DB-Main Manual Series

MDL PROGRAMMER'S GUIDE

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Chapter 1

Introduction

MDL is a Method Description Language aimed at defining methods for analysts to perform any database engineering work using the DB-MAIN CASE tool. This book is intended to method engineers, that is to say to the persons who have to define methods that will be integrated into the DB-MAIN CASE tool.

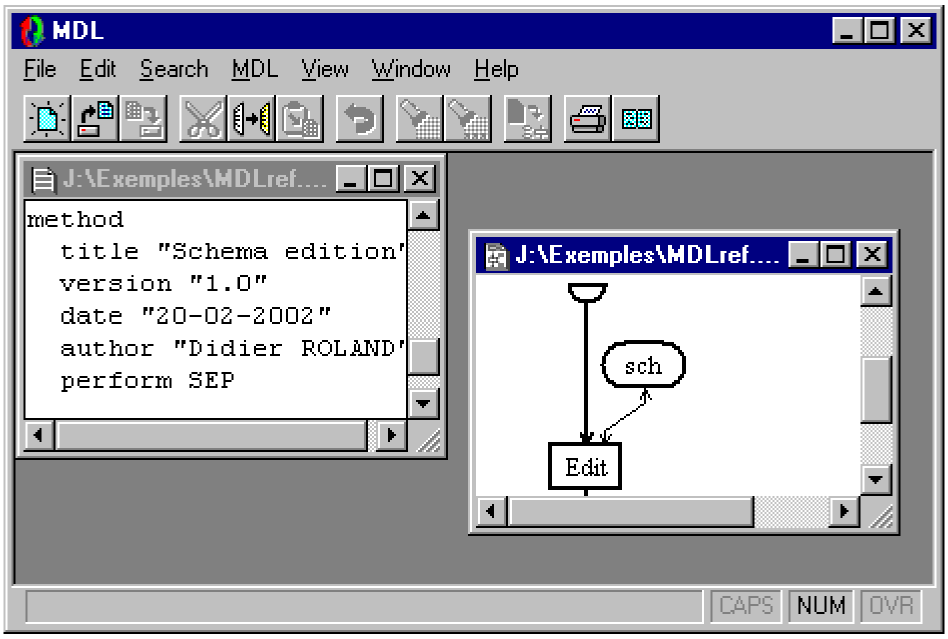
The second chapter describes the basic notions that underlies the language. Chapter 3 to 7 depict in details the syntax of the different parts of the language. Chapter 8 presents a few generalities about histories in the DB-MAIN CASE tool, these histories being a complex log of a work. Chapter 9 briefly explains how a database engineer can use a method to do his or her job for which an history will be build. Finally, chapter 10 will give a few advices to method engineers on how to build a method that will be usable by database engineers, knowing how they have to work.

Chapter 2

MDL development environment

This book is a complete reference about writing a method in the MDL language for use by the DB-MAIN CASE tool. In this chapter, we will present a simple development environment which allows a method engineer to edit an MDL file, to compile it, and to generate a .LUM file usable by the DB-MAIN CASE tool.

Figure 2.1 shows a common view of the environment. It is a traditional Windows application with a title bar, a menu, a small tool bar, a status bar in the bottom and two windows. The textual window contains an MDL source file, and the graphical windows shows the graphical representation of the method from the first window. We will examine all these components in more details.



```
method
  title "Schema edition'
  version "1.0"
  date "20-02-2002"
  author "Didier ROLAND'
  perform SEP
```

Figure 2.1 - The MDL development environment

2.1 The text window

The text window is a simple text editor with traditional basic editing functions (copy, cut, paste, undo). For more advanced editing functions such as auto-indent, parenthesis-checking and so on, the user may use another third-party text editor for edition and reload his or her texts in this window for compilation.

When this window is active, you can click on the “MDL/Compile” menu entry to compile the text. If it is syntactically correct, a graphical window appears to show the result of the compilation. If an error occurs, a message box shows the error message and selects the faulty line in the text editor.

A second compilation of a same text will reuse the same graphical window.

You can open several text files at the same time. Each text file, when compiled, will have its associated graphical window.

2.2 The graphical window

A graphical window contains the result of a compilation of the content of a text window, that is a graphical representation of a database engineering method. The user can browse through the whole method by clicking with the right mouse button on the rectangles and the ellipses to make a menu appear and clicking on the entries of this menu. Rectangles represent process types, ellipses represent product types. The signification of these notions and their graphical representation will appear more clearly withe the following chapters. The content of this window is not editable.

2.3 Menus and toolbar

2.3.1 File menu

File/New: Creates a new blank text window. Always available.

File/Open: Opens a text file in a new text window. Always available.

File/Save: Saves the current text window. Only available when a text window is active.

File/Save As...: Saves the current text window with a new file name. Only available when a text window is active.

File/Generate LUM: Generates a .LUM file with the content of the current graphical window. Only available when a graphical window is active.

File/Import LUM: Opens a .LUM file for viewing only in a new graphical window. Always available.

File/Print Preview...: Previews of a printing of the current window. Available when either a text or a graphical window is active.

File/Print...: Prints the content of the current window. Available when either a text or a graphical window is active.

File/Print Setup...: Sets the printing parameters for the next printing or preview. Available when either a text or a graphical window is active.

File/Exit: Closes all windows and exit the development environment. If a text window contains unsaved modifications, a request for saving will automatically be prompted. Always available.

2.3.2 Edit menu

Edit/undo: In a text window, undoes the last modification. In a graphical window, same effect as the ’Back’ menu entry in the contextual menu of the process title. Available when either a text or a graphical window is active.

Edit/Cut: Removes the selected text and put it in the clipboard. Available in a text window only.

Edit/Copy: In a text window, copies the selected text to the clipboard. In a graphical window, copies the whole drawing in the clipboard. Available when either a text or a graphical window is active.

Edit/Paste: Copies the content of the clipboard, if it is a text, to the current text editor. Available when a text window is active only.

Edit/Clear All: Clears the content of the current text window. Available when a text window is active only.

Edit/Delete: Removes the selected text or the character at the right of the cursor in a text. Available when a text window is active only.

2.3.3 Search menu

Search/Find...: Searches for a few characters in the current text. Only available when a text window is active.

Search/Replace...: Searches for a few characters in the current text and replaces them by other characters. Only available when a text window is active.

Search/Next: Repeat the last search or replace. Only available when a text window is active and if a search or a replace already took place.

2.3.4 MDL menu

MDL/Compile: Compiles the content of the current text window. Only available if a text window is active.

2.3.5 View menu

View/Show product types: Shows or hides the product types in the current graphical window. Only available when a graphical window is active.

View/Show titles: Shows the tiles of the process types in the current graphical window. Only available when a graphical window is active.

View/Show identifiers: Shows the identifying names of the process types in the current graphical window. Only available when a graphical window is active.

2.3.6 Window menu

Window/Cascade, Window/Tile, Window/Close All: traditional menu entries.

2.3.7 Help menu

Help/About...: "About" dialogue box with application version.

2.3.8 Title contextual menu

The title is the rectangle inside the gray area at the top of a graphical window.

Back: Shows the graphical view of the parent engineering process type. This is the reverse of the ’Open’ menu entry in the contextual menu of an engineering process type.

Properties: Shows the properties and description of the current engineering process type. Shortcut: double-click on the title.

2.3.9 Primitive process type contextual menu

A primitive process type is a rectangle in a graphical window. It looks like an engineering process type.

Properties: Shows the properties and description of the selected primitive procvess type. Shortcut: double-click on the selected primitive process type.

2.3.10 Engineering process type contextual menu

An engineering process type is a rectangle in a graphical window. It looks like a primitive process type.

Expand here: Shows or hides the complete view of the selected engineering process type, surrounded by dashes, in place of its title in the current engineering process type view.

Expand below: Shows or hides the complete view of the selected engineering process type at the bottom of the current engineering process type view.

Open: Replaces the view of the current engineering process type by the view of the selected engineering process type. Shortcut: double-click on the selected engineering process type.

Properties: Shows the properties and description of the selected engineering process type.

2.3.11 Decision contextual menu

A decision is a diamond in a graphical window.

Properties: Shows the properties and description of the selected decision. Shortcut: double-click on the selected decision.

2.3.12 Product type contextual menu

A product type is an ellipse in a graphical window.

Properties: Shows the properties and description of the selected product type. Shortcut: double-click on the selected product type.

2.3.13 Toolbar

Same as menu entry "File/New".

Same as menu entry "File/Open".

Same as menu entry "File/Save".

Same as menu entry "Edit/Cut".

Same as menu entry "Edit/Copy".

Same as menu entry "Edit/Paste".

Same as menu entry "Edit/Undo" and title contextual menu entry "Back".

Same as menu entry "Search/Find".

Same as menu entry "Search/Find Next..."

Same as menu entry "MDL/Compile".

Same as menu entry "File/Print".

Same as menu entry "File/Preview".

Chapter 3

Basic concepts

3.1 Basic definitions

The proposed design process modeling approach is based on a transformational approach according to which each *design process* transforms a (possibly empty) set of *products* into another set of products:

- a **product** is a document used, modified or produced during the design life cycle of the information system; as we focus specifically on database specification, we will describe mainly database **schemas** and database-related **texts**. These products can be grouped in **product sets** for readibility and ease of working.
- a **design process** or **process** in short is described by the operations that have been carried out to transform the products; each operation is in turn a process; atomic processes are called *primitives*, while the others will be called *engineering processes*; each process is supposed to be goal-driven, i.e. it tries to make its output products compliant with specific design criteria, generally called *requirements*;
- reporting in a precise way (1) the operations carried out during a process, (2) the products involved, and (3) the rationale according to which they have been carried in that way, form the trace or the **history** of the process;

The history of a process must follow a predefined commonly agreed upon *way of working*, called a **method**. In other words, a history is an instance of a method. More precisely, a method is defined by *process types* and *product types*:

- a **product type** defines a class of products that play a definite role in the system life cycle; a product is an instance of a product type;
- a **process type** describes the general properties of a class of processes that have the same purpose, and that process products of the same type; a process is an instance of a process type;
- the **strategy** of a process type specifies how any process of this type must be, or can be, carried out in order to solve the problems it is intended to, and to make it produce output products that satisfy its requirements; in particular, a strategy mentions what processes, in what order, are to be carried out, and following what reasoning. Only *engineering process types* are defined by a strategy. *Primitive process types* are basic types of operations that are performed by an analyst, or by a CASE tool.

Several product types can be given the same, or similar, properties. Hence the concept of **product model**. A model defines a general class of products by stating the components they are allowed to include, the constraints that must be satisfied, and the names to be used to denote them. A product type is expressed into a product model. These concepts are sketched in Figure 3.1.

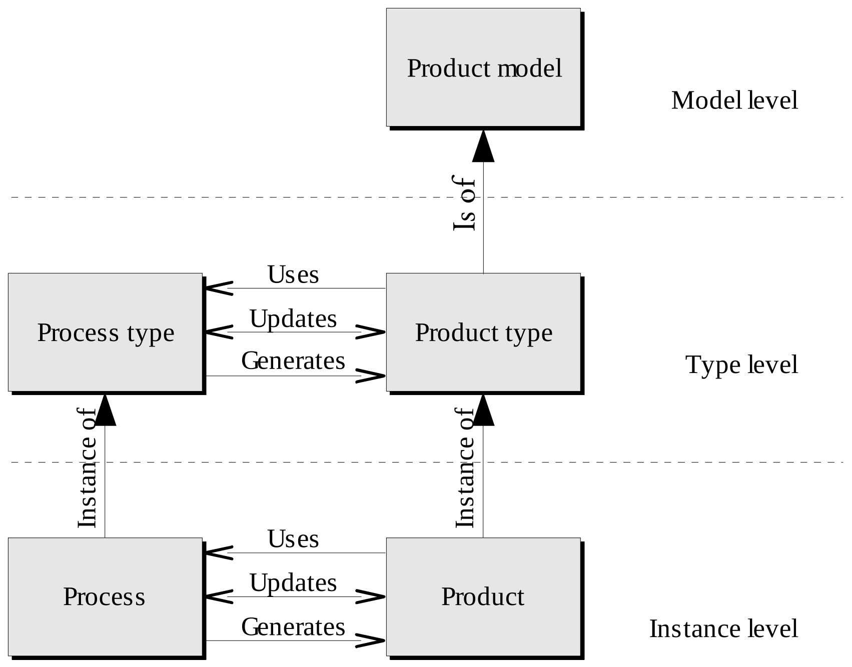


Figure 3.1 - The process modeling architecture

For instance (see Figure 3.2), the *C++ programs* model is a text model that specifies the syntax of C++ program files. *Main* and *GUI* are particular types of C++ files. The first type contains contains the core source files of an application. The second type contains all the GUI-related source files of the same application. *Management/2.0* is a particular C++ program source file that contains the main procedure of a management module. And *Management screen* is a file with all the procedures required for displaying the management module main screen. In the same way, *General Ledger* and *Personnel* are two instances of the *Conceptual schema* product type, which is expressed in the *ERA model* product model.

Figure 3.2 - Two examples of product hierarchies

In the same way, Figure 3.3 shows two process hierarchy examples. The *C++ program design* process type has a strategy that was followed by the *Management GUI functions design*. *General Ledger schema design* and *Personnel schema design* are two conceptual schema designs performed with the same pattern described by the *Conceptual schema design* type.

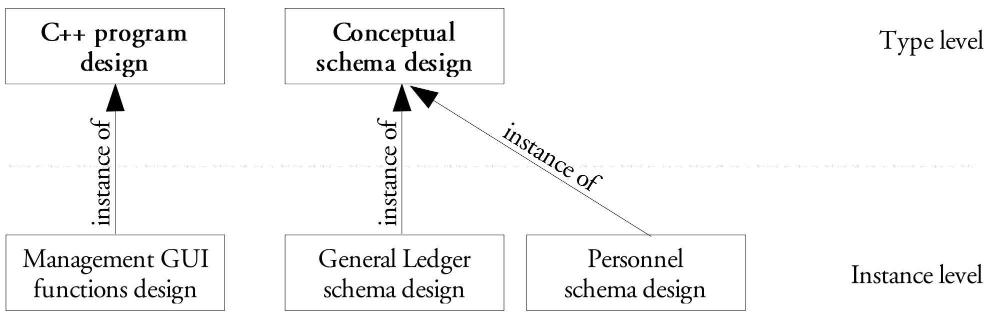


Figure 3.3 - Examples of process hierarchies

Figure 3.4 shows a complete example of a very simple project combining the product and the process hierarchies, compliant with the architecture shown in Figure 3.1.

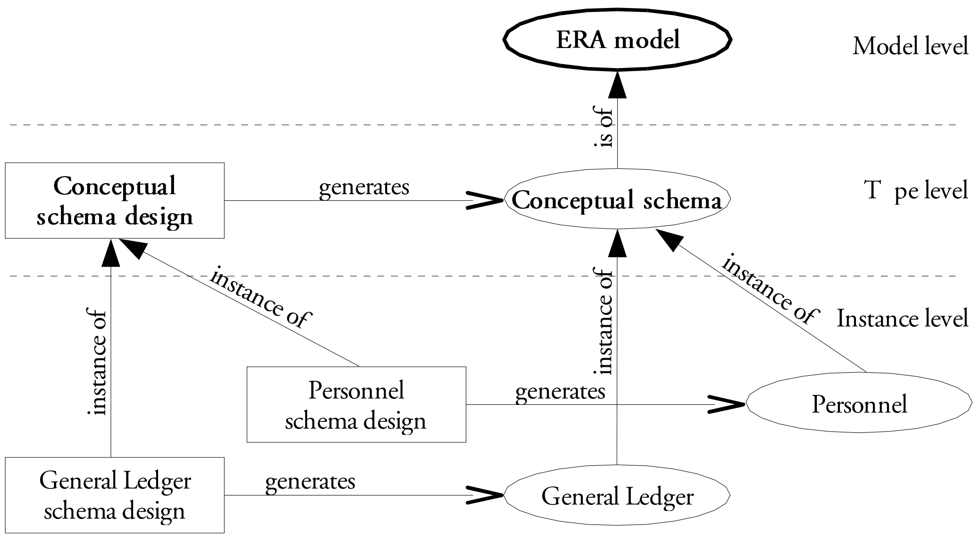


Figure 3.4 - A complete example

3.2 About the MDL language

The MDL language is used to define product models, product types and process types. It is a non-deterministic procedural like language. An MDL method is made of blocks. A block is either a process model declaration, a process type declaration or the method identification block. The strategy of a process type is a series of operations, sub-process calls, and control structures similar to traditional procedural languages (if...then, while, repeat until,...), plus a few specific non-deterministic control structures, that is to say control structures that do not impose a particular behaviour. Indeed, the MDL language is designed to be used by a human being rather than by a computer, and human beings are able to take decisions by themselves. In fact, they even like to take decisions instead of being constrained entirely. This need of freedom can only be possible through the use of such non-deterministic constructs.

The following chapters will describe all the blocks in detail. Before this, a few general rules to end this chapter.

3.2.1 Forward referencing

Forward references are not allowed. In other words, a process type definition can only reference product models, product types, toolboxes or other process types which were declared previously in the listing. For example:

```
process A
  ...
end-process

process B
  ...
  strategy
    ...
    do A
    ...
end-process
```

is a valid listing. The following one is not:

```
process A
  ...
  strategy
    ...
    do B
    ...
end-process

process B
  ...
end-process
```

As a consequence, recursivity is not allowed.

3.2.2 Comments

Comments are allowed everywhere in an MDL listing. A comment begins with the symbol % and runs up to the end of the line. For instance, the following listing contains several comments:

```
process A % First comment
  title "A" % Second comment
  % Thirsd comment
  ...
  strategy
    % Fourth comment
    if (ask"OK?") % Fith comment
      do B % Sixth comment
    else % Seventh comment
      do C; % Eigth comment
      do D % Nineth comment
            % Tenth comment
    end-if
end-process
```

Chapter 4

Method

A complete method description is a listing made of several blocks. The last block identifies the method. All others are product model descriptions, product type descriptions and process type descriptions. The blocks must be ordered in such a way that there is no forward reference. They will be defined in the following chapters. We will now focus on the method identification block.

The method identification block must be written with the following syntax:

> **method**
>   **title "***title***"**
>   **version "***version***"**
>   [**description**
>   *description text*
>   **end-description**]
>   **author "***author***"**
>   **date "***day-month-year***"**
>   [**help-file "***help-file-name***"**]
>   **perform** *process-type*
> **end-method**

where:

- *title* is the name of the method. It can be made of any character (max. 100).
- *version* is a version number. It can be made of any character (max. 16).
- *description text* is an optional small description of the method that will appear in dialog boxes in the supporting CASE tool. This text can hold on multiple lines. The first character of a line will go far left. The left margin can be symbolized with "|". In that case, this character will not appear in the dialog boxes, but spaces between it and the text will. For instance, the following description :

```
description This is a
        |       sample
        description
end-description
```

will be shown as :

```
This is a
        sample
description
```

- *author* is the name of the author. It can be made of any character (max. 100).
- *day-month-year* is the release date of the method. *day*, *month* and *year* are three integer numbers. The *year* must be coded with four digits (1998 and not 98).
- *help-file-name* is a filename containing on-line help about the method.
- *process-type* is the identifier of the process type by which the method begins. This process type must be already defined.

Chapter 5

Product Models

An in-depth analysis of database engineering methodology exhibits both strong similarities and many specific aspects. What makes them similar, among others, is that, at each level of abstraction, they rely on some variant of popular specification models. However, instead of adopting such models as off-the-shelves components, most methods redefine and customize them according to the needs, culture and available technology of the business environment. In some sense, there are as many ERA, NIAM and OMT models as there are organizations that use them. Product models are to be considered as a way to precisely define what is exactly intended by each model used by the organization. In particular, it defines the concepts, the names to denote them and the rules to be used to build any product compliant with this model. Due to practical reasons, there are two kinds of products, namely schemas and texts.

A **schema model** allows designers to specify data/information structures. The ER model proposed by Bachman in the late sixties, inspired by the pioneer DBMS IDS and popularised by Chen is such a model. The generic ER model (GER) developed in the LIBD[1] and implemented in the DB-MAIN CASE tool is an extension of the ER model. The reader should refer to the DB-MAIN reference manual [1] to have the full definition of the GER model. We will define a personalised schema model as a specialisation of a the GER model. This wide-spectrum GER model is intended to describe data/information structures at different abstraction levels and according to the most popular paradigms:

Abstraction levels	Representation paradigms
Conceptual	ERA, Merise, Merise-OO, Chen, NIAM, OMT, Booch, Fusion, UML, etc.
Logical	Relational, network, hierarchical, standard files, OO, XML schema, etc.
Physical	ORACLE 9i, SYBASE, IMS, IDS2, UDS, O2, GemStone, Microfocus COBOL, Java, XML, etc.

We will define a personalised schema model as a *specialisation* of the GER model.

A **text model** allows designers to specify every other kinds of information. Indeed, text files appear in many forms ranging from computer language source files with a very strict syntax to filled forms, and to natural language texts. We can make a rapid examination of these texts:

1. LIBD: Laboratoire d’ingénierie de bases de données, database engineering laboratory, computer science department, university of Namur.

- A C++ source file is made up of function declarations. A function is prefixed by a header and an opening curly bracket, it is made of statements, and it is terminated by a closing curly bracket. A header is made of a name and parameters, the parameters being put between parentheses and separated by commas. A statement is made of keywords, variables, constants and other symbols, and is terminated by a semi-colon. Keywords, function names, variables, constants, punctuation marks and other symbols are all made of characters which are classifiable in different sets: figures, letters, punctuation marks, mathematical symbols,...
- An XML file is a text containing markups and character data. A markup is a string enclosed between angle brackets <...>, and character data are all not surround by < and >. An XML file is made up of elements. An element starts with a start tag which is a markup and ends with an end tag which is another markup whose content is prefixed by a slash /. An element has a name, which appears in both the start and the end tag, and possibly attributes, which can be given a value in the start tag. All the character data and elements between the start tag and the end tag is the content of the element. XML being a kind of text descriptor, the result of the interpretation of an XML file is itself a text file with any other syntax.
- A form is made of sections. A section has a title and is made of questions and answers. A question and an answer are made of words, numbers or items, and punctuation marks. Items are made of words and numbers, and are prefixed by check marks. Words are made of letters.
- A text written in natural language is made of paragraphs. A paragraph is made of words and punctuation marks. A word is made of letters.

There is obvious similarities among all these text variants. Their structures can be described in a hierarchical way, each element being made of a sequence of sub-elements. In fact, all these texts are written according to a particular grammar. So, we can describe a text model by describing the grammar with which it complies.

In most computing environments such as DOS-based or Windows-based, file names have an extension. This extension is content-based: it specifies the family of programs that are allowed to process the file. In other terms, each file extension is associated with a particular grammar and the the processors that understand it. For instance, the "RTF" extension refers to word processors that understand the RTF grammar (e.g., MS Word, Star Office, FrameMaker, etc.)

We will see how we can describe a text model by defining its grammar or simply by giving a list of associated file extensions.

5.1 Schema model description

Let M be a schema model. M is a specific model we need in a particular context, such as the data model of a target DBMS or the proprietary conceptual model of a particular company. In the same way as we described the GER model, M can be defined by a set of concepts and their assembly rules. Since the GER has been designed to encompass the main constructs of the models commonly used in data engineering, we will define M as a *subset* of the GER.

More precisely, M will be defined by:

1. selecting the subset of the concepts of the GER that are relevant in the modelling domain of M
2. renaming the selected concept according to the modelling domain of M
3. define the specific assembling rules of M. For each of the selected concepts, we can specify some constraints on the way they can or cannot be used, by themselves or in their association with other concepts.

For example, a logical relational schema comprises tables, columns, keys, foreign keys and triggers. So, for expressing relational schemas, we define a *Relational model* as follows.

The most straightforward representation of a table is the GER entity type. A column will be represented by an attribute, a primary key by a primary identifier, a foreign key by a reference group. A unique constraint will best be expressed by a secondary identifier while a trigger is a special kind of processing unit attached to the entity type of its table.

The following table describes these mapping rules: all the selected concepts of the GER in the left column, and their relational name at right.

Concept	***Name***
entity type	table
simple attribute	column
primary identifier	primary key
secondary identifier	unique
reference constraint	foreign key
processing unit	trigger

Then we specify the assembling rules that define valid relational schemas, including the following:

- A schema includes at least one entity type.
- A schema includes no relationship types.
- A schema includes no is-a relations.
- An entity type comprises at least one attribute.
- Attributes are simple (atomic).
- Attributes are single-valued.
- An entity type has at most one primary identifier.
- A primary identifier is made up of mandatory (i.e., with cardinality [1-1]) attributes only.
- A reference group and its target identifier have the same composition (their components have same type and length, considered pairwise).

It must be noted that these rules express *restrictions*, in that they state properties that cannot be violated. In other words, any schema obeys model M if,

- it comprises no GER objects but those that have been explicitly selected
- it comprises all the possible GER assembly, but those that are prohibited by the rules.

Therefore, these rules will be called constraints from now on.

5.1.1 Constraints

In this section, we will describe a subset of the constraints of DB-MAIN, classified by object types. We will even write the constraint in a predicative form. So we will define **structural predicates**. For each structural predicate, we will give its name, its parameters and a short description. The complete set of structural predicates is proposed in Appendix B. Then we will see how we can assemble predicates to form more complex constraints.

a) Constraints on a schema

The first set of constraints concern the nature and the number of the components of the current schema. We will comment the first constraint in some detail. Many other constraints are built on the same pattern, and have to be interpreted in the same way.

A first constraint concerns the number of entity types that can be used in a schema. In the example above, we stated that every relational schema should have at least one entity type. But we can also set an upper limit to the size of a schema, for example because a particular DBMS cannot handle more than a given number of tables. So we can define a constraint, let us call it ET_per_SCHEMA, to specify the number of entity types that can/must appear in a schema. We can write it in a predicative form:

ET_per_SCHEMA (*min max*)	where *min* is an non-negative integer, and *max* is either an integer not less than *min* or **N** standing for infinity.

This first constraint must be read: The number of entity types *(ET) per schema* must fall in the range [*min-max*].

In the same way, we can define two additional constraints concerning the number of relationship types and collections in a schema:

RT_per_SCHEMA (*min max*)	The number of rel-type per schema must fall in the range [*min-max*].
COLL_per_SCHEMA (*min max*)	The number of collection per schema must fall in the range [*min-max*].

Application. A relational schema must include at least one table but no relationship types. In addition, the target DBMS imposes a limit of 1,000 tables. Therefore, the model describing the valid schemas for this DBMS will include the constraints,

ET_per_SCHEMA(1 1000)
RT_per_SCHEMA(0 0)

b) Constraints on an entity type

Similar constraints can be used to define valid entity types according to their components, i.e., their attributes, their groups, their processing units and the roles they play in rel-types:

ATT_per_ET (*min max*)	The number of attributes per entity type must fall in the range [*min-max*].
GROUP_per_ET (*min max*)	The number of groups per entity type must fall in the range [*min-max*].
PROCUNIT_per_ET (*min max*)	The number of processing units per entity type must fall in the range [*min-max*].
ROLE_per_ET (*min max*)	The number of roles per entity type must fall in the range [*min-max*].

The richness of the concept of group requires some specialisation of the constraint GROUP_per_ET. Hence the following constraints concerning, respectively, the primary identifiers, all the identifiers, the access keys, the reference groups (foreign keys), the coexistence groups, the exclusivity groups, the “at least one” groups, the inclusion constraints, the inverse constraints, and the generic constraints.

ID_per_ET (*min max*)	The number of identifiers per entity type must fall in the range [*min-max*].
PID_per_ET (*min max*)	The number of primary identifiers per entity type must fall in the range [*min-max*].
KEY_per_ET (*min max*)	The number of access keys per entity type must fall in the range [*min-max*].
REF_per_ET (*min max*)	The number of reference groups per entity type must fall in the range [*min-max*].
COEXIST_per_ET (*min max*)	The number of coexistence constraintss per entity type must fall in the range [*min-max*].
EXCLUSIVE_per_ET (*min max*)	The number of exclusivity constraints per entity type must fall in the range [*min-max*].
ATLEASTONE_per_ET (*min max*)	The number of at-least-one constraints per entity type must fall in the range [*min-max*].
INCLUDE_per_ET (*min max*)	The number of inclusion constraints per entity type must fall in the range [*min-max*].
INVERSE_per_ET (*min max*)	The number of inverse constraints per entity type must fall in the range [*min-max*].
GENERIC_per_ET (*min max*)	The number of generic constraints per entity type

must fall in the range [*min*-*max*].

Roles played be an entity type can also be categorised into optional ([0-j]), mandatory ([1-j]), “one” ([i-1]) and “many” ([i-j], j > 1). These categories induce specific constraints similar to those concerning groups.

Application. The definition of relational models could include the following constraints:

ATT_per_ET(1 N)
PID_per_ET(1 1)
INCLUDE_per_ET(0 0)
INVERSE_per_ET(0 0)
GENERIC_per_ET(0 0)

c) Constraints on a relationship type

Like entity types, rel-types can be made of attributes, groups, processing units and roles. So we can define similar basic predicates:

ATT_per_RT (*min max*)	The number of attributes per rel-type must fall in the range [*min*-*max*].
GROUP_per_RT (*min max*)	The number of groups per rel-type must fall in the range [*min*-*max*].
PROCUNIT_per_RT (*min max*)	The number of processing units per rel-type must fall in the range [*min*-*max*].
ROLE_per_RT (*min max*)	The number of roles per rel-type must fall in the range [*min*-*max*].

The last constraint applies on the degree of the rel-type, so we can force rel-types to be binary:

ROLE_per_RT (2 2)

Since rel-types can have groups too, constraints similar to those defined on entity types are available as well:

ID_per_RT (*min max*)	The number of identifiers per rel-type must fall in the range [*min*-*max*].
PID_per_RT (*min max*)	The number of primary identifiers per rel-type must fall in the range [*min*-*max*].
KEY_per_RT (*min max*)	The number of access keys per rel-type must fall in the range [*min*-*max*].
COEXIST_per_RT (*min max*)	The number of coexistence constraints per rel-type must fall in the range [*min*-*max*].
EXCLUSIVE_per_RT (*min max*)	The number of exclusivity constraints per rel-type must fall in the range [*min*-*max*].
ATLEASTONE_per_RT (*min max*)	The number of at-least-one constraints per rel-type must fall in the range [*min*-*max*].
INCLUDE_per_RT (*min max*)	The number of inclusion constraints per rel-type must fall in the range [*min*-*max*].
GENERIC_per_RT (*min max*)	The number of generic constraints per rel-type must fall in the range [*min*-*max*].

d) Constraints on an attribute

The constraints on the schema, entity types and rel-types concern the relations these concepts have with their environment. We will call them relationship constraints. Before defining such constraints on attributes, we can examine them for their intrinsic properties, namely their cardinality and type:

MIN_CARD_of_ATT (*min max*)	The minimum cardinality of an attribute must fall in the range [*min*-*max*].
MAX_CARD_of_ATT (*min max*)	The maximum cardinality of an attribute must fall in the range [*min*-*max*].
TYPES_ALLOWED_for_ATT (*type-list*)	The type of an attribute must belong in the list *type-list.*
TYPES_NOT_ALLOWED_for_ATT (*type-list*)	The type of an attribute cannot appear in the list *type-list.*
TYPE_DEF_for_ATT (CHAR *min max*)	The length of a *character* attribute must fall in the range [*min*-*max*].
TYPE_DEF_for_ATT (NUMERIC *min-len max-len min-dec max-dec)*	The lengths of a *numeric* attribute must fall in the ranges [*minlen*-*maxlen*] and [*mindec*-*maxdec*].

The other constraints describe the relationships attributes have with their environment:

SUB_ATT_per_ATT (*min max*)	The number of subattributes of the attribute must fall in the range [*min*-*max*]. If [*2 N*], compound attributes must comprise at least 2 subattributes.
DEPTH_of_ATT (*min max*)	The level (depth) of the attribute must fall in the range [*min*-*max*]. Attributes directly attached to their entity type or rel-type are of level 1. If [*1 2*], only two-level hierarchies of attributes are allowed.

Other constraints specify the groups an attribute can be part of: it can appear in a given number of general groups, primary identifiers, reference groups, etc.

Application. The definition of relational models could include the following constraints:

MAX_CARD_of_ATT (1 1)
TYPES_ALLOWED_for_ATT ('CHAR','NUMERIC','FLOAT','DATE')
TYPE_DEF_for_ATT (CHAR *1 255*)
TYPE_DEF_for_ATT (VARCHAR *1 65000*)
DEPTH_of_ATT(1 1)

e) Constraints on a role

A role has an intrinsic properties: its cardinality, of which we can constrain both the minimum and the maximum cardinality:

MIN_CARD_of_ROLE (*min max*)	The minimum cardinality of a role must fall in the range [*min*-*max*].
MAX_CARD_of_ROLE (*min max*)	The maximum cardinality of a role must fall in the range [*min*-*max*].

The number of entity types that can appear in a role is defined as follows:

ET_per_ROLE (*min max*)	The number of entity types playing the role must fall in the range [*min*-*max*].

Application. The definition of the Bachman Data Structure Diagram model must include the following constraints, that describe the valid rel-type patterns:

MIN_CARD_of_ROLE (0 1)
MAX_CARD_of_ROLE (1 N)
ET_per_ROLE(1 1)

f) Constraints on groups

The group is a complex and polymorph concept, so that it can be assigned a large set of constraints. We will analyse groups in their general form first, then we will examine all their specialisations.

The only intrinsic property of a group is the function(s) it is allowed to play. The parameter *yn* takes two values, namely **yes** and **no**.

ID_in_GROUP (*yn*)	A group can/cannot be an *identifier.*
PID_in_GROUP (*yn*)	A group can/cannot be a *primary identifier.*
KEY_in_GROUP (*yn*)	A group can/cannot be an *access key.*
REF_in_GROUP (*yn*)	A group can/cannot be a *reference group.*
COEXIST_in_GROUP (*yn*)	A group can/cannot be a *coexistence group.*
EXCLUSIVE_in_GROUP (*yn*)	A group can/cannot be an *exclusive group.*
ATLEASTONE_in_GROUP (*yn*)	A group can/cannot be an *at-least-one group.*
INCLUDE_in_GROUP (*yn*)	A group can/cannot be the origin of an *inclusion* constraint.
INVERSE_in_GROUP (*yn*)	A group can/cannot be declared the origin of an *inverse* constraint.
GENERIC_in_GROUP (*yn*)	A group can/cannot be the origin of a *generic* constraint.

The relationship properties of the groups that can be constrained concern their components (relationship constraints with the owners of the groups are already defined for the parents). So we can count the global number of components of the number of components of each type:

COMP_per_GROUP (*min max*)	The number of component of a group must fall in the range [*min*-*max*].
ATT_per_GROUP (*min max*)	The number of attribute components of a group must fall in the range [*min*-*max*].
ROLE_per_GROUP (*min max*)	The number of role components of a group must fall in the range [*min*-*max*].

Application. In a COBOL file, an index (unique or not) can contain only one field:

COMP_per_GROUP (1 1)

The group constraints can be specialised according to the roles the group plays. Identifiers are among the groups deserving the greatest attention. Indeed, the identifier definition can itself differ from one model to another. Furthermore, DBMSs may impose their own constraints on identifiers. For instance, one model could accept identifiers made of multi-valued attributes, while another could refuse them; or one DBMS could refuse identifiers longer than 128 characters. We can also note that the identifier definition can be different depending on their parents in some models. For example, a model can accept that an entity type has an identifier made up of compound attributes, while identifiers of multi-valued compound attributes must be made of simple attributes only.

i) Constraints for entity type identifiers

COMP_per_EID (*min max*)	The number of components of an ET identifier must fall in the range [*min*-*max*].
ATT_per_EID (*min max*)	The number of attribute components of an ET identifier must fall in the range [*min*-*max*].
OPT_ATT_per_EID (*min max*)	The number of optional attribute components of an ET identifier must fall in the range [*min*-*max*].
MAND_ATT_per_EID (*min max*)	The number of mandatory attribute components of an ET identifier must fall in the range [*min*-*max*].

SINGLE_ATT_per_EID (*min max*)	The number of single-valued attribute components of an ET identifier must fall in the range [*min-max*].
MULT_ATT_per_EID (*min max*)	The number of multivalued attribute components of an ET identifier must fall in the range [*min-max*].
COMP_ATT_per_EID (*min max*)	The number of compound attribute components of an ET identifier must fall in the range [*min-max*].
ROLE_per_EID (*min max*)	The number of role components of an ET identifier must fall in the range [*min-max*].
OPT_ROLE_per_EID (*min max*)	The number of optional role (its minimum cardinality is 0) components of an ET identifier must fall in the range [*min-max*].
MAND_ROLE_per_EID (*min max*)	The number of mandatory role (its minimum cardinality is strictly positive) of the components of an ET identifier must fall in the range [*min-max*].
ONE_ROLE_per_EID (*min max*)	The number of "one" role (its maximum cardinality is 1) components of an ET identifier must fall in the range [*min-max*].
N_ROLE_per_EID (*min max*)	The number of "many" role (its maximum cardinality is strictly greater than 1) components of an ET identifier must fall in the range [*min-max*].

ii) Constraints for relationship type identifiers

A similar list of constraints exists for rel-type groups. The constraint names are suffixed with _RID.

iii) Constraints for attribute identifiers

The third list for groups defined on multi-valued compound attributes will be shorter because they can never be made up of roles:

COMP_per_AID (*min max*)	The number of components of an attribute identifier must fall in the range [*min-max*].
ATT_per_AID (*min max*)	The number of attribute components of an identifier must fall in the range [*min-max*].
OPT_ATT_per_AID (*min max*)	The number of optional attribute components of an attribute identifier must fall in the range [*min-max*].
MAND_ATT_per_AID (*min max*)	The number of mandatory attribute components of an attribute identifier must fall in the range [*min-max*].
SINGLE_ATT_per_AID (*min max*)	The number of single-valued attribute components of an attribute identifier must fall in the range [*min-max*].
MULT_ATT_per_AID (*min max*)	The number of multivalued attribute components of an attribute identifier must fall in the range [*min-max*].
COMP_ATT_per_AID (*min max*)	The number of compound attribute components of an attribute identifier must fall in the range [*min-max*].

iv) Constraints for primary identifiers

Though primary identifiers form a subset of the identifiers, they may, in some models be assigned specific constraints. For instance, a candidate key in a relational schema can be made up of optional columns, but a primary key comprises mandatory columns only.

The constraints are similar to those described here above, with suffix _EPID for entity type primary identifiers, _RPID for rel-type primary identifiers and _APID for attribute primary identifiers.

v) Constraints for reference groups

Reference groups reference identifiers. So it is logical to want to define reference keys the same way we defined identifiers. In fact, since reference keys can only be defined on entity types and never on rel-types, nor on attributes, we will define the new list of predicates for reference keys in the same way as we did for entity type identifiers:

COMP_per_REF (*min max*)	The number of components of a reference group must fall in the range [*min*-*max*].
ATT_per_REF (*min max*)	The number of attribute components of a reference group must fall in the range [*min*-*max*].
OPT_ATT_per_REF (*min max*)	The number of optional attribute components of a reference group must fall in the range [*min*-*max*].
MAND_ATT_per_REF (*min max*)	The number of mandatory attribute components of a reference group must fall in the range [*min*-*max*].
SINGLE_ATT_per_REF (*min max*)	The number of single-valued attribute components of a reference group must fall in the range [*min*-*max*].
MULT_ATT_per_REF (*min max*)	The number of multivalued attribute components of a reference group must fall in the range [*min*-*max*].
COMP_ATT_per_REF (*min max*)	The number of compound attribute components of a reference group must fall in the range [*min*-*max*].
ROLE_per_REF (*min max*)	The number of role components of a reference group must fall in the range [*min*-*max*].
OPT_ROLE_per_REF (*min max*)	The number of optional role (its minimum cardinality is 0) components of a reference group must fall in the range [*min*-*max*].
MAND_ROLE_per_REF (*min max*)	The number of mandatory role (its minimum cardinality is strictly positive) of the components of a reference group must fall in the range [*min*-*max*].
ONE_ROLE_per_REF (*min max*)	The number of "one" role (its maximum cardinality is 1) components of a reference group must fall in the range [*min*-*max*].
N_ROLE_per_REF (*min max*)	The number of "many" role (its maximum cardinality is strictly greater than 1) components of a reference group must fall in the range [*min*-*max*].

vi) Constraints for access keys

An access key is a technical property often attached to identifiers and to reference groups, so we can define constraints similar to those of identifiers and reference groups, identified by their suffix _KEY.

vii) Constraints for existence constraints

Coexistence, *exclusive* and *at-least-one* groups are simpler properties. Their definition is context independent, so they do not need special refinement.

viii) Constraints for inverse groups and user-defined constraints

Inverse groups can only be made up of a single object attribute, so they need no specific constraints. Generic constraints are user-defined. Since their semantics is user-defined as well, and due to the variety of their interpretation, no specific constraints exist for them. We will see later on how to do it anyway in a personalised way.

g) Constraints on is-a relations

Is-a relation have two intrinsic properties, namely totality and disjunction:

TOTAL_in_ISA (*yn*)	Totality property is allowed or not.
DISJOINT_in_ISA (*yn*)	Disjoint property is allowed or not.

Relations between their members can be seen as generalisation or specialisation:

SUPER_TYPES_per_ISA (*min max*)	The number of supertypes of an entity type must fall in the range [*min*-*max*].
SUB_TYPES_per_ISA (*min max*)	The number of subtypes of an entity type must fall in the range [*min*-*max*].

h) Constraints on names

The name of the components of a schema can be constrained by syntactic rules. This is particularly true for physical schemas, where name formation rules of the DBMS must be strictly enforced.

i) Valid characters and length

ALL_CHARS_in_LIST_NAMES (*list*)	The names must comprise characters from the list *list*.
NO_CHARS_in_LIST_NAMES (*list*)	The names must comprise characters that do not appear in the list *list*.
LENGTH_of_NAMES (*min max*)	The length of a name must fall in the range [*min*-*max*].

ii) Reserved and valid words

DBMSs generally impose that special words of the DDL cannot be used to name schema constructs (reserved words) and impose some naming conventions (restricted set of characters for instance).

NONE_in_LIST_NAMES (*list*)	The name of a construct cannot belong in the list of words *list*.
NONE_in_FILE_NAMES (*file*)	The name of a construct cannot belong in the list of words stored in the file *file*.
ALL_in_LIST_NAMES (*list*)	The name of a construct must belong in the list of words *list*.
ALL_in_FILE_NAMES (*file*)	The name of a construct must belong in the list of words stored in the file *file*.

The names in *list* and *file* can be constants (exact words) or expressions in the regular grammar used by the name name processing assistant of the supporting CASE tool [1].

i) User-defined constraints

Providing a complete predicate list would be unrealistic. DB-MAIN proposes a list of the main constraints that are relevant in the most widespread models, in legacy, current and future (at least as foreseeable) systems. This pragmatic approach obviously cannot meet all the requirements that could emerge in all possible situations. DB-MAIN offers a more general expression mean to define ad hoc constraints: it allows the analyst to develop his/her own predicates in the form of boolean functions within the Voyager 2 language.

A generic constraint is defined in each group of concepts:

V2_CONSTRAINT_on_SCHEMA (*voyager-file voyager-function parameters...*)
V2_CONSTRAINT_on_ET (*voyager-file voyager-function parameters...*)
V2_CONSTRAINT_on_RT (*voyager-file voyager-function parameters...*)

and so on with all suffixes: _ATT, _ROLE, _EID, _RID, _AID, _EPID, _RPID, _APID, _REF, _KEY, _ISA, _NAMES. In these constraints, *voyager-file* is the name of the Voyager 2 executable file containing the function *voyager-function* to execute; *parameters* is a single string containing all the parameters to pass to the function, its format being dependant on the function. Since both the file and the function are passed as parameters, a database engineer can build libraries of functions, and to use only the constraint(s) he or she needs for the current model, possibly several for a same concept. The syntax of this constraint is detailed in appendix A.17 with an example.

Application. In an IMS hierarchical schema, relationship types cannot form cycles. This cannot be expressed with the predefined constraints, but it can be checked by a Voyager 2 function, let us call it *IsThereCycles*, which can be placed in a library called *IMS.OXO*[2]. It does not need a parameter. We can also measure the number of levels in a hierarchy with a function *HierarchyDepth*, placed in the same library, with two parameters: *min* and *max* to specify that the number of levels in a hierarchy must fall in the range [*min*-*max*].

```
V2_CONSTRAINT_on_RT (IMS.OXO IsThereCycles)
V2_CONSTRAINT_on_RT (IMS.OXO HierarchyDepth 1 8)
```

Furthermore, the user can extend the GER model by defining dynamic properties on every concept. Another group of constraints has been defined on dynamic properties:

DYN_PROP_of_SCHEMA (*dynamic-property parameters*)
DYN_PROP_of_ET (*dynamic-property parameters*)
DYN_PROP_of_RT (*dynamic-property parameters*)

and so on with every other suffix. *Dynamic-property* is the name of a dynamic property defined on the concept corresponding to the constraint suffix, and *parameters* are the parameters whose syntax depends on the property definition. The syntax is detailed in appendix A.16 with several examples.

Application. Let us suppose an integer dynamic property named security-level is defined on entity types. We need a constraint to ensure that its value is comprised between 0 and 4 which are the only meaningful values:

```
DYN_PROP_of_ET (security-level 0 4)
```

j) Complex constraints

The structural predicates presented so far can be assembled to form complex constraints through the use of the standard *not*, *and* and *or* logical operators. We will call such an logical expression a **structural rule**. In the same way a structural predicate is a constraint that must be satisfied by each concerned component of a schema, the structural rule is also a constraint that must be satisfied by each component of the schema. The two following examples show two structural rules:

COMP_per_EID (1 N)	for each entity type identifier ID:
and ROLE_per_EID (0 0)	*either* ID comprises one or several components and comprises no
or COMP_per_EID (2 N)	roles,
and ROLE_per_EID (1 N)	*or*, if ID comprises roles, it must comprise two or more compo-
	nents.
ROLE_per_RT (2 2)	for each relationship type R:
or ROLE_per_RT (3 4)	*either* R comprises two roles,
and ATT_per_RT (1 N)	*or* R is N-ary and has attributes
or ROLE_per_RT (3 4)	*or* R is N-ary, has no attributes and has no *one* (i.e. [0-1] or [1-1])
and ATT_per_RT (0 0)	roles
and ONE_ROLE_per_RT (0 0)	

A complex constraint must satisfy the following rules:

1. all its predicates apply on the same concept. For example, the following example is valid:

```
ATT_per_RT (0 0) and role_per_RT (2 N)
```

while the next one is not:

2. .OXO is the standard extension for Voyager executable files.

ATT_per_ET (1 N) and ATT_per_RT (0 0)

Guessing what the author probably meant, this constraint should be rewritten as:

ATT_per_ET (1 N)
ATT_per_RT (0 0)

2. The logical operators have their traditional priority rules. So, *not* operators are executed first, then the *and* operators, and finally the *or* operators. Parenthesis are not supported so every logical formula can be expressed in its *disjunctive normal form*, i.e. as a disjunction of conjunctions, with the use of distributive laws. For instance, if *P*, *Q* and *R* are predicates,

P and (*Q* or *R*) = (*P* and *Q*) or (*P* and *R*) = *P* and *Q* or *P* and *R*

Now, we can built a more comprehensive definition of the relational model, that is to say, of the set of constraints any RDBMS-compliant schema must meet:

ET_per_SCHEMA (1 N)	A schema includes at least one entity type.
RT_per_SCHEMA (0 0)	A schema includes no relationship types.
SUB_TYPES_per_ISA(0 0)	A schema includes no is-a relations.
ATT_per_ET (1 N)	An entity type comprises at least one attribute.
SUB_ATT_per_ATT (0 0)	Attributes are simple (atomic). In other words, the number of sub-attribute per attribute is exactly 0.
MAX_CARD_of_ATT (1 1)	Attributes are single-valued. In other words, their maximum cardinality is exactly 1.
PID_per_ET (0 1)	An entity type has at most one primary identifier.
OPT_ATT_per_EPID (0 0)	A primary identifier is made up of mandatory (i.e., with cardinality [1-1]) attributes only.
ID_per_ET (0 0)	If an entity type has some identifiers,
or ID_per_ET (1 N)	at least one of them is an access key.
and ID_NOT_KEY_per_ET (0 0)	
V2_CONSTRAINT_on_REF (REL.OXO RefConsistency)	A reference group and its target identifier have the same composition (their components have same type and length, considered pairwise). This complex constraint is checked by a user-defined function *RefConsistency.*
ALL_CHARS_in_LIST_NAMES (ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz0123456789$_) and NONE_in_LIST_NAMES(_$,$$) and LENGTH_of_NAMES(0 31) and NONE_in_FILE_CI_NAMES (ResWords.nam)	The names of the components of the schema must be valid: 1. They must be made of letters and figures and symbols $ and _ only 2. They cannot end by the symbols $ and _ 3. They cannot be longer than 31 characters long 4. They cannot be reserved words of the language, the complete list of these words being in the file ResWords.nam.

5.1.2 Schema model description syntax

The definition of a schema model **M** follows the following pattern:

```
schema-model name [is inherited-schema-model]
    title "title"
    [description
        description text
    end-description]
    concepts
        concept-name "local-name"
        concept-name "local-name"
        ...
    constraints
        rule
        diagnosis "diagnosis-string"
        rule
        diagnosis "diagnosis-string"
        ...
end-model
```

where :

- *name*: an identifier that will be used to reference **M** throughout the method description. This name must be made of maximum 100 letters (lower case or upper case, but no accents), figures, "-" or "_".
- *inherited-schema-model*: another schema model from which the current schema model can inherit its definition (concepts and constraints); this is optional.
- *title*: a more readable name of **M** that will be used by the supporting CASE tool user interface. It can be made of any character (max. 100). It does not need to be identifying.
- *description text* is an optional small description of the model that will appear in dialog boxes in the supporting CASE tool. See the method *description text* for the syntax.
- *concept-name*: one of the concepts of the GER model **M** is made up of. For instance, a relational model has the concept of entity type (renamed *table*, see below) but not the concept of relationship type. So *entity_type* will appear in the list, but not *rel_type*. The allowed concept names are the following:

access_key	at_least_one_constraint	atomic_attribute
attribute	call_relation	coexistence_constraint
collection	compound_attribute	constraint
decomposition_relation	entity_type	exactly_one_constraint
exclusive_constraint	generic_constraint	group
identifier	in_out_relation	inverse_constraint
is_a_relation	note	object
primary_identifier	processing_unit	project
referential_attribute	referential_constraint	rel_type
role	schema	secondary_identifier
sub_type	super_type	text
user_constraint	variable	

- *local-name* is the renaming of a concept into the local model. For instance, the GER concept of entity type will be renamed in an ER model defined in a French-speaking company with name *Entité*, in an OO model with name *Classe d'objets* and in a relational model with name *Table*.
- *rule* is a structural rule as defined above. A rule is a boolean expression the terms of which are predicates. Boolean operateors are **not**, **and**, **or**. A predicate has a name and parameters enclosed between parantheses. The syntax of the parameters depends on the predicate name. A few examples

were shown above. The parameters are in fact a list of characters which will only be interpreted by the methodological engine, not by the MDL compiler. This list of characters can thus contain any character excepted the closing parenthesis. To use a parenthesis in the parameters anyway, it must be preceeded by a backslash character (\). The backslash character itself must be doubled (\\). In a general rule, any character preceeded by a backslash is used as is in the parameter string.

- *diagnosis-string* is associated with a rule. It contains a message to be printed on screen when the rule is violated. This message can be made of any character (max. 255). It can contain the special word "&NAME" to include the name of the object that violates the rule.

Figure 5.1 shows the MDL definition of a simple physical SQL model.

```
schema-model SQL-MODEL
        title "SQL model"
        description
                |Simple SQL model:      no supertype/subtype structures,
                |                       no rel-types,
                |                       no compound attributes,
                |                       no multivalued attributes,
                |                       primary keys enforced;
                |                       valid referential constraints allowed
                |                       access keys required;
                |                       valid names enforced.
        end-description
        concepts
                entity_type             "table"
                attribute               "column"
                atomic_attribute        "column"
                primary_identifier      "primary key"
                secondary identifier    "unique"
                reference_constraint    "foreign key"
                processing_unit         "trigger"
        constraints
                ET_per_SCHEMA (1 N) % A schema includes at least one entity type.
                        diagnosis "The schema should contain at least one table."
                RT_per_SCHEMA (0 0) % A schema includes no relationship types.
                        diagnosis "The schema should not contain rel-types."
                SUB_TYPES_per_ISA(0 0) % A schema includes no is-a relations.
                        diagnosis "The schema should contain no is-a relations."
                ATT_per_ET (1 N) % An entity type comprises at least one attribute.
                        diagnosis "Table &NAME should contain at least one column."
                SUB_ATT_per_ATT (0 0) % Attributes are simple (atomic).
                        diagnosis "Column &NAME should be atomic."
                MAX_CARD_of_ATT (1 1) % Attributes are single-valued.
                        diagnosis "Column &NAME should be single-valued."
                PID_per_ET (0 1) % An entity type has at most one primary identifier.
                        diagnosis "Table &NAME has too many primary keys."
                OPT_ATT_per_EPID (0 0) % A primary id. is made up of mandatory att. only.
                        diagnosis "Primary key &NAME should not contain an optional column."
                ID_per_ET (0 0) % If an entity type has some identifiers,
                or ID_per_ET (1 N) % at least one of them is an access key.
                  and ID_NOT_KEY_per_ET (0 0)
                        diagnosis "Table &NAME should have an access key among its
                                                                  unique constraints"
                V2_CONSTRAINT_on_REF (REL.OXO RefConsistency)
                        diagnosis "Referential constraint &NAME does not match its target."
```

```
                    ALL_CHARS_in_LIST_NAMES (ABCDEFGHIJKLMNOPQRSTUVWXYZ
                                                  abcdefghijklmnopqrstuvwxyz0123456789$_)
                     and NONE_in_LIST_NAMES(_$,$$)
                     and LENGTH_of_NAMES(0 31)
                     and NONE_in_FILE_CI_NAMES (ResWords.nam)
                            diagnosis "&NAME is an invalid name."
      end-model
```

Figure 5.1 - MDL definition of an SQL schema model

5.2 Text model description

Like a schema model, a text model can be defined by a selection and renaming of concepts form a general text model, and by a series of constraints on the selected concepts.

In the beginning of this chapter, we saw four typical examples of texts. They can be expressed within the following *general text model* (GTM):

> A text is a series of *text elements*. Each text element is either a *character* or a itself series of text elements.

To define the structure of a text, we have to define its grammar. In other words, we have to define each text element by giving its name and its structure. Since the number and the structure of elements are dependant on the text format, it is not possible to dissociate the naming conventions from the constraints as we did with schema models. Hence, the whole definition of a text model holds in its grammar. We will define a text grammar with the *pattern definition language* (PDL) offered by DB-MAIN for text analysis and program slicing purposes.

5.2.1 Defining a grammar: the PDL language

The grammar is expressed by a series of patterns close to a BNF notation with variables. The language is the Pattern Definition Language (PDL).

A pattern is of the form:

> *pattern_name* ::= *expression*

where *pattern_name* is any word beginning by a letter and made of no more than 100 letters and figures, and *expression* describes the syntax of the pattern. The expression can be made of strings, of other patterns, of variables, and of some operators. We will describe all these elements below.

The simplest pattern is a simple string. For instance:

> OpeningSymbol ::= “begin”

It means that the single word “begin”, when found in the analysed texts, will always be understood as an opening symbol, even if we do not know what is opened, which will be declared by other patterns. For instance,

> Sequence ::= OpeningSymbol Instructions ClosingSymbol

is a pattern using three other patterns in sequence. Note that PDL requires the patterns OpeningSymbol, Instructions and ClosingSymbol to be declared before the pattern Sequence.

In the following we will call a string a *terminal symbol*, and we will call pattern names appearing at the right of the “::=” sign a *non-terminal symbol*. We will also use the term *symbol* when we do not want distinguish terminal from non-terminal symbols.

There is second kind of terminal symbol: a character range. For example, the pattern

> Figure ::= range(0-9)

is matched by every character whose ASCII code is comprised between the code of “0” and the code of “9”, that is by “0”, “1”, “2”, “3”, “4”, “5”, “6”, “7”, “8” and “9”.

The last kind of terminal symbol is a *grep expression*. Grep is a well-know unix originated tool aimed at searching for a string in a file; the string can be expressed as a complex expression with various possibilities. The syntax of these expressions is well-known and presented in a lot of books and in the Unix man pages, so we will not remind it here. Such an expression has to be enclosed between double quotes and prefixed by “\g”. For example, the following pattern defines a general space as a series of single space character, of tabulations, and of ends-of-line:

Space ::= \g“[\t\n]*”

A third kind of symbol is a variable. A variable is in fact a non-terminal symbol prefixed by “@” the instanciation of which is stored, for future reuse by some functions of the CASE environment, when the pattern matches a part of a text file.

For instance, in the pattern

Sequence ::= OpeningSymbol @Instructions ClosingSymbol

@Instructions is a variable. When this pattern matches a text, all the part that matches the non-terminal symbol Instruction is kept for the CASE environment to use it.

All the symbols defined above can be assembled with some operators to form expressions. The simplest assembling is the sequence used in the examples above: symbols are written in the order of appearance, simply separated by a space when necessary to avoid confusion.

A symbol can be made optional with square brackets. In the following example, the Instructions are optional, so empty sequences are allowed:

Sequence ::= OpeningSymbol [Instructions] ClosingSymbol

A symbol can also be repeated several times. The * operator is used for this. In the following examples, the pattern Instructions is defined as an unlimited number of Instruction’s:

Instructions ::= Instruction*

We can in fact repeat several symbols in sequence by grouping the symbols of the sequence between parentheses. For instance, if every Instruction as to be terminated by a semi-colon:

Instructions ::= (Instruction Space ”;” Space)*

Finally, the | operator can be used to separate a few alternatives. For instance:

ArithmeticOperator ::= “+” | “-” | “*” | “/”

The complete language syntax is presented in appendix B.

Let us examine a small complete example:

Figure ::= range(0-9)
Number ::= Figure Figure*
Operator ::= “+” | “-” | “*” | “/”
Calculus ::= Number (Operator Number)* “=” @Number

This simple grammar expresses the syntax of a file containing a simple arithmetic calculus with integer numbers. A file containing the following single line is correct with respect to this grammar:

12*5+35=95

When the syntax of this file is checked with the grammar, the @Number variable is initialised with the value 95, which can be used by the CASE environment.

On the contrary, the following files are not valid:

12*5+35=95 15/5+6=9	*the grammar does not allow several calculus*
1.2 * (5 + 35) = 48	*floating numbers, parenthesis and spaces are not allowed*
95=12*5+35	*operators are only allowed at left side of =*

But the following file is correct because only the syntax is checked, not the semantics:

1=2

By example, a complete Integer Calculus text model can be defined as:

```
Figure ::= range(0-9)
Number ::= Figure Figure*
Operator ::= “+” | “-” | “*” | “/”
Calculus ::= Number (Operator Number)* “=” @Number
```

In practice, a more realistic grammar is the one of SQL or Cobol. These are much more complicated grammars which lead to much longer PDL descriptions. When reverse engineering a Cobol application, it is necessary to write this grammar in order to allow the CASE environment and engineers who use it to analyse correctly the source files. But, for some different tasks, such as generating an SQL DDL from an SQL compliant schema, which is done automatically by a generator, detailing this precisely the grammar is useless. In fact, we just need to express that the generated file contains an SQL DDL. In the DOS/Windows based environments, it suffices to know the extension of a file to know what it contains. So, we can define a text model grammar by a list of possible file extensions. For instance, it is well known that a “.txt” file contains free text, a “.cpp” file is a C++ file, and a “.sql” file contains an SQL DDL. So we can simply define an SQL DDL text model by its concept selection and renaming, and by the “.sql” extension.

5.2.2 The text model description syntax

The specification of a **text model** can be simple when no syntax is enforced. Otherwise, the file including the grammar of the contents of the texts is mentioned.

```
text-model name is [inherited-text-model]
    title "title"
    [description
        description text
    end-description]
    extensions "extension", "extension",...
    [grammar "grammar"]
end-model
```

where :

- *name*: an identifier that will be used to reference **M** throughout the method description. This name must be made of maximum 100 letters (lower case or upper case, but no accents), figures, "-" or "_".
- *inherited-text-model*: another text model from which the current text model can inherit its definition extensions; this is optional.
- *title*: a more readable name of **M** that will be used by the supporting CASE tool user interface. It can be made of any character (max. 100).
- *description text* is an optional small description of the model that will appear in dialog boxes in the supporting CASE tool. See the method *description text* for the syntax.
- *extension* is a possible file extension for a file containing a text of this model. As file extensions are usually associated with the same kind of files, they suffice for describing the content of a file. For instance, ***extension*** *"cob"* means that text of this model are all COBOL files, therefore they are texts with a COBOL syntax. An extension can be made of any character (max. 100).
- *grammar* is the name of a file containing a series of patterns written in the *Pattern Definition Language*: a PDL file (*.pdl) as described above. This is optional.

Here are two examples of text models.

```
text-model PLAIN-TEXT
    title "Plain ASCII text"
    description
      ASCII file that can be read by text editors
    end-description
```

```
        extensions "rpt", "txt"
end-model

text-model COBOL-PROGS
        title "COBOL programs"
        extensions "cob"
        grammar "COBOL.PDL"
end-model
```

Chapter 6

Global product types

A product type **D** is an identified document used and/or produced by engineering process type **P**. When an instance p of **P** is performed, it uses/generates an instance d of **D**. In some cases, p can involve several instances d_i of **D**, or several instances p_i of **P** can each involve an instance d_i of **D**. A product type is compliant with a product model that defines which concepts, which names and which assembly rules can be used to make each instance of this product type. In this chapter, we will define global product types, i.e. product types that are accessible during any process. Product types can also be local to **P**. This later case will be discussed in Chapter 8.

The syntax of global product type description is the following :

> **product** *name*
>   **title** "*title*"
>   [**description**
>   *description-text*
>   **end-description**]
>   **model** [**weak**] *model-name*
>   [**multiplicity [***min-max***]**]
> **end-product**

where :

- *name* is an identifying name of the product type throughout the method. This name must be made of maximum 100 letters (lower case or upper case, but no accents), figures, "-" or "_".
- *title* is a second name that is aimed at representing the product type in the supporting CASE tool in a more readable way then the identifier. It can be made of any character (max. 100).
- *description-text* is an optional free text describing the product type in a natural language. This description is to be used by the supporting CASE tool user interface. Its syntax is the same as the *description-text* of the method.
- *model-name* is the name of the product model the current product type is a type of. It must be the identifier of a previously defined product model (schema model or text model). If the **weak** keyword is specified, products of this type should preferably respect all the constraints declared in the product model, but some transgressions are bearable.
- *min* is the minimum number of products of type D that must be defined in order to be able to start processes that use that type (d_1...d_n are instances of **D**, *min* $\leq$ n). *min* is an integer value.

- *max* is the maximum number of products of type D that can be defined in order to be able to start processes that use that type ($d_1 ... d_n$ are instances of **D**, $n \leq max$). It is an integer value or *N* (possibly *n*) to represent infinity.

Note that the multiplicity line is optional. When it is not specified, *min* is assumed to be equal to 0 and *max* is assumed to be equal to *N*.

In the graphical representation of a method, a product type is shown as an ellipsis.

The following example shows a product type definition:

```
product Optimized Schema
    title "Logical Optimized Schema"
    description
        Logical binary schema including optimization constructs
    end-description
    model BACHMAN-MODEL
    multiplicity [0-1]
end-product
```

Chapter 7

Toolboxes and external functions

Among the different kinds of primitive process types a method can use, two of them need to be previously defined: toolboxes and external functions. Toolboxes need to be declared and filled with a series of tools. External functions are Voyager 2 functions whose signature needs to be declared in order for the methodological engine to be able to find them and to know how to handle parameters.

7.1 Toolbox

A toolbox **T** is a subset of the supporting CASE tool functions that can be used at a particular time. The language is able to describe the activity to follow by an analyst until a certain point. When this point is reached, the only thing the CASE tool can do is to let the analyst work by herself and to prevent her to do mistakes by allowing her to use some particular tools only. These tools are grouped in a toolbox. Several toolboxes can be defined by the language. The process types defined in Chapter 8 will allow the use of the toolboxes when needed. A toolbox has an identifying name, a readable title, possibly a textual description and a list of tools. Toolboxes can be defined hierarchically. If a toolbox is defined on the basis of another toolbox, it inherits all its tools. The new toolbox is then defined by adding or removing tools from the original toolbox. The syntax of a toolbox description is the following:

> **toolbox** *name* [**is** *inherited-toolbox*]
>   **title "***title***"**
>   [**description**
>   *description-text*
>   **end-description**]
>   **add**/**remove** *tool-name*
>   **add**/**remove** *tool-name*
>   ...
> **end-toolbox**

where:

- *name* identifies **T** in the method. This name must be made of maximum 100 letters (lower case or upper case, but no accents), figures, "-" or "_".
- *inherited-toolbox* is the name of another toolbox from which **T** inherits its definition. This is optional.
- *title* is a second, more readable, name that will be used in the supporting CASE tool user-interface. It can be made of any character (max. 100).

- *description-text* is an optional free text describing the toolbox in a natural language. This description is to be used by the supporting CASE tool user interface. Its syntax is the same as the *description-text* of the method.
- *tool-name* is the name of a tool to add to or to remove from the toolbox. This name is a predefined name provided by the supporting CASE tool. Appendix D lists all the tools provided by DB-MAIN. The number of tools that can be added is unlimited.

The following example shows a toolbox description.

> **toolbox** TB_BINARY_INTEGRATION
>   **title** "Binary schema integration"
>   **description**
>   This toolbox allows you to integrate a slave schema into a master schema.
>   **end-description**
>   **add** SCHEMA_INTEGRATION
> **end-toolbox**

7.2 External function declarations

External functions are primitive process types that have to be performed by third-party tools. In order for them to be accessible, they have to be declared with their signature. These special functions will be developed in a 4GL. Voyager 2 is the 4GL of DB-MAIN that can be used for that purpose. The syntax of such a declaration is:

> **extern** name **"***voyager-file***".***voyager-function***(***param-type param-name*,...**)**

where:

- *name* is the name by which the function will be identified throughout the method.
- *voyager-file* is the compiled Voyager 2 file name (*.oxo) that contains the function.
- *voyager-function* is the name of a Voyager 2 function that is defined in *voyager-file*. It must be declared exportable and return an integer value. The semantic of this integer value depends on the intended use of the function:
  - If it is a boolean expression aimed at being used in expression, a value of 0 means false and all other non-null value means true.
  - If it is a function aimed at being used as a primitive process type, it should return 1 if it performed correctly and 0 if an error occurred. All other values are undefined and should never be returned. It is also to be noted that the function should handle error messages by itself.
- *param-type* is a formal argument of the function. It can take several values depending of the actual function. And the actual function has to be written with respect to what the method engineer wants :
  - To pass an integer value in input of the actual function, it must be defined with an integer parameter and *param-type* must be **integer**.
  - To pass a string in input of the actual function, it must be defined with a string parameter and *param-type* must be **string**.
  - To pass a product type in input or in update of the actual function, it must be defined with a list parameter and *param-type* must be **list**. In that case, when the function will be called, the list will be initialised with all the product of the passed type. It is to be noted that the function cannot modify the list (add or remove products) but all the products can be modified; so it is to the function to be aware of not modifying input products.
  - To pass a product type in output so that the function can create new products of the passed type, the function has to be defined with a product type parameter and *param-type* must be **type**. The Voyager 2 function has to create the new product with the *create*

instruction; for instance, to create a schema, if the schema type passed in parameter is called st:

```
create(SCHEMA,...,SCHEMA_TYPE:st)
```

- *param-name* is the name of the parameter. This name is only used for readability of the source code and is no other use; it is simply skipped by the compiler.

For instance, a Voyager 2 function can be defined in file c:\functions\lib.oxo as:

```
export function integer F(list L, integer I, product_type T) {...}
```

So it needs to be declared with the followin line:

extern extf “c:\functions\lib.oxo”.F (**list**, **integer**, **type**)

In the method, this function will be known as *extf* and will need a product type the products of which will be passed in input or in update, an integer value and a product type for the products that will be generated in output.

Chapter 8

Process types

A process type is the description of the activity that must/can be carried out to solve, in a general way, a class of problems. Though a process type can describe a non-procedural behaviour, it is fairly close to the concept of procedure in standard programming languages. In particular, a process type has an *external description*, which states its activation condition and environment as well as its effect (its specification in software engineering terms) and an *internal description*, which states how the effect can be achieved. We will call *interface* the external description of a process type and *strategy* its internal description.

Only engineering process types are provided with an internal description. Indeed, primitive process types being built-in functions of the supporting CASE tool, we have to take them as they come, i.e., as black boxes with immutable specifications. We will now study how to specify and model an engineering process type.

8.1 Engineering process type decomposition

An engineering process type is the description of a class of processes, which are themselves activities performed in order to reach a given goal. The internal description is often simplified when expressed in terms of sub-process types, each of these sub-processes having its own description. When working with large problems, it is generally recommended to divide them into smaller sub-problems and to solve each of them independently. When designing a method, each sub-problem will be solved by a process type. All these process types will be assembled with control structures to solve the larger problem. Hence, a complex engineering process type can be decomposed in a hierarchy of process types.

For instance, a simple forward engineering database design (*FEDD*) can be decomposed in four main phases (a complete case study using this method is shown in chapter 10):

1. Conceptual analysis.
2. Logical design.
3. Physical design.
4. Coding.

Then each of these phases can also be decomposed in several steps:

1. Conceptual analysis: problem analysis – conceptual normalisation.
2. Logical design: relational design – name processing.
3. Physical design: index setting – storage allocation.

4. Coding: coding parameters setting – SQL generation.

We can go further by refining the *relational design* process type in several simpler steps:

Relational design: is-a relations transformation – non-functional rel-types transformation – attributes flattening – resolving identifiers – transformation of rel-types into reference keys.

In this decomposition, *FEDD*, *conceptaul analysis*, *logical design*, *physical design*, *coding*, and *relational design* are engineering process types. Others are primitive process types.

We will say that the execution of a process *requires* the execution of sub-processes. Or that a process type *uses* a sub-process type.

Each engineering process type in a decomposition defines its own context into which specific product types are defined. Some of them are defined in the interface, others are part of the internal description. When a process *p* of type *P* requires the execution of a sub-process *q* of type *Q*, products must be passed between them: a product *x* being of a given type T_1 in the context of *P* must be affected another type T_2 in the context of *Q*. So, during the execution of *q*, the same product is of two different types at the same time, in two different contexts.

A product type has cardinality constraints which specify the minimum and the maximum number of product instances that can be of that type at a precise moment. This moment depends on the usage of the product type as we will see below.

Formal parameters are product types of the interface used in input, in output or in update by a process type. Section 8.3 is concerned about them.

An **internal product type** is a product type used by the strategy whose instances are temporarily created and used during the execution of a process of this type, and that disappear at completion of the process. It is declared locally to a process type and has no existence outside of it. When a process starts, its internal product types have no instance. Some instances can be created from scratch, can be copies of products of other types, or can be generated by a sub-process. These internal products can then be modified. Before terminating the process in which it has been created, an internal product, or part of it, can be copied into an output product. Since there is no product of this type at the beginning of a process, the minimal cardinality of the type cannot be checked permanently. But it can be checked when the process ends as a control tool. The maximum cardinality can be checked permanently.

A **product set** is a container used by the strategy that can accommodate any number of products. It allows products to be collected in order to be handled all at once. The products can be of different types. As we will see later, sets can be used in set operations (union, intersection,...). They can also be used everywhere a product type is needed in input or update; in that case, all products of the set having the correct type are used, the others being simply left aside. For instance, let us assume we have an ORACLE-SQL and a DB2-SQL schema types, both compliant with a SQL-MODEL, are available. Let us assume we also have an integration process type defined with an SQL product type in input which is compliant with the SQL-MODEL. To integrate all the schemas, we can define a product set as the union of the set of the products of ORACLE-SQL type and the set of products of DB2-SQL type and pass that new set to a new integration process. Since the set is empty when a process starts and since the content of the set is always the result of a set operation (like the union) or product selection (the user has to choose the products to put in the set, as we will see later), the cardinality constraint of the set can be checked after each operation or selection.

From now on, for homogeneity and clarity reasons, we will consider product types as special product sets. Indeed, since a product type is a class of products that play a definite role in the system life cycle, it can be considered to be a product set that cannot be modified by set operations. Each time we use the term *product set*, the reader should understand *product type or product set*, excepted when explicitly stated.

A strategy is the internal description of a process type, More precisely, a **strategy** is the description of how a process instance can/must be carried out. It comprises the list of process types to perform and the way they can be carried out (the control flow). An important aspect of engineering process strategies is that they can range from completely deterministic to fully human-controlled. Consequently, the control structure offered by the process model must include both imperative and non-deterministic control structures. Through the analysis of a large collection of published, experimental and pragmatic methods, we have identified a small set of control structures that seem sufficient at the present time, but that still need evaluation. The proposal is fairly large and general though. In particular, it can describe in an elegant way unstructured toolbox-based approaches (*do all what you want, the way you want, on any product*), completely deterministic procedures (*just choose the input product then click here*) and a large range of strongly- or loosely- constrained procedures.

8.2 The process description

The MDL specification of a process type **P** states the input/output flows of the process, as well as the way it must be carried out. It has the following syntax:

```
process name
        title "title"
        [description
                description-text
        end-description]
        [input input-product-type, input-product-type,...]
        [output output-product-type, output-product-type,...]
        [update update-product-type, update-product-type,...]
        [intern intern-product-type, intern-product-type,...]
        [set product-set, product-set,...]
        [explain "explain-section"]
        strategy
                strategy
end-process
```

where:

- *name* identifies **P** in the method. This name must be made of maximum 100 letters (lower case or upper case, but no accents), figures, "-" or "_".
- *title* is a second, more readable, name of **P** that will be used in the supporting CASE tool user-interface. It can be made of any character (max. 100).
- *description-text* is an optional free text describing the toolbox in a natural language. This description is to be used by the supporting CASE tool user interface. Its syntax is the same as the *description-text* of the method.
- *input-product-type*: a local product type used as a formal parameter for input products as described below.
- *output-product-type*: a local product type used as a formal parameter for output products as described below.
- *update-product-type*: a local product type used as a formal parameter for updated products as described below.
- *intern-product-type*: a local product type which is not a formal parameter. Hence, product of this type have no existence outside processes of type **P**. Local product types are described below.
- *product-set*: a local product set that can be used for handling large quantities of products by using set operators. Product sets are described below.
- *explain-section*: the section of a help file that explains the goal and the way of working of any process of type **P**. This section has a name that can be made of any character.
- *strategy*: the way of carrying out the instances of **P**. Strategies are described below.

8.3 Formal parameters

8.3.1 Parameter properties

Most generally, a process of a given type uses some products to produce and/or modify other products. A product type can play three roles in the interface of a process type: input, output and update.

- **Input product type**: it is a class of products that can be used during the execution of a process. These products can be referenced, consulted, analysed or copied, but cannot be modified nor created. When a process starts, the class is initialised with a series of products. The number of these products must match the minimum and maximum constraints of the product type.
- **Output product type**: it is a class of products generated by a process. When the process starts the output type has no instances. They have to be created or copied from other product types and modified. The number of products of that type has to match the minimum and maximum constraints when the process ends.
- **Update product type**: it is a class of products that can be modified during a process. When a process starts, the class is initialised with a series of products. The number of these products has to match the minimum and maximum constraints of the product type. During the process, products can be referenced, copied, modified but cannot be created.

We will see in section 8.3.2 that we can also add new products to a non-initially-empty class using these three roles only.

Let *P* be an engineering process type and *Q* be a process type, such that *Q* is used by *P*. Let us denote by *I* a product type declared as input of *Q*, *O* a product type declared as output of *Q* and *U* a product type declared as update by *Q*. Let us examine what can be passed to *I*, *O* and *U*. In other words, let us examine what product type *T* declared in the context of *P* can have its products passed to *I* or *U*, or can receive products from *O*.

A product type *T* of *P* used in input of *Q* must be compatible with *I*. We will say that *T* is **I-compatible** with *I* if and only if one of the following propositions holds:

- *T* and *I* are of the same model
- the model of *T* inherits from the model of *I*.

Indeed, since products of type *T* exist before the use of *Q* and since the product type *I* is simply a product type aimed at seeing these products inside *Q*, the model of *I* has to be the same or to be more general than the model of *T*; the model of *T* must be a sub-model of the model of *I* in order to avoid unmanageable structures.

A product type *T* of *P* used in output of *Q* must be of a type compatible with *O*. We will say that *T* is **O-compatible** with *O* if and only if one of the following propositions holds:

- *T* and *O* are of the same model
- the model of *O* inherits from the model of *T*.

Indeed, since *O* is the type of new products inside *Q* and since these products have to be mapped to type *T*, products of type *O* cannot contain structures that could not be valid in type *T*. So *O* has to be of a more restrictive model than *T*, at best of the same model as *T*.

If there already exists some products of type *T* before *P* uses *Q*, none of these products will be considered as instances of *O*, but all instances of type *O* will be mapped to *T* when *Q* ends without affecting the pre-existing products of type *T*.

A product type *T* of *P* used in update by *Q* must be of a type compatible with *U*. We will say that *T* is **U-compatible** with *U* if and only if T and *U* are of the same model. Indeed, *U* cannot be of a more restrictive model than the model of *T* for the mapping when the process starts, and *U* cannot be of a more general model than the model of *T* since the products modified by the instance of *Q* still have to be of type *T in the context of P*.

When a process type calls a sub-process type and passes a product type, it means all the products of that type. This has to be possible according to the type cardinalities. Indeed, when a product type *T* is passed by *P* to an input product type *I* of a *Q* or to an update product type *U* of *Q*, the number of instances of *T* must fall in the range of the cardinalities of *I* or *U*; when a product type *T* of *P* receives products from a product type *O* of *Q*, the number of instances of *O* must fall in the range of the cardinalities of *T*. This constraint could be checked at method definition time by comparing the cardinalities of *I*, *U*, or *O* with the cardinalities of *T*, but this can lead to unnecessarily too much constraining situations, so it will actually be checked at execution time.

8.3.2 Using parameters

Let us imagine we are designing a process type *P* and we need to define a sub-process type *Q* to solve a particular problem. *P* uses a product type, say *T*, whose instances will be passed to *Q* (for consultation or for modification) or produced by *Q* and passed back to *P*. Let us classify our possible needs along three independent axes:

1. *Q* can (1a) or cannot (1b) create (and modify) new products of type *T*.
2. *Q* can (2a) or cannot (2b) modify existing (before the use of *Q*) products of type *T*.
3. Existing products of type *T* are (3a) or are not (3b) accessible from *Q*.

This leads to eight parameter passing patterns:

- 1b-2b-3a: existing products of type *T* are accessible, thought non modifiable, inside *Q* and no new products can be created. It suffices to declare an input product type *I* in *Q* and pass *T* to *I*.
  Example:
  ```
  process-type Q
    input I
    ...
  process-type P
    ...
    do Q(T)
  ```
- 1b-2a-3a: existing products of type *T* are accessible and modifiable inside *Q*, but new products cannot be created. It suffices to declare an update product type *U* in *Q* and pass *T* to *U*.
  Example:
  ```
  process-type Q
    update U
    ...
  process-type P
    ...
    do Q(T)
  ```
- 1a-2ab-3b: *Q* can create new products but cannot access old products of type *T* (note that since old products are not accessible, we do not need to distinguish cases 2a and 2b). This is the role of an output product type *O* declared in *Q* to which product type *T* can be passed.
  Example:
  ```
  process-type Q
    output O
    ...
  process-type P
    ...
    do Q(T)
  ```
- 1a-2b-3a: existing products of type *T* are accessible, thought not modifiable by *Q* and new products of type *T* can be created. The solution is simply to declare two product types *I* in input and *O* in output and to pass *T* to both of them.
  Example:
  ```
  process-type Q
    input I
    output O
    ...
  ```

```
process-type P
   ...
   do Q(T,T)
```

- 1a-2a-3a: existing products of type *T* are accessible and modifiable inside *Q* and new products of type *T* can be created. The solution is simply to declare two product types *U* in update and *O* in output and to pass *T* to both of them.
  Example:
  ```
  process-type Q
     update U
     output O
     ...
  process-type P
     ...
     do Q(T,T)
  ```
- 1b-2ab-3b: existing products of type *T* are not accessible and none can be created. This is absolutely useless and distinguishing cases 2a and 2b do not change the situation.

8.4 Local product types

In Chapter 6 we saw how to define global product types. We will now focus on local product types. The semantics of global and local product types is the same, the only difference is in the scope: global product types can be used anywhere in the method, while local product types can only be referenced in the strategy of the process type in which they are declared.

Properties of global and local product types are the same. They all have a name (identifier), a title, a minimum and maximum multiplicity and they are all of a product model. But, local product types do not have a description. Their definitions hold on a single line:

name [**[***min*-*max***]**] [**"***title***"**] **:** [**weak**] *model-name*

where:

- *name* is an identifying name of the product type inside de process type. This name must be made of maximum 100 letters (lower case or upper case, but no accents), figures, "-" or "_".
- *min* is the minimum multiplicity that represents the minimum number of products of this type that must be used (or created) during a work that follows the method (d_1...d_n, *min* ≤ n). It is an integer value.
- *max* is the maximum multiplicity that represents the maximum number of products of this type that can be used (or created) during a work that follows the method (d_1...d_n, n ≤ *max*). It is an integer value or *N* (possibly *n*) to represent infinity.
- *title* is a second name that is aimed at representing the product type in the supporting CASE tool in a more readable way than the identifier. It can be made of any character (max. 100). It is optional. If omitted, it is assumed to be the same as *name*.
- *model-name* is the name of the product model the current product type is a type of. It must be the identifier of a previously defined product model (schema model or text model).
- If the **weak** keyword precedes the *model-name*, products of this type should preferably respect all the constraints declared in the product model, but some transgressions are bearable.

Note that the multiplicity is optional. By default, *min* = 1 and *max* = *N*.

For instance, in the declaration of a conceptual schema integration process, we can declare two input product types *master* and *secondary* both conforming with a conceptual model, the first one with multiplicity [1-1] represents the master schema and the second one with multiplicity [1-*N*] represents all the secondary schemas that will be integrated into the first one.

8.5 Product sets

A product set is a mean of grouping products in order to use them all together. A product set as no semantics, the different products do not need to share properties in order to be put in a set. For instance, a set can contain both a COBOL source file and a C++ schema. The purpose of product sets is three-fold:
- to reduce the number of products that have to be shown in the project (just show the set and not all the products in it)
- to ease handling of products (it is easier to select one set than twenty products)
- to allow the strategy to group products with set operators as presented in section 8.6.10 (union, intersection,...).

Product sets have a name (identifier), a title and a minimum and maximum cardinality. Their definitions hold on a single line:

name [**[***min-max***]**] [**"***title***"**]

where:

- *name* is an identifying name of the product set inside de process type. This name must be made of maximum 100 letters (lower case or upper case, but no accents), figures, "-" or "_".
- *min* is the minimum cardinality that represents the minimum number of products in this set (d_1...d_n, *min* ≤ n). It is an integer value.
- *max* is the maximum cardinality that represents the maximum number of products of this set (d_1...$d_{n,}$ n ≤ *max*). It is an integer value or *N* (possibly in lower case, *n*) to represent infinity.
- *title* is a second name that is aimed at representing the product set in the supporting CASE tool in a more readable way then the identifier. It can be made of any character (max. 100). It is optional. If omitted, it is assumed to be the same as *name*.

Note that the multiplicity is optional. By default, *min* = 1 and *max* = *N*.

8.6 The strategy

The strategy is declared in a semi-algorithmic way with the control structures described below. We will examine all the control structures of the language. For each of them we examine the syntax, the semantics and the graphical representation. They are also accompanied by an example of an history in graphical view. These histories are very simple ones that are obtained in a straightforward way from the process. More sophisticated and realistic histories will be shown in Chapter 9.

8.6.1 Graphical conventions

The basic elements of every strategy are the sub-process types that have to be performed during the execution of instances of the process type, the product types that are used, modified or generated, as well as the control flow (in what order the sub-processes are performed) and the data flow (how the products are used by the sub-processes).

A process type will be shown by a rectangle enclosing its name. A product type will be shown as an ellipse containing the product type name.

The control flow will be shown with bold arrows linking process types: an arrow from a process type to another one means that an instance of the former must be completed before an instance of the latter can start. The control flow starts with symbol ◡ and ends with symbol ◠.

The data flow will be shown with thin arrows linking process types and product types: an arrow from a product type toward a process type means that the instances of the process type use instances of the product type (input); an arrow in the reverse direction means that the instances of the process type create instances of the product type (output); a double headed arrow indicates that the instances of the process type both use and modify instances of the product type (update).

The external description of the process type (its interface) is described within a grey box. It shows graphically the name of the process type as well as the name and the role (input, output and update) of its product types.

For the ease of understanding of the various control flows, we will give for them a sample history[1]. They will be shown graphically too. Processes will be represented with rectangles, and products will be ellipses. Only the data flow will be represented, with thin arrows. Indeed the processes will be drawn top down in the order of their sequential execution (and from left to right on a same level if they are several versions of the performance of a same process type), making the drawing of the instance control flow useless. All the histories shown in this chapter will be easy to understand with these few tips and are shown for illustration only.

8.6.2 The sequence

The sequence is the most traditional control structure that decomposes a task in simpler tasks that have to be performed in the specified order, one after the other. In a traditional programming language like Pascal, sequences are represented by a list of statements separated by semicolons. In software engineering, including database engineering, performing sequences of actions is a common pattern. The syntax of a sequence is the following:

```
[sequence]
        sub-structure;
        sub-structure;
        ...
[end-sequence]
```

where:

- *sub-structure* is one of the substructures or sub-process calls defined in this chapter.

Note that both the **sequence** and the **end-sequence** keywords have to appear together or none at all. In fact they should never be used excepted when necessary, by example inside a one/for/each structure.

In Figure 8.1, we can see a sequence made of process types *A* and *B* and its graphical representation. The history shows how product r is transformed by process *a* into product *s* and *s* is transformed by *b* into product t.

8.6.3 The *while* structure

The *while* structures indicate that the encompassed structure must be done again and again while the condition is satisfied. If the condition is not satisfied the first time it is evaluated, then the sub-structure will never have to be performed. The syntax of the structure is the following:

```
while (condition) repeat
        sub-structure
end-repeat
```

where:

- *condition* is an expression the syntax and semantics of which is discussed in section 8.6.11
- *sub-structure* is any structure or sub-process call as described in this chapter.

1. As defined in chapter 2.

A(R,S);
B(S,T)	

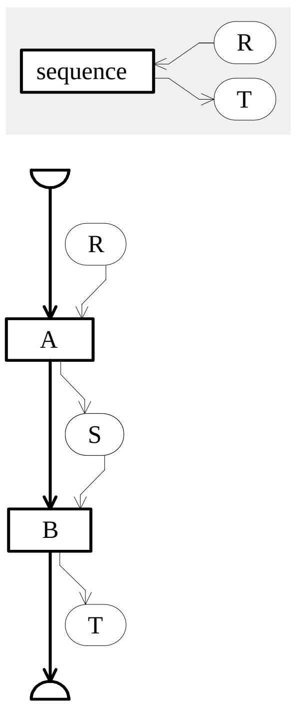
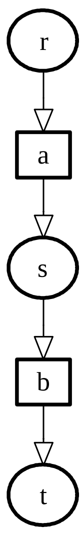
	

Figure 8.1 - A sequence

In Figure 8.2, the structures show that a process of type *A* can be done several times until condition *C* is satisfied. The histories show that *A* is in fact done twice, each time with a particular result to condition *C*. In the first structure, *A* takes *R* in input and produces *S*. On the history, we see that a new product of type *S* is generated at each execution of *A*. In the second structure, *A* updates *R* and, on the history, we see that *A* always updates the same product *r*.

8.6.4 The *repeat...until* structure

The *repeat...until* structure indicates that the encompassed structure must be done again and again until the condition is satisfied. The sub-structure must be done at least once. The syntax of the structure is the following:

```
repeat
    sub-structure
end-repeat until (condition)
```

where:

- *condition* is an expression the syntax and semantics of which is discussed in section 8.6.11
- *sub-structure* is any structure or sub-process call as described in this chapter.

Figure 8.3 shows the graphical representation of the repeat structure. In this example, we see that processes of type *A* should update products of type *R* until condition *C* is satisfied. The history shows that *C* was not satisfied after the first execution of *A*, but *C* was OK after the second execution.

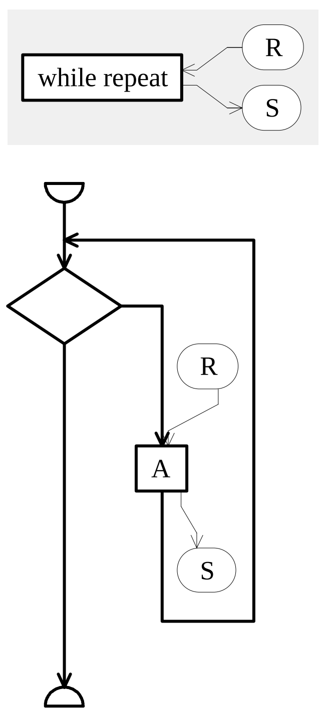
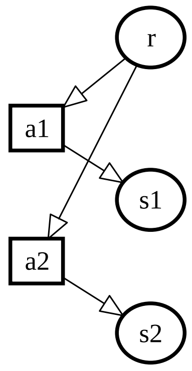
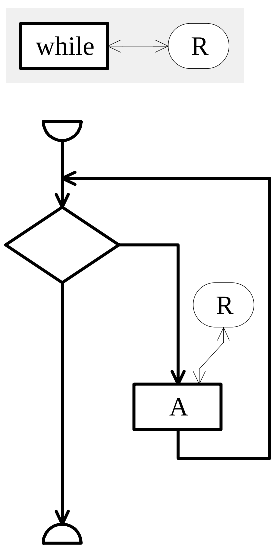
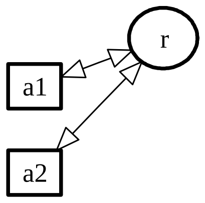
while (C) **repeat** A(R,S) **end-repeat**	
	
while (C) **repeat** A(R) **end-repeat**	
	

Figure 8.2 - Two while structures

repeat
A(R)
end-repeat until (C)	

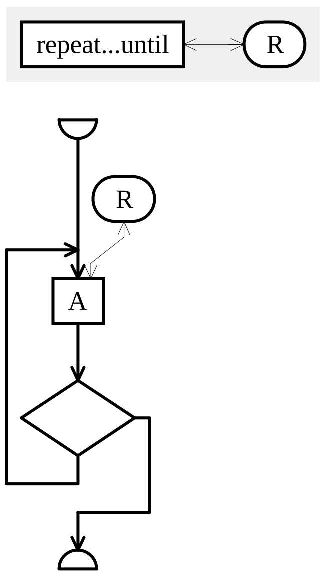
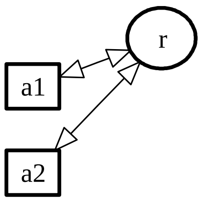
	

Figure 8.3 - A repeat...until structure

8.6.5 The *repeat* structure

The *repeat* structure looks very similar to the *repeat...until* structure. The only difference is that no condition is specified. During a process, the analyst is the one who decides if he wants to perform the sub-structure one more times or if he wants to go on. The syntax is:

```
repeat
    sub-structure
end-repeat
```

where:

- *sub-structure* is any structure or sub-process call as described in this chapter.

Figure 8.4 shows the graphical representation of a *repeat* structure. The history shows that the user decided to perform *A* twice.

8.6.6 The *if...then...else* structure

Like in traditional imperative languages, an *if...then...else* structure can be very useful to decide on the basis of a specified condition whether to do an action or not (*if...then*) or to choose between two alternatives (*if...then...else*). The syntax is the following:

```
if (condition) then
    sub-structure-1
[else
    sub-structure-2]
end-if
```

where:

- *condition* is an expression the syntax and semantics of which is discussed in section 8.6.11

repeat
A(R)
end-repeat	

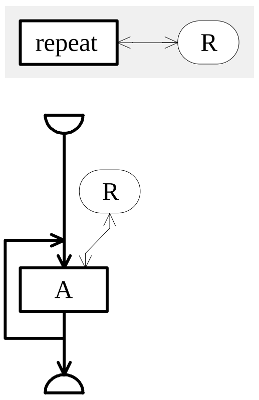
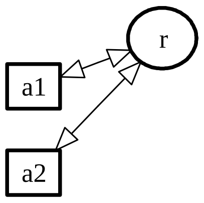
	

Figure 8.4 - A repeat structure

- *sub-structure-1* is any structure or sub-process call as described in this chapter. It is executed when *condition* is satisfied.
- *sub-structure-2* is any other structure or sub-process call as described in this chapter. It is optional. If it is present, it is executed when *condition* is not satisfied.

Figure 8.5 shows the graphical representation of an *if...then...else* structure where a process of type *A* is executed if condition *C* is satisfied and a process of type *B* otherwise. The history shows that condition *C* is satisfied and thus a process *a* has been performed.

8.6.7 The *one*, *some*, *each* structures

The *one*, *some* and *each* structures are non-classical structures in imperative languages. They are user driven structures. The *one* structure means that the user has to choose one structure among all those that are presented and to execute it and no other one. The *some* structure means that the user can choose several (or just one or none or all) sub-processes and execute them. He can do them in any order. Finally, the *each* structure means that the user must execute each sub-structure but, on the contrary of a sequence, in any order he wants. the syntax of those substructures is the following:

```
one                         some                        each
        sub-structure;              sub-structure;              sub-structure;
        sub-structure;              sub-structure;              sub-structure;
        ...                         ...                         ...
end-one                     end-some                    end-each
```

where:

- *sub-structure* is any other structure or sub-process call as described in this chapter.

Figure 8.6 shows a graphical representation of these structures (in fact a *some* structure). In the history, we see that the analyst chose to perform a process of type *A* only.

8.6.8 The *for* structure

A product type can have several instances. But some process types can work on one product only. The *for* structure allows a process type to be executed once for every instance of a product type. The syntax of the *for* structure is the following:

```
for one product-set in product-type-or-set do
        sub-structure
end-for
```

if (C) **then**
A(R,S,T)
else
B(R,T)
end-if	

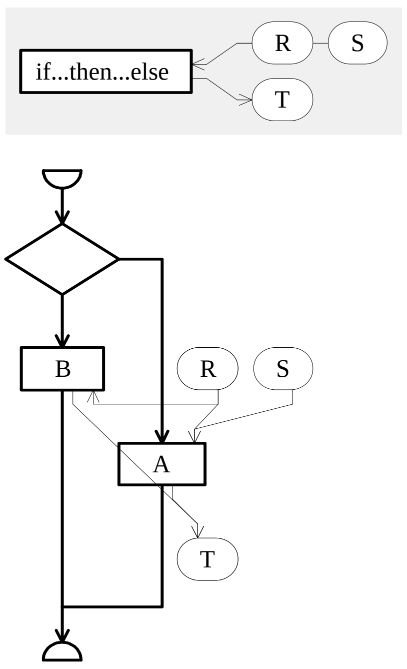
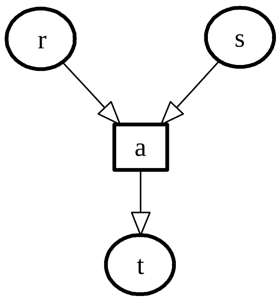
	

Figure 8.5 - An if...then...else structure

```
for some product-set in product-type-or-set do
    sub-structure
end-for

for each product-set in product-type-or-set do
    sub-structure
end-for
```

where:

- *product-set* is a product set that must be declared with multiplicity [1-1]. At each iteration, the set is filled with one element of the *product-type-or-set*. The element is the product type whose instance is one, some or each instance or *product-type-or-set at its turn.*
- *product-type-or-set* is the product type the instance of which have to be used one at a time. In the **for one** form, one instance of *product-type* must be used. In the **for some** form, the user has to choose a set of product of type *product-type* to use. Finally, in the **for each** form, every product of *product-type* has to be used.
- *sub-structure* is any other structure or sub-process call as described in this chapter.

In Figure 8.7, each instance of *R* at its turn is renamed *R'* and used as an input for *A*. In the history, we can see that *R* has two instances and they are used each at its turn by different instances of *A*.

One
A(R,T);
B(R,T)
end-one
	some
	A(R,T);
	B(R,T)
	end-some
		each
		A(R,T);
		B(R,T)
		end-each	

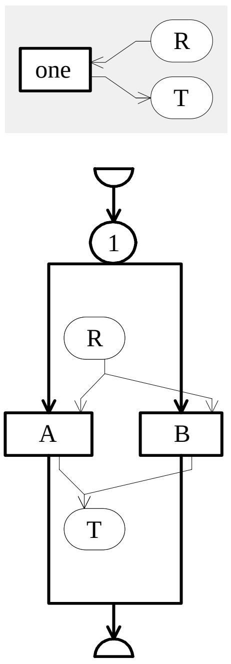
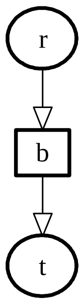
			

Figure 8.6 - one-some-each structures

8.6.9 Sub-process calls

In the first seven sections, we saw how to specify a strategy, a way of combining several sub-processes. But we still have not seen what a sub-process is. In this section, we will have a look on every available sub-process types.

8.6.9.1 To call a sub-process

A process-type can be refined into sub-process types, some of them being complete engineering process types with there own strategy. The *do* keyword allows a process type to use its engineering sub-process types.

> **do** *sub-process* **(***parameter, parameter,...***)**

where:

- *sub-process* is the identifier of the sub-process to call.
- *parameter* is a product type or a product set (they will be distinguished in this paragraph) passed to the sub-process. The parameters must be in the same order as declared in the sub-process, and they need to be compatible with the formal parameters declared in the sub-process; in other words, actual and formal parameters must be of types based on the same model, or, an actual input parameter can be of a type based on a model which is a specialisation of the model of the formal input parameter, and an actual output parameter can be of a type based on a model which is a generalisation of the model of the formal output parameter. Note that a product set can only be passed in input or in update; new products must get a type. If a parameter is a product type, all the products of that type will be passed to the sub-process. If the parameter is a product set, the set itself will be passed, but only the input and update products it contains that are compatible with the formal product type will

be in the set inside the sub-process. But the product set parameter can be prefixed by “**content:**” in order to pass only the products it contains rather than itself

Figure 8.8 shows a process call example. Process Q calls process P passing X, Y and Z in parameters. X is associated with A, Y with B and Z with C. When the call occurs, every products of type X are copied and cast to product type A and every products of type Y are copied and cast to type B. When process P ends, all products of type C are copied and cast to type Z and the control is passed back to process Q that goes on.

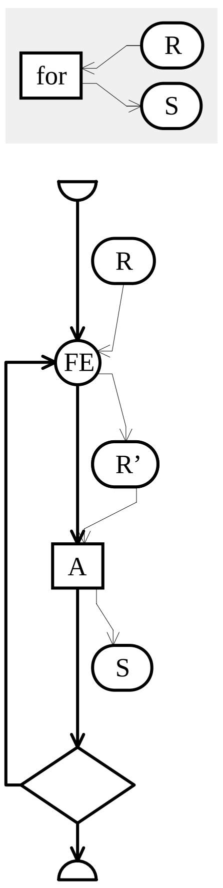
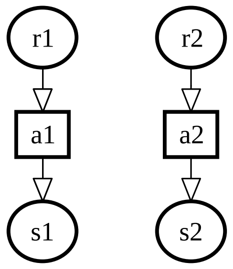
for each R’ **in** R **do** A(R',S) **end-for**	
	

Figure 8.7 - A for structure

```
process P
        ...
        input A,B
        output C
        ...
end-process
```

```
process Q
        ...
        intern X,Y,Z
strategy
        ...
        P(X,Y,Z)
        ...
end-process
```

Figure 8.8 - A sub-process call example

8.6.9.2 To allow the use of a toolbox

At some point in the refinement process, a process type can no more be refined. At that time, the process can just either do some technical tasks automatically or give an analyst some tools she can use and let her work by herself. In this section we will examine the later case. The strategy shows what toolbox defined previously can be used and on what product types. The syntax is the following:

toolbox *toolbox*[**[log** *log-level***]](***product-type-or-set***,***product-type-or-set***,...)**

where:

- *toolbox* is the identifier of a previously defined toolbox.
- *log-level* is an optional configuration parameter which specifies how the actions performed by the analyst should be performed. It can be one of the following values :

off	Turns off the logging facility
replay	Enacts the minimum recording facility: the log will contain only the information that are necessary to replay the actions performed. This includes only the identifier of the components that are transformed, the transformations performed and the data entered by the analyst.
all	Enacts the maximum recording facility: the log file contains all the same information as in the *replay* log plus the state before transformation of all the components that are modified by the transformation. For instance, the transformation of an entity-type into entity rel-type will log the name before transformation of the entity-type, as well as the name of all rel-types connected to that entity-type, as well as the name of all roles played in the rel-types. This is usefull to be able to reverse the transformation.

  If the [log ...] configuration parameter is not present, the default log state of the supporting CASE tool should be used.

- *product-type-or-set* is the identifier of a product type (either local or global) or a product set. *toolbox* can work on every instances of *product-type*. The number of product types used as actual arguments of a toolbox is unlimited.

Figure 8.9 shows an example of a toolbox call: a product of type *A* can be updated freely by the analyst using the toolbox *TB*.

```
toolbox TB              process P
    ...                           ...
end-toolbox                 update A
                                  ...
                            strategy
                                  ...
                                  toolbox TB(A);
                                  ...
                        end-process
```

Figure 8.9 - A toolbox call

8.6.9.3 To perform a global transformation

The supporting CASE tool is able to perform some technical tasks automatically. These are generally some repetitive and tedious transformations. The usage of a global transformation is the following:

glbtrsf [**"***title***"**] [**[log** *log-level***]**] **(***schema-type-or-set***,**
global-transfo[**(***scope***)**]**,**
global-transfo[**(***scope***)**]**,...)**

where:

- *title* is an optional readable string that will be printed on screen to name the transformation.
- *log-level* is an optional configuration parameter which specifies how the actions performed by the analyst should be performed. It can be one of the values defined in the toolbox section. If the [log ...] configuration parameter is not present, the default log state of the supporting CASE tool will be used.
- *schema-type-or-set* is a group of schema to work on; all the schemas of that type or set will be transformed.
- *global-transfo* is the identifier of a global transformation. All these identifiers are listed in Appendix C.
- *scope* is a schema analysis rule (see Chapter 5) that defines the scope of the transformation. This is optional. If not present, the default scope is used. This default scope depends on the transformation. If present the rule will reduce the default scope.

For instance, the following global transformation will transform all rel-types of schema S into entity types:

glbtrsf "All rel-types into entity types" (S,**RT_into_ET**)

while the following one will only transform non-binary rel-types into entity types:

glbtrsf(S,**RT_into_ET**(**ROLE_per_RT**(3 **N**)))

8.6.9.4 To call an external function

At some point it may be interesting to develop some special functions in a 4GL. Voyager 2 is the 4GL of DB-MAIN that can be used for that purpose. The syntax of such a call is:

external *voyager-function* [**[log** *log-level***]**] **(***parameter,parameter,...***)**

where:

- *voyager-function* is the name of a Voyager 2 function that is defined in an extern section. It must return an integer value (1: OK, 0: error) and it should handle error messages itself.
- *log-level* is an optional configuration parameter which specifies how the actions performed by the analyst should be performed. It can be one of the values defined in the toolbox section. If the [log ...] configuration parameter is not present, the default log state of the supporting CASE tool will be used.
- *parameter* is an actual argument to pass to the function. It must match the declaration. A parameter declared as *integer* must receive an integer number. A parameter declared as *string* must receive a double-quoted string. A parameter declared as *list* can receive any product type or product set; all the products of a product type will be passed in a list to the function that can use or modify them (it is important to be careful not to pass an input process type to a function that modifies the products); a product set will be passed itself; and all the products of a product set prefixed by the **content:** keyword will be passed like the products of a product type. Finally, a parameter declared as *type* can receive any output or intern product type. Products of these types will not be accessible inside the function, but the function will be able to create new products of that type. To allow an external function to both use the existing products of a given type P and create new products of the same type P, the function has to be defined with two parameters, one as a list and the other as a product type, and P has to be passed to both parameters.

Figure 8.10 shows an example of an external function call: *A* can be updated by function *F.*

```
process P
          ...
    update A
          ...
    strategy
          ...
          external "library.oxo".F (A,"string",10);
          ...
end-process
```

Figure 8.10 - An external function call

8.6.9.5 To use a data extractor

The supporting CASE tool should be able to import data structures from a text into a schema (for example, COBOL data division into a COBOL compliant schema). The procedure that allow this extraction is the following:

extract *extractor***(***source-text***,***destination-schema***)**

where:

- *extractor* is the identifier of the data extractor to use. It depends on the supporting CASE tool (DB-MAIN versions 3 and more recent recognize SQL, COBOL, IDS_II and IMS).
- *source-text* is a text-type. All the texts of this type will be analyzed.
- *destination-schema* is a schema type. All extracted schemas will be of this type.

Example:

extract COBOL(COBOL_FILE,COBOL_SCHEMA)

allows the CASE tool to extract COBOL data structures from COBOL source files into COBOL compliant schemas.

8.6.9.6 To use a generator

The supporting CASE tool should be able to generate database creation scripts from schemas. The following process does the job:

generate *generator***(***source-schema***,***destination-text***)**

where:

- *generator* is the identifier of the generator. It depends upon the supporting CASE tool (DB-MAIN versions 3 and more recent recognize STD_SQL, VAX_SQL, ACA_SQL, STD_SQL_CHK, VAX_SQL_CHK, ACA_SQL_CHK, COBOL, IDS).
- *source-schema* is a schema type. All schemas of this type will be used to generate the new text files.
- *destination-text* is a text type: the type of all the texts that will be generated.

Example:

generate COBOL(COBOL_SCHEMA,COBOL_FILE)

allows the CASE tool to generate files containing COBOL data divisions from COBOL-compliant schemas.

8.6.10 Built-in procedures

In addition to the sub-process calls presented in the previous section, the MDL language has a few built-in procedures for handling product sets.

We will examine, for each built-in procedure, what happens with the example shown in Figure 8.11. It shows 2 product types and 1 product set: product type A is instanciated by products a1 and a2, product type B is instanciated by product b1, and product set C contains the product b1.

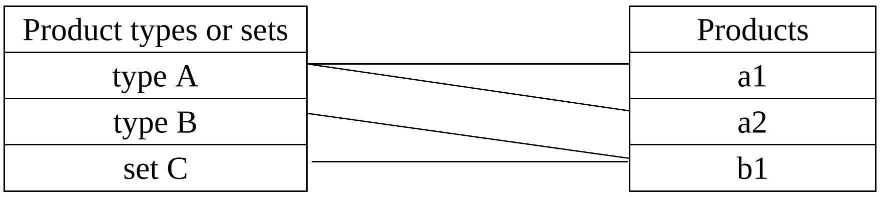


Figure 8.11 - A product set example

8.6.10.1 To create a new product of a given type

When a process type has to produce an output product, it is sometimes necessary to built it completely. The *new* keyword allows a process to generate a blank product, the name of which will be asked to the analyst. This command needs one argument which is a product type. The syntax of the command is the following:

new (*product-type***)**

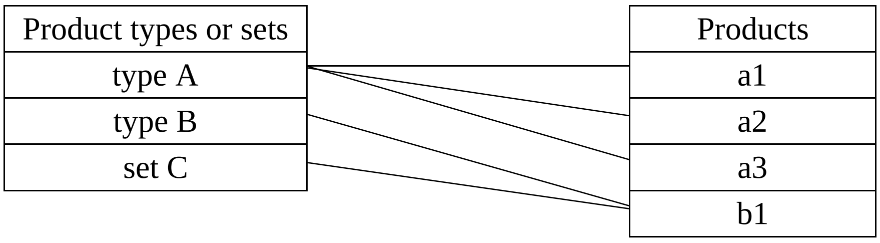
where:

- *product-type* is the type of the new product to generate. At run-time, the product type will have one more instance, which is a blank product.

In the example of Figure 8.11 -, the command

new (A)

gives:



8.6.10.2 To import a schema from another project

When a schema already exists in another project, it is sometimes more interesting to import it in the new project then to reenter it. Import can also be useful with big projects: several analysts work on separate sub-projects, and, in a phase of importation and integration, all these sub-projects are assembled in a master one. This command needs one argument which is a product type. The syntax of the command is the following:

import (*product-type***)**

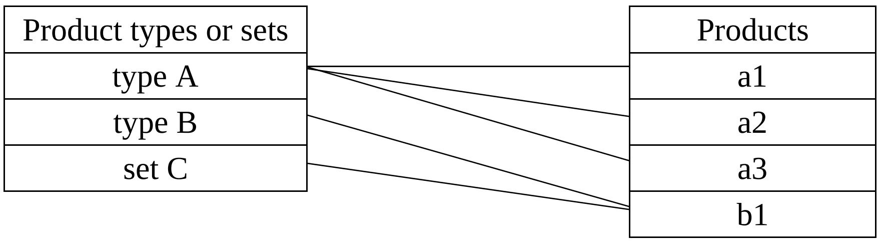
where:

- *product-type* is the type of the schema that will be imported. At run-time, the schema type will have one more instance, which is the imported schema.

In the example of Figure 8.11 -, the command

import (A)

gives:



8.6.10.3 To make a copy of a product

When a process type has to generate output products, it is sometimes possible to make a copy of other products and to modify them. The *copy* procedure allows a process to copy one set of products, that is to say to make a copy of each product of the set and to cast them to the specified type. The new products have the same name as the original ones, but they have a different version number which is asked to the analyst. The syntax of the *copy* command is the following:

copy (*source-product-type-or-set***,***destination-product-type***)**

where:

- *source-product-type-or-set* is the product set to copy.
- *destination-product-type* is the product set to which the copies of the products will be cast.

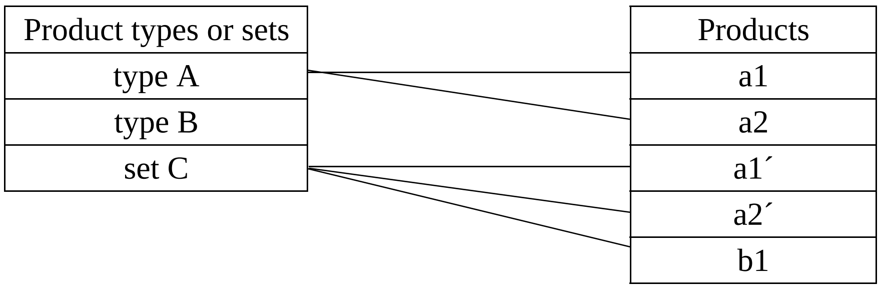
Note that the *source-product-type-or-set* and the *destination-product-type*, if they are both product types, must be of the same model, or the model of the *source-product-type* must be a sub-model of the model of the *destination-product-type*.

If the source is a product type, all the products of that type will be copied. If the source is a product set, all its products will be copied and the set will contain all the new products and only them. If the source is a product set prefixed by "**content:**", all its products will be copied, but the set will not be modified, it will still contain the original products.

In the example of Figure 8.11 -, the command

copy (A,C)

gives:



where a1 is identical to a1´ and a2 is identical to a2´; b1 is not more in B (not destructed, just no more in B).

8.6.10.4 To define a product set as the result of a computation on other product sets

A new set can be built on the basis of other sets or product types. For instance, traditional set operators (union, intersection, subtraction) can be used to combine sets. The syntax of the *define* command is the following:

define (*product-set***,***set-expression***)**

where:

- *product-set* is the new product set, result of the *set-expression*.
- *set-expression* is one of those below. The first seven are deterministic, computer driven and the last two are user driven. In these definitions, *set* is either a product type, a product set or the result of another set expression, the instances of which are the manipulated sets.

set, the set expression simply is a product set or a product type.

union (*set-expr1***,***set-expr2***)**, the traditional union set operator (*set1* ∪ *set2*) where *set1* is the result of *set-expr1* and *set2* is the result of *set-expr2*, two set expressions.

inter (*set-expr1***,***set-expr2***)**, the traditional intersection set operator (*set1* ∩ *set2*) where *set1* is the result of *set-expr1* and *set2* is the result of *set-expr2*, two set expressions.

minus (*set-expr1***,***set-expr2***)**, the traditional difference set operator (*set1* \ *set2*) where *set1* is the result of *set-expr1* and *set2* is the result of *set-expr2*, two set expressions.

subset (*set-expr***,***rule***)** to extract a sub-set of products out of a product set (result of set expression *set-expr*); the rule is made of the predicates used to define a schema model in Chapter 5; the resulting subset is made of all the products of the *set* that satisfy the rule.

origin (*set-expr***)** defines a set of products made of the origin of the products in the result of *set-expr*. The origin of a product, according to the history, is defined in Chapter 9; it is the set of products that were used to generated the given product.

target (*set-expr***)** defines a set of products made of the target of the products in the result of *set-expr*. The target of a product, according to the history, is defined in chapter Chapter 9; it is the set of the products that are produced by using the given product.

choose-one (*set-expr***)** asks the user to choose one product in the resulting set of *set-expr* and defines a new set with it.

choose-many (*set-expr***)** asks the user to choose one or many products in the resulting set of *set-expr* and defines a new set with them.

first (*set-expr***)** defines a new set containing the first product inserted in the set resulting from *set-expr*.

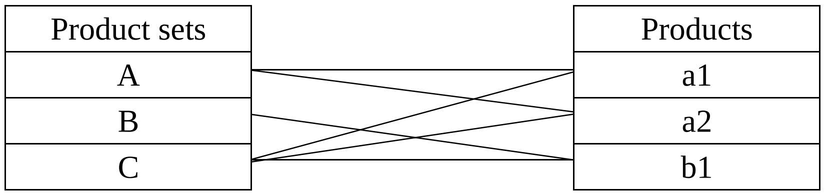
last (*set-expr***)** defines a new set containing the last product inserted in the set resulting from *set-expr*.

remaining (*set-expr***)** defines a new set containing all elements from *set-expr* except one. This one is the result of **first**(*set-expr*).
Hence, *set-expr* = **union**(**first**(*set-expr*),**remaining**(*set-expr*))
and **inter**(**first**(*set-expr*),**remaining**(*set-expr*)) is empty.

In the example of Figure 8.11 -, the command

define (C,**union**(A,B))

gives:



8.6.11 Expressions

Some control structures (if...then...else, while, repeat...until) need an expression. In this section, we will examine every possible form of expression. They can be formal and strict, formal but not strict, or even not formal at all. That way, the expressions are as flexible as control structures to allow a method to be both a strict way to follow or a guideline for a human-controlled process.

An expression is made of boolean functions which can be combined with traditional boolean operators (and, or, not). There are two kinds of functions: product evaluation functions that concern the syntax or semantics of products and product set evaluation functions that concern the content of a product set without looking at the products themselves.

8.6.11.1 The *exists* function

Does it exist some objects in the given schema for which the schema analysis constraints are satisfied?

exists (*schema-type-or-set***,***schema-analysis-constraints***)**

where:

- *schema-type-or-set* is the group of schemas to analyse. Every schema of this set or type is analysed. The answer of the *exist* function is *yes* if the result is *yes* for at least one schema.

- *schema-analysis-constraints* is a list of comma-separated schema analysis constraints such as presented in chapter Chapter 5.

This is a strong condition which must be satisfied, except if the *weak* keyword is appended in front of it:

weak exists (*schema-type-or-set***,***schema-analysis-assistant***)**

This is a weak condition: it is better if it is satisfied, but it is not mandatory. At runtime, the result of the evaluation will be presented to the user and she will be the one who decides whether to keep the result (*yes* or *no*) or force the opposite.

8.6.11.2 User oriented textual condition

A message in clear text can be printed on the screen for the user to take a decision:

ask "*string***"**

This is always a weak condition. The user is the only one who can take the decision.

8.6.11.3 The *model* function

Are the products of the given set conform to the given model ? Strong condition.

model (*product set***,***product model***)**

- *product set* is the set of products to analyze. Every product of this set is analyzed. The answer of the *model* function is *yes* if the result is *yes* for every product.
- *product model* is one of the product models defined in a *schema-model* or *text-model* section of the method (see chapter Chapter 5).

This is a strong condition. But, like for the *exists* function, the *weak* keyword can be append in front of it:

weak model (*product set***,***product model***)**

8.6.11.4 External Voyager 2 function

Schema analysis functions allow the user to specify formal expressions, but they are limited. More complex functions can be written in the Voyager 2 language and used with the *external* keyword:

external "**.oxo file***".***function* **(***parameters***)**

where:

- **.oxo file* is the compiled Voyager 2 file that contains the function.
- *function* is the name of the Voyager 2 function. It must return an integer value (0: false, 1:true).
- *parameters* are the parameters to be passed to the function. They depend on the function (product list, string or number).

This is a strong condition. But, like for the *exists* function, the *weak* keyword can be appended in front of it:

weak external "**.oxo file***".***function* **(***parameters***)**

8.6.11.5 Product set evaluation functions

Is the number of products in the given set greater, equal or less than the given number ?

count-greater (*product-type-or-set***,***nb***)**

count-equal (*product-type-or-set***,***nb***)**

count-less (*product-type-or-set***,***nb***)**

count-greater-equal (*product-type-or-set***,***nb***)**

count-less-equal (*product-type-or-set***,***nb***)**

count-different (*product-type-or-set***,***nb***)**

where:

- *product-type-or-set* is the group of products to be analyzed.
- *nb* is the reference number, an integer value.

These are strong conditions. But, like for the *exists* function, the *weak* keyword can be append in front of them.

8.6.11.6 Operators

Complex conditions can be built by linking the simple expressions defined above by the following operators:

- **and**
  This is the traditional logical binary operator. Its result is *yes* when, and only when, both its operands are *yes*.
- **or**
  This is the traditional logical binary operator. Its result is *yes* when, and only when, at least one of its operands is *yes*.
- **not**
  This is the traditional logical unary operator. Its result is *yes* when its operand is *no* and *no* when its operand is *yes*.

8.6.12 Miscellaneous

8.6.12.1 message

The *message* instruction simply allows the method to show a message to the user. The message is a simple string. When this instruction is executed, the user sees a simple box with the message and a button labelled "OK" for closing the window.

The syntax is the following:

> **message "***message***"**

Chapter 9

History

The history is the memory of a project. It is made of all the products used, modified or generated during the project as well as all the processes that were performed in order to transform or generate these products. The history is in fact a structured trace of an actual execution of a process following a method described with the MDL language. During the whole process, the analyst had to make choices, to do hypotheses, to try several possibilities, to take decisions,... all of which are recorded in the log file too. In fact, the history is a graph rather than a simple sequence of operations, as we will explain below. But, it is still possible to extract an ideal history from this graph, i.e. the history that would have been obtained if the analyst had no hesitation to do the perfect job directly.

This chapter only presents basic elements about histories. For more information, the reader will refer to the DB-MAIN reference manual [1].

9.1 Basic elements

Before going further in the description of an history, it is important to understand the following terms:

Let us remember (Chapter 2) that a **product** is either a database schema or a text, a **process** is a series of actions performed to transform products, a **primitive process** is made of basic actions performed sequentially and recorded in a textual way, and an **engineering process** is made of sub-process calls performed in a complex way (that can be repersented as a graph) resulting of human intelligent decisions.

At some times engineers may face particular problems that cannot be solved in a straightforward way:

- It can be a very arduous problem for which the engineer sees several ways of working but does not know which one will take the less efforts. In this case, it can be useful to begin and do a little bit of the work in each way and make an estimation of the effort, than to pursue in the best way.
- It can also be a very complex problem for which several solutions are possible but one has to be better than the other and it is not possible to guess which one a priori. In that case, it is necessary to try every solutions and compare them afterwards.
- It can also be a very complex problems for which only one solution is possible but there are several ways of starting and the engineer knows that all but one will lead nowhere. This is like in a labyrinth. The engineer has to try several ways until he or she finds the good one.
- The engineer has to formalise a problem, but some points are not very clear in his or her mind. So he or she sketches several ideas of solution as a basis for discussion with other people.
- Or maybe the engineer wants to make different tests for his or her own curiosity.

In all these cases, the list being non-exhaustive, the pattern to find a solution is always the same: try different ways of working, then choose the best obtained result. So, different processes of the same type are performed on the basis of the same products, but with different ideas, different hypotheses, in mind. An **hypothesis** reduces a problem to a particular context, during an engineering process. This hypothesis must be recorded in the history in a textual form, expressed in natural language. The result of all these processes are different **versions** of the same products.

After the analyst has produced several versions of a product, he or she has to take a **decision**, that is to choose the better version of the end product among all. Hence, a decision is a choice made afterwards of a better hypothesis. This decision must be recorded in the history with the rationales that lead to it. Like an hypothesis, a decision is a text written in a natural language. All this has to be performed independently of the method since the user is the one who decides when to make several hypotheses.

9.2 Structure

9.2.1 The complexe structure

An history is a tree in which nodes are graphs and leaves are log files. Let us examine this.

An history resluting from the use of a method will have a similar structure. Since a method is made of a main engineering process type that calls sub-process types and so on down to the use of primitives, an history will have a similar tree structure. The root of the history is an engineering process. It contains one or several sub-processes. Each of them is stamped with the date and time they were started. Hence it is possible to sort them. The root node has children which are those sub-processes, in the order of their starting from left to right. These sub-processes can be either primitive processes or engineering processes. In the first case, the sub-processes are leaves of the tree. Engineering processes, on the other hand, are nodes[1] just like the root node. The children, even if they are started in sequential order, are not necessarily performed that way (hypotheses, decisions,...); in fact, a node is an oriented graph, the nodes of which are products and sub-processes, the arcs being input/output links. Figure 9.1 shows a small example of history. The root node is labeled *Library project* and has two children : *Logical design* and *Physical design*. Each node has its graph. Note that the drawing is incomplete, all seven primitive processes (children) of *Logical design* and *Physical design* are not shown; they would be drawn with their log file.

9.2.2 Derived structures

If we look at an history and remove all the branches corresponding to hypotheses which have not been retained and whose end products have been discarded, keeping the live branches only, we produce a **linear history**. This derived history is important since it describes the way the final products could have been obtained should the engineer have proceeded without any hesitation. Replaying this history on the source products will yield the same output products as the actual process did.

A **flat history** shows the primitive process instances only. This concept is interesting because it is the easiest form of history to record. Indeed, since it represents no engineering processes, it is methodology-neutral, and can be built by simple CASE tools. In some situations, it could be the only form of history available. Such could be the case for loosely structured activities, such as some scenarios of reverse engineering.

A **dependency history** is a reduced history in which no process appear, only products with dependencies derived from the processes. We say that a product depends on another if the second one was used to generate the first one. For instance, a process using product A and generating product B would be replaced by a dependency between A and B.

9.2.3 Graphical presentation

An history can be shown graphically (see Figure 9.1). In fact, only engineering processes, that is the processes that follow a defined strategy, can be shown graphically. For primitive processes, the suppor-

1. It is to be noted that an engineering process node does not necessarily have children. When it is created, it has no children until a first sub-process if started and this does not need to be done straight away. So, an engineering process can temprarily be a leaf in the tree.

ting CASE tool just logs the sequence of operations the engineer performs. It can be shown in a textual way, possibly with annotations.

The main tree of the history can be simply shown in a textual way as can be seen on Figure 9.2, which shows the same example as Figure 9.1.

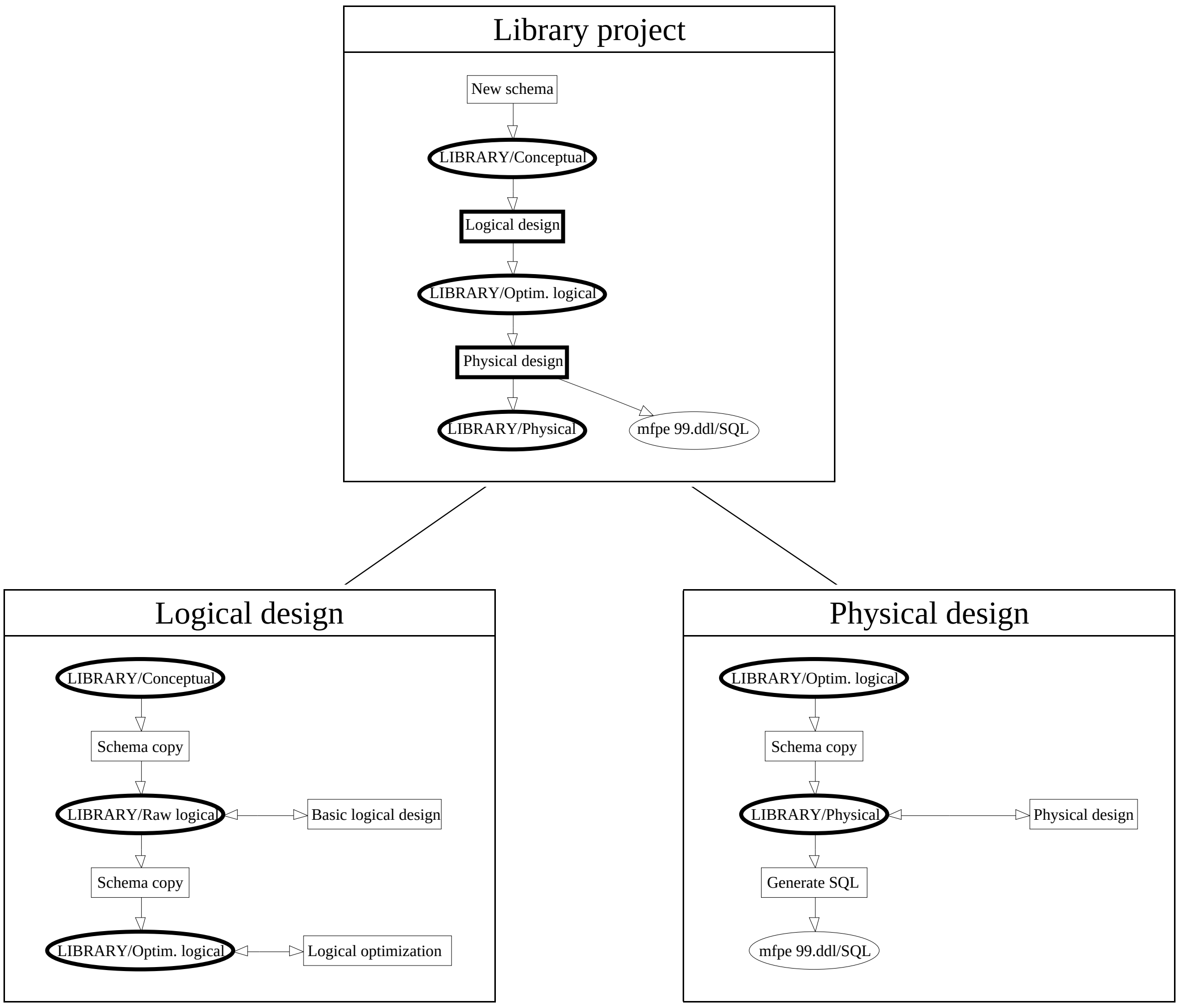


Figure 9.1 - A small history example of a forward enginerring project.

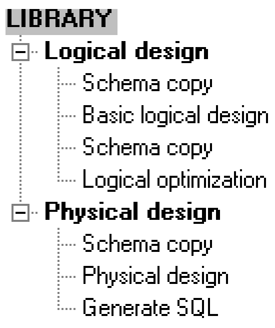

LIBRARY
- **Logical design**
  - Schema copy
  - Basic logical design
  - Schema copy
  - Logical optimization
- **Physical design**
  - Schema copy
  - Physical design
  - Generate SQL

Figure 9.2 - The main tree of the history shown in Figure 9.1.

The basic graphical representation of an engineering process (see the three graphs on Figure 9.1) is more or less similar to the graphical representation of the strategy it follows. Processes are drawn as rectangles (bold lines for engineering processes, thin lines for primitive processes) like process types (always bold lines), and products are drawn as ellipses (bold lines for schemas, thin lines for texts) like product types (always bold lines). But, if a strategy is process oriented (the strategy shows what sub-processes have to be carried on and their control flow, the product types are added around with another kind of arrows to give more information about process types), an history is product oriented: the history shows what products were manipulated and generated and the processes show where the products come from, arrows showing the data flow. Decisions are shown with pentagons, a single headed arrow showing all the products that entered in the choice and that were rejected, a double headed arrow showing what products are kept. Figure 9.4 shows an example of engineering process basic view.

Derived structures can also be shown graphically. Figure 9.3 shows a flat dependency derived view of the history of Figure 9.1.

Figure 9.4 shows a reverse engineering process. The engineer made two hypotheses and did the work with each of them, leading to both *schema enrichment* processes and to both versions of the resulting product: *LIBRARY/1* and *LIBRARY/2*. The engineer then made the decision to keep only one version: *LIBRARY/2*. The dependency derived view corresponding to this history is shown too. Processes and decisions are removed and the dependencies between products they cause are shown with arrows.

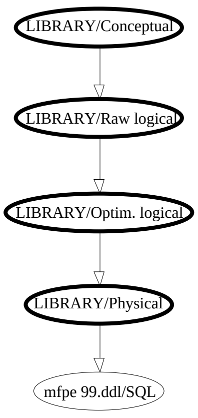


Figure 9.3 - An example of flat dependency derived view of history shown in Figure 9.1.

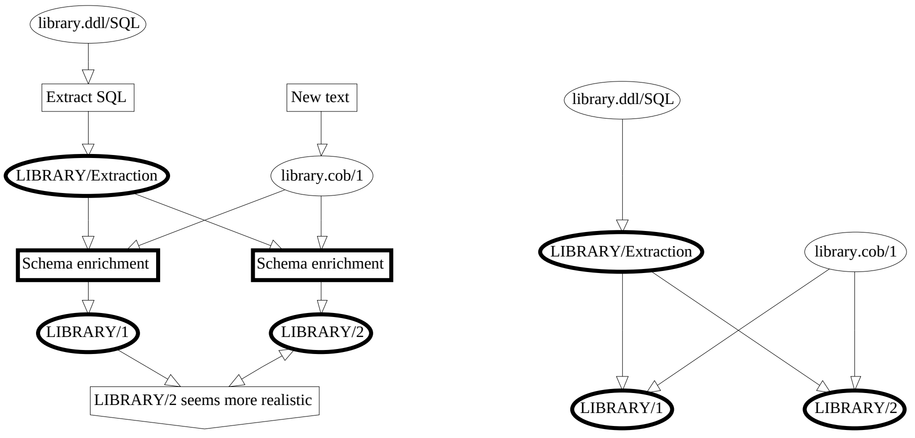


Figure 9.4 - An example of basic view of an engineering process from a reverse engineering project. This process shows two different processes performed on the basis of two hypotheses, and the decision taken afterward. The example also shows, at right, a dependency derived view of the same process.

9.3 Building an history while using a method

In this section we will see how an history is built by the supporting CASE tool. When a database engineer starts a new project, he or she chooses a method and begins to follow it. The CASE tool has to build the history automatically according to the actions of the engineer; these actions arise in concordance with the method. We will now examine how every action proposed by a method or self-decided by the engineer is recorded.

We will sketch the main actions performed by the CASE tool when a method is followed. Understanding this is useful for the method engineer to write a good method that will generate correctly documented histories. More rules about designing a method will be presented in the following chapter, and a more complete description of method usage can be found in the DB-MAIN user's manual [1].

9.3.1 Primitive processes

When a primitive process is performed, two kinds of information need to be stored: the fact that the primitive process is performed and how it is performed.

Since a primitive process is always performed as a part of an engineering process, the fact that the primitive process is performed is simply recorded by adding a node in the graph of the engineering process. So, each time a primitive process is performed, a new node is created in the graph of an engineering process, and so in the global tree of the history. This node is labelled with a name. It also has to be annotated with a reference to the primitive process type that was performed in the method. Furthermore, some edges must be created to connect the primitive process with the products it uses, modifies, or generates in the graph of its engineering process.

The recording of the way the primitive process was performed depends on the kind of the performed primitive process type and on what we want to do with the history. If we want the simplest history possible, just aimed at being replayed for documentation (logging level=replay):

- A built-in process will always be performed the same way, it suffices to know it had been performed be able to replay it. It is not necessary to store anymore information with the primitive process than the simple reference to the primitive process type.
- Global transformations, since all the configuration parameters are set at method definition time, do not need anymore information to be performed again. All the needed information are stored in the method.
- An external process type needs more information to be executed. Indeed, when a primitive process of this kind is performed, the database engineer may be asked some questions at run time. The answers of the engineer have to be stored. Since a process type can be performed several times, and since the engineer can decide of new responses every time, it is necessary to store these parameters with each primitive process. So, a simple log file is stored with all the values. The node representing the primitive process in the graph will simply receive a reference to that log file.
- A manual process type using a toolbox must entirely be performed by an analyst. So the primitive processes must be reflected by a log file containing all the actions performed by the analyst, as depicted above. The node representing the primitive process type in the graph has a reference to this log file.

On the contrary, if we want an history aimed at being reused for more complex tasks, such as reversing the history, it can be useful to record every single action in a log file (logging level=all). Indeed, primitive processes of any kind that modifies a product will do it in several little steps which can all be recorded. It can also be useful to record the parts of the products that will be transformed just before the transformation, in particular before non semantic preserving transformations.

Let us recall that the logging level (none, replay or all) can be specified in a method for every primitive process type that modifies a product (toolbox and glbtrsf).

9.3.2 Engineering processes

As for a primitive process, an engineering process needs to record two kinds of information, the fact it is performed and the way it is performed.

When the project begins, the history has to be created. A new engineering process is created with a blank graph that will grow all along the life cycle of the project, and the main tree of the history is initialised with that engineering process as the root and only node.

During the project, when an engineering process type has to be performed, a new node has to be added in the graph of the engineering process the new one is a part of, and the new engineering process has also to appear as a new leaf in the history tree. In the same time, a new blank graph is created that will grow during the performance of the engineering process. In the graph of the father engineering process, edges need to be created between the new node and all the products it uses or modifies. The product it generates will only be known much later, when the process is over; so edges to link the engineering process to its output products will only be added when the process ends.

To perform an engineering process means, for the database engineer, to follow the strategy of the process type. When he or she has to perform a sub-process, either a primitive or an engineering one, we already saw how the things happen, but he or she also has to follow some control structures. A control structure is a programming concept which has no equivalence at the instance level. In the history, are only stored the effects of the control structures, possibly with the decisions that have to be taken:

- A sequence of process types in the strategy gives rise to a sequence of processes in the history.
- When an *if* structure is encountered in the strategy, its condition has to be evaluated. The result of this evaluation, a decision, is stored in the history: a node is appended to the graph with edges linking the products on which the decision is based to the new node. In fact, the decision is stored in the history as a special primitive process. Then one branch of the *if* structure is followed, and will lead to a trace in the history. Since the other branch is simply ignored, there will be no trace of it in the history.
- A *repeat structure, possibly a while* or an *until* structure, will lead to the fact that some sub-process types (possibly one or several organised with another control structure) will have to be performed several times. It will result in the appearance of several processes of the same type in the history. If a condition (*while* and *until* structures) has to be evaluated at each iteration of the loop, each decision will also be stored in the history.
- The *one*, *some* and *each* structures, like the *if* structure will also make some branches only to be performed and only these branches will leave a trace in the history. If the engineer wants to store the rationales that conducted him or her to choose those branches, he or she can add, voluntarily, a decision to the history or a comment in the description to the performed process.
- A *for* structure works like a *repeat* structure at the only difference that the user has to choose a new product in a given set at each iteration. This choice will simply be stored in the history through the edges which will link the processes of each iteration.

9.3.3 Hypotheses, versions and decisions

At some times an engineer may face particular problems that cannot be solved in a straightforward way, so, he or she performs several processes of the same type on the basis of the same products, but with different hypotheses in mind, leading to different versions of the same products. Then the engineer takes the decision to keep one or several of the versions to go on.

It is useful to keep in the history all the trials and the hypotheses that lead to these trials. Indeed, it may be useful, later, to remind why one solution was chosen and, maybe more important, why other solutions where rejected. This can help to avoid to do all the same trials another time for another project.

This situation will be shown in the history by as many nodes as performed processes, each one annotated by its hypothesis, and one more for the decision, annotated with the (or the list of) chosen product and the rationales of the choice. Oriented edges will have to be created too, from the different versions of the product to the decision to show which ones have been taken into account in the decision process, and the chosen versions will have to be marked as such as well. In fact, like the decision forced by the method (by some control structures), a decision taken by an engineer is stored in the history as a special primitive process.

Chapter 10

A few methodological elements

To write a traditional imperative computer program is a complex task that requires a lot of knowledge, not only of the syntax and semantics of the chosen computer language, but also of algorithmic notions and programming paradigms. If a program is not well written, it might not provide the awaited results. To design a good method is even more complicated. Not only the result is important, but the way to go to it is important too. Of course, well-structured and clean traditional programs are preferable to dirty programs for the ease of maintenance, but the computer itself does not care about the programming style. At the contrary, a method is designed to be followed by human beings and they do not like dirty jobs. If a method is not clear and easy enough to be used, it will simply be abandoned. So the method engineer must have one more goal during his or her designs: the acceptability of the method not only for the quality of its results and for the ease of use of its interface, but also for the ease to understand and follow the algorithms.

To write a good method is such a complex task that the subject deserves a complete thesis, we cannot pretend to do it here. We will just examine a few basic elements and raise a few problems that have to be taken into account by every method designer, focusing our attention on the fact that a method is aimed at being followed by human beings rather than being executed by a computer.

In a first part, we will see basically how to structure product models. In a second time, we will state a few facts about product types. Finally, we will focus on process types, we will see what makes a method very different from a computer program.

10.1 Product model declarations

Product models are very important because the whole method is based on them. So, a good identification of the needed product models and a good declaration of them are the keystone of the method. Indeed, a car maker could not build a car assembly line without knowing precisely what car it wants to build.

The very first step the method engineer who designs a new method should perform is to model the products the database engineer will receive and the products that will have to be generated. System requirement reports, COBOL listings, Java listings, print screens and all other texts can be modelled very easily since a file extension suffices to describe them in the present state of the research, but this could take much more efforts if, as mentioned in chapter 2, the text models could be refined as much as database schema models which can be described very precisely within the MDL language.

All the intermediate products that will be useful during the project, even if they are not aimed at being divulged, also need some precise models for the help of database engineers. But these intermediate product models will only show their usefulness during the definition of the process types, so they can be defined only at that moment, during the definition of the needs for a sub-process definition.

A database schema model is made of two parts: the concepts and the constraints. The concepts, as defined in chapter 2, is a simple glossary that establishes a correspondence between the terms used in the GER model and the terms which are particular to the model the method engineer is defining; this is a rather simple task. But the definition of the constraints really deserves a good understanding of the model to define, a good understanding of the predicative constraint language, and a good awareness of the level of help the method engineer wants to provide to the database engineer. The understanding of the model to define and of the predicative constraint language sounds natural, but the awareness of the database engineer needs is easily underestimated, leading to unusable model definitions.

The usability of a validation constraint lays in the fact that it can often be expressed in several ways:

- A same constraint can sometimes be expressed on different concepts. For instance, the constraint “MIN_CON_of_ROLE(1 N)” stating that every role should be mandatory means the same as the constraint “OPT_ROLE_per_ET(0 0)” that states that no entity type should play an optional role. They are equivalent in the sense that each time a role invalidates the first one, it also invalidates the second one (since every role must by played by an entity type) and conversely. But, once they are violated, they report different information: the first rule provides the culprit role, while the second one only reports the name of the entity type that plays the incorrect role; if this entity type plays several roles, this information is less precise.
- Several constraints can be grouped in a single rule or they can remain separated in several rules. For example, to state that all attributes of a schema have to be atomic and single-valued, like in an SQL table, we can either use the two simple constraints “SUB_ATT_per_ATT(0 0)” and “MAX_CARD_of_ATT(1 1)” or combine them in a single rule “SUB_ATT_per_ATT(0 0) and MAX_CARD_of_ATT(1 1)”. The first solution has the advantage that each rule returns its own list of problematic attributes, so we know that the attributes in the first list are compound and that attributes in the second list are multi-valued. In the second solution, we only have a single list of problematic attributes and we have to check each attribute to know what its problem really is. But the single list of problematic attributes of the second solution can be seen as an advantage since this integrated list enumerates each problematic attribute only once, even those that cumulate both problems while the first solution will report them twice, once with each rule.
- The content of the diagnosis message is of great importance too. Indeed, if the rule itself is rather easily readable by the method engineer, it may prove to be hardly understandable by a database engineer which is more interested by the lists of problematic constructs than by the rules themselves. So the diagnosis messages have to translate clearly the meaning of the rule in a human native language. It may also suggest a solution to solve the problem. For instance, the message “The attribute &NAME is compound, it should be disaggregated” is preferable to the message “rule SUB_ATT_per_ATT(0 0) violated by &NAME.”

10.2 Product type declarations

Product types can be declared locally to a process type or globally to all process types. Similarly, in traditional programming languages like Pascal, C or Fortran, variables can also be declared globally to the whole program or locally to a procedure[1]. But the comparison does not hold further.

In imperative programming languages, variables can either be of a given type or be a pointer (or a reference) to a memory location of a given type. When a procedure ends, its local variables are destroyed. This means that, if not copied to output parameters, the content of the non-pointer variables is lost and pointers to memory locations are lost too; non-freed memory locations become not accessible.

When using an MDL method, the memory of the system is the history. Since the history keeps everything, products of the local types cannot be destroyed. They will not be available anymore for the following processes of other types, excepted if they are of an output type, but they will still be accessible to who wants to read the history. And since the products have to survive to the end of a process, their

1. Or to a function.

type have to survive too. Nothing will be destroyed. All is a simple matter of scope: the product types that are local to a process type, and their instances, are accessible by processes of the type and by no other processes of another type, but are always accessible for consultation by human beings in the history.

With imperative programming languages, it is often recommended to declare as much variables as possible locally, passing them from procedure to procedure using parameters, and to use global declarations for variables that are used by all procedures or which are so big, such as arrays, that passing them in parameters costs too much in processing time or memory use. When using an MDL method, since only references to products in the history are passed, the problem of size does not exist, so global product types should only be used for products that must be accessible throughout the whole projects.

10.3 Process type declarations

To write a process type can be seen as similar to writing a procedure in an imperative programming language since the MDL language is based on the paradigm, using the same basic control structures. This should be true if a method was not aimed at being used by a human being because computers just execute what is ordered to them without trying to understand what they are doing, and without complaining that they would prefer to do the same thing another way that would need less efforts or that they already did the exactly same action several times before.

Without willing to be exhaustive, we will now examine several situations that should been seen with a different point of view by a traditional imperative language programmer and by a method engineer.

10.3.1 Loops

If we want to design a strategy that begins by the collect of interview reports, using what we learned from traditional imperative languages programming, we will surely write one of the two following MDL strategy chunks containing a *while and a repeat-until* structures:

```
1.    while (ask “Do you want to collect a new interview report?”) repeat
          new (InterviewReport)
      end-repeat

2.    repeat
          new (InterviewReport)
      end-repeat until (ask “Have you finished collecting interview reports?”)
```

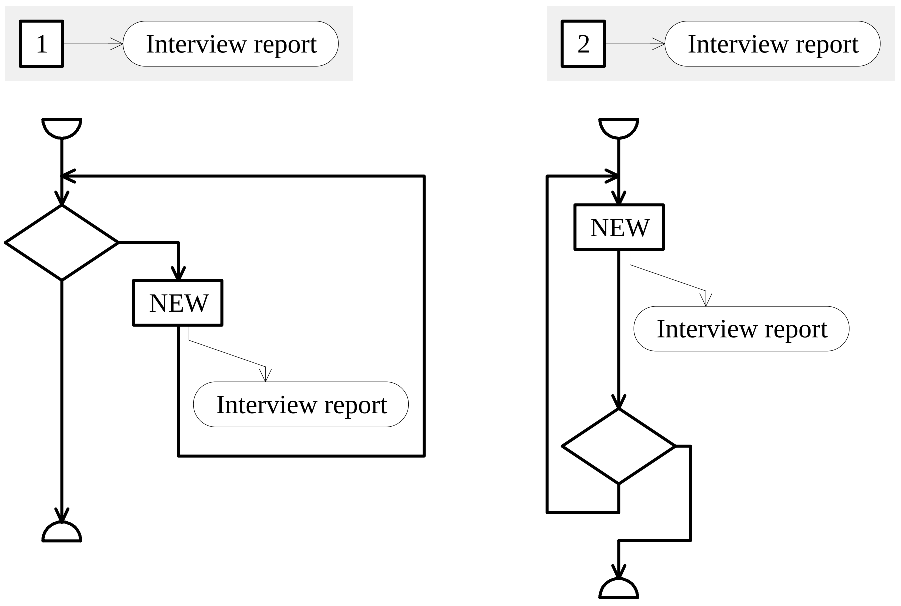


Figure 10.1 - History chunks 1 and 2

They both allow the users to collect as many interview reports as they want. In fact, the first one allows users not to collect any report at all, while the second one forces the users to collect at least one report. For them to be really equivalent, we would have to modify them, either the first one as the chunk 1' below for 1' to be equivalent to 2 if we want to force that at least one report is collected.

```
1'.   while (count-less(InterviewReport,1) or
                    ask “Do you want to collect a new interview report?”) repeat
          new (InterviewReport)
      end-repeat
```

Or we can change the second one as follows for 1 to be equivalent to 2' if we want the users to be able not to collect a single report:

```
2'.   if (ask “Do you want to read interview reports?”) then
          repeat
              new (InterviewReport)
          end-repeat until (ask “Have you finished collecting interview reports?”)
      end-if
```

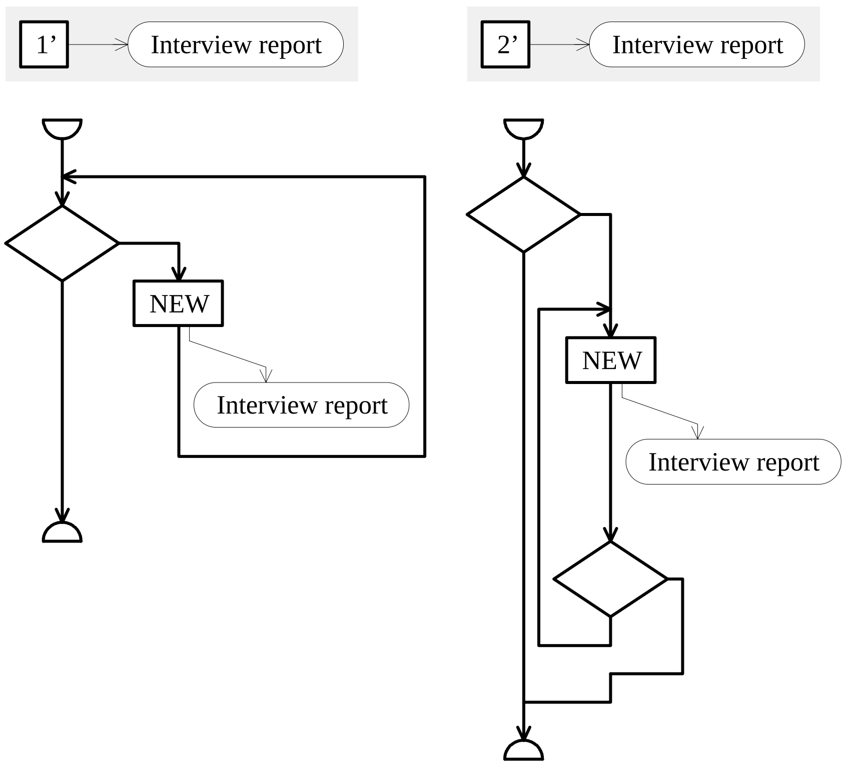


Figure 10.2 - History chunks 1' and 2'

But these strategy chunks are not aimed at being used by computers, but rather by human beings. We have a lot of difference with computers:

- We are able to have a glance at an algorithm before executing it. So we are able to understand what we will have to do and what we will need before doing it. Computers are only capable of starting to execute directly, step by step, and to stop when a problem occurs. We are able to forecast, computers are not.
- We are lazy, we do not like to work when it is not necessary, so we will not start a process if we can foresee a problem by looking rapidly at the algorithm. Computers do not care and will do the job until they reach the problem they could not foresee.

- We like simplicity, computers do not care about that. We prefer simpler structures such as the 1 and 2 above, rather than the 1' or the 2'. They are more readable, easier to understand.
- We are able to think and to take intelligent decisions by ourselves.

So, if we encounter a strategy containing the chunk 1, we will see that we will not be able to go further than the collecting loop if we do not have interview reports and we will certainly not begin to follow the strategy. So, in practice, even if it is not mathematically correct, we can say that chunks 1 and 2 are equivalent. But, among them, which one is the best? It is difficult to say. In fact, some people will prefer the first one where the question is asked before collecting each report, others will prefer the second one where the question is asked after each report is collected. But, since we are all lazy, one remark that most people will do is that it is annoying, when we have a lot of interview reports, to answer the same question again and again until the last report is collected. So, finally, the strategy chunk most people will prefer is the following one:

```
3.    repeat
          new (InterviewReport)
      end-repeat
```

It allows people to do exactly the same: to collect at least one interview report, and to stop whenever they want without the need to answer the same question several times.

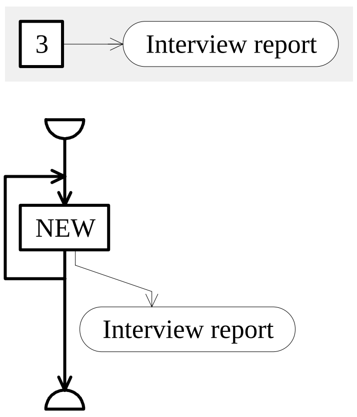


Figure 10.3 - History chunk 3

10.3.2 Sequences and *each* structures

Computer programs as well as methods often need that several actions are performed just one time. Let *A1* and *A2* be either two program instructions or two process types. If both *A1* and *A2* modify the same variables or the same products, or if only one of them modifies variables or products used by the other, they have to be performed in the correct order, they are used within a sequence. But it may happen that both *A1* and *A2* use or modify different variables or products. In this case, we will say that *A1* and *A2* are independent. They can still be used within a sequence, but they can be swapped without impact on the final result. Computers need a precise description of what they have to do. So it is the role of the programmer to decide whether it is *A1* or *A2* that will have the first place in the sequence. But human beings are able to decide by themselves what they prefer to do first, so it would be nice for the method designer to leave to the final user the freedom of the choice. This is why the *each* keyword has been added to the MDL language.

Very often, when processes of several types have to be performed, they can be grouped, all the non-independent process types in the same group, no two independent process types in the same group. Then, all the process types within each group can be ordered in sequence and all the sequences can be presented in parallel to the end-user within an *each* control structure. For example, if *P1, P2, P3* and *P4* are four process types, *P1* having in output a product type used in input by *P2*, *P3* and *P4* using a same product type in modification, *P4* supposing *P3* was previously performed, and *P1*, *P2* being individually independent from *P3* and *P4*, the following strategy chunk, graphically shown in Figure 10.4, is certainly the best way to model the situation:

```
each
        sequence
                P1;
                P2
        end-sequence;
        sequence
                P3;
                P4
        end-sequence
end-each
```

In this example, the six sequences *P1-P2-P3-P4* (Figure 10.5), *P1-P3-P2-P4*, *P1-P3-P4-P2*, *P3-P4-P1-P2*, *P3-P1-P4-P2*, and *P3-P1-P2-P4* would give the same results, but they give a less readable algorithm and they impose more constraints to the final database engineer.

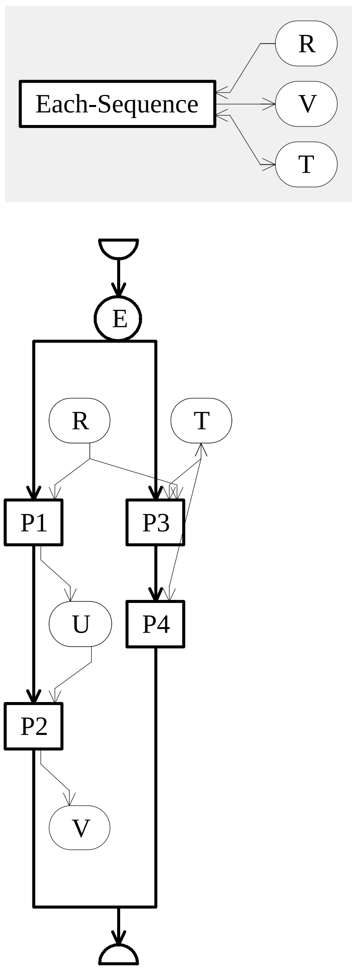


Figure 10.4 - A combination of each and sequences

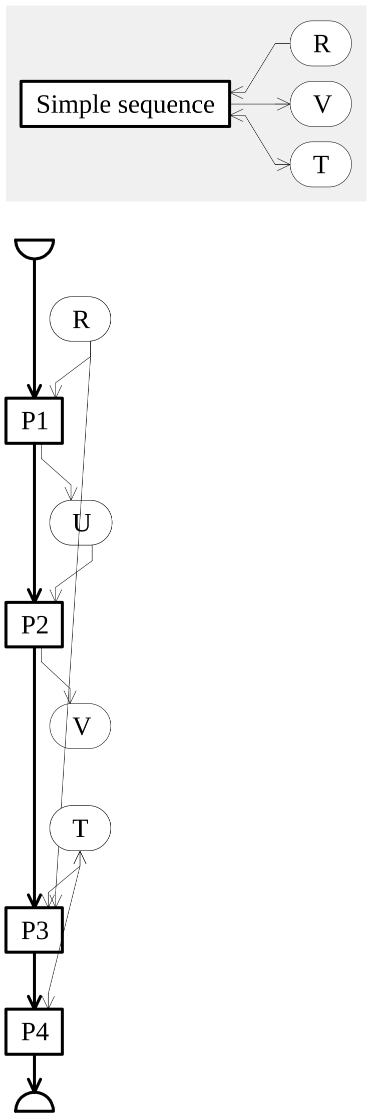


Figure 10.5 - A simple sequence

10.3.3 Process use

Let us examine the two situations presented in Figure 10.6 and in Figure 10.7. Figure 10.6 shows a strategy chunk that creates a new blank schema and that uses a sub-process called *Update* which updates the new product, which fills it. Let us note the use of an expanded style of drawing to show both a process and a sub-process on the same view. In Figure 10.7, it is the *output* sub-process itself that creates the new product before filling it. The two situations, on a strictly theoretical point of view, will provide the same results. A machine would execute them indifferently. But they both bring a different perception of the problem to a human being: the first method gives a greater importance to the *New* primitive process, the fact of creating a new schema is strategically as important as filling it, while the *New* primitive process is a simple technical act in the second method.

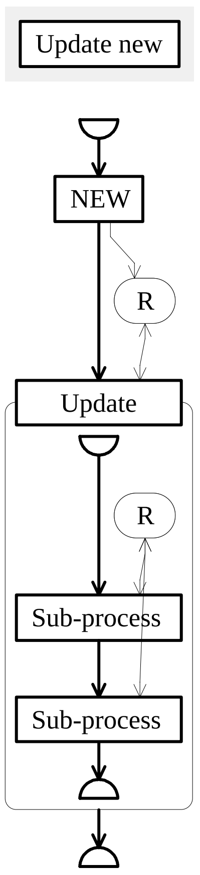


Figure 10.6 - A method chunk updating a blank product

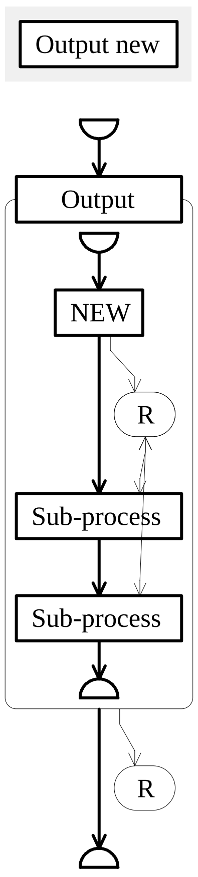


Figure 10.7 - A method chunk creating a new product

When programming with traditional imperative languages, a similar situation is the initialisation of a pointer variable by allocating memory and the initialisation of the allocated memory. The choice between splitting both operations in a procedure and a sub-procedure or grouping both of them in a same procedure will generally be induced by the number of times they have to be performed, and the diversity of situations in which they have to be performed: if five procedures need to create exactly the same data structure, a situation similar to the second one is certainly the best choice; if the five procedures need similar data structures of personal size, a situation similar to the first one will certainly be a better choice. But this is simply a technical choice which has no impact on the final result, the people who will use the program will not know and will even not bother to know how the program works.

Of course, when developing a method, technical details similar to those above can have to be taken into account, but the perception problem that does not exist with programming will generally have a much greater importance.

By writing two different strategies to obtain a same final result[2], the method engineer can also allow or disallow engineers some possibilities. In Figure 10.8, the engineer can update the products of type *R* by performing the sub-process. In Figure 10.9, the engineer has to copy the products of *R* before updating the copies. In the second case, the engineer has the possibility to make several copies of each product before updating them according to various hypotheses, then to choose the best solution. In the first case, it is more complicated: the engineer can make several draft copies of the products by himself and update each draft copy according to an hypothesis, but, when he or she has taken the decision of the best solution, the updates must be performed again to the original products, possibly by playing the history of the best draft.

Another difference between the two situations is the possibility, when browsing through the history for documentation, to watch at the original schema more easily in the second case since it will directly appear in the *Input-Output* process history graph.

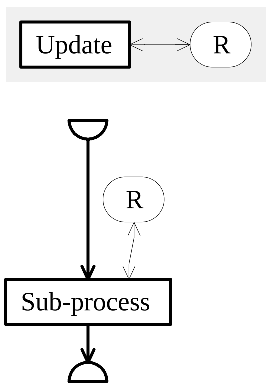


Figure 10.8 - A method chunk updating a product

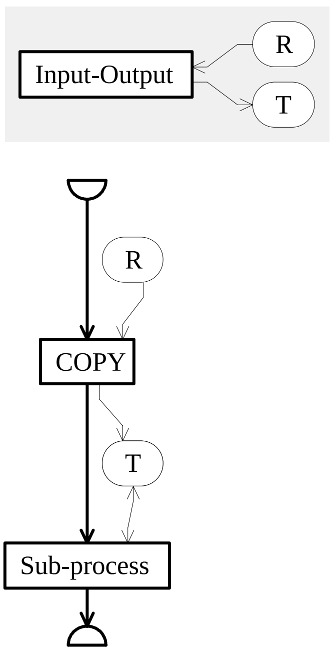


Figure 10.9 - A method chunk generating a new product

10.3.4 Degrees of freedom

One of the greatest differences between computers and human beings, as it already appeared in every situations above, is the ability of the human being to take decisions, to act freely. Without methodological help, a well-trained human being is capable to do a database engineering job entirely by himself or herself while a computer needs much more than a methodological help, it needs to be precisely guided step by step. Between these two extremes, a methodological help is aimed at guiding human beings while restraining their freedom of doing whatever they want. But how much freedom is it good to leave to the user ? As we will see now, the degree of freedom a method engineer can leave to database engineers is left to his or her own will; the MDL language contains a series of concepts that allow a great flexibility.

2. Since the parameters are different in both situations, the process types that use these two ones have to be different, but they can be easily adapted for one or the other to reach the same result.

10.3.4.1 Primitive processes

Primitive processes can be classified in four groups:

1. Process types as easy to use as pushing a button. Just ask for a process of one of these types to be performed and the job is done entirely automatically. We will call them **basic automatic process types**. The *new* entry in the *file* menu of any application is such a process type.
2. Process types that are as easy to use as pushing a button when they are correctly configured, this configuration having to be done once and for all by a specialist. This tuning can be done at method design time by a method engineer so that the users will not even notice it was so. We will call these process types the **configurable automatic process types**. For example, the spell checking facility of every word processor does its job automatically when the right dictionaries are installed.
3. Process types that can still be executed automatically but which needs to be configured defore each use, by the user himself or herself. They are called the **user configurable automatic process types**. For instance, before photocopying a document, it is necessary to manually set the correct number of copies, the contrast, the zoom factor, and the paper size, then the machine does the rest.
4. Finally, some processes cannot be performed automatically by a machine, the user has to do them entirely by themselves. We will call their types the **manual process types**. The interpretation of interview reports for drawing a raw conceptual schema, that is the understanding of natural language, is an example of such a process type.

The *basic automatic process types* are fully automated and gives absolutely no control to their users. The *configurable automatic process types* can only be configured by the method engineer developing a method, but still leave no possibility of action to the database engineers who will use the method. In fact, the two first kinds of primitive processes give no freedom of action to the user because they are fully computer-oriented. The *user configurable automatic process types* allow the database engineers to act with a little bit more freedom at the initialisation of the process, but these engineers will still undergo its actual execution. Finally, the *manual process types* offers much more freedom to their users. When processes of this last kind are supported by a toolbox, the degree of freedom can even be regulated by the choice of the tools in the toolbox.

For instance, the following process of the second group automatically transforms all the functional rel-types of a schema S into referential attributes:

```
glbtrsf ( S, ”RT_into_REF ( ATT_per_RT (0 0)
                            and ROLE_per_RT (2 2)
                            and N_ROLE_per_RT (0 1))
```

The following toolbox allows database engineers to do the same job manually, possibly leaving a few rel-types unchanged. In other words, the database engineers have the freedom of choosing what they think needs to be transformed:

```
toolbox RT-to-REF
    title “RT-to_REF”
    add tf-RT-into-att
end-toolbox
```

Finally, the following toolbox also allows database engineers to perform the same transformations, but also to edit a little bit the schema in order to prepare it for the transformation when needed:

```
toolbox RT-to-REF
    title “RT-to_REF”
    add tf-RT-into-att
    add delete-attribute
    add delete-role
    add tf-RT-into-ET
end-toolbox
```

So we can say that all these three examples allow database engineers to perform the same job, but give them different levels of responsibility and of freedom in their actions.

10.3.4.2 Sequence, one, some, each structures

We showed above how the *each* structure can be used instead of a sequence, with independent sub-processes, to give more freedom to the user. Another interesting structure is the *one* structure. It has the same degree of freedom as the *each* structure since it imposes the number of sub-process to be performed too: exactly one. But a little bit more freedom can be added to the *one* structure. By the addition of an empty sequence alternative, the method engineer may allow the database engineer to choose one process or none:

```
one
    sub-process 1;
    sub-process 2;
    ...
    sequence  end-sequence
end-one
```

The *some* structure gives even more freedom to the database engineer who has the possibility to execute sub-processes of any number of enumerated types, from one to all, without regard to the selection order. By the adjunction of an empty sequence to an *some* structure, the database engineer can be given the possibility to perform sub-processes from none to all enumerated types.

Finally, if the method engineer combines a *one*, a *some* or an *each* structure with a *repeat...end-repeat* loop, the database engineer will even be able to perform several processes of each type. For instance,

```
one
    repeat sub-process1 end-repeat;
    repeat sub-process2 end-repeat;
    ...
end-one
```

allows the database engineer to perform several times the same process, and

```
repeat
    one
        sub-process1;
        sub-process2;
        ...
        sequence  end-sequence
    end-one
end-repeat
```

allows him or her to perform processes of any number of types, any number of times, in any order, possibly nothing. The freedom of action is almost total in this last case.

10.3.4.3 Sets

In Figure 10.4, we can see that the process type *P1* uses products of type *R* in input and produces products of type *U*. When a database engineer uses this method, there can be several products of type *R* which are passed to *P1* at the same time, the number of products of the same type being in a range defined in the product type definition. By default, when a new process of a given type starts, all the products of the required types are passed to the new process. During its performance, the database engineer is allowed to work effectively with all the products or with only some of them. The freedom of action is large. For example, let us suppose a database engineer has five text files of type *InterviewReport*, named *ir1,...,ir5*, at his or her disposal, and let us assume *Conceptual* is a schema type. If he or she encounters the following strategy chunk he or she can perform a first analysis process with *ir1* to generate a first conceptual schema, then perform a second analysis process with *ir3*, *ir4* and *ir5* to generate a second conceptual schema:

```
do Analysis(InterviewReport,Conceptual)
```

It is possible for the method engineer to reduce such a freedom by using the *for* control structure. A first restriction lays in the use of the *for some* structure which forces the user to perform actions on some products one by one. He or she can choose whatever products to work with, in any order, but all actions have to be performed on one product at a time. For instance, if a user has to follow the following strategy chunk in the same context as above, he or she can decide to perform four processes of type *Analysis*, the first time with *ir1*, the second time with *ir3*, the third time with *ir5* and the fourth time with *ir4*, giving a total of four conceptual schemas:

```
for some IR in InterviewReport do
    do Analysis(IR,Conceptual)
end-for
```

A further restriction is imposed by the *for one* and the *for each* structures because they impose that, respectively, exactly one of the products or all the products must be used one by one. For instance, still in the context above, the following strategy chunk obliges the user to choose exactly one of the five interview reports and to treat this one only:

```
for one IR in InterviewReport do
    do Analysis(IR,Conceptual)
end-for
```

And the strategy chunk below makes mandatory the treatment of all interview reports, one at a time:

```
for each IR in InterviewReport do
    do Analysis(IR,Conceptual)
end-for
```

10.3.4.4 Weak conditions

Even when using more traditional structures as *if...then...else*, *while*, *repeat...until*, a method engineer can give several degrees of freedom to the final user of the method. What is common to those three control structures is that they need a condition. A condition is an expression as defined in Chapter 5 where three types of expressions were shown: formal and strict, formal non-strict, and non-formal.

Formal and strict expressions are the kind of expressions that can be found in every traditional procedural programming language. They are the kind of expression that are expressed correctly and without ambiguities with a well-defined syntax and semantic and that can be calculated in a deterministic way by a computer. Formal and strict conditions of the MDL language are formal expression based conditions that can be computed by the supporting CASE environment. Users of methods containing such conditions have no choice but to accept their result.

Formal non-strict conditions are formal expression based too, so they can be computed by the supporting CASE environment, but the database engineers who are confronted to them have the possibility to accept the results or to refute them. In this case, the supporting CASE environment can be seen as a well-advised help that should wisely be followed, even if the freedom of the engineers to accept the advice or not is total.

Finally, non-formal conditions cannot be understood by the supporting CASE environment, only the engineers meeting them have the possibility and the total freedom to choose an answer. But they do not have the possibility not to answer.

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Appendix A

The MDL Syntax

A.1 BNF notation

::= is the definition symbol. The left member is the defined term, the right member its definition. For instance,
<a> ::= t means that *<a>* is defined as *t*.

<...> angle brackets encompass the terms that have a definition. When placed at the left side of ::=, it shows the term that is defined. At the right side of that symbol, it must be replaced by its definition. For instance, *<b> ::= t*, defines *<b>* as *t*, and in *<a> ::= r<b>s*, *<b>* is replaced by its definition and thus *<a>* is defined as *rts*.

| stands for an alternative. Either the left member or the right member may be used. They are two possible definitions. For instance, *<a> ::= <b>|<c>* means that *<a>* may be defined either as *<b>* or *<c>*.

[...] encompasses a facultative part of a definition. For instance, *<a> ::= <b>[<c>]* means that *<a>* may be defined either as *<b>* or as *<b><c>*

{...} encompasses a repeatable part of a definition. That part may be used zero, one or many times. For instance, *<a> ::= <b>{<c>}* means that *<a>* may be defined either as *<b>*, *<b><c>*, *<b><c><c>*,...

$\{...\}_{m\text{-}n}$ encompasses a repeatable part of a definition with a limit on the number of repetitions. That part may be used at least m times and at most n times. For instance, *<a> ::= <b>*$\{<c>\}_{0\text{-}3}$ means that *<a>* may be defined either as *<b>*, *<b><c>*, *<b><c><c>* or *<b><c><c><c>*.

A.2 Miscellaneous rules

A.2.1 Spaces and comments

For the readability of the grammar, spaces between grammar elements are not specified. In fact, they should be appended "intelligently":
- no spaces between letters of a word or between figures forming a number
- mandatory spaces between separated words both made of letters and/or figures
- optional spaces between special symbols or words and symbols.

For example:

do normalise(SQL-schema)

Spaces are mandatory between *do* and *normalise* and optional everywhere else; the following is equivalent:

do normalise (SQL-schema)

A space is any series of blank (ASCII code 32), tab (ASCII code 8) or new line (ASCII codes 13 and/or 10) characters.

Comments are also considered as spaces: they can be put anywhere a space is allowed. A comment begins with the **%** character and is terminated with the end of the line. For instance:

do normalise(SQL-schema)	**%** this is a comment
do optimise(SQL-schema)	**%** this is another comment

A.2.2 Forward references

Forward references are not allowed.

A.3 Multi-purpose definitions

These definitions make a useful set for the following. They include the definition of special characters such as an end-of-line, an end-of-file,... and the definition of special strings such as valid-names that will serve as identifiers, human readable texts, comments,...

The characters used are the following :

<EOL>	::= *End-Of-Line character*
<EOF>	::= *End-Of-File character*
<letter>	::= **a**|**b**|**c**|**d**|**e**|**f**|**g**|**h**|**i**|**j**|**k**|**l**|**m**|**n**|**o**|**p**|**q**|**r**|**s**|**t**|**u**|**v**|**w**|**x**|**y**|**z**| **A**|**B**|**C**|**D**|**E**|**F**|**G**|**H**|**I**|**J**|**K**|**L**|**M**|**N**|**O**|**P**|**Q**|**R**|**S**|**T**|**U**|**V**|**W**|**X**|**Y**|**Z**
<figure>	::= **1**|**2**|**3**|**4**|**5**|**6**|**7**|**8**|**9**|**0**
<valid-character>	::= <letter>|<figure>|**-**|**_** *characters recognised by the language for identifiers*
<readable-character>	::= *any readable ASCII character but* <EOL> *and* <EOF>*. These characters are used for messages that appear on the screen during the use of the model.* *A double quote must be doubled ("").*
<any-character>	::= *any character but* <EOL> *and* <EOF>
<really-any-character>	::= *any character but* <EOF>

Those characters can be combined. A valid-name is a string that is recognised by the language as an identifier. And some readable text is any text that will be displayed on screen such as messages, contextual names,... Strings are used for any suite of parameters of any type. Numbers are positive integers.

<free-text>	::= {<any-character>}
<totally-free-text>	::= {<really-any-character>}
<valid-name>	::= {<valid-character>}$_{1-100}$ *a name used for identifiers*
<readable-name>	::= **"**{<readable-character>}$_{0-100}$**"** *a human readable and meaningful name*
<string>	::= **"**{<readable-character>}$_{0-255}$**"** *a human readable and meaningful string of characters*
<textual-description>	::= **description** <totally-free-text> **end-description** *A description is a free text of any length, the '*|*' character may be used as the left margin indicator.* *Almost every block can have a description.*
<number>	::= <figure>{<figure>}

A.4 Method description

A method is made of product models (schema models and text models), as well as product types and process types. Finally, a special paragraph describes the method itself with a title, a version, an author, a date, possibly a description or a help file and the main process type.

<Method>	::= <block> {<block>} <method-description>
<block>	::= <extern-decl>|<schema-model>|<text-model>|<product-type>|<toolbox>| <task-model>
<method-description>	::= **method** <method-title> <method-version> [<textual-description>] <method-author> <method-date> [<method-help>] <method-perform> **end-method**
<method-title>	::= **title** <readable-name>
<method-version>	::= **version** <version-name>
<version-name>	::= "{<readable-character>}$_{16}$"
<method-author>	::= **author** <readable-name>
<method-date>	::= **date** <date>
<date>	::= "<day>**-**<month>**-**<year>"
<day>	::= {<figure>}$_{2-2}$
<month>	::= {<figure>}$_{2-2}$
<year>	::= {<figure>}$_{4-4}$
<method-help>	::= **help-file** <felp-file-name>
<help-file-name>	::= <string>
<method-perform>	::= **perform** <task-name>

A.5 External declaration

The language allows the methodological engine to use external functions, i.e. user-defined functions written in the Voyager 2 language. These functions must be declared before they can be used.

<extern-decl>	::= **extern** <external-fct-name> <real-ext-fct-name> **(** [<ext-param-decl>] **)**
<external-fct-name>	::= <valid-name>
<real-ext-fct-name>	::= <voyager-file>**.**<voyager-fct>
<voyager-file>	::= <readable-name>
<voyager-fct>	::= <valid-name>
<ext-param-decl>	::= <ext-param> {**,** <ext-param>}
<ext-param>	::= <ext-param-type> [<ext-param-name>]
<ext-param-type>	::= **list** | **type** | **integer** | **string**
<ext-param-name>	::= <valid-name>

A.6 Expressions

Some expressions are needed at several places.

<expression>	::= <and-expression> [**or** <expression>]
<and-expression>	::= <not-expression> [**and** <and-expression>]
<not-expression>	::= [**not**] <weak-expression>
<weak-expression>	::= [**weak**] <elem-expression>
<elem-expression>	::= <exists-expr>|<model-expr>|<external-expr>|<ask>|<built-in-expr>|<parenth-expr>
<exists-expr>	::= **exists (** <product-name> **,** <sch-anal-expr> {**,** <sch-anal-expr>} **)**
	*the comma acts as a **and**, all expressions must be **true** for the result to be **true***
<model-expr>	::= **model (** <product-name> **,** <model-name> **)**
<external-expr>	::= **external** <external-fct-name> **(** [<ext-parameters>] **)**
<ext-parameters>	::= <ext-parameter> {**,** <ext-parameter>}
<ext-parameter>	::= [**content:**]<product-name>|<string>|<number>
<ask>	::= **ask** <string>
<built-in-expr>	::= <built-in-fct-name> <misc-parameters>
<built-in-fct-name>	::= <valid-name>
<misc-parameters>	::= **(** <parameter> {**,** <parameter>} **)**
<parameter>	::= <product-name>|<string>|<number>
<parenth-expr>	::= **(** <expression> **)**
<sch-anal-expr>	::= <and-sch-anal-expr> [**or** <sch-anal-expr>]
<and-sch-anal-expr>	::= <not-sch-anal-expr> [**and** <and-sch-anal-expr>]
<not-sch-anal-expr>	::= [**not**] <elem-sch-anal-expr>

<elem-sch-anal-expr>	::= <constraint-name> <cstr-param>
	a first-order logic predicate
<constraint-name>	::= <valid-name>
	the name of a validation function of the supporting CASE tool
<cstr-param>	::= **(**{<any-character>}$_{0\text{-}255}$**)**
	strings for the parameters of predicates; their syntax may vary depending on the context in which they are used. Characters ’(’, ’)’ and ’\’ must be prefixed by ’\’

A.7 Schema model description

The schemas we consider are the DB-MAIN generic entity-relationship schemas. They must be conform to a given specified model. The main task to perform to specify the semantic aspect of a model is the renaming of the concepts. All the objects of a schema have a generic name. But this name is not always suited to all contexts. For instance, in an SQL-compliant schema, we prefer to speak about tables rather then entity types. The concept part is the place where all the generic terms are renamed. The syntactic specification can be obtained by constraining the schema. A constraint is a first-order predicate made of a function name and some parameters. The functions having these names are primitive validation processes. A rule is a logical formula in which the terms are predicates and operators and boolean operators AND, OR, NOT. The constraining of the schema is made of a series of such rules. To each rule is associated a diagnosis. A diagnosis is a message that is printed on the screen to tell the user when the rule is not satisfied.

<schema-model>	::= **schema-model** <model-header> <model-title> [<textual-description>] [<schema-concepts>] [<model-constraints>] **end-model**
<model-header>	::= <model-name>[**is** <model-name>]
<model-name>	::= <valid-name>
<model-title>	::= **title** <readable-name>
	title to be written to the screen
<schema-concepts>	::= **concepts** {<concept-line>}
<concept-line>	::= <concept-name> <readable-name>
	one concept with its conceptual name
<concept-name>	::= <valid-name>
<model-constraints>	::= **constraints** {<constraint-block>}
<constraint-block>	::= <rule> <diagnosis-line>
	one single constraint line
<rule>	::= <sch-anal-expr>
<diagnosis-line>	::= **diagnosis** <diagnosis-string>
	the message to be displayed when the constraint is violated
<diagnosis-string>	::= <string>
	a readable and meaningful string

A.8 Text model description

A text is any product that is not a schema in the sense here above. An identifying name must be given to a text model as well as a readable name and a list of possible file extensions.

<text-model>	::= **text-model** <model-header> <model-title> [<textual-description>] <extensions> [<grammar>] **end-model**
<extensions>	::= **extensions** <extension-name> {**,** <extension-name>}
<grammar>	::= **grammar** <grammar-file>
<grammar-file>	::= <readable-name>
<extension-name>	::= <string>

A.9 Product type description

A product type has an identifying name, a readable name, a reference model and possibly a description.

<product-type>	::= **product** <product-name> <product-title> [<textual-description>] <product-model> [<multiplicity>] **end-product**
<product-name>	::= <valid-name>
<product-title>	::= **title** <readable-name>
	title to be written to the screen
<product-model>	::= **model** [**weak**] <model-name>
<multiplicity>	::= **multiplicity** <min-max-mult>
<min-max-mult>	::= **[** <min-mult> **-** <max-mult> **]**
<min-mult>	::= <number>
<max-mult>	::= <number>|**n**|**N**

A.10 Toolbox description

A tool is a product transformation. For instance, a function for adding an entity-type is a tool. A toolbox is a set of such tools. It can be defined from an empty toolbox in which we add all the tools we need or from another one by adding or removing tools.

<toolbox>	::= **toolbox** <toolbox-header> <toolbox-title> [<textual-description>] <toolbox-body> **end-toolbox**
<toolbox-header>	::= <toolbox-name> [**is** <toolbox-name>]
<toolbox-name>	::= <valid-name>
	the toolbox identifier
<toolbox-title>	::= **title** <readable-name>
	name to be written to the screen
<toolbox-body>	::= <toolbox-line> {<toolbox-line>}
<toolbox-line>	::= <add-line>|<remove-line>
<add-line>	::= **add** <tool-name>
<remove-line>	::= **remove** <tool-name>
<tool-name>	::= <valid-name>
	the name of a function of the supporting case tool

A.11 Process type description

A process type is defined in three parts: a header with its name, its external definition and its internal definition.

The external definition contains some methodological aspects and a static definition of the process. Firstly, a title in clear text. It is that title that the user will see on screen. Secondly, the name of a section in the help file that should contain a description of the process. The user can read that file whenever he wants while performing a process of that type. Finally, the static description of the process type simply shows what product types are required in input and what product types are provided in output or updated, with the model they are conform to and possibly their multiplicity. If a product model is prefixed by *weak*, that means a product actually used should preferably be conform to the specified model but this is not mandatory. The internal definition begins with the schema types used as the internal workplaces. Finally, the strategy shows how the process has to be performed.

<task-model>	::= **process** <task-name> <task-body> **end-process**
<task-name>	::= <valid-name>
	the task identifier
<task-body>	::= <task-title> [<textual-description>] <models-section> [<explain-line>] <strategy>
<task-title>	::= **title** <readable-name>
	title to be used by the user interface
<models-section>	::= [<input-line>] [<output-line>] [<update-line>] [<intern-line>] [<set-line>]
<input-line>	::= **input** <product-list>
	the product types expected in input that will not be modified
<product-list>	::= <product-element> {**,** <product-element>}
<product-element>	::= <product-name> [<multiplicity>] [<UI-name>] **:** [**weak**] <model-name>
<UI-name>	::= <readable-name>

```
<output-line>              ::= output <product-list>
                           the product types produced in output
<update-line>              ::= update <product-list>
                           the product types expected in update (input, transformation, output)
<intern-line>              ::= intern <product-list>
                           the product types to which the internal schemas must (or should) conform
<set-line>                 ::= set <product-set-list>
                           the product types to which the internal schemas must (or should) conform
<product-set-list>         ::= <product-set-element> {, <product-set-element>}
<product-set-element>      ::= <product-set-name> [<multiplicity>] [<UI-name>]
<product-set-name>         ::= <valid-name>
<explain-line>             ::= explain <explain-section>
                           the section in the help file where explanation and suggestions can be found
<explain-section>          ::= <readable-name>
<strategy>                 ::= strategy <sequence>
                           body of a process
<sequence>                 ::= <action> {; <action>}
                           perform all actions in the specified order
<action>                   ::= |<elem-action>|<compl-action>
                           action to be carried out, possibly no action
<elem-action>              ::= <do-action>|<toolbox-action>|<external-action>|<glbtrsf-action>|<extract-action>|
                                   <generate-action>|<message-action>|<built-in-action>
<do-action>                ::= do <task-name> ( [<do-prod-parameters>] )
<do-prod-parameters>       ::= [content:]<product-name> {, [content:]<product-name>}
<toolbox-action>           ::= toolbox <toolbox-name> [[log <log-level>]] <tb-prod-parameters>
<log-level>                ::= off | replay | all
<tb-prod-parameters>       ::= ( <product-name> {, <product-name>} )
<external-action>          ::= external <external-fct-name> [[log <log-level>]] <ext-parameters>
<glbtrsf-action>           ::= glbtrsf["<transfo-name>"] [[log <log-level>]] ( <product-name> , <global-transfo>
                                   {, <global-transfo>} )
<global-transfo>           ::= <transfo-name> (<free-text>)
<transfo-name>             ::= <valid-name>
<extract-action>           ::= extract <extractor-name> ( <source-file> , <dest-schema> )
<extractor-name>           ::= <valid-name>
<source-file>              ::= <product-name>
<dest-schema>              ::= <product-name>
<generate-action>          ::= generate <generator-name> ( <source-schema> , <dest-file> )
<generator-name>           ::= <valid-name>
<source-schema>            ::= <product-name>
<dest-file>                ::= <product-name>
<message-action>           ::= message <string>
<bulti-in-action>          ::= <new-action>|<copy-action>|<import-action>|<cast-action>|<define-action>
<new-action>               ::= new (<product-name>)
<copy-action>              ::= copy (<product-name>,<product-name>)
<import-action>            ::= import (<product-name>)
<cast-action>              ::= cast (<product-name>,<product-name>)
<define-action>            ::= define (<product-set-element>,<product-set-expr>)
<product-set-expr>         ::= <product-set-op> <product-set-expr-list>
<product-set-op>           ::= union | inter | minus | subset | origin | target | choose-one | choose-many |
                                   first | remaining
<product-set-expr-list>    ::= ( <product-set-expr> {, <product-set-expr>} )
<compl-action>             ::= <iterate>|<choose>|<alternate>
                           complex action
<iterate>                  ::= <repeat>|<while-repeat>|<repeat-until>|<for>
<repeat>                   ::= repeat <sequence> end-repeat
<while-repeat>             ::= while <parenth-expr> <repeat>
<repeat-until>             ::= <repeat> until <parenth-expr>
<for>                      ::= for <one-some-each> <product-name> in <product-name> do <sequence> end-for
<one-some-each>            ::= one | some | each
```

<choose>	::= <one>|<some>|<each>
<one>	::= **one** <sequence> **end-one**
	perform one action from the list
<some>	::= **some** <sequence> **end-some**
	perform at least one action from the list in any order
<each>	::= **each** <sequence> **end-each**
	perform each action from the list in any order
<alternate>	::= **if** <parenth-expr> **then** <sequence> [**else** <sequence>] **end-if**
	carry out one action or the other according to the condition

Appendix B

Predicates

B.1 Constraints on schema

ET_per_SCHEMA (*min max*)
The number of entity types per schema must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

RT_per_SCHEMA (*min max*)
The number of rel-types per schema must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

COLL_per_SCHEMA (*min max*)
The number of collections per schema must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

DYN_PROP_of_SCHEMA (*dynamic_property parameters*)
Check some properties of the dynamic properties.
☞ See section B.17

SELECTED_SCHEMA
Search for all selected objects. This constraint should not be used for validation.
☞ No parameters.

MARKED_SCHEMA
Search for all marked objects. This constraint should not be used for validation.
☞ No parameters.

V2_CONSTRAINT_on_SCHEMA (*V2-file V2-predicate parameters*)
A call to a Voyager 2 boolean function. This constraint returns the result of the function. It provides an easy way to add any new constraint.
☞ See section B.16

B.2 Constraints on collections

ALL_COLL
Used for a search, this constraint finds all collections. It should not be used for a validation.

☞ No parameters.

ET_per_COLL (*min max*)
The number of entity types per collection must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

DYN_PROP_of_COLL (*dynamic_property parameters*)
Check some properties of the dynamic properties.
☞ See section B.17

SELECTED_COLL
Search for all selected objects. This constraint should not be used for validation.
☞ No parameters.

MARKED_COLL
Search for all marked objects. This constraint should not be used for validation.
☞ No parameters.

V2_CONSTRAINT_on_COLL (*V2-file V2-predicate parameters*)
A call to a Voyager 2 boolean function. This constraint returns the result of the function. It provides an easy way to add any new constraint.
☞ See section B.16

B.3 Constraints on entity types

ALL_ET
Used for a search, this constraint finds all entity types. It should not be used for a validation.
☞ No parameters.

ATT_per_ET (*min max*)
The number of attributes per entity type must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

ATT_LENGTH_per_ET (*min max*)
The sum of the size of all the attributes of an entity type must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

ROLE_per_ET (*min max*)
The number of roles an entity type can play must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

ONE_ROLE_per_ET (*min max*)
Entity types play between *min* and *max* roles with maximum cardinality = 1.
☞ *min* and *max* are integer constants or N.

N_ROLE_per_ET (*min max*)
Entity types play between *min* and *max* roles with maximum cardinality > 1.
☞ *min* and *max* are integer constants or N.

MAND_ROLE_per_ET (*min max*)
The number of mandatory roles played by entity types must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

OPT_ROLE_per_ET (*min max*)
The number of optional roles played by entity types must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

GROUP_per_ET (*min max*)
The number of groups per entity type must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

ID_per_ET (*min max*)
The number of identifiers per entity type must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

PID_per_ET (*min max*)
The number of primary identifiers per entity type must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

ALL_ATT_in_ID_ET (*yn*)
If parameter is "yes", all the identifiers of an entity type contain all attributes (possibly with or without some roles) or the entity type has no explicit identifier. If parameter is "no", an entity type must have at least one identifier which does not contain all the attributes of the entity type.
☞ yn is either yes or no.

ALL_ATT_ID_per_ET (*min max*)
The number of primary identifiers made of attributes only must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

HYBRID_ID_per_ET (*min max*)
The number of hybrid identifiers (made of attributes, roles or other groups) must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

KEY_ID_per_ET (*min max*)
The number of identifiers that are access keys must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

ID_NOT_KEY_per_ET (*min max*)
The number of identifiers that are not access keys must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

KEY_ALL_ATT_ID_per_ET (*min max*)
The number of identifiers made of attributes only which are access keys must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

EMBEDDED_ID_per_ET (*min max*)
The number of overlapping identifiers must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

ID_DIFF_in_ET (*type*)
All the identifiers of an entity type are different. Similarity criteria are function of the specified *type*: *components* indicates that all the elements of both identifiers are the same, possibly in a different order, *components_and_order* forces the components in both identifiers to be in the same order for the identifiers to be identical. For instance, let an entity type have two identifiers, one made of attributes A and B, the other made of attributes B and A. They will be said to be identical when *type* is *components* and different in the other case.
☞ *type* is either **components** or **components_and_order**.

KEY_per_ET (*min max*)

The number of access key groups per entity type must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

ALL_ATT_KEY_per_ET (*min max*)
The number of access keys made of attributes only must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

HYBRID_KEY_per_ET (*min max*)
The number of hybrid access keys must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

ID_KEY_per_ET (*min max*)
The number of access keys that are identifiers too must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

KEY_PREFIX_in_ET (*type*)
An access key is a prefix of another identifier or access key. *type* specifies whether the order of the attributes must be the same in the access key and in the prefix or not.
This constraint is particularly well suited for using the assistant for search. To use it in order to validate a schema, it should be used with a negation (not KEY_PREFIX_in_ET).
☞ *type* is either **same_order** or **any_order**.

REF_per_ET (*min max*)
The number of reference groups in an entity type must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

REF_in_ET (*type*)
Referential constraints reference groups of type *type*.
☞ *type* is either **pid** to find ET with primary identifiers or **sid** to find ET with secondary identifiers.

COEXIST_per_ET (*min max*)
The number of coexistence groups per entity type must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

EXCLUSIVE_per_ET (*min max*)
The number of exclusive groups per entity type must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

ATLEASTONE_per_ET (*min max*)
The number of at-least-one groups per entity type must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

INCLUDE_per_ET (*min max*)
The number of include constraints in an entity type must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

INVERSE_per_ET (*min max*)
The number of inverse constraints in an entity type must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

GENERIC_per_ET (*min max*)
The number of generic constraints in an entity type must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

PROCUNIT_per_ET (*min max*)
The number of processing units per entity type must be at least *min* and at most *max*.

☞ *min* and *max* are integer constants or N.

COLL_per_ET (*min max*)
The number of collections an entity type belongs to must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

DYN_PROP_of_ET (*dynamic_property parameters*)
Check some properties of the dynamic properties.
☞ See section B.17

SELECTED_ET
Search for all selected objects. This constraint should not be used for validation.
☞ No parameters.

MARKED_ET
Search for all marked objects. This constraint should not be used for validation.
☞ No parameters.

V2_CONSTRAINT_on_ET (*V2-file V2-predicate parameters*)
A call to a Voyager 2 boolean function. This constraint returns the result of the function. It provides an easy way to add any new constraint.
☞ See section B.16

B.4 Constraints on is-a relations

ALL_ISA
Used for a search, this constraint finds all is-a relations. It should not be used for a validation.
☞ No parameters.

SUB_TYPES_per_ISA (*min max*)
An entity type can not have less than *min* sub-types or more than *max* sub-types.
☞ *min* and *max* are integer constants or N.

SUPER_TYPES_per_ISA (*min max*)
An entity type can not have less than *min* super-types or more than *max* super-types.
☞ *min* and *max* are integer constants or N.

TOTAL_in_ISA (*yn*)
Is-a relations have (yes) or do not have (no) the *total* attribute.
☞ *yn* is either **yes** or **no**.

DISJOINT_in_ISA (*yn*)
Is-a relations have (yes) or do not have (no) the *disjoint* attribute.
☞ *yn* is either **yes** or **no**.

DYN_PROP_of_ISA (*dynamic_property parameters*)
Check some properties of the dynamic properties.
☞ See section B.17

SELECTED_ISA
Search for all selected objects. This constraint should not be used for validation.
☞ No parameters.

MARKED_ISA
Search for all marked objects. This constraint should not be used for validation.
☞ No parameters.

V2_CONSTRAINT_on_ISA (*V2-file V2-predicate parameters*)
A call to a Voyager 2 boolean function. This constraint returns the result of the function. It provides an easy way to add any new constraint.
☞ See section B.16

B.5 Constraints on rel-types

ALL_RT
Used for a search, this constraint finds all rel-types. It should not be used for a validation.
☞ No parameters.

ATT_per_RT (*min max*)
The number of attributes per rel-type must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

ATT_LENGTH_per_RT (*min max*)
The sum of the size of all the attributes of a rel-type must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

ROLE_per_RT (*min max*)
The number of roles played in a rel-type must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

ONE_ROLE_per_RT (*min max*)
Rel-types have between *min* and *max* roles with maximum cardinality = 1.
☞ *min* and *max* are integer constants or N.

N_ROLE_per_RT (*min max*)
Rel-types have between *min* and *max* roles with maximum cardinality > 1.
☞ *min* and *max* are integer constants or N.

MAND_ROLE_per_RT (*min max*)
The number of mandatory roles in a rel-types must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

RECURSIVITY_in_RT (*min max*)
The number of times an entity type plays a role in a rel-type should be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

GROUP_per_RT (*min max*)
The number of groups per rel-type must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

ID_per_RT (*min max*)
The number of identifiers per rel-type must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

PID_per_RT (*min max*)
The number of primary identifiers per rel-type must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

ALL_ATT_ID_per_RT (*min max*)
The number of identifiers made of attributes only must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

HYBRID_ID_per_RT (*min max*)

The number of hybrid identifiers (made of attributes, roles or other groups) must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

EMBEDDED_ID_per_RT (*min max*)
The number of overlapping identifiers must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

ID_DIFF_in_RT (*type*)
All the identifiers of a rel-type are different. Similarity criteria are function of the specified *type*: *components* indicates that all the elements of both identifiers are the same, possibly in a different order, *components_and_order* forces the components in both identifiers to be in the same order for the identifiers to be identical. For instance, let an entity type have two identifiers, one made of attributes A and B, the other made of attributes B and A. They will be said to be identical when *type* is *components* and different in the other case.
☞ *type* is either **components** or **components_and_order**.

KEY_per_RT (*min max*)
The number of access keys per rel-type must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

COEXIST_per_RT (*min max*)
The number of coexistence groups per rel-type must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

EXCLUSIVE_per_RT (*min max*)
The number of exclusive groups per rel-type must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

ATLEASTONE_per_RT (*min max*)
The number of at-least-one groups per rel-type must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

INCLUDE_per_RT (*min max*)
The number of include constraints in a rel-type must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

GENERIC_per_RT (*min max*)
The number of generic constraints in a rel-type must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

PROCUNIT_per_RT (*min max*)
The number of processing units per rel-type must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

DYN_PROP_of_RT (*dynamic_property parameters*)
Check some properties of the dynamic properties.
☞ See section B.17

SELECTED_RT
Search for all selected objects. This constraint should not be used for validation.
☞ No parameters.

MARKED_RT
Search for all marked objects. This constraint should not be used for validation.
☞ No parameters.

V2_CONSTRAINT_on_RT (*V2-file V2-predicate parameters*)
A call to a Voyager 2 boolean function. This constraint returns the result of the function. It provides an easy way to add any new constraint.
☞ See section B.16

B.6 Constraints on roles

ALL_ROLE
Used for a search, this constraint finds all roles. It should not be used for a validation.
☞ No parameters.

MIN_CON_of_ROLE (*min max*)
The minimum connectivity of role must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

MAX_CON_of_ROLE (*min max*)
The minimum connectivity of role must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

ET_per_ROLE (*min max*)
The number of entity types per role must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

DYN_PROP_of_ROLE (*dynamic_property parameters*)
Check some properties of the dynamic properties.
☞ See section B.17

SELECTED_ROLE
Search for all selected objects. This constraint should not be used for validation.
☞ No parameters.

MARKED_ROLE
Search for all marked objects. This constraint should not be used for validation.
☞ No parameters.

V2_CONSTRAINT_on_ROLE (*V2-file V2-predicate parameters*)
A call to a Voyager 2 boolean function. This constraint returns the result of the function. It provides an easy way to add any new constraint.
☞ See section B.16

B.7 Constraints on attributes

ALL_ATT
Used for a search, this constraint finds all attributes. It should not be used for a validation.
☞ No parameters.

MIN_CARD_of_ATT (*min max*)
The minimum cardinality of an attribute must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

MAX_CARD_of_ATT (*min max*)
The maximum cardinality of an attribute must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

DEPTH_of_ATT (*min max*)

The depth of a compound attribute, that is the amount of encompassing compound attributes plus one, must be at least <min> and at most <max>. For instance, in order to select all sub-attributes, use this constraint with <min>=2 and <max>=N.
☞ *min* and *max* are integer constants or N.

SUB_ATT_per_ATT (*min max*)
The number of sub-attributes of a compound attribute is at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

TYPES_ALLOWED_for_ATT (*list*)
List of allowed types of attribute.
☞ *list* is the list of all allowed types (**BOOLEAN**, **CHAR**, **DATE**, **FLOAT**, **NUMERIC**, **VARCHAR**), separated with a space.

TYPES_NOTALLOWED_for_ATT (*list*)
List of all forbidden types of attribute.
☞ *list* is the list of all forbidden types, separated with a space: **BOOLEAN CHAR DATE FLOAT NUMERIC VARCHAR**.

TYPE_DEF_for_ATT (*type parameters*)
Specification of the parameters for a type of attributes. For instance, to specify that all numbers should be coded with 1 to 5 digits and 0 to 2 decimals :
TYPE_DEF_for_ATT NUMERIC 1 5 0 2
☞ *type* is the type of attribute for which the parameters must be specified.
☞ *parameters* is the list of parameters for the type; the content of that list depends on the type :
CHAR *min-length max-length*
FLOAT *min-size max-size*
NUMERIC *min-length max-length min-decimals max-decimals*
VARCHAR *min-length max-length*
BOOLEAN *min-size max-size*
DATE *min-size max-size*
☞ *min-...* and *max-...* are integer constants or N.

PART_of_GROUP_ATT (*min max*)
The number of groups the attribute is a component of is at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

ID_per_ATT (*min max*)
The number of identifiers per attribute is at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

PID_per_ATT (*min max*)
The number of primary identifiers per attribute is at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

PART_of_ID_ATT (*min max*)
The number of foreign keys the attribute is a component of is at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

KEY_per_ATT (*min max*)
The number of access keys per attribute is at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

REF_per_ATT (*min max*)

The number of referential group per attribute is at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

PART_of_REF_ATT (*min max*)
The number of referential groups the attribute is a component of is at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

DYN_PROP_of_ATT (*dynamic_property parameters*)
Check some properties of the dynamic properties.
☞ See section B.17

SELECTED_ATT
Search for all selected objects. This constraint should not be used for validation.
☞ No parameters.

MARKED_ATT
Search for all marked objects. This constraint should not be used for validation.
☞ No parameters.

V2_CONSTRAINT_on_ATT (*V2-file V2-predicate parameters*)
A call to a Voyager 2 boolean function. This constraint returns the result of the function. It provides an easy way to add any new constraint.
☞ See section B.16

B.8 Constraints on groups

ALL_GROUP
Used for a search, this constraint finds all groups. It should not be used for a validation.
☞ No parameters.

COMP_per_GROUP (*min max*)
The number of terminal components in a group must be at least *min* and at most *max*. A component is terminal if it is not a group. For instance, let *A* be a group made of an attribute *a* and another group *B*. *B* is made of two attributes *b1* and *b2*. Then *A* has got three terminal components: *a*, *b* and *c*.
☞ *min* and *max* are integer constants or N.

ATT_per_GROUP (*min max*)
The number of attributes per group must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

ROLE_per_GROUP (*min max*)
The number of roles per group must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

GROUP_per_GROUP (*min max*)
The number of groups per group must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

ID_in_GROUP (*yn*)
Identifiers are (yes), are not (no) allowed.
☞ *yn* is either **yes** or **no**.

PID_in_GROUP (*yn*)
Primary identifiers are (yes), are not (no) allowed.

☞ *yn* is either **yes** or **no**.

KEY_in_GROUP (*yn*)
Access keys are (yes), are not (no) allowed.
☞ *yn* is either **yes** or **no**.

REF_in_GROUP (*yn*)
Reference groups are (yes), are not (no) allowed.
☞ *yn* is either **yes** or **no**.

COEXIST_in_GROUP (*yn*)
Coexistence groups are (yes), are not (no) allowed.
☞ *yn* is either **yes** or **no**.

EXCLUSIVE_in_GROUP (*yn*)
Exclusive groups are (yes), are not (no) allowed.
☞ *yn* is either **yes** or **no**.

ATLEASTONE_in_GROUP (*yn*)
At_least_one groups are (yes), are not (no) allowed.
☞ *yn* is either **yes** or **no**.

INCLUDE_in_GROUP (*yn*)
Include constraints are (yes), are not (no) allowed.
☞ *yn* is either **yes** or **no**.

INVERSE_in_GROUP (*yn*)
Inverse constraints are (yes), are not (no) allowed.
☞ *yn* is either **yes** or **no**.

GENERIC_in_GROUP (*yn*)
Generic constraints are (yes), are not (no) allowed.
☞ *yn* is either **yes** or **no**.

LENGTH_of_ATT_GROUP (*min max*)
The sum of the length of all components of a group must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

DYN_PROP_of_GROUP (*dynamic_property parameters*)
Check some properties of the dynamic properties.
☞ See section B.17

SELECTED_GROUP
Search for all selected objects. This constraint should not be used for validation.
☞ No parameters.

MARKED_GROUP
Search for all marked objects. This constraint should not be used for validation.
☞ No parameters.

V2_CONSTRAINT_on_GROUP (*V2-file V2-predicate parameters*)
A call to a Voyager 2 boolean function. This constraint returns the result of the function. It provides an easy way to add any new constraint.
☞ See section B.16

B.9 Constraints on entity type identifiers

ALL_EID

Used for a search, this constraint finds all entity type identifiers. It should not be used for a validation.
☞ No parameters.

COMP_per_EID (*min max*)

The number of components of an entity type identifier must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

ATT_per_EID (*min max*)

The number of attributes per entity type identifier must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

OPT_ATT_per_EID (*min max*)

An entity type identifier must have between *min* and *max* optional attributes.
☞ *min* and *max* are integer constants or N.

MAND_ATT_per_EID (*min max*)

An entity type identifier must have between *min* and *max* mandatory attributes.
☞ *min* and *max* are integer constants or N.

SINGLE_ATT_per_EID (*min max*)

An entity type identifier must have between *min* and *max* single-valued attributes.
☞ *min* and *max* are integer constants or N.

MULT_ATT_per_EID (*min max*)

An entity type identifier must have between *min* and *max* multi-valued attributes.
☞ *min* and *max* are integer constants or N.

MULT_ATT_per_MULT_COMP_EID (*min max*)

An entity type identifier made of several components must have between *min* and *max* multi-valued attributes.
☞ *min* and *max* are integer constants or N.

SUB_ATT_per_EID (*min max*)

An entity type identifier must have between *min* and *max* sub-attributes.
☞ *min* and *max* are integer constants or N.

COMP_ATT_per_EID (*min max*)

An entity type identifier must have between *min* and *max* compound attributes.
☞ *min* and *max* are integer constants or N.

ROLE_per_EID (*min max*)

The number of roles per entity type identifier must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

OPT_ROLE_per_EID (*min max*)

An entity type identifier must have between *min* and *max* optional roles.
☞ *min* and *max* are integer constants or N.

MAND_ROLE_per_EID (*min max*)

An entity type identifier must have between *min* and *max* mandatory roles.
☞ *min* and *max* are integer constants or N.

ONE_ROLE_per_EID (*min max*)

An entity type identifier must have between *min* and *max* single-valued roles.
☞ *min* and *max* are integer constants or N.

N_ROLE_per_EID (*min max*)
An entity type identifier must have between *min* and *max* multi-valued roles.
☞ *min* and *max* are integer constants or N.

GROUP_per_EID (*min max*)
The number of groups per entity type identifier must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

ALL_EPID
Used for a search, this constraint finds all entity type primary identifiers. It should not be used for a validation.
☞ No parameters.

COMP_per_EPID (*min max*)
The number of components of a entity type primary identifier must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

ATT_per_EPID (*min max*)
The number of attributes per entity type primary identifier must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

OPT_ATT_per_EPID (*min max*)
An entity type primary identifier must have between *min* and *max* optional attributes.
☞ *min* and *max* are integer constants or N.

MAND_ATT_per_EPID (*min max*)
An entity type primary identifier must have between *min* and *max* mandatory attributes.
☞ *min* and *max* are integer constants or N.

SINGLE_ATT_per_EPID (*min max*)
An entity type primary identifier must have between *min* and *max* single-valued attributes.
☞ *min* and *max* are integer constants or N.

MULT_ATT_per_EPID (*min max*)
An entity type primary identifier must have between *min* and *max* multi-valued attributes.
☞ *min* and *max* are integer constants or N.

MULT_ATT_per_MULT_COMP_EPID (*min max*)
An entity type primary identifier made of several components must have between *min* and *max* multi-valued attributes.
☞ *min* and *max* are integer constants or N.

SUB_ATT_per_EPID (*min max*)
An entity type primary identifier must have between *min* and *max* sub-attributes.
☞ *min* and *max* are integer constants or N.

COMP_ATT_per_EPID (*min max*)
An entity type primary identifier must have between *min* and *max* compound attributes.
☞ *min* and *max* are integer constants or N.

ROLE_per_EPID (*min max*)
The number of roles per entity type primary identifier must be at least *min* and at most *max*.

☞ *min* and *max* are integer constants or N.

OPT_ROLE_per_EPID (*min max*)
An entity type primary identifier must have between *min* and *max* optional roles.
☞ *min* and *max* are integer constants or N.

MAND_ROLE_per_EPID (*min max*)
An entity type primary identifier must have between *min* and *max* mandatory roles.
☞ *min* and *max* are integer constants or N.

ONE_ROLE_per_EPID (*min max*)
An entity type primary identifier must have between *min* and *max* single-valued roles.
☞ *min* and *max* are integer constants or N.

N_ROLE_per_EPID (*min max*)
An entity type primary identifier must have between *min* and *max* multi-valued roles.
☞ *min* and *max* are integer constants or N.

GROUP_per_EPID (*min max*)
The number of groups per entity type primary identifier must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

DYN_PROP_of_EID (*dynamic_property parameters*)
Check some properties of the dynamic properties.
☞ See section B.17

SELECTED_EID
Search for all selected objects. This constraint should not be used for validation.
☞ No parameters.

MARKED_EID
Search for all marked objects. This constraint should not be used for validation.
☞ No parameters.

V2_CONSTRAINT_on_EID (*V2-file V2-predicate parameters*)
A call to a Voyager 2 boolean function. This constraint returns the result of the function. It provides an easy way to add any new constraint.
☞ See section B.16

B.10 Constraints on rel-type identifiers

ALL_RID
Used for a search, this constraint finds all rel-type identifiers. It should not be used for a validation.
☞ No parameters.

COMP_per_RID (*min max*)
The number of components of a rel-type identifier must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

ATT_per_RID (*min max*)
The number of attributes per rel-type identifier must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

OPT_ATT_per_RID (*min max*)
A rel-type identifier must have between *min* and *max* optional attributes.

☞ *min* and *max* are integer constants or N.

MAND_ATT_per_RID (*min max*)

A rel-type identifier must have between *min* and *max* mandatory attributes.
☞ *min* and *max* are integer constants or N.

SINGLE_ATT_per_RID (*min max*)

A rel-type identifier must have between *min* and *max* multi-valued attributes.
☞ *min* and *max* are integer constants or N.

MULT_ATT_per_RID (*min max*)

A rel-type identifier must have between *min* and *max* single-valued attributes.
☞ *min* and *max* are integer constants or N.

MULT_ATT_per_MULT_COMP_RID (*min max*)

A rel-type identifier made of several components must have between *min* and *max* multi-valued attributes.
☞ *min* and *max* are integer constants or N.

SUB_ATT_per_RID (*min max*)

A rel-type identifier must have between *min* and *max* sub-attributes.
☞ *min* and *max* are integer constants or N.

COMP_ATT_per_RID (*min max*)

A rel-type identifier must have between *min* and *max* compound attributes.
☞ *min* and *max* are integer constants or N.

ROLE_per_RID (*min max*)

The number of roles per rel-type identifier must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

OPT_ROLE_per_RID (*min max*)

A rel-type identifier must have between *min* and *max* optional roles.
☞ *min* and *max* are integer constants or N.

MAND_ROLE_per_RID (*min max*)

A rel-type identifier must have between *min* and *max* mandatory roles.
☞ *min* and *max* are integer constants or N.

ONE_ROLE_per_RID (*min max*)

A rel-type identifier must have between *min* and *max* single-valued roles.
☞ *min* and *max* are integer constants or N.

N_ROLE_per_RID (*min max*)

A rel-type identifier must have between *min* and *max* multi-valued roles.
☞ *min* and *max* are integer constants or N.

GROUP_per_RID (*min max*)

The number of groups per rel-type identifier must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

ALL_RPID

Used for a search, this constraint finds all rel-type primary identifiers. It should not be used for a validation.
☞ No parameters.

COMP_per_RPID (*min max*)

The number of components of a rel-type primary identifier must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

ATT_per_RPID (*min max*)
The number of attributes per rel-type primary identifier must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

OPT_ATT_per_RPID (*min max*)
A rel-type primary identifier must have between *min* and *max* optional attributes.
☞ *min* and *max* are integer constants or N.

MAND_ATT_per_RPID (*min max*)
A rel-type primary identifier must have between *min* and *max* mandatory attributes.
☞ *min* and *max* are integer constants or N.

SINGLE_ATT_per_RPID (*min max*)
A rel-type primary identifier must have between *min* and *max* single-valued attributes.
☞ *min* and *max* are integer constants or N.

MULT_ATT_per_RPID (*min max*)
A rel-type primary identifier must have between *min* and *max* multi-valued attributes.
☞ *min* and *max* are integer constants or N.

MULT_ATT_per_MULT_COMP_RPID (*min max*)
A rel-type primary identifier made of several components must have between *min* and *max* multi-valued attributes.
☞ *min* and *max* are integer constants or N.

SUB_ATT_per_RPID (*min max*)
A rel-type primary identifier must have between *min* and *max* sub-attributes.
☞ *min* and *max* are integer constants or N.

COMP_ATT_per_RPID (*min max*)
A rel-type primary identifier must have between *min* and *max* compound attributes.
☞ *min* and *max* are integer constants or N.

ROLE_per_RPID (*min max*)
The number of roles per rel-type primary identifier must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

OPT_ROLE_per_RPID (*min max*)
A rel-type primary identifier must have between *min* and *max* optional roles.
☞ *min* and *max* are integer constants or N.

MAND_ROLE_per_RPID (*min max*)
A rel-type primary identifier must have between *min* and *max* mandatory roles.
☞ *min* and *max* are integer constants or N.

ONE_ROLE_per_RPID (*min max*)
A rel-type primary identifier must have between *min* and *max* single-valued roles.
☞ *min* and *max* are integer constants or N.

N_ROLE_per_RPID (*min max*)
A rel-type primary identifier must have between *min* and *max* multi-valued roles.
☞ *min* and *max* are integer constants or N.

GROUP_per_RPID (*min max*)
The number of groups per rel-type primary identifier must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

DYN_PROP_of_RID (*dynamic_property parameters*)
Check some properties of the dynamic properties.
☞ See section B.17

SELECTED_RID
Search for all selected objects. This constraint should not be used for validation.
☞ No parameters.

MARKED_RID
Search for all marked objects. This constraint should not be used for validation.
☞ No parameters.

V2_CONSTRAINT_on_RID (*V2-file V2-predicate parameters*)
A call to a Voyager 2 boolean function. This constraint returns the result of the function. It provides an easy way to add any new constraint.
☞ See section B.16

B.11 Constraints on attribute identifiers

ALL_AID
Used for a search, this constraint finds all attribute identifiers. It should not be used for a validation.
☞ No parameters.

COMP_per_AID (*min max*)
The number of components of an attribute identifier must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

ATT_per_AID (*min max*)
The number of attributes per attribute identifier must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

OPT_ATT_per_AID (*min max*)
An attribute identifier must have between *min* and *max* optional attributes.
☞ *min* and *max* are integer constants or N.

MAND_ATT_per_AID (*min max*)
An attribute identifier must have between *min* and *max* mandatory attributes.
☞ *min* and *max* are integer constants or N.

SINGLE_ATT_per_AID (*min max*)
An attribute identifier must have between *min* and *max* single-valued attributes.
☞ *min* and *max* are integer constants or N.

MULT_ATT_per_AID (*min max*)
An attribute identifier must have between *min* and *max* multi-valued attributes.
☞ *min* and *max* are integer constants or N.

MULT_ATT_per_MULT_COMP_AID (*min max*)
An attribute identifier made of several components must have between *min* and *max* multi-valued attributes.
☞ *min* and *max* are integer constants or N.

SUB_ATT_per_AID (*min max*)
An attribute identifier must have between *min* and *max* sub-attributes.
☞ *min* and *max* are integer constants or N.

COMP_ATT_per_AID (*min max*)
An attribute identifier must have between *min* and *max* compound attributes.
☞ *min* and *max* are integer constants or N.

GROUP_per_AID (*min max*)
The number of groups per attribute identifier must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

ALL_APID
Used for a search, this constraint finds all attribute primary identifiers. It should not be used for a validation.
☞ No parameters.

COMP_per_APID (*min max*)
The number of components of an attribute primary identifier must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

ATT_per_APID (*min max*)
The number of attributes per attribute primary identifier must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

OPT_ATT_per_APID (*min max*)
An attribute primary identifier must have between *min* and *max* optional attributes.
☞ *min* and *max* are integer constants or N.

MAND_ATT_per_APID (*min max*)
An attribute primary identifier must have between *min* and *max* mandatory attributes.
☞ *min* and *max* are integer constants or N.

SINGLE_ATT_per_APID (*min max*)
An attribute primary identifier must have between *min* and *max* single-valued attributes.
☞ *min* and *max* are integer constants or N.

MULT_ATT_per_APID (*min max*)
An attribute primary identifier must have between *min* and *max* multi-valued attributes.
☞ *min* and *max* are integer constants or N.

MULT_ATT_per_MULT_COMP_APID (*min max*)
An attribute primary identifier made of several components must have between *min* and *max* multi-valued attributes.
☞ *min* and *max* are integer constants or N.

SUB_ATT_per_APID (*min max*)
An attribute primary identifier must have between *min* and *max* sub-attributes.
☞ *min* and *max* are integer constants or N.

COMP_ATT_per_APID (*min max*)
An attribute primary identifier must have between *min* and *max* compound attributes.
☞ *min* and *max* are integer constants or N.

GROUP_per_APID (*min max*)

The number of groups per attribute primary identifier must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

DYN_PROP_of_AID (*dynamic_property parameters*)
Check some properties of the dynamic properties.
☞ See section B.17

SELECTED_AID
Search for all selected objects. This constraint should not be used for validation.
☞ No parameters.

MARKED_AID
Search for all marked objects. This constraint should not be used for validation.
☞ No parameters.

V2_CONSTRAINT_on_AID (*V2-file V2-predicate parameters*)
A call to a Voyager 2 boolean function. This constraint returns the result of the function. It provides an easy way to add any new constraint.
☞ See section B.16

B.12 Constraints on access keys

ALL_KEY
Used for a search, this constraint finds all access keys. It should not be used for a validation.
☞ No parameters.

COMP_per_KEY (*min max*)
The number of components of an access key must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

ATT_per_KEY (*min max*)
The number of attributes per access key must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

OPT_ATT_per_KEY (*min max*)
An access key must have between *min* and *max* optional attributes.
☞ *min* and *max* are integer constants or N.

MAND_ATT_per_KEY (*min max*)
An access key must have between *min* and *max* mandatory attributes.
☞ *min* and *max* are integer constants or N.

SINGLE_ATT_per_KEY (*min max*)
An access key must have between *min* and *max* single-valued attributes.
☞ *min* and *max* are integer constants or N.

MULT_ATT_per_KEY (*min max*)
An access key must have between *min* and *max* multi-valued attributes.
☞ *min* and *max* are integer constants or N.

MULT_ATT_per_MULT_COMP_KEY (*min max*)
An access key made of several components must have between *min* and *max* multi-valued attribute.
☞ *min* and *max* are integer constants or N.

SUB_ATT_per_KEY (*min max*)
An access key must have between *min* and *max* sub-attributes.

☞ *min* and *max* are integer constants or N.

COMP_ATT_per_KEY (*min max*)
An access key must have between *min* and *max* compound attributes.
☞ *min* and *max* are integer constants or N.

ROLE_per_KEY (*min max*)
The number of roles per access key must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

OPT_ROLE_per_KEY (*min max*)
An access key must have between *min* and *max* optional roles.
☞ *min* and *max* are integer constants or N.

MAND_ROLE_per_KEY (*min max*)
An access key must have between *min* and *max* mandatory roles.
☞ *min* and *max* are integer constants or N.

ONE_ROLE_per_KEY (*min max*)
An access key must have between *min* and *max* single-valued roles.
☞ *min* and *max* are integer constants or N.

N_ROLE_per_KEY (*min max*)
An access key must have between *min* and *max* multi-valued roles.
☞ *min* and *max* are integer constants or N.

GROUP_per_KEY (*min max*)
The number of groups per access key must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

DYN_PROP_of_KEY (*dynamic_property parameters*)
Check some properties of the dynamic properties.
☞ See section B.17

SELECTED_KEY
Search for all selected objects. This constraint should not be used for validation.
☞ No parameters.

MARKED_KEY
Search for all marked objects. This constraint should not be used for validation.
☞ No parameters.

V2_CONSTRAINT_on_KEY (*V2-file V2-predicate parameters*)
A call to a Voyager 2 boolean function. This constraint returns the result of the function. It provides an easy way to add any new constraint.
☞ See section B.16

B.13 Constraints on referential groups

ALL_REF
Used for a search, this constraint finds all referential constraints. It should not be used for a validation.
☞ No parameters.

COMP_per_REF (*min max*)
The number of components of a reference group must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

ATT_per_REF (*min max*)
The number of attributes per reference group must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

OPT_ATT_per_REF (*min max*)
A reference group must have between *min* and *max* optional attributes.
☞ *min* and *max* are integer constants or N.

MAND_ATT_per_REF (*min max*)
A reference group must have between *min* and *max* mandatory attributes.
☞ *min* and *max* are integer constants or N.

SINGLE_ATT_per_REF (*min max*)
A reference group must have between *min* and *max* single-valued attributes.
☞ *min* and *max* are integer constants or N.

MULT_ATT_per_REF (*min max*)
A reference group must have between *min* and *max* multi-valued attributes.
☞ *min* and *max* are integer constants or N.

MULT_ATT_per_MULT_COMP_REF (*min max*)
A reference group made of several components must have between *min* and *max* multi-valued attribute.
☞ *min* and *max* are integer constants or N.

SUB_ATT_per_REF (*min max*)
A reference group must have between *min* and *max* sub-attributes.
☞ *min* and *max* are integer constants or N.

COMP_ATT_per_REF (*min max*)
A reference group must have between *min* and *max* compound attributes.
☞ *min* and *max* are integer constants or N.

ROLE_per_REF (*min max*)
The number of roles per reference group must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

OPT_ROLE_per_REF (*min max*)
A reference group must have between *min* and *max* optional roles.
☞ *min* and *max* are integer constants or N.

MAND_ROLE_per_REF (*min max*)
A reference group must have between *min* and *max* mandatory roles.
☞ *min* and *max* are integer constants or N.

ONE_ROLE_per_REF (*min max*)
A reference group must have between *min* and *max* single-valued roles.
☞ *min* and *max* are integer constants or N.

N_ROLE_per_REF (*min max*)
A reference group must have between *min* and *max* multi-valued roles.
☞ *min* and *max* are integer constants or N.

GROUP_per_REF (*min max*)
The number of groups per reference group must be at least *min* and at most *max*.
☞ *min* and *max* are integer constants or N.

LENGTH_of_REF (*operator*)
The length of a reference group (the sum of the length of its components) must be equal, different, smaller than or greater than the length of the referenced group.
☞ *operator* is either **equal**, **different**, **smaller** or **greater**.

TRANSITIVE_REF (*yn*)
The group is a transitive referential constraints. For instance, A(a,b), B(a,b) and C(b) are 3 entity types. (A.a,A.b) is a reference attribute of (B.a,B.b), A.b is a reference attribute of C.b and B.b is a reference attribute of C.b. In that case, the referential constraint from A.b to C.b is redundant and should be suppressed.
☞ *yn* is either **yes** or **no**.

DYN_PROP_of_REF (*dynamic_property parameters*)
Check some properties of the dynamic properties.
☞ See section B.17

SELECTED_REF
Search for all selected objects. This constraint should not be used for validation.
☞ No parameters.

MARKED_REF
Search for all marked objects. This constraint should not be used for validation.
☞ No parameters.

V2_CONSTRAINT_on_REF (*V2-file V2-predicate parameters*)
A call to a Voyager 2 boolean function. This constraint returns the result of the function. It provides an easy way to add any new constraint.
☞ See section B.16

B.14 Constraints on processing units

ALL_PROCUNIT
Used for a search, this constraint finds all processing units. It should not be used for a validation.
☞ No parameters.

DYN_PROP_of_PROCUNIT (*dynamic_property parameters*)
Check some properties of the dynamic properties.
☞ See section B.17

SELECTED_PROCUNIT
Search for all selected processing units. This constraint should not be used for validation.
☞ No parameters.

MARKED_PROCUNIT
Search for all marked processing units. This constraint should not be used for validation.
☞ No parameters.

V2_CONSTRAINT_on_PROCUNIT (*V2-file V2-predicate parameters*)
A call to a Voyager 2 boolean function. This constraint returns the result of the function. It provides an easy way to add any new constraint.
☞ See section B.16

B.15 Constraints on names

CONCERNED_NAMES (*list*)

This predicate retains all the objects of specified types. This is a very special predicate in the sense that it does not really treats about object names, but that it should only be used in conjunction with other predicates on names. Indeed, it has no real sense by itself, but it allows other predicates to restrict their scope. For instance, to restrict entity type and rel-type names to 8 characters, the following validation rule can be used :

```
CONCERNED_NAMES ET RT
   and LENGTH_of_NAMES 1 8
or not CONCERNED_NAMES ET RT
```

☞ *list* is a list of object types separated by spaces. The valid object type names are those used as the suffixes of all the prodecates: SCHEMA, COLL, ET, RT, ATT, ROLE, ATT, GROUP, EID, EPID, RID, RPID, AID, APID, KEY, REF, PROCUNIT.

NONE_in_LIST_NAMES (*list*)

The names of the schema, entity types, rel-types, attributes, roles, groups, processing units and collections are not in the list *list*.

☞ *list* is a list of words separated by a comma. All the characters between two commas belong to a word, spaces included. The syntax of the words is the same as for the name processor. Hence, it is possible to use the following special characters: ^ to represent the beginning of a line, $ to represent its end, ? to represent any single character and * to represent any suite of characters. For instance: ^_*, *_$. This list forbids any name that begins by _ or end by _.

NONE_in_LIST_CI_NAMES (*list*)

The names of the schema, entity types, rel-types, attributes, roles, groups, processing units and collections are not in the list *list*. The comparison between names and words in the list is case insensitive.

☞ *list* is a list of words separated by a comma. All the characters between two commas belong to a word, spaces included. The syntax is similar to the one described in the NONE_in_LIST_NAMES constraint.

ALL_in_LIST_NAMES (*list*)

The names of the schema, entity types, rel-types, attributes, roles, groups, processing units and collections are in the list *list*.

☞ *list* is a list of words separated by a comma. All the characters between two commas belong to a word, spaces included. The syntax is similar to the one described in the NONE_in_LIST_NAMES constraint.

ALL_in_LIST_CI_NAMES (*list*)

The names of the schema, entity types, rel-types, attributes, roles, groups, processing units and collections are in the list *list*. The comparison between names and words in the list is case insensitive.

☞ *list* is a list of words separated by a comma. All the characters between two commas belong to a word, spaces included. The syntax is similar to the one described in the NONE_in_LIST_NAMES constraint.

NONE_in_FILE_NAMES (*file_name*)

The names of the schema, entity types, rel-types, attributes, roles, groups, processing units and collections can not be in the file with the name *file_name*.

☞ *file name* is the name of an ASCII file that contains a list of all the forbidden names. Each line of the file contains a name. All the characters of a line are part of the name, excepted the end of line characters. The syntax is similar to the one described in the NONE_in_LIST_NAMES constraint.

NONE_in_FILE_CI_NAMES (*file_name*)

The names of the schema, entity types, rel-types, attributes, roles, groups, processing units and collections can not be in the file with the name *file_name*. The comparison between names and words in the file is case insensitive.

☞ *file_name* is the name of an ASCII file that contains a list of all the forbidden names. Each line of the file contains a name. All the characters of a line are part of the name, excepted the end of line characters. The syntax is similar to the one described in the NONE_in_LIST_NAMES constraint.

ALL_in_FILE_NAMES (*file_name*)

The names of the schema, entity types, rel-types, attributes, roles, groups, processing units and collections are in the file with the name *file_name*.

☞ *file_name* is the name of an ASCII file that contains a list of all the forbidden names. Each line of the file contains a name. All the characters of a line are part of the name, excepted the end of line characters. The syntax is similar to the one described in the NONE_in_LIST_NAMES constraint.

ALL_in_FILE_CI_NAMES (*file_name*)

The names of the schema, entity types, rel-types, attributes, roles, groups, processing units and collections are in the file with the name *file_name*. The comparison between names and words in the file is case insensitive.

☞ *file_name* is the name of an ASCII file that contains a list of all the forbidden names. Each line of the file contains a name. All the characters of a line are part of the name, excepted the end of line characters. The syntax is similar to the one described in the NONE_in_LIST_NAMES constraint.

NO_CHARS_in_LIST_NAMES (*list*)

The names of the schema, entity types, rel-types, attributes, roles, groups, processing units and collections can not contain any character of the list *list*.

☞ *list* is a list of characters with no separator. For example: &é"'()§è!çà{}@#[]

ALL_CHARS_in_LIST_NAMES (*list*)

The names of the schema, entity types, rel-types, attributes, roles, groups, processing units and collections must be made of the characters of the list *list* only.

☞ *list* is a list of characters with no separator.
For example: ABCDEFGHIJKLMNOPQRSTUVWXYZ

LENGTH_of_NAMES (*min max*)

The length of names of the schema, entity types, rel-types, attributes, roles, groups, processing units and collections must be at least *min* and at most *max*.

☞ *min* and *max* are integer constants.

DYN_PROP_of_NAMES (*dynamic_property parameters*)

Check some properties of the dynamic properties.

☞ See section B.17

SELECTED_NAMES

Search for all selected objects. This constraint should not be used for validation.

☞ No parameters.

MARKED_NAMES

Search for all marked objects. This constraint should not be used for validation.

☞ No parameters.

V2_CONSTRAINT_on_NAMES (*V2-file V2-predicate parameters*)

A call to a Voyager 2 boolean function. This constraint returns the result of the function. It provides an easy way to add any new constraint.
☞ See section B.16

B.16 Using Voyager 2 constraints

Voyager 2 constraints can be used with all object types. They are called V2_CONSTRAINT_on_...

They allow the user to create new constraints. This may be very useful to look for complex patterns that can not be expressed with all the simple predefined constraints. All the V2-CONSTRAINT_on_... are used the same way, they all need three parameters :

V2_CONSTRAINT_on_... (V2-file *v2-predicate parameters*)

where *v2-file* is the name of the Voyager 2 program that contains the function to execute, *v2-predicate* is the name of the Voyager 2 function and *parameters* all its parameters.

The Voyager 2 function must be declared as an integer function with two parameters: the object of the repository that must be analyzed (an entity type for instance) and a string containing all the parameters. The value returned by this function must be 0 if the constraint is not satisfied and any value different of 0 otherwise. The function must be declared as exportable.

Note that every character up to the first closing parenthesis) is part of the parameters. To include this character in the parameters, it must be prefixed by a back slash \. The back slash itself must be doubled.

Example :

Let Num_tech_id_per_et be the name of a Voyager 2 function that verifies if an entity type has a valid number of technical identifiers. It is in the program ANALYSE.V2, compiled as ANALYSE.OXO in directory C:\PROJECT. This function needs two parameters, one that is a minimum valid number of technical identifiers and the other that is a maximum valid number. The declaration of the Voyager 2 function in the file ANALYSE.V2 should look like :

```
export function integer Num_tech_id_per_et(entity_type: ent, string: arguments)
```

and the constraint in the analyzer script should look like :

```
V2_CONSTRAINT_on_ET (C:\\PROJECT\\ANALYSE.OXO Num_tech_id_per_et 0 1)
```

B.17 Using DYN_PROP_OF_... constraints

All dynamic property constraints are of the form:

DYN_PROP_of_XXX (*dynamic_property parameters*)

where XXX is either SCHEMA, COLL, ET, ISA, RT, ROLE, ATT, GROUP, EID, RID, AID, KEY, REF, PROCUNIT, NAMES.

dynamic_property is the name of a dynamic property defined on constructs of type XXX. If the name contains a space character, it must be surrounded by double quotes. The name cannot itself contain double quotes. E.g.: owner, "account number" are valid names.

parameters is a series of parameters, the number and the type of which depend on the *dynamic_property*, as shown hereafter.

The dynamic property can be declared either mono-valued or multi-valued.

1. If the dynamic property is multi-valued, the *parameters* string is one of the following:

count *min max*

It specifies that the number of values (whatever they are) is comprised between *min*, an integer number, and *max*, an integer number or N.

one *mono_valued_dynamic_property_parameters*

It specifies that exactly one of the values must satisfy the *mono_valued_dynamic_property_ parameters*. In fact, each values treated as if the dynamic property was mono-valued; all the values that satisfy the property are counted and the multi-valued property is said to be satisfied if the count equals one.

some *mono_valued_dynamic_property_parameters*

It specifies that at least one of the values must satisfy the *mono_valued_dynamic_property_ parameters*. In fact, each value is treated as if the dynamic property was mono-valued; all the values that satisfy the property are counted and the multi-valued property is said to be satisfied if the count is greater or equal to one.

each *mono_valued_dynamic_property_parameters*

It specifies that every values must satisfy the *mono_valued_dynamic_property_parameters*. In fact, each value is treated as if the dynamic property was mono-valued and the multi-valued property is said to be satisfied if every value satisfy the "mono-valued property".

2. If the dynamic property is mono-valued (or one value of a multi-valued property is analysed), the *parameters* string format depends on the type of the dynamic property:

- If the dynamic property is of type Integer, parameters are: *min max*

The dynamic property value must be comprised between *min* and *max*, integer constants or N.

- If the dynamic property is of type Char, parameters are: *min max*

The dynamic property value must be comprised, in the ASCII order, between *min* and *max*, two character constants.

- If the dynamic property is of type Real, parameters are: *min max*

The dynamic property value must be comprised between *min* and *max*, two real constants.

- If the dynamic property is of type Boolean, the single parameter is either **true** or **false**

The dynamic property value must be either true or false.

- If the dynamic property is of type String, parameters are *comparison_operator string*

The comparison operator must be one of: =, <, >, **=ci**, **<ci**, **>ci**, and **contains**. = is the strict equality of both the *string* value and the dynamic property value, < means *string* comes before the dynamic property value in alphabetical order, and > is the inverse; **=ci**, **<ci** and **>ci** are the case insensitive equivalents of =, <, >; **contains** is the sub-string operator that checks whether *string* is a sub-string of the dynamic property value.

Examples:

DYN_PROP_of_ATT (view count 2 N)

Searches for all attributes used in at least two views (view is the DB-MAIN built-in dynamic property for the definition of views)

DYN_PROP_of_ET(owner = "T. Smith")

Assuming owner is a mono-valued string dynamic property defined on entity types, this constraints looks for all entity types owned by T. Smith.

DYN_PROP_of_ET("modified by" some contains "Smith")

Assuming modified by is a multi-valued string dynamic property defined on entity types which contains the list of all the persons who modified the entity type, this constraint looks for all entity types modified by Smith.

DYN_PROP_of_ATT(line 50 60)

line is a mono-valued integer dynamic property defined on all constructs generated by the COBOL extractor. This constraint looks for all constructs obtained from the extraction of a specific part (lines 50-60) of the COBOL source file.

Appendix C

Global transformations

C.1 Transformations

A transformation is designed to perform a given action on a set of objects. A default set is defined for each transformation. This set may be refined to a subset defined by a predicative rule (see Chapter 5 and Appendix B).

Here follows a list of all transformations with their default scope:

ET_into_RT, default scope: all entity types.
Transform all entity types satisfying the preconditions of the elementary transformation into rel-types.

ET_into_ATT, default scope: all entity types.
Transform all entity types satisfying the preconditions of the elementary transformation into attributes.

ADD_TECH_ID, default scope: all entity types.
Add a technical identifier to all entity types. This transformation should never be used without refinement of the scope.

SMART_ADD_TECH_ID, default scope: all entity types.
Add a technical identifier to all entity types that do not have one but should for all rel-types to be transformable into referential constraints.

ISA_into_RT, default scope: all is-a relations.
Transform all is-a relations into binary one-to-one rel-types.

RT_into_ET, default scope: all rel-types.
Transform all rel-types into entity types. This transformation should never be used without refinement of the scope.

RT_into_ISA, default scope: all rel-types.
Transform all binary one-to-one rel-types that satisfy the preconditions of the elementary transformation into is-a relations if it can be done without dilemma (the remaining is-a relations can possibly be transformed with the elementary transformation).

RT_into_REF, default scope: all rel-types.

Transform all rel-types into referential attribute(s).

RT_into_OBJATT, default scope: all rel-types.
Transform all rel-types into object-attribute(s).

REF_into_RT, default scope: all referential attribute.
Transform all referential attributes into rel-types.

ATT_into_ET_VAL, default scope: all attributes.
Transform all attributes into entity types using the value representation of the attributes. This transformation should never be used without refinement of the scope.

ATT_into_ET_INST, default scope: all attributes.
Transform all attributes into entity types using the instance representation of the attributes. This transformation should never be used without refinement of the scope.

OBJATT_into_RT, default scope: all object attributes.
Transform all object attributes into a rel-type.

DISAGGREGATE, default scope: all attributes.
Disaggregate all compound attributes.

INSTANCIATE, default scope: all attributes.
Transforms all multivalued atomic attributes into a list of single-valued attributes.

MATERIALIZE, default scope: all attributes.
Materializes all user-defined attributes, replaces them with their definition.

SPLIT_MULTIET_ROLE, default scope: all roles.
Split all the rel-types that contain one or more multi-ET roles.

AGGREGATE, default scope: all groups
Aggregate all groups. This transformation should never be used without refinement of the scope.

GROUP_into_KEY, default scope: all groups
Add the access key property to all groups.

RENAME_GROUP, default scope: all groups
Give a new meaningful name to each group. This name is unique in the schema. Note that the old name is lost forever.

REMOVE_KEY, default scope: all access keys
Remove all access keys.

REMOVE_PREFIX_KEY, default scope: all access keys
Remove all access keys that are a prefix of another one.

REMOVE_TECH_DESC, default scope: all objects of the schema, except the schema itself
Remove the technical description of all the objects of the schema.

REMOVE, default scope: NONE; the definition of a scope is mandatory
Remove all the objects that are in the specified scope. The deleted objects are lost forever. Note that this transformation is very special, it does not exactly conform to the definition of a transformation since there is no default scope.

NAME_PROCESSING, default scope: NONE; the definition of a scope is mandatory

Process the name and short name of the selected objects. The parameters (in the script) must be interpreted in two parts. The second one is the rule defining the set of objects to process. The first parameter is the patterns; it has the following syntax:

'L' stands for the conversion of uppercase letters to lowercase letters;

'U' stands for the conversion of lowercase letters to uppercase letters;

'C' stands for 'capitalization';

'A' stands for accents removal;

'S' stands for shortening and is followed by the maximum size of new names;

'P' stands for patterns and is followed by the list of patterns with the following syntax:

search_pattern_1;replace_pattern_1;...;search_pattern_n;replace_pattern_n;

In the patterns, semi-colons and backslashes are prefixed by a backslash.

MARK, default scope: NONE; the definition of a scope is mandatory

Mark all the objects that are in the specified scope.

Note that this transformation is very special, it does not exactly conform to the definition of a transformation since there is no default scope and no real transformation.

UNMARK, default scope: NONE; the definition of a scope is mandatory

Remove the mark of all the marked objects that are in the specified scope.

Note that this transformation is very special, it does not exactly conform to the definition of a transformation since there is no default scope and no real transformation.

EXTERN, default scope: NONE; the definition of a scope is mandatory

Call an external Voyager 2 function, i.e. a user defined function. This function may work on any type of objects.

C.2 Control structures

ON (<rule>)...ENDON

This structure allows us to reduce the scope of a set of transformations. The *rule* is evaluated and the set of objects it finds will be the scope of all the subsequent transformations until the ENDON keyword.

During execution, it is possible that a transformation destroys an object of the scope. In that case, this object is no more available for the following transformations. It is also possible that a transformation creates an object that validates the rule of the ON clause. In that case, this object will not be added to the scope. To address this question, the ON...ENDON structure can be inserted in a LOOP...ENDLOOP structure.

Note that ON...ENDON structure can not overlap, there can not be an ON...ENDON structure inside another ON...ENDON structure.

LOOP...ENDLOOP

This structure allows us to perform the same actions several times until a fix point is reached. The LOOP keyword is just a label: when encountered, it does nothing. All the transformations that follow it are performed until the ENDLOOP keyword is reached. Then, if one or more transformations have effectively modified the schema, all these transformations are performed once more. This will continue until the schema has reached a fix point for these transformations, i.e. none of them modifies the schema.

Note that LOOP...ENDLOOP structures can be included one into another.

Appendix D

DB-MAIN tools

advanced-global-transfo	all	change-prefix
colour	create	create-attribute
create-call-rel	create-collection	create-constraint
create-data	create-decomp-rel	create-entity-type
create-att-attribute	create-att-group	create-et-attribute
create-et-group	create-et-processing-unit	create-in-out-rel
create-note	create-rt-attribute	create-rt-group
create-rt-processing-unit	create-sch-processing-unit	create-group
create-identifier	create-meta-prop	create-processing-unit
create-rel-type	create-role	create-user-domain
create-variable	create-view	delete
delete-attribute	delete-call-rel	delete-collection
delete-constraint	delete-data	delete-decomp-rel
delete-entity-type	delete-group	delete-in-out-rel
delete-meta-prop	delete-note	delete-processing-unit
delete-rel-type	delete-role	delete-user-domain
delete-variable	delete-view	edit-connection
export	extract	externals
generate	global-transfo	mark
modify	modify-attribute	modify-call-rel
modify-collection	modify-constraint	modify-data
modify-decomp-rel	modify-entity-type	modify-group
modify-in-out-rel	modify-meta-prop	modify-meta-prop-value
modify-note	modify-processing-unit	modify-rel-type
modify-role	modify-sem-desc	modify-tech-desc
modify-user-domain	modify-variable	modify-view
name-processing	object-integration	quick-sql
ref-key-search	relational-model	schema-analysis
schema-integration	text-analysis	tf-add-tech-id
tf-aggregate	tf-att-into-ET	tf-disaggregate
tf-ET-into-att	tf-ET-into-RT	tf-isa-into-RT
tf-list-into-multi-att	tf-materialize-domain	tf-multi-att-conversion
tf-multi-att-into-list	tf-multi-att-into-single	tf-multi-ET-role-into-RT

tf-obj-att-into-RT	tf-ref-group-into-RT	tf-RT-into-att
tf-RT-into-ET	tf-RT-into-isa	tf-RT-into-obj-att
tf-single-att-into-multi	tf-split-merge	