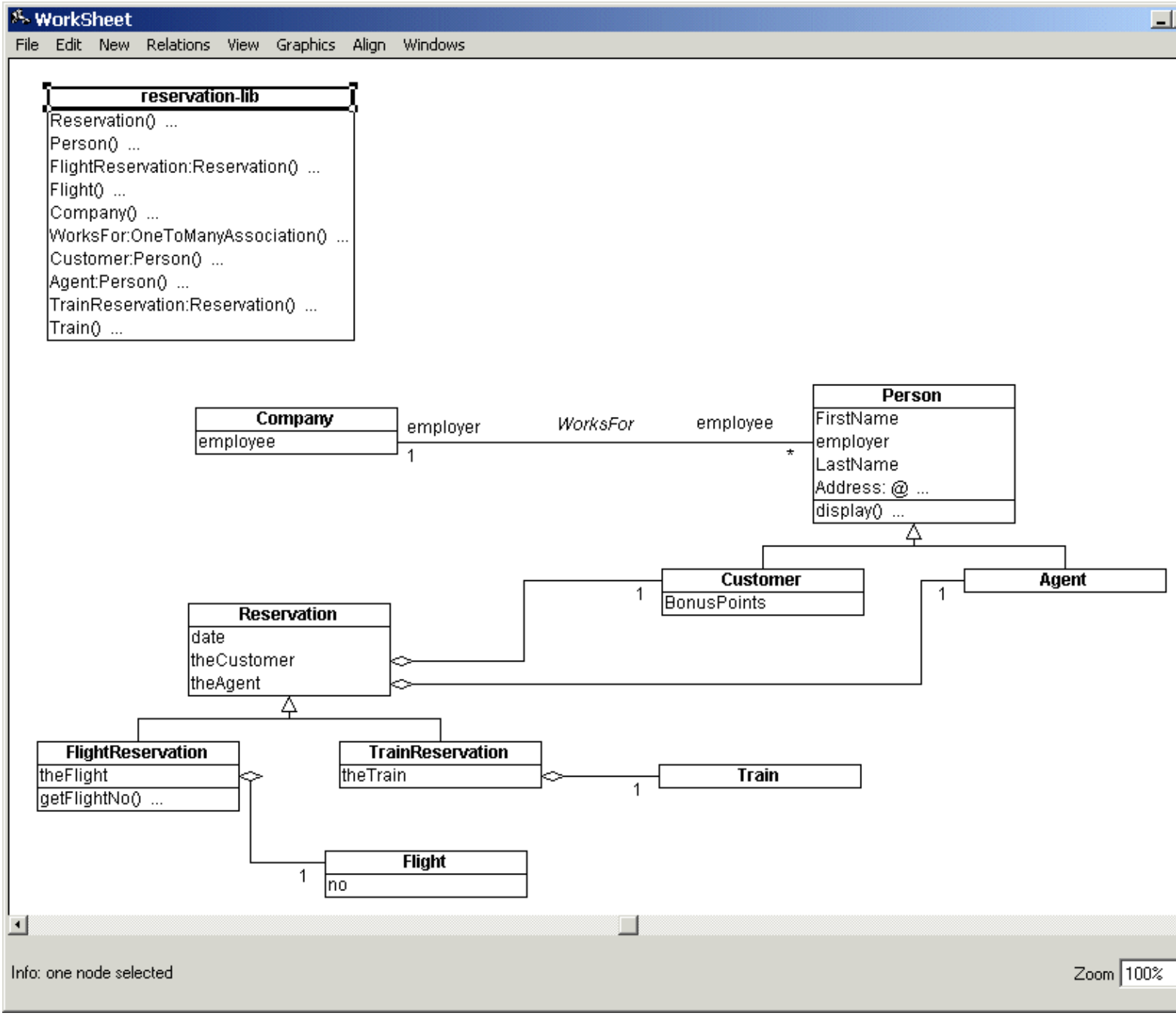
Had the embed option been chosen the code would have looked like this:

```
Person: (# ...; employer:@AssociationOne(# element:: Company #) #);
Company: (# employee:@AssociationMany(# element:: Person #) #)
```

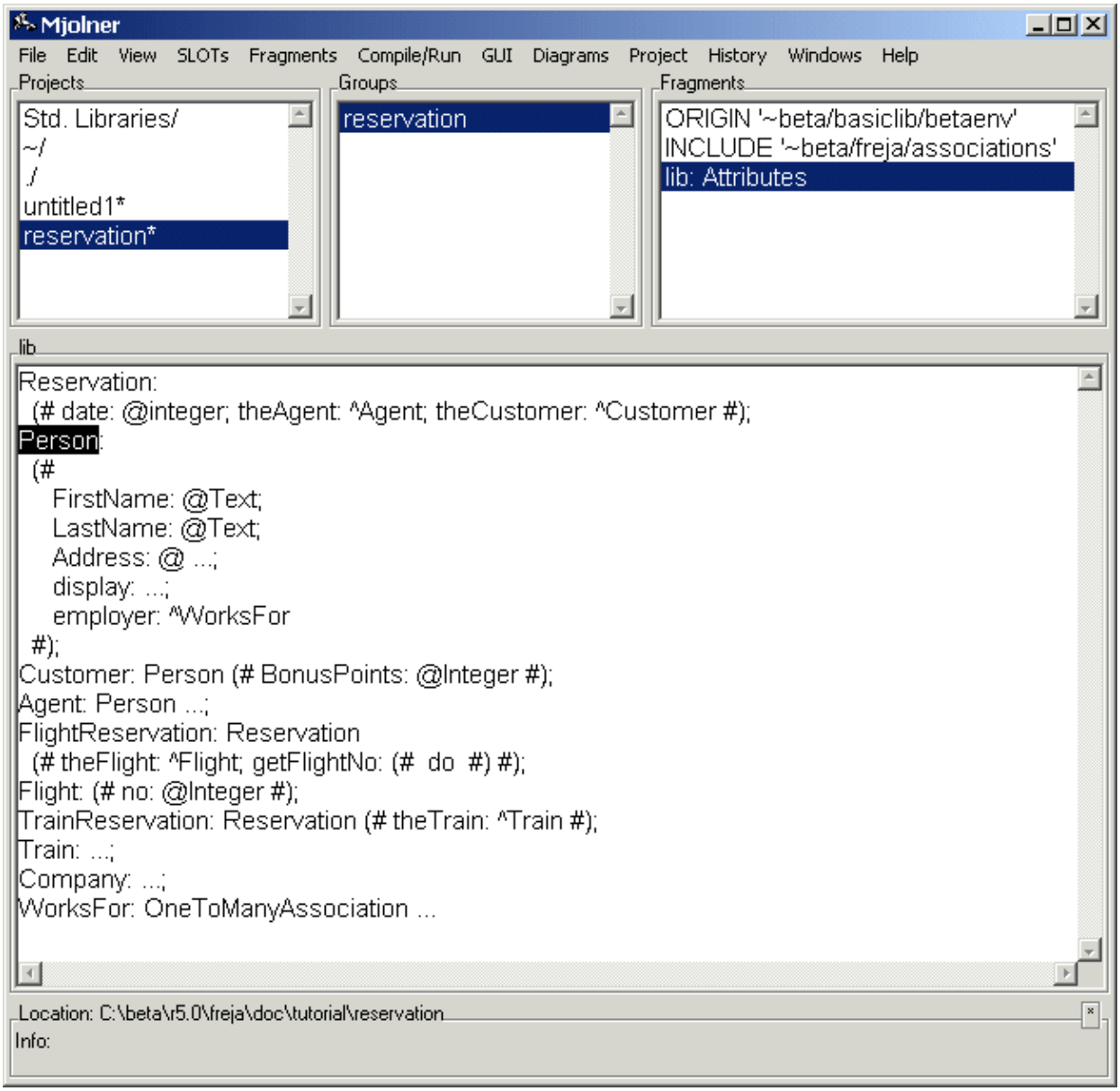
Notice that in this case no separate association class is generated.

Completing the Code in Code Editor

Consider the following design diagram which could be considered as complete at the design level:



To fill out the code details, the code editor, the textual representation editor must be activated:



The textual representation of the design might, however, not be complete. For example, it still contains operations with empty do-parts. To fill out the do-part of the getFlightNo operation in the FlightReservation Class select the entire getFlightNo pattern in the code editor. Enter text edit mode and type in the appropriate action sequence. For example:

```
getFlightNo:
  (#
     do theFlight.no->putint
   #)
```

Notice: When entering text edit mode with the entire getFlightNo pattern selected we are warned that such editing *might* have the consequence that parts of the diagram have to be rebuildt. In this case, however, we choose to ignore the warning and enter text edit mode anyway. As it turns out the diagram was not affected at all by the edit because only a do-part was changed (action sequences do not have a visual representation in the diagrams; only static structures have).

After filling out more code in the code editor, e.g. further action sequences of the objects, the compiler is activated in the *Compile/Run* menu of the code editor.

If the compiler reports a semantic error, the corresponding node is also selected in Freja.

When the program is semantically correct and it can be executed and tested. In this phase Freja will typically not be activated. When the program has been tested and considered fulfilling the requirements, the design diagrams may have become obsolete, and need to be updated, i.e. reverse engineering is necessary. This is done by activating Freja on the BETA program.

---

[1] An aggregation is said to be one-to-many if the multiplicity of the part is one and the multiplicity of the whole is more than one.

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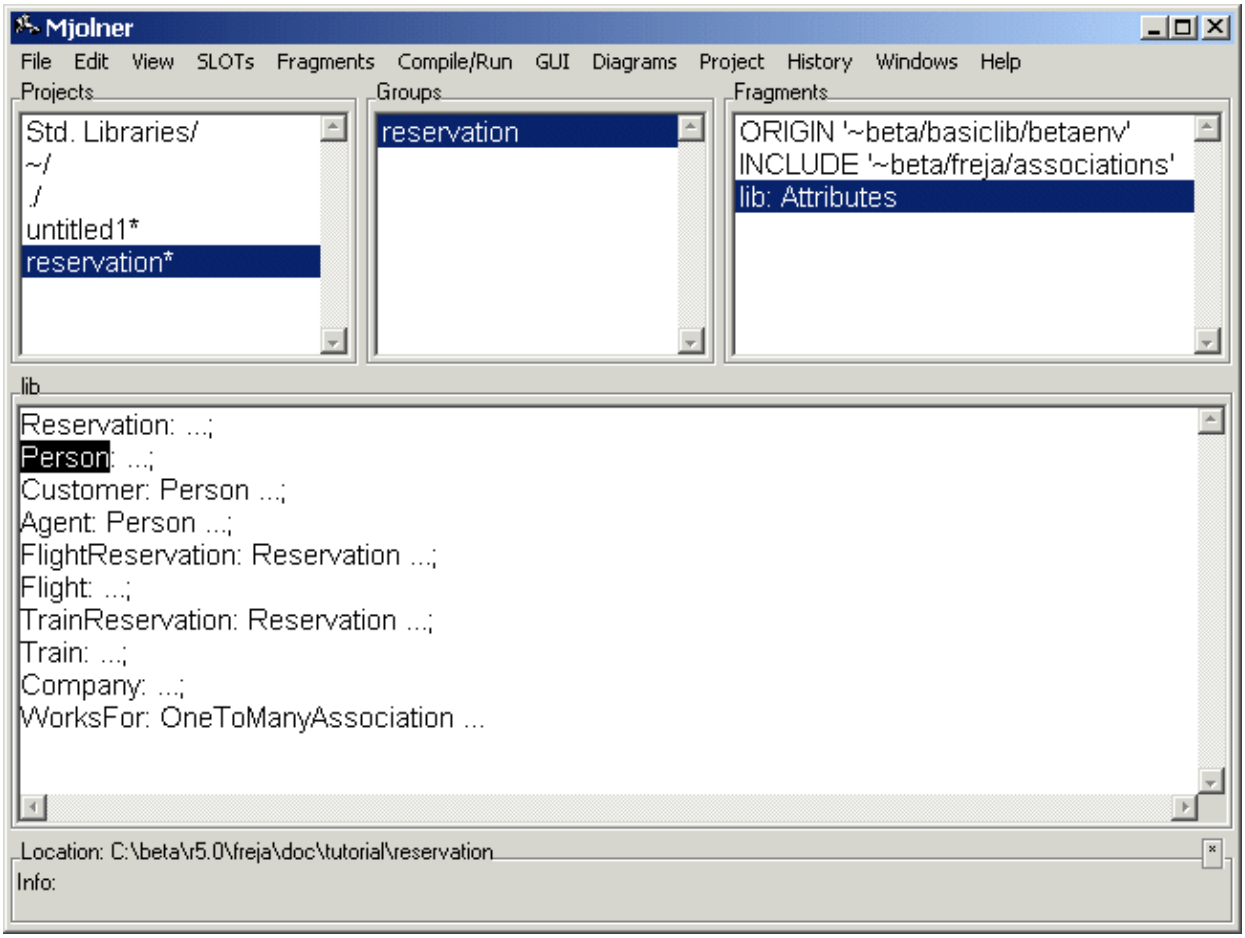
CASE Tool

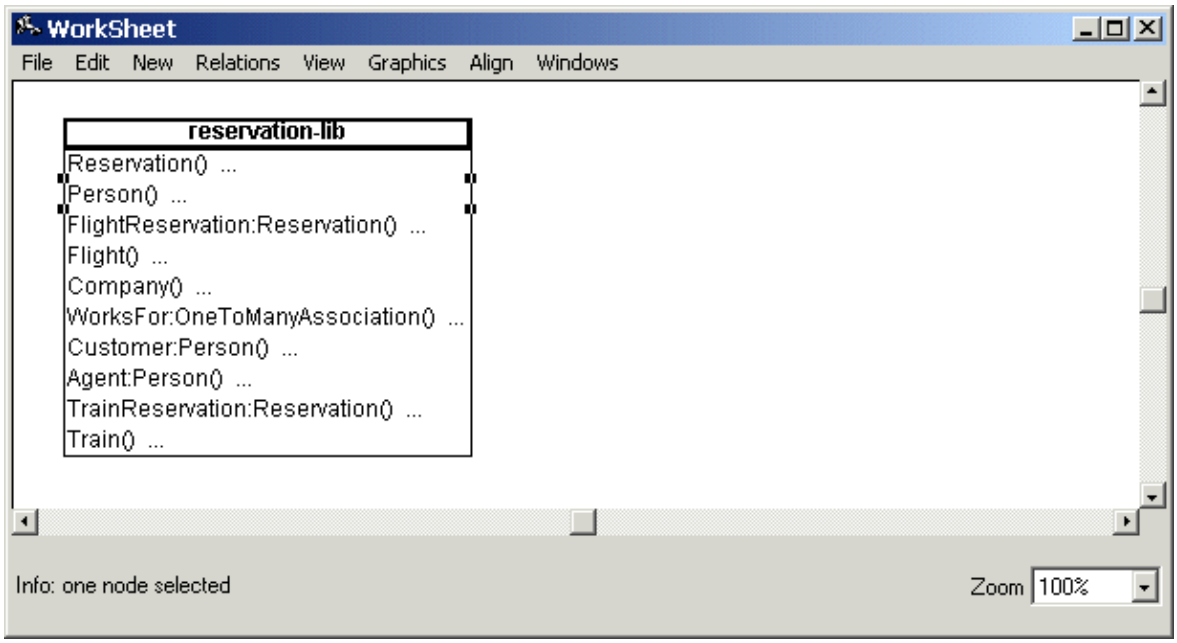
Reverse Engineering

Class Diagrams

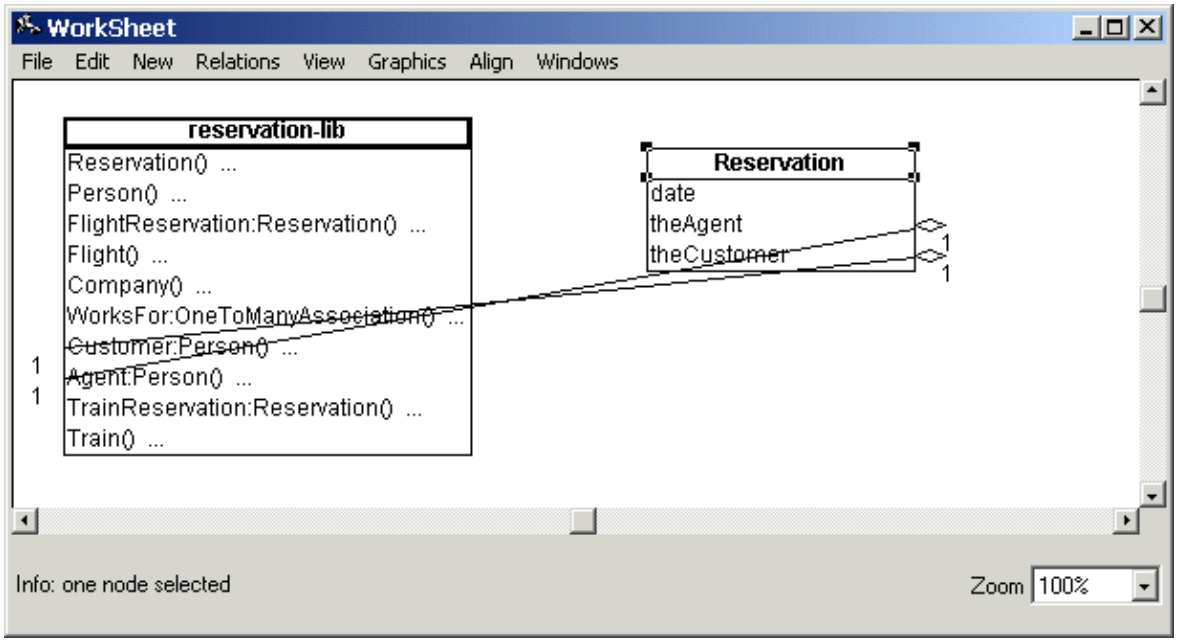
To extract the design diagrams from the BETA code, the program is opened in the CASE tool. Consider the following program shown in the code editor:



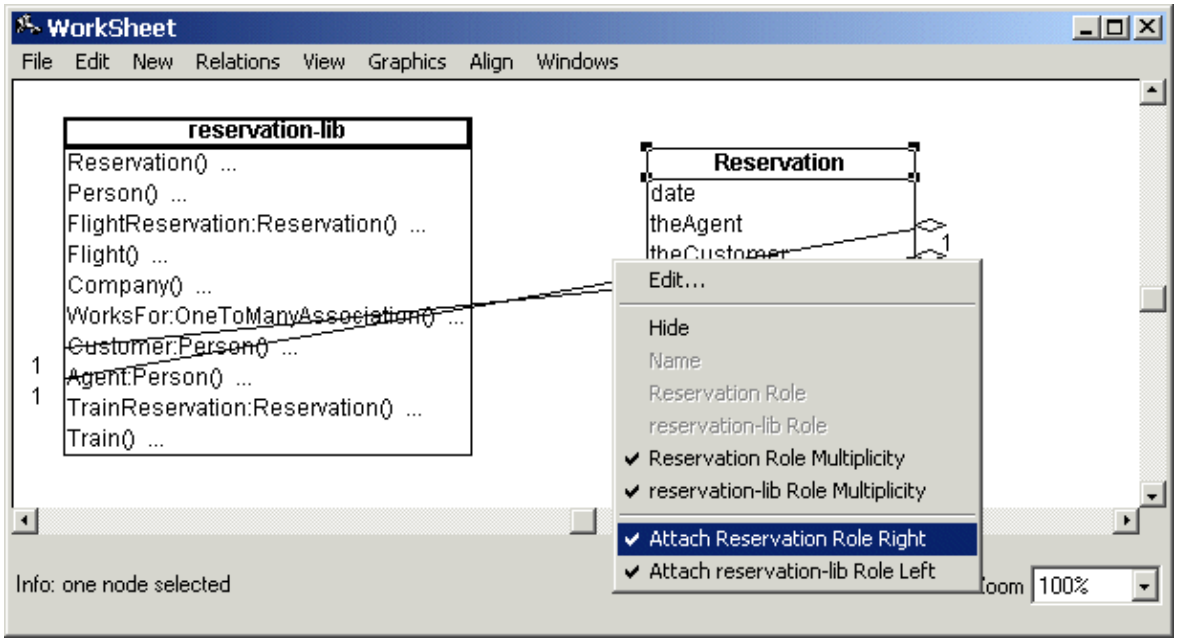
When opening this program in Freja the following diagram initially appears:



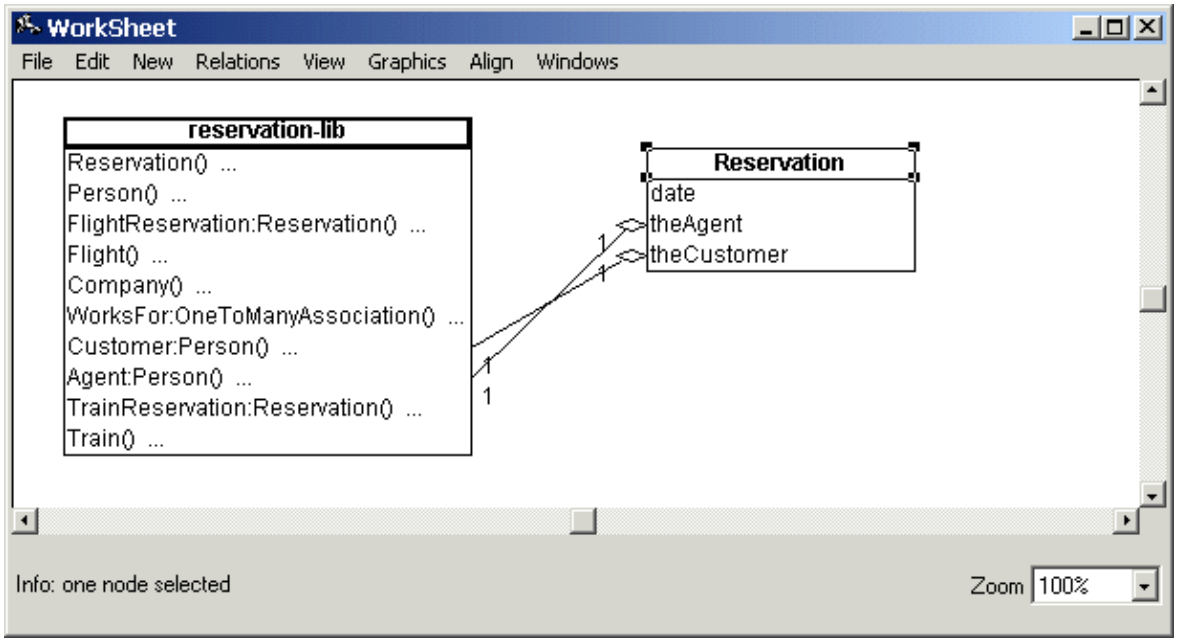
This is an abstract design view of the program. A detailed design diagram can be obtained by detailing selected parts of the diagram. If an entry contains three dots (...) it can be detailed. Below the class Reservation is detailed by double-clicking on the Reservation attribute:



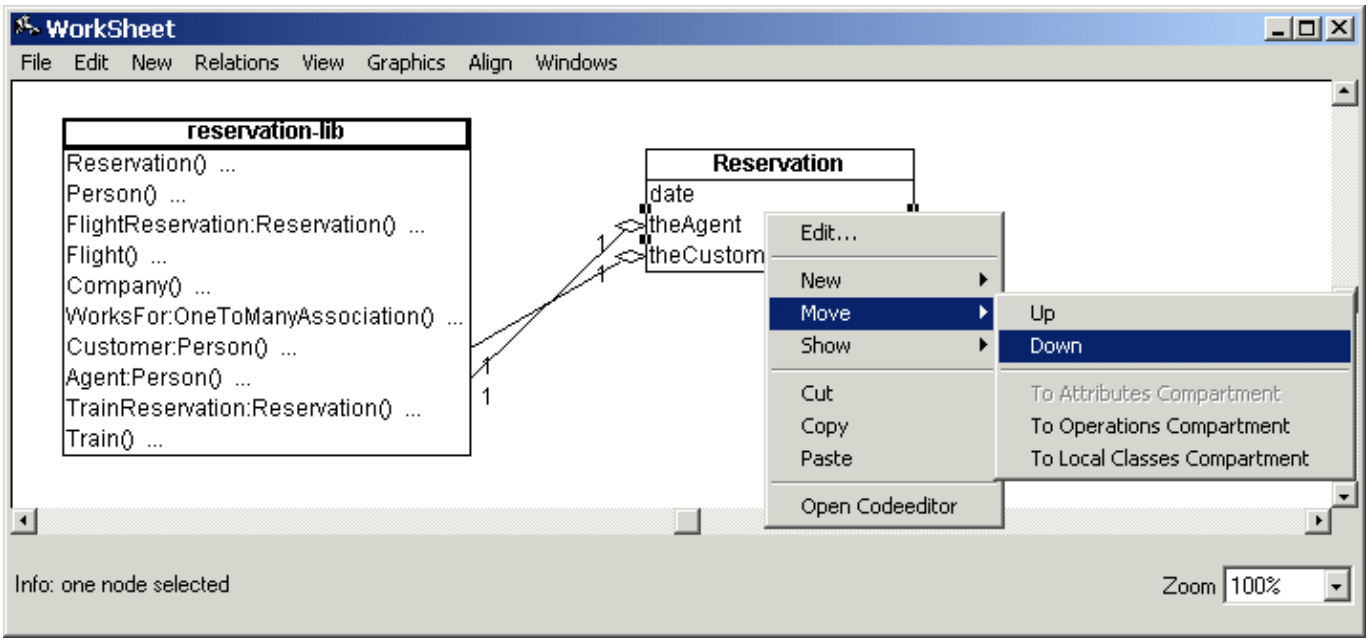
This intial layout of course can be changed to make the diagram appear graphically more appealing. To prevent the shown association connectors from crossing over the class boxes, point the mouse cursor to a connector and right-click it to get a popup-menu:



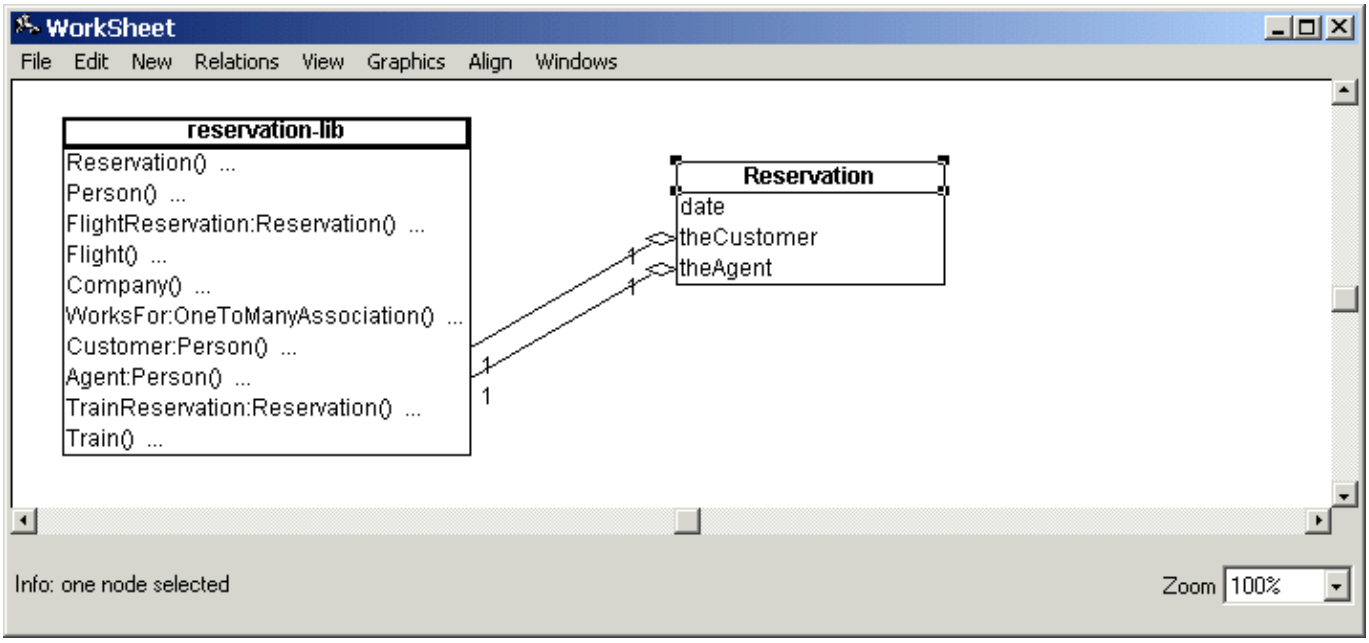
Select the checked item, *Attach Reservation Role Right*, to make one end of the connector attach itself to the left side of the class instead of the right. Repeat this operation to change the other points of attachment of the two connectors, to make the diagram look like this:



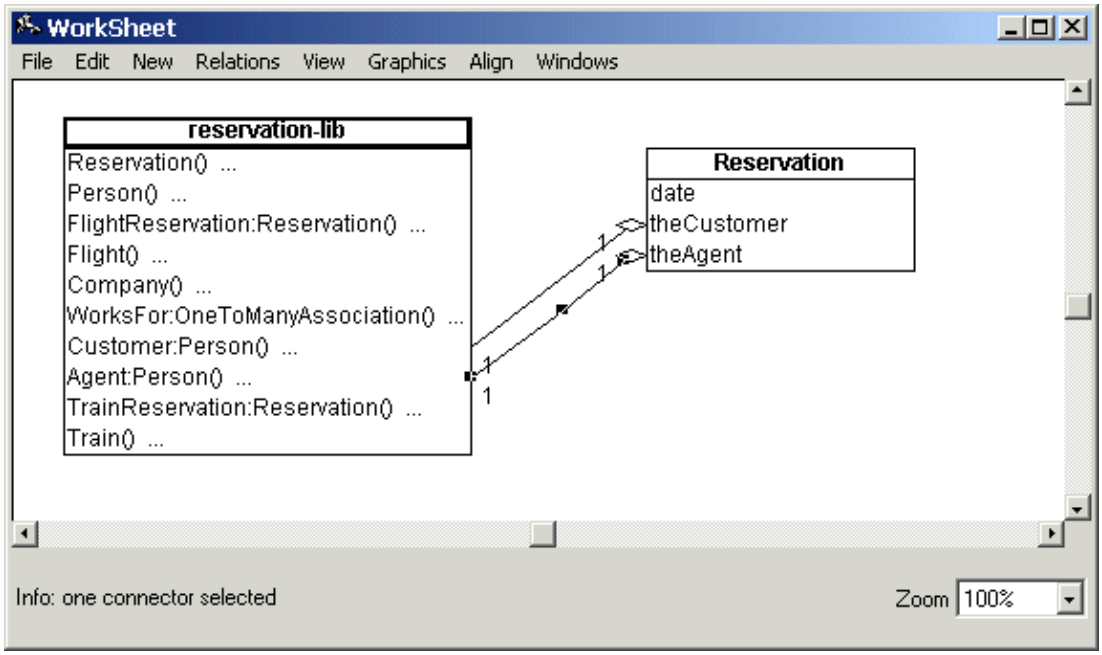
To prevent the two connectors themselves from intersecting one of the endpoints has to be moved. Right-click the attribute theAgent of the Reservation class:



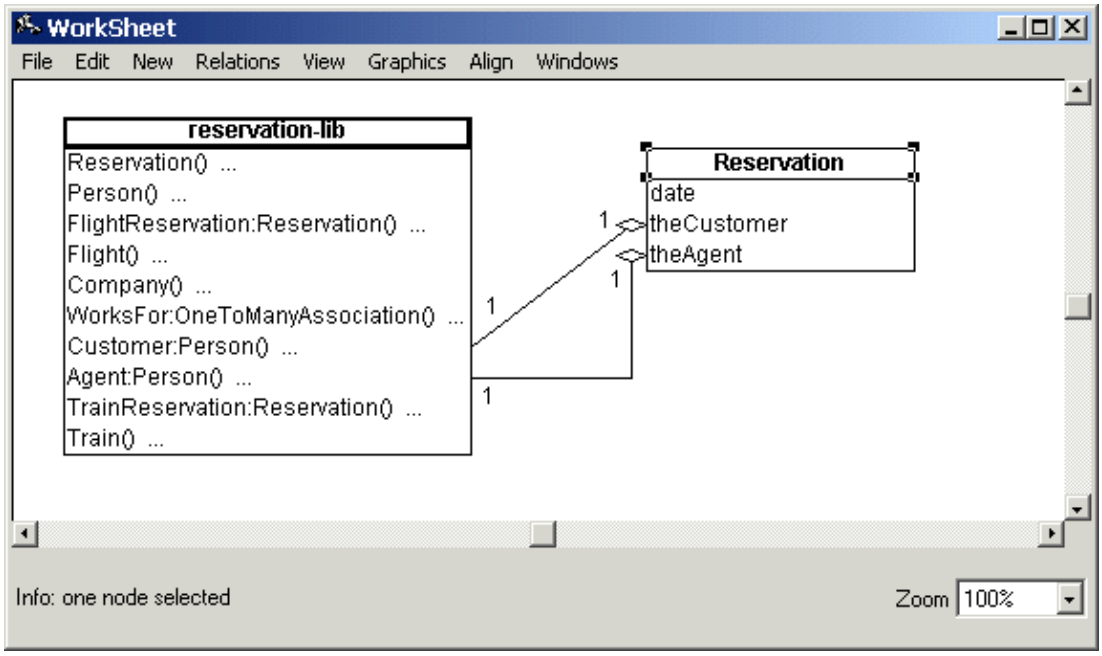
Select *Move:Down* to move the attribute one position down in the class box:



To further visually seperate the two connectors, you might want to bend one connector away from the other. This can be done by inserting a new edge somewhere on the line constituting the connector you wish to bend. To do this, double-click the connector in the place where you want the new edge inserted:



A small rectangular dot appears where the edge was inserted and this new dot can now be dragged to a new position to obtain the desired bending of the connector:



Further classes may be detailed and the layout adjusted in ways similar to above.

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CASE Tool - Tutorial

The Notation

The graphical design notation used in the CASE tool, Freja, is UML.

UML is the result of the efforts of Jim Rumbaugh, Grady Booch and Ivar Jacobson[2] to unify their methods: OMT (Object Modeling Technique), Booch and OOSE (Object-Oriented Software Engineering).

The current version of Freja supports Class diagrams.

The class diagrams illustrate the static structure of the model with symbols for class, aggregation, association and specialization. In Freja design diagrams and code are tightly integrated. As a consequence class diagrams can also be seen as an illustration of the static structure of a BETA program. In this sense UML class symbols correspond to BETA patterns, UML aggregations to BETA whole-part and reference compositions and UML specializations to BETA specializations. A symbol that is not directly found as a language construct in BETA is an association.

The most recent updates on the Unified Modeling Language are avialable via the worldwide web: http://www.rational.com.

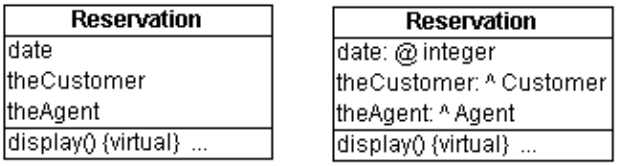
---

[2] All employees of Rational Software Corporation

Class Diagrams

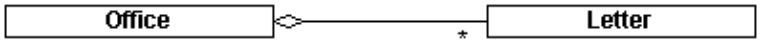
Class

A class is shown as a box with a title (the name of the class) and an optional list of local attributes, operations and classes. The two class symbols shown below are actually two different views on the same class (Reservation). The left symbol showing only the names of the attributes and the right symbol showing full type information of the attributes. In the following examples one or the other view will be used depending on the illustrative purposes of the example.



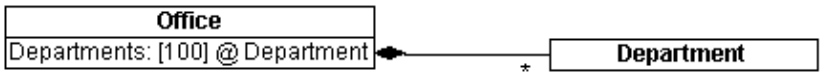
Aggregation

Aggregation is shown as a line connecting two class symbols. A diamond is attached to one end of the line. The diamond is attached to the class that is the aggregate.



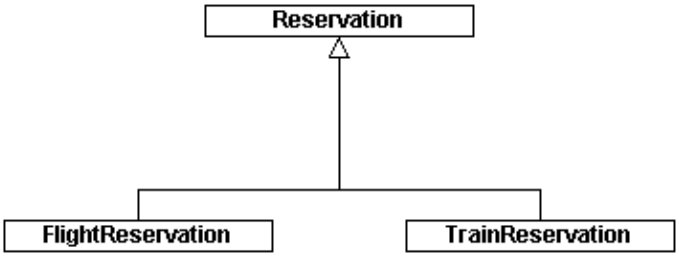
Multiplicities are shown at each end of the aggregation. Multiplicities may either by an integer value or an integer interval on the form lower-bound...upper-bound. In addition, the star character (*) may be used for upper-bound, denoting an unlimited upper bound. In the above example the multiplicities mean that an office may contain zero or more letters.

The diamond attached to the aggregate may either be hollow or filled. If it is hollow the implementation of the aggregation is said to be by-reference and if it is filled it is said to be by-value. The first case corresponds to reference composition in BETA, the second to whole-part composition.



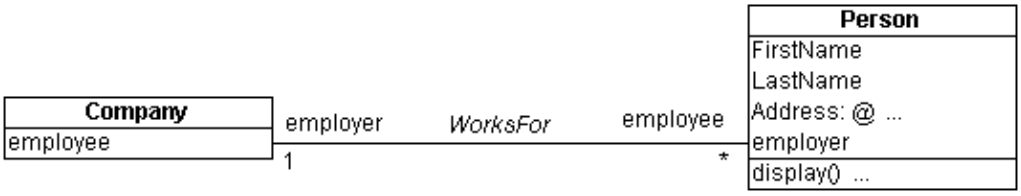
Specialization

Specialization is illustrated as a tree of class symbols. A line is drawn between the subclass and the superclass with an arrow at the end connected to the superclass.



Association

An association is shown as a line connecting two class symbols.



Multiplicities are shown on each end of the association. The syntax of the multiplicities on associations is exactly the same as the syntax of the multiplicities on aggregations. In the above example the multiplicities mean that a company may be associated to zero or more persons through the relation works-for and a person is related to exactly one company (i.e. in this example a person may not have more than one employer).

Apart from multiplicities role names may be attached to each end of the association. A role name indicates the role played by the class attached to the end of the line near the role. For instance in the above example the role of a company seen from the view of a person is an employer (and vice versa).

Finally the association may be given a name. In the above example the name of the association is WorksFor.

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The Notation

Object Diagrams

Static Object

Rounded box in solid linestyle. If the object is pattern-defined the name of the pattern is shown following the ':' after the name of the object. If the object is singularly defined only the name of the object is shown.

<<fig>>

Dynamic Object

Rounded box in dashed linestyle. The name of the pattern that the object is an instance of is shown inside the box.

<<fig>>

Notice:

A dynamic object is shown inside the object where the corresponding pattern is defined and not where the object is created ('the dynamic object is shown where it conceptually belongs').

Operation

Ellipse in a dashed linestyle. The name of the operation is shown inside the ellipse. Detailed operations are for practical reasons shown as rounded boxes in a dashed linestyle. Detailed operations can be distinguished from detailed dynamic objects through the fact that the text '(PROC)' is appended to the name of the operation when it is detailed.

<<fig>>

Active Object

Both static and dynamic objects can be active ('have an execution thread of their own', components in BETA terms). These are shown with two parallel lines inside the object - one in each side.

<<fig>>

Dynamic Object Creation

Arrow in dashed linestyle. Going from the creating object to the created dynamic object.

<<fig>>

Operation Call

Arrow in solid linestyle. Going from the calling object to the called operation.

<<fig>>

Composition

Currently only whole-part composition is displayed in the object diagrams. In the notation, part objects are simply shown nested inside their enclosing objects.

<<fig>>

Interface Builder

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Interface Builder

An Example Application

This tutorial will demonstrate how to use Frigg to make a small address book application. The application is structured into three parts:

addressbook The classes that defines the data objects in the application.

addressbookgui The classes that defines the graphical user interface.

addressbookappl The controlling application that ties the data model to the graphical user interface.

The data model is created in Freja (Mjølner BETA CASE tool). The following diagram describes the data model for the addressbook application:

<<fig>>

The Freja manual can be consulted to get an explanation of the graphical notation used in the diagram.

Here is a short description of the classes in the diagram:

addressbook Has a list of persons.

person Has a number of simple attributes: name, CPR etc., a reference to the current address, and a list of occupations.

address Simple attributes: Street, city etc.

occupation Can be teacher, student and employee. This part of the model is left out of the application for simplicity.

The addressbook model does not have visibility to the addressbookgui (i.e. it does not INCLUDE the addressbookgui fragmentgroup). This ensures that the addressbook data objects can be made persistent objects.

The addressbookgui does not know about the addressbook data model. This allows the addressbook user interface to be reused in other applications.

The addressbookappl includes both the data model and the user interface, and ties the two together.

The following sections will explain how to create the user interface and the application.

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Interface Builder

Creating the User interface

Creating the adressbookgui fragmentgroup

The sourcebrowser that are part of Frigg are activated by writing

frigg

in the command line (UNIX) or by double-clicking the Frigg icon (Macintosh).

Activating Frigg, the sourcebrowser window will appear:

<<fig>>

Here the addressbookgui fragmentgroup is already created. This was done by using the New Window Library command in the Interfacebuilder menu. This fragmentgroup has ORIGIN in guienvall and contains a GUIenvLib fragmentform. The GUIenvLib fragmentform can contain specializations of the window class in Lidskjalv (The Mjølner BETA user interface framework).

Creating the addressbook window

The addressbook window are created as a specialization of window via the Create Window command in the Interfacebuilder menu:

<<fig>>

In the create dialog the name of the window are entered and the inherits from popup menu are set to window. Pressing OK in the dialog the graphical editor window appears:

<<fig>>

The empty area with a border is the content area of the window. This area has been resized to the desired size by dragging the border.

The palette to the left of the content area contains the standard Lidskjalv window items, such as push-button and text field.

Adding items

The first items that will be added to the window, is simple text label and text fields. This is the fourth and the fifth item on the simple item palette. The items are added by dragging the items from the palette to the content area of the window.

<<fig>>

Here the items are added, and the text in the labels are changed to 'Name:', 'Phone:' and 'CPR:'. These changes are made via the 'Object Info Dialog' that are invoked by selecting an item and then choosing the 'Object Info' in the 'Edit' menu:

<<fig>>

The items are arranged in the window by using the alignment commands in the 'Align' menu.

Changing the Name

The items are given default names in the source code that looks like 'editText1' and 'staticText2', but since these items needs to be referred to in the application (in order to tie the user interface to the data model) it is a good idea to change the names. This is done by choosing the 'Edit Name' command in the 'Edit' menu:

<<fig>>

Here the name of one of the text fields are changed to 'nameField', which will be easier to remember later.

Compound items

The address part of the addressbook window are going to be a canvas, which is a compound item. This is the fifth item from the bottom on the palette. A canvas contains other items in its local coordinate system. Initially the canvas is empty, and then items can be added to the canvas. These objects move when the canvas are moved.

<<fig>>

Here the address canvas has been added. The object info dialog has been used to give the canvas an 'etched in' border. The 'Address:' label are not part of the canvas, but are added to the window.

The address fields 'street' and 'city' can now be added to the canvas by dragging from the palette to the canvas.

<<fig>>

Now the address fields are added. At the bottom of the window three push-buttons are added. They perform the main functions in the addressbook window. The other functions can be put in the menubar.

NOTE: The menubar can not be specified in the graphical editor. It will have to be coded in Sif, see the Lidskjalv manual for information about doing this.

Furthermore a separator is placed between the buttons and the 'address' canvas.

Now the user interface is complete. In the next section one way to tie the user interface and the data model together in an application, will be explained.

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Interface Builder Building the Application Structure of Generated Code The code generated by Frigg is divided into two different files: addressbookgui The public accessible portion of the window i.e. the declaration of the addressbook window. addressbookguibody The private attributes of the window. The addressbookgui fragmentgroup are named by the user when choosing the 'New Window Library' command. The body file is created by Frigg. A Sif editor is opened on the declaration of the addressbook window by selecting the content area of the window and choosing 'Open Subeditor' in the 'Edit' menu: <<fig>> All the items of the window are hidden in the private attributes of the window. These attributes can be edited in Sif by double-clicking <<SLOT addressBookWindowPrivate: descriptor>> The addressBookWindowPrivate fragment is located in 'addressbookguibody''. Here is a portion of this fragmentgroup:

```
ORIGIN 'addressbookgui'
-- addressBookWindowPrivate: Descriptor --
(# ...
   nameField: @editText
     (# open::<
```

```
          (#
          do (346,30)->size;
             (54,14)->position;
          #)
     #);
   addressGroup: @canvas
     (# streetField: @editText
          (# ... #);
        ...
     #);
   ...
#)
```

Extending the Public Interface

The interface of the addressBookWindow needs to be extended to allow the application to access certain parts of the implementation of the window.

In this example two principles will be used:

Text Fields: For each text field in the addressBookWindow a simple attribute is added to the interface of addressBookWindow that changes the content of the text field.

Push buttons: For each push-button, a virtual procedure is added that is called when the user presses the button.

In the following code this is done for 'nameField' and 'findBtn':

```
addressBookWindow: window
  (#
     nameField:
       (* Changes the content of the textfield 'NameField' *)
       (# theName: ^text
       enter theName[]
       <<SLOT enterNameField:DoPart>>
       #);

     onFind:<
       (* Is called when the user presses the 'Find' button *)
       (#  do INNER #);
     ...
  #)
```

The implementation of <<SLOT enterNameField:DoPart>>, must be placed in the 'addressbookguibody'. The implementation looks like this:

```
-- enterNameField:DoPart --
do theName[] -> private.nameField.contents
```

The 'find' button needs to call the 'onFind' virtual. This is done by selecting the 'find' button in the graphical editor and choosing 'Edit Virtuals' in the 'Edit' menu.

<<fig>>

The invoked dialog presents the available event types of the push-button. 'onFind' should be called in the 'onMouseUp' event. Selecting 'onMouseUp' and pressing 'edit' will open a Sif editor on a furtherbinding of 'onMouseUp'.

<<fig>>

Here 'onMouseUp' is furtherbound to call 'onFind'.

The Application

The application module, 'addressbookAppl' includes both the user interface and the data model.

```
ORIGIN 'addressbookgui';
INCLUDE '~beta/persistentstore/persistentstore';
INCLUDE 'addressbook';
-- program: Descriptor --
GUIenv
(# PS: @persistentStore;
     (* Use persistentstore to store the data objects *)
   theAddressBook: ^addressBook;
   theAddressBookWindow: @addressBookWindow
     (# currentInx: @integer;

        showPerson:
          (# thePerson: ^addressBook.person;
          enter thePerson[]
          do (*
              * Change the content of the name field etc.
              *)

             thePerson.name[] -> nameField;
             ...;
          #);

        onFind::
          (# do (* Invoke a find dialog *) #);

        open::
          (#
          do (*
              * Fetch the first person
              *)

             1 -> currentInx
               -> theAddressBook.inxGet -> showPerson;
          #);
     #)
do (*
    * Get the addressbook data in 'uni'
    *)

    'uni' -> PS.openWrite;
   ('AddressBook', addressBook##)
       -> PS.get -> theAddressBook[];

   (*
    * Open the addressbook window
    *)

   theAddressBookWindow.open;
#)
```

Here the extended interface of the addressBookWindow are used to make the data model and the graphical user interface work together. The interface to the text fields in the window are used to show a person in the address book window. The virtual procedure 'onFind' are furtherbound to invoke a 'find' dialog. Persistentstore is used to retrieve the addressbook data objects.

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Debugger - Tutorial

Debugger

The Debugger in the Mjolner System is called Valhalla.
The user interface of Valhalla consists of a main window containing a menu and a number of different windows (views) displaying different aspects of the debugged program (called the Valhalla Universe). The Valhalla Universe is a top-level window, containing different internal windows for displaying different aspects of the execution state of the debugged process. Below a very short description of the different window types in the Valhalla Universe is given before we go on to describe how to get started using Valhalla.

- The object views display the state of BETA objects and components.*[1]*
- The stack views display the runtime stack of the debugged process.
- The stackbrowser view, which is a combined code, stack and object view.

Details on the functionality of the window types follows in the tutorial and in the reference manual following the tutorial.

---

[1] Components are BETA objects that have their own thread of control.

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Debugger

Getting Started

In this tutorial, the program record will be used as an example. This program consists of the files
```
~beta/debugger/demo/record
~beta/debugger/demo/recordlib
```

and uses
```
~beta/containers/hashTable
```

The files record and recordlib are listed in appendix A. To get hands-on experience using Valhalla, you should copy record and recordlib to a directory of your own, compile them, and then read the tutorial while strolling along on your own workstation:
```
> cd ~beta/debugger/demo
> cp record* myDir
> cd myDir
> beta record
```
Or on windows:
```
> copy %BETALIB\demo\beta\record* myDir
> cd myDir
> beta record
```
It is not neccessary to compile the program, you can also do that from within the Mjolner tool.

Start the Mjolner tool by typing:
```
mjolner
```

at the UNIX prompt or selecting the icon if you are using a Window system. Open the record example (could be specified at commandline). If you have not compiled the record.bet program allready select "Compile record" in the "Compile/Run" menu. When you have a compiled program, select "Debug recode" in the "Compile/Run" menu. Valhalla is not started. It will initialy perform a check of all involved files, this can take from a few seconds to a minut depending on program size and your computer. Valhalla will then open the Valhalla Universe.

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An Example Usage

This section assumes the record program has been compiled as described in the previous section. Running record results in a runtime error:

```
> cd myDir
> record
# BETA execution aborted: Reference is none
# Look at 'record.dump'
```

If you have the Mjolner tool running, you can run record by choosing "Run record" from "Compile/Run" menu.

Now let's use Valhalla to locate the cause of the error. Start Valhalla by typing choosing "Debug Record"

Valhalla will initialize and open the Valhalla Universe as shown[2] in .

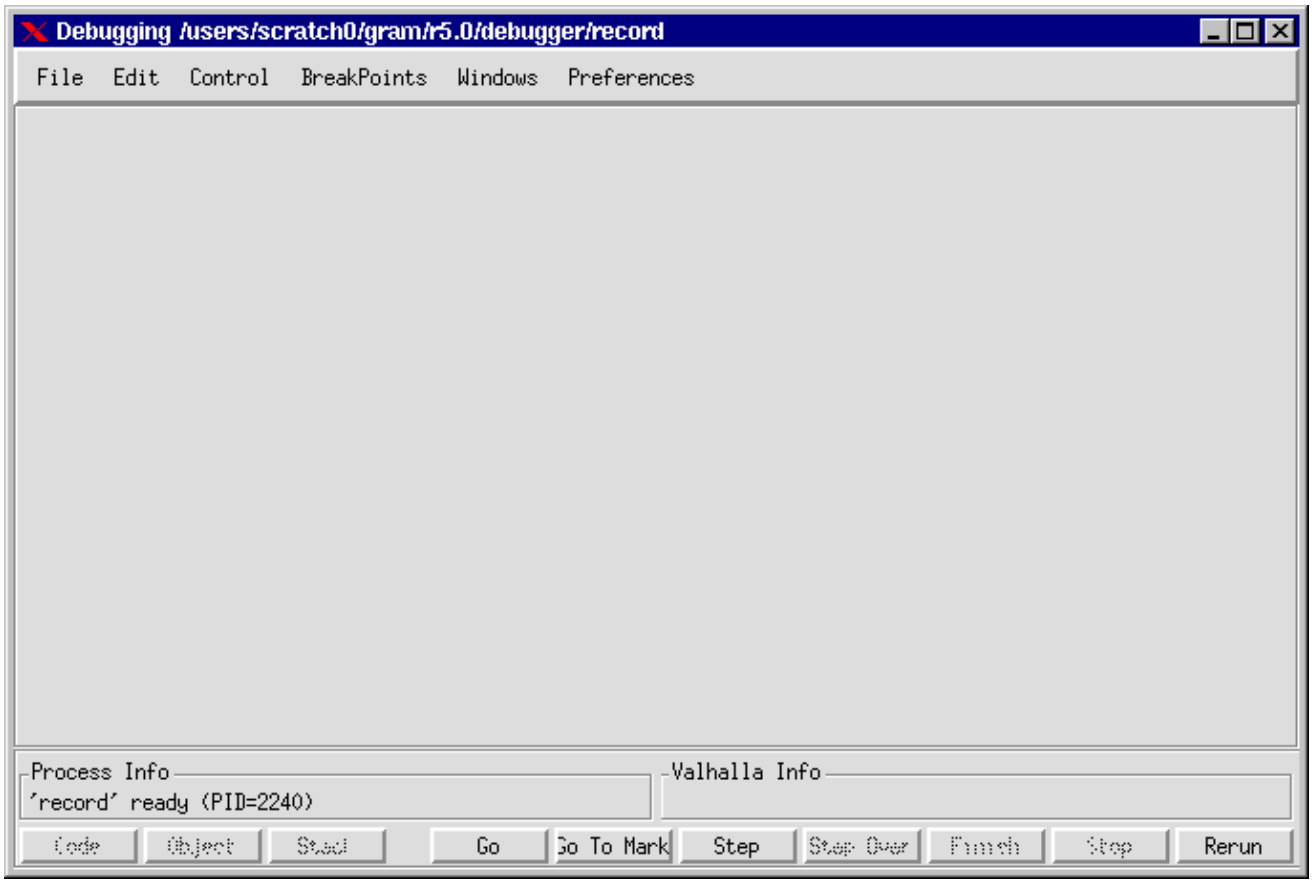

Figure 1: The Valhalla Universe

If the record program took any commandline arguments, we could specify these using the command-line editor. Choose "Command-line" from the "Edit" menu in the Valhalla Universe.

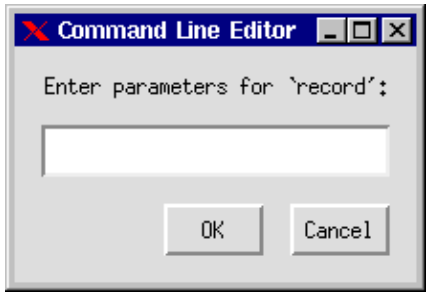

Figure 2: The commandline Editor

The Valhalla Universe defines a number of menus. Most commands in these menus operate on the state of the debugged process, or enables control over the debugger process.

The middle pane of the Valhalla Universe contains a view area in which the different local views will be displayed.

Finally the bottom pane contains three areas: the Process Info Area, the Valhalla Info Area, and the Buttons Area.

In the Process Info area, you will see different messages related to the debugged process. In , you see the message: No Process, indication that no process is being debugged at this point.

In the Valhalla Info Area, you will find different messages related to the operation of Valhalla (status messages, error messages, etc.). In , no Valhalla messages are displayed.

In the Buttons areas, you find a number of buttons, which are short-cuts to often used commands, also found in the menus of the Valhalla Universe.

After we now have presented the Valhalla Universe, we continue the record example. When Valhalla has finished initializing, the program code for the debugged program (debuggee) is displayed in the sourcebrowser. Note that the program-descriptor is shown. If you had any other code opened you can find back to it using the "History"-menu.

We are now ready to start execution of the record application. We do this by pressing the *Go* button in the Buttons Area. The application will now begin execution, and since there in this case is a runtime error, the debugged process will not complete. Since the application is being debugged, the application does not terminate as usual, but will signal the error to Valhalla.

Note that a new code view is now visible in the sourcebrowser. This new code view displays the code being executed at the time of the runtime error, and highlights the exact source code that gave rise to the runtime error.

The name of the code view opened is Fragment: lib and the pattern in the source code is newBook, implying that the newBook pattern is defined in a fragment, called lib. From here, you can now use the semantic browsing facilities described in the Mjølner Tool manuals ([MIA 99-39], [MIA 99-40], [MIA 99-34]) to find the definitions of the different names in the displayed source code. If the semantic links refer to source code, not in the current code view, new code views are created, displaying the proper source code (similar to Open Separate in Sif). If, during browsing, you forget what imperative caused the error, or cannot find the window containing that imperative, just press the *Code* button, and Valhalla will raise (and wriggle) the window with the offending imperative selected.

A number of other informations about program state at time of error would be useful in order to decide what caused the error:

- What is the state of these objects.
- What was the call chain at time of error.

In the following sections we will consider how to obtain these informations.

Inspecting object state

Above we found that Valhalla automatically displayed the source code containing the offending imperative. Usually, in order to determine the cause of the error, one has to consider the state of the objects in the executable to understand what caused the error. To browse the state of the objects, Valhalla implements so-called object views.

The immediately most interesting object, related to the error is the so-called Current Object, which is the object that executed the offending imperative. We can gain access to the current object by pressing the *Object* button in the Buttons Area. This will result in an object view being displayed in the Universe. This object view will display the state of the Current Object at the time of the error.

More generally, whenever the debugged process is stopped, pressing the *Object* button in the Buttons Area of the Valhalla Universe opens an object view displaying the current object if already open in the Universe, the object view will be raised (and wriggled). If we press the *Object* button, we get the following contents of the Universe:

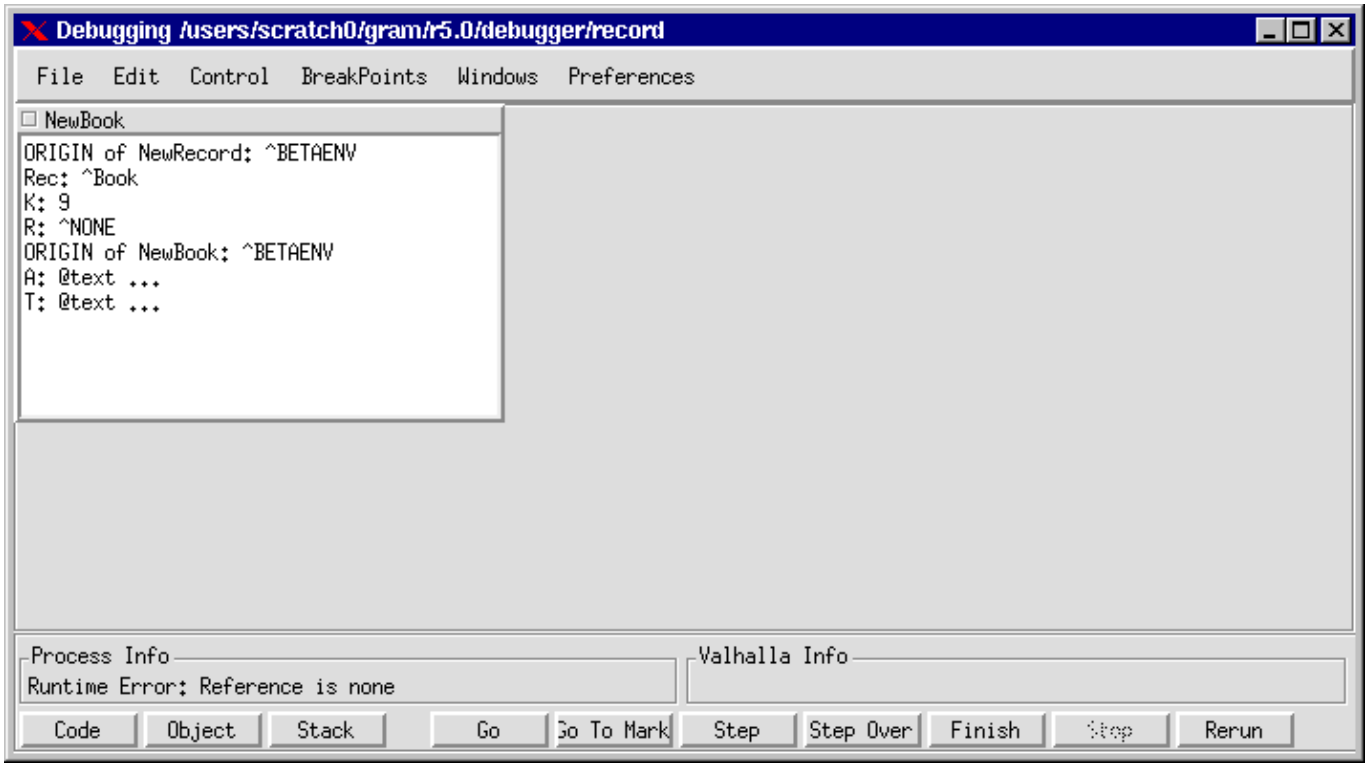

Figure 3: Object view opened at time of error

From the object view in figure 3, we see that the current object at time of error was an instance of the pattern NewBook. The state of the object is displayed in the window. The Rec attribute is a reference to an object and is therefore described only by the name of its pattern, followed by ~ and a number. If we double-click the line Rec: ^Book~3, a new object view is opened, displaying the state of the object referred to by Rec (as shown in figure 4):

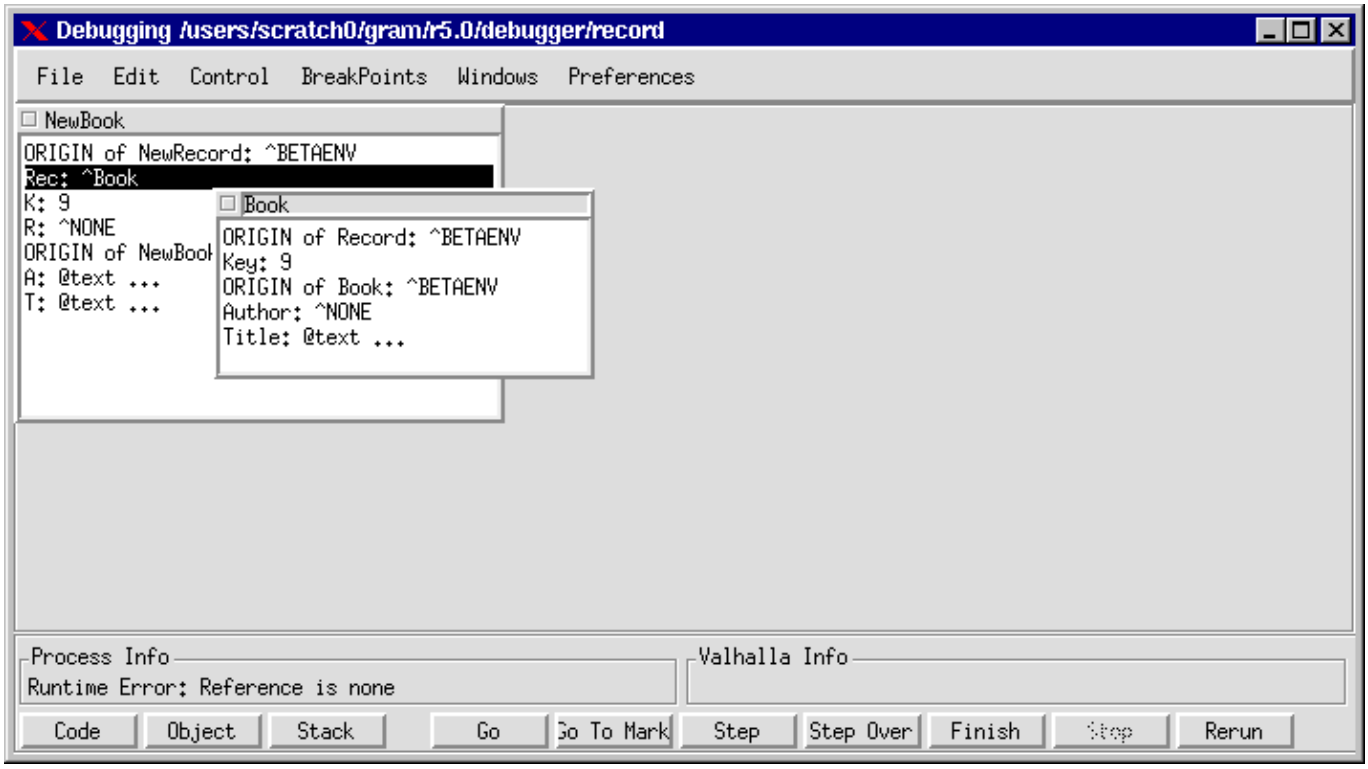

Figure 4: Object view displaying the new attribute of the failing object

As it can be seen, the author attribute of Rec is NONE. This is actually the reason for the runtime error in record. As you probably remember, the failing imperative was A->Rec.Author and because Rec.author is NONE, this results in a runtime error. If you do not remember, simply press the *Code* button in the Buttons Area of the Universe.

Since author is a dynamic reference to a Text object, we could correct the error by changing author to become a static instance of Text (exchanging ^ with @).

Eventhough we have now found the source of error, there is still a number of Valhalla features that have not yet been demonstrated. As a consequence we just continue this tutorial to introduce you to more of the Valhalla functionality.

Some attributes are shown contracted (shown by the ...). These ... indicate that these objects are complex objects, with inner structure. You can see the inner structure (and state) by double clicking on the attribute. If we do this on e.g. the A attribute, we get the following screen:

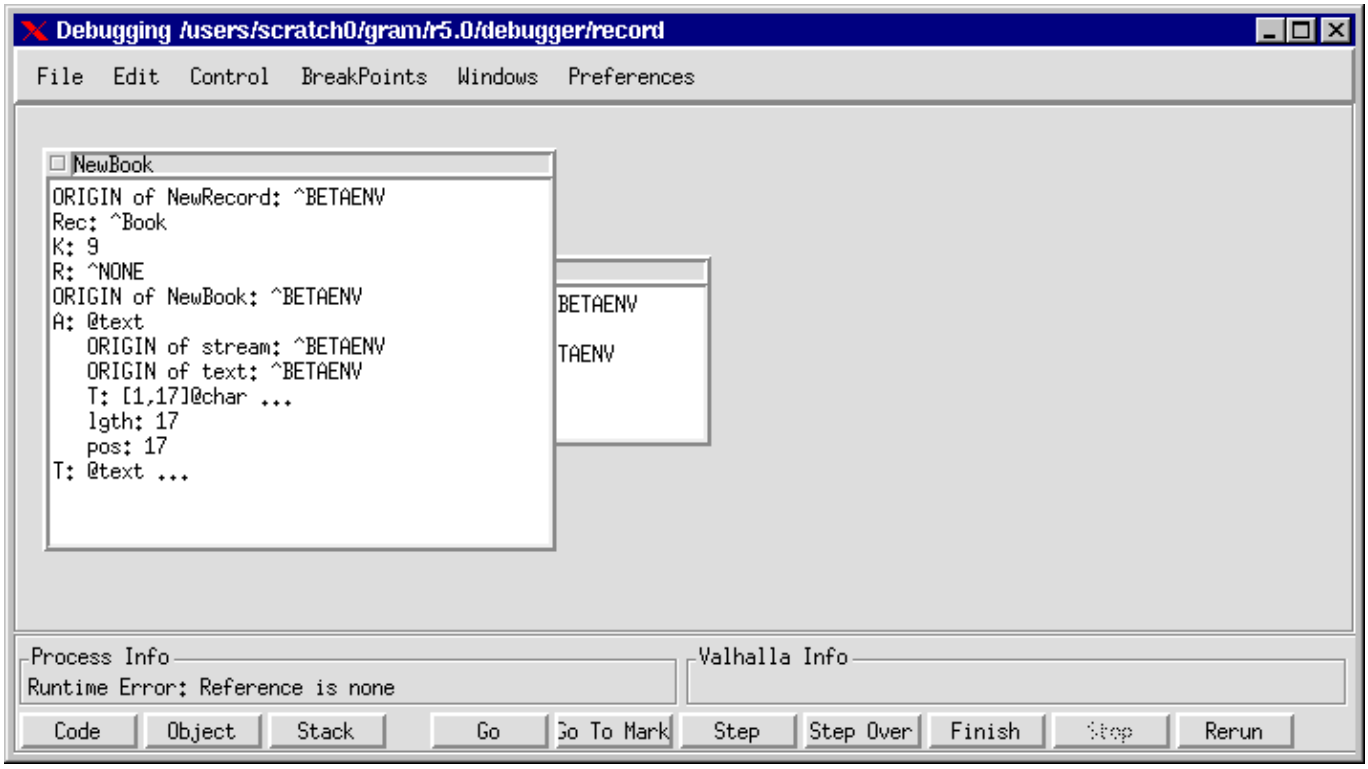

Figure 5: Detailing static objects

Note, that in contrast to when we followed the Rec attribute in , no new object view is opened, but the state of the A attribute is shown inline. This is due to the fact, that A is a static object, whereas Rec is a dynamic object reference.

Object views are updated every time the program stops by hitting a breakpoint, receiving a signal or in case of a runtime error.

Inspecting the call chain

Now we know where and why the error happened. But how did we get there? To answer this question we use the stack view: We can get a stack view by pressing the *Stack* button in the Button Area.

The stack view shows the process stack at time of error. Each line in the stack view refers to a stack frame, with the most recent as the top-most line:

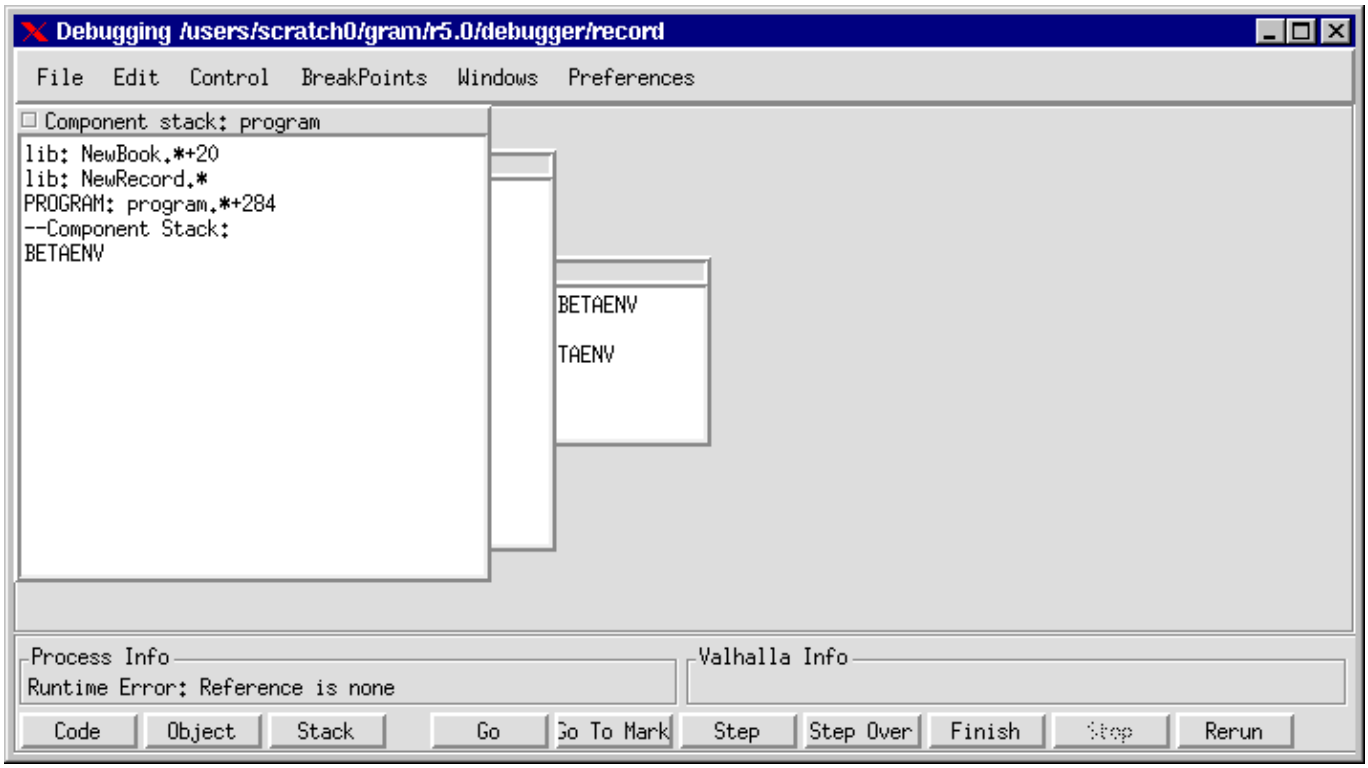

Figure 6: The stack view

By double-clicking on the lines in the stack view, code views are opened, displaying the code related with this stack frame (with the active imperative selected). By holding the right mouse button down on a line, you get a small menu from where you can create object views, displaying the state of the corresponding stack frame.
In the bottom of the stack we can see that there is only one component present. This is the main component corresponding to the main program pattern, which is allways present.

Rerunning the program

If it during a debugging session becomes necessary to restart the debugged process (e.g. to try to trace the location of the error after having inserted some breakpoints), we can rerun the debugged process by pressing the *Rerun* button in the Buttons Area. The debugged process will then be reinitialized and prepared to start from the beginning again. All existing program state is cleared by the rerun, but existing breakpoints are maintained.

Setting a Breakpoint

Until now, Valhalla has decided when to interrupt the debugged process, doing so because of a 'Reference is NONE' error. We have not yet seen an example of controlling the program execution in greater detail. To do this we are now going to restart the debugged process and trace the program flow until time of error

We press the *Rerun* button, and Valhalla now restarts the process and makes it ready to be restarted.*[3]*

We now examine the code view, locating the invocation of the erroneous NewBook pattern. We now want to make the process continue execution until it is about to execute NewBook. We can do this by setting a breakpoint immediately before the invocation.

We click at the BETA imperative containing the generation and execution of a NewBook object. Then select *Set Breakpoint* from the *Breakpoints* menu in the Universe. An breakpoint marker (>>1>>) appears in front of the imperative to mark the presence of a breakpoint (the 1 indicates that this is the first breakpoint). You can also set the breakpoint by using the popup-menu associated with the right mouse button. The process will thus be interrupted just before this imperative is about to be executed. Figure 7 displays the look of the code view at this point.

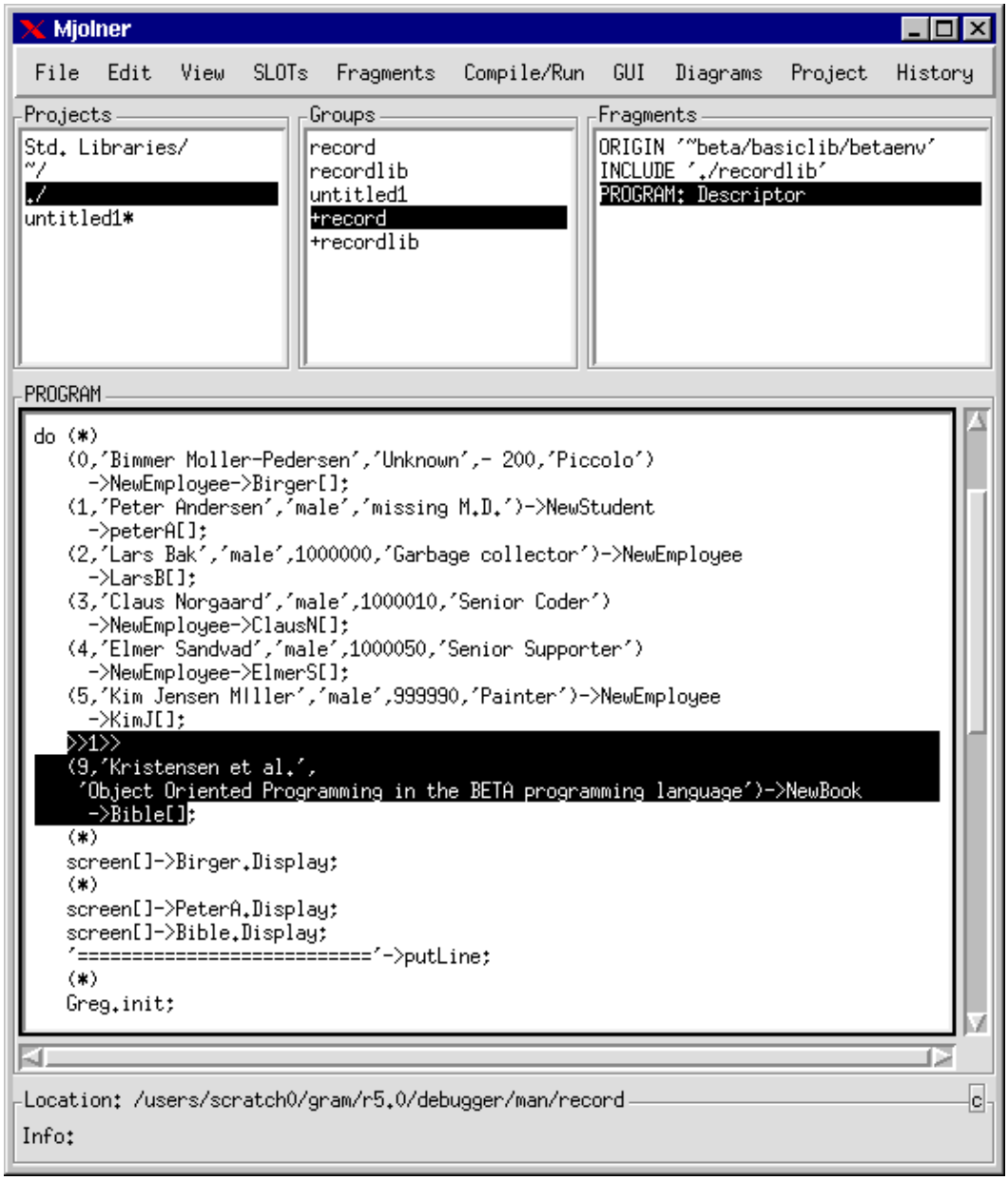

Figure 7: Your first breakpoint

Having set the breakpoint we make the debugged process begin execution by pressing the *Go* button. The process now runs until the breakpoint is hit. Then Valhalla updates all open code, stack and object views to display the current state of the debugged process.

Alternatively, we could have selected the *Step Over* button a number of times. *Step Over* executes the imperatives one by one, returning control to Valhalla after each imperative. This would bring the debugged process to exactly the same imperative, but by executing an imperative at the time in the PROGRAM fragment.[4]

Now we would like to continue until the first imperative executed by NewBook.

From here we might want to trace the execution more closely. We can do this by using the *Step* button. *Step* is a single step facility, which executes one single BETA imperative at a time. This implies, that *Step Over* executed entire patterns in a single step, since *Step Over* is intuitively single stepping at the imperative level of the visible code in the code view, whereas *Step* will stop execution e.g. immediately after a pattern invocation have been initiated, setting a breakpoint before the first imperative in the invoked pattern.

If we now press the *Step* button repeatedly, we can now follow the execution closely, until we reach the point immediately before the offending imperative.

The End

You have now concluded a tour of the most important Valhalla facilities. To get a more detailed description of these facilities as well as others not covered in this tutorial, please consult the reference manual.

---

[2] Screen dumps shown in the tutorial shows the views as they would have been if you had not copied the example program to a directory of your own, but simply compiled them in the ~beta/debugger/demo directory.

---

[3] All breakpoints set before rerunning the program will continue being set.

---

[4] *Step Over* sets a breakpoint at the imperative following the current imperative in the current pattern and thus skips procedure calls that might be embedded in the current imperative.

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Debugger - Tutorial

Appendix A

This appendix contains the source code for the BETA program used as example in the tutorial. The source consists of the files record.bet and recordlib.bet.

```
ORIGIN '~beta/basiclib/betaenv';
(* record.bet
 *
 * COPYRIGHT
 *                       Copyright Mjølner Informatics, 1989 - 1999
 *                       All rights reserved.
 *)
INCLUDE 'recordlib'
--- PROGRAM:descriptor ----
(#      Birger, PeterA, Bible, LarsP, ClausN, ElmerS, KimJ:  ^Record;
        Greg: @Register;
        Ereg: @Register
        (# element::< Employee;
           Display::< (#do '/Employee '->putText; INNER #);
        #);
do      (0 ,'Bimmer Moller-Pedersen','Unknown',- 200,'Piccolo')
                -> &NewEmployee->Birger[];
        (1,'Peter Andersen','male','missing M.D.')
                -> &NewStudent->peterA[];
        (2,'Lars Bak','male',1000000,'Garbage collector')
                -> &NewEmployee->LarsP[];
        (3,'Claus Norgaard','male',1000010,'Senior Coder')
                -> &NewEmployee->ClausN[];
        (4,'Elmer Sandvad','male',1000050,'Senior Supporter')
                -> &NewEmployee->ElmerS[];
        (5,'Kim Jensen M|ller','male',999990,'Painter')
                -> &NewEmployee->KimJ[];
        (9,'Kristensen et al.','Object Oriented Programming in the BETA language')
                -> &NewBook->Bible[];
        Birger.Display; PeterA.Display; Bible.Display;
        '=========================='->putText; newline;
        Greg.init; Ereg.init;
        Birger[]->Greg.insert; Bible[]->Greg.insert; PeterA[]->Greg.insert;
        ClausN[]->Ereg.insert; LarsP[]->Ereg.insert; ElmerS[]->Ereg.insert;
        KimJ[]->Ereg.insert;
        Greg.display; Ereg.display;
        (if LarsP[]->Ereg.has then
            'LarsP in employee register'->puttext
         else
            'LarsP not in employee register'->puttext
        if);
        newline;
        (if LarsP[]->Greg.has then
            'LarsP in general register'->puttext
         else
            'LarsP not in general register'->puttext
        if);
        newline;
#)

ORIGIN '~beta/basiclib/betaenv';
(* recordlib.bet
 *
 * COPYRIGHT
 *  Copyright Mjølner Informatics, 1989 - 1994
 *  All rights reserved.
 *)
```

```
INCLUDE '~beta/containers/hashTable'
--- lib:attributes ---
Record:
  (# key: @Integer;
     Display:< (* declaration of a virtual (procedure) pattern  *)
       (#
       do newline;
          '------------------'->putText; newline;
          'Record:      Key  = '->putText; Key->putInt; newline;
          INNER
       #);
  #);
Person: Record
  (# name,sex: @Text;
     Display::<  (* a further binding of Display from Record *)
       (#
       do 'Person:      Name = '->putText; name[]->putText; newline;
          '             Sex  = '->putText; sex[]->putText; newline;
          INNER
       #);
  #);
Employee: Person
  (# salary: @Integer; position: @Text;
     Display::<
       (#
       do 'Employee:    Salary = '->putText;   salary  ->putInt; newline;
          '             Position = '->putText; Position[]->putText; newline;
          INNER
       #);
  #);
Student: Person
  (# status: @Text;
     Display::<
       (#
       do 'Student:     Status = '->putText; Status[]->putText; newline;
          INNER
       #)
  #);
Book: Record
  (# author, title: ^Text;
     Display ::<
       (#
       do 'Book:        Author = '->putText; Author[]->putText; newline;
          '             Title  = '->putText; Title[]->putText; newline;
          INNER
       #)
  #);
NewRecord:
  (# resultType:< Record;
     new: ^resultType;
     key: @Integer;
  enter key
  do &resultType[]->new[];
     key->new.key;
     INNER;
  exit new[]
  #);
NewPerson: NewRecord
  (# resultType::< Person;
     N,S: @Text
  enter (N,S)
  do N->new.Name; S->new.Sex;
     INNER;
  #);
NewEmployee: NewPerson
  (# resultType::< Employee;
```

```
     S: @Integer; P: @Text
  enter (S,P)
  do S->new.Salary; P->new.Position;
     INNER;
  #);
NewStudent: NewPerson
  (# resultType::< Student;
     S: @Text
  enter S
  do S->new.Status;
     INNER;
  #);
NewBook: NewRecord
  (# resultType::< Book;
     A,T: @Text
  enter (A,T)
  do A->new.Author; T->new.Title;
     INNER;
  #);

Register: HashTable
  (# element::< Record;
     (* Virtual class specifying the (generic) element
      * type of the hashtable. *)

     hashfunction::< (# do e.key->value #);
     (* Specialization of the hashfunction to use on
      * elements of the hashtable. *)

     Display:<
       (* Display all elements of the table. *)
       (#
       do newline; '############ Register Display '->putText;
          INNER;
          newline;
          scan (# do current.display #);
          '############ End Register Display #######'->putText; newline
       #);

     Has:
       (* Check if an element is present in the table. *)
       (# e: ^element;
          found: @Boolean;
       enter e[]
       do
          e[]->hashfunction->findIndexed
          (# predicate::< (# do current.key = e.key->value #);
             notFound::< (# do false->found #);
          do true->found;
          #);
       exit found
       #);
  #)
```