For it is unworthy of excellent men to lose hours like slaves in the labor of calculation which could safely be relegated to anyone else if machines were used.

Gottfried Wilhelm Leibniz (1646 - 1716)
## Contents

1 **Introduction** 4  
   1.1 MSC Classification .............................................. 4  
   1.2 About Concise .................................................. 5  
   1.3 Disclaimer ........................................................ 5  

2 **Theory** 5  
   2.1 Semantic Memory .................................................. 5  
   2.2 Object .................................................................. 6  
   2.3 Sem ................................................................. 6  
   2.4 Record ............................................................... 6  
   2.5 Externals ............................................................ 7  
   2.6 Names ................................................................... 7  
   2.7 Semantic Graph ..................................................... 8  
   2.8 Node ..................................................................... 8  
   2.9 Edge ................................................................... 9  
   2.10 Types and Categories .............................................. 9  
   2.11 Type Systems ....................................................... 9  
   2.12 Type Sheets ........................................................ 10  
   2.13 Annotated type sheet and Usages .............................. 10  
   2.14 Elementary acts ..................................................... 10  

3 **Concise** 11  
   3.1 Starting Concise ..................................................... 12  
   3.2 Main Window ......................................................... 12  
   3.3 Session ................................................................. 13  
   3.4 Sections of the semantic memory ............................... 13  
   3.5 Serialization .......................................................... 14  
   3.6 Views ................................................................. 14  
      3.6.1 View Containers ............................................. 14  
      3.6.2 Graph View .................................................... 15  
      3.6.3 Text View ....................................................... 16  
      3.6.4 Type Sheet View ............................................ 16  
      3.6.5 Record View .................................................. 16  
   3.7 Type Sheet Check .................................................... 16  
   3.8 Code Record Execution ........................................... 17  
      3.8.1 File View ........................................................ 17  
   3.9 Users ................................................................. 17  
   3.10 Configuration ....................................................... 17  
   3.11 Debug ............................................................... 17  
   3.12 Editing Help ......................................................... 18  

4 **Appendix** 18  
   4.1 Serialization ........................................................ 18  
      4.1.1 External table .................................................. 18  
      4.1.2 Authority codes .............................................. 19  
      4.1.3 Language codes .............................................. 19  
      4.1.4 Dictionary ....................................................... 20  
      4.1.5 View roots ...................................................... 20  
      4.1.6 Semantic memory ............................................ 20  
      4.1.7 Requirements .................................................. 20  

1 Introduction

The programming system Concise is a graph-based universal programming system for manipulating semantic information stored in the semantic memory (2.1). It combines in a novel way the capabilities of imperative programming and object-oriented programming.

To manipulate the semantic memory (2.1), one programs in an integrated development environment IDE, working with text views of the partial semantic representation of the program to be created. The control of all manipulations resides itself in the semantic memory, with programs represented by records consisting of so-called acts (elementary programming steps). Acts are executable when called by other acts, or directly by the user of Concise.

Graphical and textual views (3.6) enable the user to see, understand, analyze, and modify the content of the semantic memory, and hence of documents, programs and data structures. In particular, there are (currently rudimentary) facilities for semantically accurate automatic document creation in LaTex, written in a user-extensible controlled form of natural mathematical language.

Users will be able to customize Concise to match their level of expertise, the wanted degree of safety, and the preferred form of views, using a user configuration file. Features not corresponding to the specifications in this file are invisible in the IDE unless explicitly asked for during a session.

Although currently only an English version is available, Concise is set up to facilitate the easy generation of multiple-language versions of the documentation and the text appearing in the IDE. In particular, type systems (2.11) and dictionaries are implemented in a way that incorporates multiple language names and multiple meanings of names created by different authorities.

The web page on FMathL (http://www.mat.univie.ac.at/~neum/FMathL.html) (Formal Mathematical Language) contains detailed information about the theoretical background of Concise.

Note: The present help information is available both within Concise via the Help button, and separately as a PDF document in <devdir>/docu/Manual.pdf. See Editing Help (3.12) for making changes in this document.

1.1 MSC Classification

Language of mathematics [education; new]: 97E40
Languages and software systems (knowledge-based systems, expert systems, etc.): 68T35
Text processing; mathematical typography: 68U15
Abstract data types; algebraic specification: 68Q65 18C50
Mathematical aspects of software engineering (specification, verification, metrics, requirements, etc.): 68N30
Knowledge representation: 68T30, 68T35, 97R50
Natural language processing: 68T50, 03B65, 91F20
Logic of natural languages: 03B65 68T50, 91F20
Philosophy of mathematics: 00A30 03A05
Specification and verification (program logics, model checking, etc.): 68Q60
Mathematical modeling: 97Mxx, 00A71
e-Learning: 97U50
Nonnumerical algorithms: 68W05
Graph theory (in relation to CS): 68R10
Grammars and rewriting systems: 68Q42
Formal languages and automata: 68Q45 03D05, 68Q70, 94A45
Semantics: 68Q55 03B70, 06B35, 18C50
1.2 About Concise

*Concise* was created by Ferenc Domes and Kevin Kofler based on the theoretical foundation elaborated by Arnold Neumaier, Peter Schodl and Hermann Schichl.

**Development History and Funding:**

Concise 0.9: (2010-2011) was created during the MoSMath project, funded by the Austrian Science Fund (FWF) under contract number P20631. Their support is gratefully acknowledged.

1.3 Disclaimer

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The short version: **NO WARRANTY!**

2 Theory

This section describes the concepts needed to understand the *Concise* system.

2.1 Semantic Memory

The semantic memory is an organized collection of objects \(^{(2.2)}\); parts of the semantic memory are typically displayed as semantic graphs with edges connecting these objects. The graph representation of the semantic memory can be viewed in a graph view \(^{(3.6.2)}\).

The semantic memory changes during a session \(^{(3.3)}\); its current state at any time is given by the semantic mapping that associates to any two objects \(a\) and \(b\) a third object \(c=a\cdot b\), which must be empty if \(a\) or \(b\) is empty. In other words, the semantic mapping changes over time (formally, a semantic mapping valued function of time) is called the semantic memory. Formally, the semantic memory of a *Concise* session is therefore a function of time that assigns a semantic mapping to each point in time during which the session exists. But the time-dependence is suppressed in notation and terminology. Depending on the context, we use \(SM\) as abbreviation both for the semantic memory and for the semantic mapping at a particular time.

The contents of the semantic memory can be also viewed as an ordered collection of semantic units called sems \(^{(2.3)}\). Each sem is given by an expression \(\text{handle.field}=\text{entry}\), where handle, field and entry are
nonempty objects. By definition, the fields of each handle are unique. Therefore adding a sem to the semantic memory replaces an existing sem having the same handle and field, which now points to the newly added entry.

In Concise, the semantic memory is implemented as an associative array of associative arrays of integers:

\[
\text{TreeMap}\langle\text{Integer, TreeMap}\langle\text{Integer, Integer}\rangle\rangle\ \text{sems}.
\]

The entry of a sem is found by looking up the handle from the sem, thereby obtaining the associative array

\[
\text{TreeMap}\langle\text{Integer, Integer}\rangle\ \text{fieldEntryMap}
\]

and then looking up the field from the \text{fieldEntryMap}, thereby finding the entry.

Ordinary objects are represented as positive integers in the semantic memory, while negative integers reference external objects. The number 0 represents the empty (undefined or null) object. Ordinary objects may be associated with names.

The root object of the semantic memory of Concise is of type Secretary and has a field name which specifies the name of the secretary given by the user (default is 'Matilde', see starting concise).

2.2 Object

Objects are the contents of the semantic memory and are organized through sems. Associated to each object is a record, which consists of all objects that can be reached from the object by following a sequence of moves along sems from their handle to their entry.

Each object may have a value to which it refers. A value is a datum external to the semantic memory but accessible through it by Concise.

Examples of values are wall clock times, pictures, files, but also (depending on the implementation) arrays, floating-point numbers, and integers. Concise acts on these values according to information stored in the semantic memory, by accessing external processors that can read or change values.

In addition, certain values can be converted into semantic information represented in the semantic memory, or in the reverse direction.

2.3 Sem

A semantic unit (short sem) is a triple \( h.f=e \) consisting of three nonempty objects, its handle \( h \), its field \( f \), and its entry \( e \). The sems are contained in the semantic memory.

- According to this definition, given a handle \( h \) and a field \( f \), the semantic memory uniquely determines the entry \( h.f \); but if this entry is empty, there is no associated sem.
- If the handle \( f \) is given, we refer to \( e \) also as the entry of the field \( f \).
- If the entry \( e \) is nonempty, we call \( f \) a field of the handle, and say that \( h \) has the field \( f \).
- By definition of a state of Concise, it depends on the current state of the semantic memory whether a handle has a particular field and which entry a field has.

Roughly, fields are used to look up something, while entries are used to contain something.

A sem template is a temporary version of a sem, not part of the current state of the semantic memory but ready to be added to it.

2.4 Record

A record originating from an object (handle) is the set of all unique sems contained in the sem sequences originating from the given handle.
A sem sequence of length $n$ is given by $\text{handle.field}_1.\text{field}_2. \ldots . \text{field}_n = \text{entry}$ and interpreted as the sequence of sems $\text{handle.field}_1 = \#1$, $\text{#1.field}_2 = \#2$, $\ldots$, $\text{#(n-1).field}_n = \text{entry}$. A sem sequence of length 1 is just a sem.

Clearly, a semantic memory allows one to construct arbitrarily complex records. In contrast to records in programming languages such as Pascal, records in semantic memory may contain cycles. Indeed, backreferences are an important part of the design of the type systems (2.11); for example, they allow labelled context-free grammars to be defined as type systems.

2.5 Externals

Negative object ids from the semantic memory (2.1) are associated with external objects by the externals table. Formally the externals table maps each (negative) object id to an external by:

\[
\text{HashMap}\langle \text{Integer, External} \rangle \text{ id-ExtTable}.
\]

There are two major categories of externals, the unique externals and the mutable externals. Unique externals are objects which are unique in the way that no two unique externals of the same type with the same value may exist in the external table. Technically, each unique external is mapped to a (negative) object id by

\[
\text{HashMap}\langle \text{UniqueExternal, Integer} \rangle \text{ uniqExt-IdTable}.
\]

The 1-1 correspondence of ids and unique externals allows one to find newly inserted unique externals in the external table; if a unique external of the same type and value already exists then no new id is created for it but the existing id is returned. On the other hand, there is no way to change the value of a unique external.

This is, however, possible for mutable externals. There can be several mutable externals having the same type and value in the external table, and their values can be changed freely. Typical examples for unique externals are names, colors, fonts etc., while typical examples for mutable externals are strings, numbers, matrices, etc..

External tables are serialized as described in the corresponding part of the Serialization (4.1.1) Section. For the currently implemented external types refer to the external types (4.3) part of the Appendix.

2.6 Names

An ordinary object (with a positive id) can be associated with a name, i.e., alphanumeric strings not beginning with a digit. In Concise different objects have different names and any unnamed objects may be referred to by artificial names beginning with a dollar-sign ($\$\$). Since programs created by different authors must cooperate, one needs a way to disambiguate names, and this must be recorded in the interpreter-generated section of the semantic memory. Concise proceeds via a dictionary when a word has several meanings, by distinguishing meanings by their source, here called an authority. For example, there is an authority called System, referring to the standard distribution of Concise. Language support is realized by introducing different languages, for instance all default system names have the language English.

Formally, the dictionary entries are created in English and in the System authority, by entering for each quadruple ($\text{name},\text{#lang},\text{#auth},\text{#ob}$) the six sems

\[
\text{FindName.}\text{#ob.}\text{#lang.}\text{#auth} = \text{#name}
\]
\[
\text{FindOb.}\text{#lang.}\text{#name.}\text{#auth} = \text{#ob}.
\]

If it is the first time that the object id $\text{#ob}$ of a new dictionary entry is referenced in the dictionary, the additional sem

\[
\text{FindAuth.}\text{#ob} = \text{#auth}
\]

is created. Names can be substituted for the same object under different languages and authorities; e.g., adding the entries ($\text{Integer,English,ExternalTypes,5001}$) and ($\text{int,English,OptProblem,5001}$) to the dictionary, results in two names Integer and int, having the same $\text{#lang=English}$, $\text{#ob=5001}$, and we have
FindAuth.5001 = ExternalTypes since the entry (Integer,English,ExternalTypes,5001) was inserted first.
The handles FindName, FindAuth, FindOb are located in:
  
  Dictionary.FindName=FindName
  Dictionary.FindAuth=FindAuth
  Dictionary.FindOb=FindOb, while dictionary root can be found under (System, English) in:
  

2.7 Semantic Graph

Semantic graphs allow users of Concise to graphically view the part of the semantic memory they currently focus on. (Besides such graphical views (3.6.2), which may be of a varying kind, there are also various textual views (3.6.3).) A semantic graph is a labelled directed graph whose nodes (2.8) and directed edges (2.9) (arcs) are labelled by objects in such a way that every arc from a node labelled h to a node labelled e is labelled by a field f such that h.f=e is a sem.

The rules selecting the sems represented in the view can be configured by the user, also whether different nodes are allowed to have the same label.

In a drawing on the Concise screen, each arc defines an arrow labelled by the name of the field going from a node labelled by the name of the handle to a node labelled by the name of the entry. In the standard view, the arrows are not drawn explicitly but always go either downwards or horizontally from left to right. The horizontal arrow is reserved for sems whose field is type; thus the type of a node (if displayed) is found on its right side. If the value of a node is drawn in a semantic graph, it appears in a square box to the left of the node.

Although several nodes of a semantic graph in graphical display may carry the same label, all nodes with the same label denote the same object in the semantic memory. This enables transparent drawings even for complex semantic relations by decomposing them through the use of multiple nodes for the same object.

2.8 Node

A node is an object shown in the graph view (3.6.2). A node has a certain shape containing its name or its identifier. Nodes without names are called unnamed nodes. Each node has a number of outgoing and incoming edges (2.9). The outgoing edges are called the child edges of the node while the incoming edges are called the parent edges of the node. The child (parent) edges are unique, that means there cannot be two child (parent) edges having the same name (under the same language and authority, see names (2.6)) or identifier.

- Left clicking on the node label selects the node.
- Right clicking on it brings up the menu of all actions applicable for the clicked node. The selectable actions may depend on the previous actions done on the node as well as the number of children, node type etc.
- Left clicking on a node two times centers the view on it and folds or unfolds its children.
- Pressing the left button on a node and moving the mouse drags the node in the view.
- Node shapes, colors, fonts etc. can be adjusted in the configuration (3.10).
- The configuration also contains special options for customizing the representation of unnamed nodes.
2.9 Edge

An edge is an object shown in the graph view (3.6.2). An edge has a label showing its name or its identifier. An edge has a source (parent) and a target (child) node (2.8). This defines its direction. In terms of sems, the label of an edge is the field, that of the source is the handle, and that of the target is the entry. The direction of an edge in the graph view (if not given by the default mentioned above) is signalled by an arrow shown either in the edge label or at the end of the arrow line. - Left clicking on the edge label selects the edge.
- Right clicking on it brings up the menu of all actions applicable for the clicked edge. The selectable actions may depend on the previous actions done on the edge as well as the parent and child node etc.
- Pressing the left button on an edge and moving the mouse bends the edge.
- Edge widths, colors, label fonts etc. can be adjusted in the configuration (3.10).
- The configuration also contains special options for customizing the visualization edge directions.

2.10 Types and Categories

In semantic memory, each object (handle, entry) can have a type. A type defines some requirements for the sems originating form the typed object. These requirements can be posed on the sems of a record in a various forms, moreover, inheretence and subtyping is possible. To define a type, one expresses the corresponding requirements in text documents called type sheets (2.12).

Information in the SM is organized in records (2.4). When using a record, or passing it to some algorithm, we need information about the structure of this record, as we do not want to examine the whole graph every time a record is used. For this reason we assign types to objects and categories to sems. These assignments are always made by means of a particular type systems (2.11). Then with respect to these assignments, it can checked in linear time whether a record is well-formed (well typed) or not (ill typed). To be more accurate, If a handle or entry abides the restrictions given by its type it is called well typed and ill typed otherwise. If a record (2.4) contains only well typed objects it is called a well typed record.

Types are defined as a paritcular form of categories. In other words, A category is a generalization of type allowing to define abstract unions of types. The set of categories in a type systems (2.11) is ordered by an irreflexive partial order relation. Categories (and types) are defined in a type systems. Type systems are stored as type sheets (2.12) which can be checked for correctness by using the type sheet checker (3.7).

For more details on types, categories, type systems and type sheets refer to the paper: Peter Schodl, Arnold Neumaier – The FMathL type system, available at the FMathL homepage (http://www.mat.univie.ac.at/~neum/FMathL/papers/types.pdf).

2.11 Type Systems

A type system is a collection of a set of objects which are called the categories of that type system. Type systems are written as type sheet (2.12). The type sheets from the <concisedir>/sheets/import directory are automatically loaded when Concise starts. This directory contains type sheets for essential type systems like BasicTypes.cnt and optional ones. The optional ones have numbers in their file names indicating the order in which they are imported, e.g., 2-ElementaryActs.cnt means that the type system ElementaryActs is the second optional type system. Adding a new, numerated type sheet to this directory results in automatic import of the new type system at the next time Concise is started.

Note that errors in the imported type sheets may prevent Concise from starting up, and must be corrected or removed in order to get the system work again. See type sheet check (3.7).

In Concise all imported type systems can be found under (System, English) in:
All type system names are inserted in the System authority and all type names of the type system under the authority of the type system itself. This enables one to have distinct type systems with distinct type definitions sharing the same name.

For more details on type systems refer to the paper: Peter Schodl, Arnold Neumaier – The FMathL type system, available at the FMathL homepage [http://www.mat.univie.ac.at/~neum/FMathL.html].

2.12 Type Sheets

As it mentioned before, type systems (2.11) are expressed as a system of declared categories and types. Categories can be defined by text called a type declaration. A text document that contains one or more type declarations is called a type sheet (.cnt files). The first line of a type sheet contains the name of a type system it defines or enlarges. Every of the following lines either creates a new category (via the name of the category followed by a colon), or specifies the category, by a keyword possibly followed by further specifications. Every line in a type sheet beginning with an exclamation mark (!) is a comment.

The consistency of a type sheet is checked by type sheet checker (3.7).

2.13 Annotated type sheet and Usages

An annotated type sheet is consisted of a type system (2.11) equipped with grammars. This kind of type sheet (2.12) has a more complex syntax, allowing for comments and rendering information. The adjective annotated means that we are adding additional information, which we call usages, to the type specifications. Those usages represent grammar rules in EBNF form, allowing to specify any context-free grammar, in a way which also specifies how the output record has to be built. In particular, instead of category names, we refer to field names, which tell us not only what type is expected, but also in what field it shall end up.

2.14 Elementary acts

In the semantic memory, all objects of type .act are executable in Concise. A program is represented by a directed graph of executable objects whose arcs are the sms with field next (which belong to handles of type do or goto). Loop are simply directed cycles in this graph, and can be entered and left by means of entering or exiting arcs. In low level programming, the arcs are set directly, while in high level programming, they are set by means of more systematic control structures.

Elementary acts are different command types which define the lowest typed programming level in Concise. These are the lowest level commands intended for general use. From elementary acts one can easily create the control stuctures of the common programming languages. The text view of a program or program piece is given by a code sheet. The 14 different command types defining the individual elementary acts are as follows:

**DO**
This command is used to creat a sequence of conditionally executed acts.

**GOTO**
This commnad performs a one-way transfer of control from one line of code to another line.

**RETURN**
This command performs a normal return to the invoking function.
ASSIGN
This command is defined to assign variables in the semantic memory and expressed as
l=r
In this expression, the content of r (the entry of r.content) is assigned to l.content where l must be a variable.

SET
For assigning an entry we use this statement and expressed as
h.f=<i>:<y>
h.f=e

GET
This command is used to manipulate sems [2,3] and expressed as
e = h.f
Where the target of h.f is assigned to content of e (e.content).

IDENTICAL
This command is used to compare objects and values.
z=(x=y)
assign true value to z if x and y contain the same object, and false otherwise.

CONVERT
This command is the standard conversion.
y= convert(x,t)
convert x to type t according to a standard protocol and assigns the result to y.

VCOPY
This command is used to copy an external value to a variable.
x= Vcopy(y)
Copy the external type and value of y to x. But if y is not external, set x to empty.

FORALLFIELDS
This command allows us to create loops over all fields of a specified handle, except of the type fields.
ForAllFields of f of x
a
end

CALL
This command call a function pushes the previous frame onto a function stack, and creates a new local frame for the control of its execution.

RESUME

3 Concise
This section describes all features of the Concise system. The theoretical background needed to understand this part is described in the theory [2] section.
3.1 Starting Concise

When Concise is started the first time, a small window called the session selector will ask for the location where the session files shall be stored. The suggested default location is `<concise dir>/data/Default.cns`. Later, after the session was saved more often than once, the session selector also allows one to revert to an older saved session.

Then a name of the secretary has to be chosen. The secretary is the root of the Concise session (see sections of the semantic memory (3.4)). The default secretary name is Matilde.

Finally, username and password have to be provided, used for identification of the different users inside Concise. (For more details on this topic, see Section Users (3.9).)

Then the main window (3.2) of Concise will appear.

3.2 Main Window

When you start Concise, and entered your user name and password, the following window will appear:

The enumerated parts are listed as follows:

- **1** - this is the menu bar containing basic actions like saving and exiting the application showing the help or editing the configuration (3.10).
- **2** - this is the tab where the name of root of the active view container (3.6.1) is shown. If you open more view containers you get new tabs like this one and you can switch between them by clicking on the tabs.
- **3** - this is the main graph view (3.6.2) of the current view container. Right click on it to open the menu of with different options or hold the left mouse button and move the mouse to pan the view. Using the mouse wheel you can zoom in or out. More mouse actions are listed in the Graph View (3.6.2) Section.
- **4** - these are space holders for other views in the same container. Right click on one of them to open a new view (3.6) in the corresponding part of the view container.
- **5** - this is your root node (2.8) of the central graph view, named (2.9) the Secretary. Right click on
it to open the menu of with different options. Double click on it to unfold its child edges and child nodes. For different mouse actions and applicable keyboard shortcuts see the Graph View Section.

- **6** - this label show the type of the node.
- **7** - the number of children is shown there.
- **8** - the name of the authority (owner and creator) of the node can be found here.
- **9** - this small text field is used to display system messages.

### 3.3 Session

The full semantic memory can be saved as a session.

When Concise is started, either a new session is created or a saved session is restored.
- Upon creating a new session, the user is asked to enter a name for the root object of the semantic memory. This object is the secretary, has the type Root and contains as a record the complete semantic memory.
- The session selector allows to load the last or older saved sessions. The default save location can also be adjusted in the session selector. The last saved session has the extension .cns while the older sessions end with .cnb. For more details on the session selector as well as starting Concise for the first time, we refer to the Section Starting Concise.

When Concise is closed, the current session can be saved by choosing Exit and Save from the appearing dialog. Obsolete saved sessions can be deleted manually by deleting the corresponding .cns and .cnb files. For removing all saved sessions and restarting the system, choose Edit->Reset Session from the top menu bar of Concise. Note that, since secretary name and user information are also stored in the session, one will be prompted again to choose them.

**Compatibility issues:** If the basic functionality of Concise is drastically changed in a new version, the saved session may contain data incompatible with the new version. In this case one may continue to use the old session on one’s own risk, or create a new empty one. To ensure compatibility with a new version, it is therefore advisable to additionally serialize important user data. In particular, keep the previous version of Concise to be able to do this even after an upgrade!

### 3.4 Sections of the semantic memory

The semantic memory contains the full semantic information relevant for having Concise work correctly, including the information about names of concepts and their translation to different languages.

The root object of the semantic memory is of type Root is called the Secretary and contains as a record the complete semantic memory. The name of the secretary is given by the user upon the creation of a new session. This name (and additional information created later) is stored as children of the object Root.Identity=Identity.

Concise has access to the values of objects, to auxiliary information needed for navigation through and searching the semantic matrix, and to external processors with which operations can be performed on the values.

A complete semantic memory therefore has four different sections, represented by records whose handles (children of the Secretary) hav the names Library, Index, Dictionary, and Workspace.

(i) The Library stores original information, including programs and background data. This is also the place where a user works and edits.
(ii) The Index stores tables for referencing and searching the library. In particular, it has nametables for disambiguation, as standard lexica and dictionaries. (But the contents is in the library, not in the index.)
(iii) The Dictionary stores lexical and grammatical information about the terms used, in various languages.
(iv) The Workspace stores, separately for each user, their preferences, views of the semantic memory, and private objects. It also contains, separately for each user, all auxiliary information generated by the IDE during a session or via the execution of objects.

However, all four sections use identical forms of representation and the same programs work on them in the same way.

All data generated by the Concise interpreter for more than intermediate calculations is stored in the workspace of the semantic memory, separately for each concurrent user (if there are several). The complete semantic memory is storable as a session, a compact, but platform dependent binary file (with ending .cns), from which the SM can be reconstructed quickly and uniquely on the same platform. Therefore, an interrupted interactive session can be quickly resumed later by reloading the stored session.

The workspace of the semantic memory can also be used later to reason statistically about the interpreting process, or to create permanent summaries of interest about a library.

3.5 Serialization

Concise can perform a standard serialization of views to .cnv files according to specification given in the Serialization (4.1) Section of the Appendix. From the resulting .cnv file the deserialization can recover the serialized view (even when the SM was essentially empty before loading it).

3.6 Views

Graphical and textual views enable the user to see, understand, analyze, and modify the content of the semantic memory (2.1), and hence of documents, programs and data structures.

For each view, there is an object that serves as the root of the view, also called the view root. Some views (e.g., graph view (3.6.2)) can have any object as root, while others need an object of a certain type (e.g., the root object text view (3.6.3) must be of type TextDocument).

Each view has its own management in the semantic memory; different views are completely independent, working on the semantic memory but not on the other views. For example, each graph view only (un)folds his own nodes and not the underlying object, and of two nodes for the same object, one may be folded and the other may be unfolded.

The information required for managing the view information is stored in the workspace (see sections of the semantic memory (3.4)).

It is possible to see several views at the same time, or have multiple starting objects in the same view; see view containers (3.6.1).

3.6.1 View Containers

Each view in Concise is contained in a view container. A view container can contain up to nine views. The center view is the root view of the view container and cannot be closed. When a new container is created, the center view is active, and the other eight empty parts are shown as thin black areas around it: In these empty parts of the view container, new views can be opened or closed by right clicking on them and choosing the corresponding items of the menu.
- Changing the active view container is done by left clicking on the tabs containing its name.
- Each view container can be renamed by right clicking on their tabs.
- Pressing the left mouse button on the tab of a nonactive view container and dragging it into a non center area of the active view container copies the center view of the dragged view container into the selected area.
and closes the dragged view container.

### 3.6.2 Graph View

Using a graph view is one way to navigate, modify, and use the objects stored in the semantic memory (2.1). The objects in the graph view are represented either as a **node** (2.8) or as an **edge** (2.9).

- All edges and nodes have a label. A label either shows the name of the node or edge, or a number after a hash (#) sign. The latter case indicates that the node or edge is unnamed, but it can be referenced by the given number. The numbers are unique, and the names are unique under a given language and authority (for more on authorities see the Section **Names** (2.6)).

Left clicking on a node or an edge label selects the corresponding node or edge. Right clicking on a node or an edge label opens a small menu showing the list of options applicable for the clicked object.

There are a number of global options that do not require a selected node or edge. These can be accessed by right clicking outside a node or an edge label.

In general, one can issue commands in a graph view by using the mouse and selecting an option from small popup menus. Alternatively, the menu items below the view can be used to issue commands.

- Clicking the left button once on a node or an edge selects the node or the edge.
- Clicking the left button twice on a node centers the view on it and folds or unfolds it.
- Pressing the left button on a node or an edge and moving the mouse drags the node or the edge.
- Pressing the left button outside a node or an edge and moving the mouse moves the view inside the viewport.
- Turning the mouse wheel zooms the view in or out with respect to the position where the mouse pointer is located.
- Pressing the middle button on a node and moving the mouse allows to add sems.
- Pressing the middle button on an edge and moving the mouse to a node sets a new target for the edge.
- Clicking the right button on a node or an edge brings up the allowed options for the clicked node or edge.
- Clicking the right button elsewhere brings up the general options applicable for the current view.

**Fixed Keyboard shortcuts:**
- The arrow keys move the view inside the viewport.
- The keys + and - zoom in and out at the current mouse position.
- Pressing backspace centers on the root and resets the zooming.
- If a node or edge is selected, pressing space centers the view on it.
- When an edge is selected, pressing delete deletes the selected edge.

**Custom Keyboard shortcuts:**
- Custom keyboard shortcuts can be defined by clicking the middle or right mouse button on a menu item in the node/edge specific or the general options menu. The shortcuts are stored in the semantic memory under Workspace.Global.GraphViewMenu in the accelerator fields of the MenuItem entries.
- Alternately, custom keyboard shortcuts which are the defaults for each session can be defined by adding/modifying the accelerator field in the MenuItem entries of the record sheet <concisedir>/data/GraphViewMenu.cnr.

### 3.6.3 Text View

Records of the type TextDocument can be shown in a text view. For an example of text views, read the compressed record sheet con1.cnr.bz from the <concisedir>/test directory into the semantic memory by right clicking on the current graph view and choosing Read->Record Sheet. The default location for the record sheet read is Library.TextDocuments.con2=con2. Right click on one of the black borders in the current view, select the option New Text View, enter con1 or select the root node con1, press ok and the text view will appear.

It is possible to mark parts of the text view and inspect the record corresponding to the marked part by right clicking on the text view and selecting Edit->New view from the menu. Close a text view by selecting Appearance->Close view.

### 3.6.4 Type Sheet View

The type sheet view enables to modify, save, parse and import type systems. The commands applicable for this view can be accessed by right clicking on the view and selecting them from the context menu. Alternately, commands can be performed via keyboard shortcuts. The allowed shortcut key combinations can be read in the context menu.

### 3.6.5 Record View

Records views show a whole record originating from a selected node. This part is unfinished and untested.

### 3.7 Type Sheet Check

A type sheet consistency check is automatically performed on all imported type sheets, but may also be called manually on an arbitrary type sheet by calling

```
java -cp Concise.jar concise.TypeSheetChecker <-flags> <full path>/<sheetname>.cnt.
```

Flags:
- c - convert .cnt to .cnr,
- s - show the type system.

It is also possible to modify the checksheet (for Linux) or checksheet.bat (for Windows) scripts located in the main Concise directory. These scripts can be used to conveniently call the type sheet consistency
checker for type sheets under development. A type sheet should be loaded to Concise only after it was validated by this script.

3.8 Code Record Execution

A code record is a record containing an executable Concise program. To create a code record, Concise currently needs a code record sheet. (Later, these will be replaced by code sheets, which simplifies their creation and editing.)

The code record sheet can be loaded from the GUI by selecting the read>code record sheet option and executing it by choosing execute>act. Code record sheets can be loaded and executed automatically from the operation system command line by writing:

```
```

- h display help
- x execute the loaded code records
- n no graphical output
- cnrfile... one or more .cnr code record sheet files

The scripts execcs (for Linux) or execcs.bat (for Windows) can be also modified and used in order to support the development of new code record sheets.

3.8.1 File View

File views open an external file. Currently only text files can be opened.

3.9 Users

The first time Concise is started, it prompts for creating a new user or entering an existing username and a password. In the semantic memory, the user root of the active user (referenced as <userroot>) can be found in: Secretary.Users.CurrentUser, while other existing users can be accessed from: Secretary.Users.<username>

The <userroot> contains the username, password, user home and the user configuration.
- The active user should work and store its data in: <userroot>.UserHome which can be conveniently accessed from: Secretary.UserHome
- The user configuration (3.10) can be accessed from: <userroot>.Config
- The view information is stored in: Secretary.Workspace.UserData.<username>

If Concise was closed and the session was saved, this information is used to restore the working state when the system is started again.

3.10 Configuration

The configuration of the currently active user (3.9) contains a number of global settings that can be used to customize the look and feel of Concise. Like all user settings, it can be accessed from the top menu bar Edit->Configuration, alternatively from <userroot>.Config (see the Section Users (3.9)), or by right clicking on a graph view and selecting selecting user configuration from the appearing menu.

3.11 Debug

To enable the debug mode of Concise, place a file called debug in the main Concise directory. Starting Concise while the debug mode is active skips the authentication procedure and automatically logs into the system with the user name Developer and password developer. In addition to this, more details about the system will be printed on the console when Concise starts.
3.12 Editing Help

If one has checked out the whole Concise development version (in the directory `<devdir>`) from the repository, one can edit this help by modifying `<devdir>/progs/concise/src/concise/resources/help.txt.

The formatting commands can be found at the beginning of the help.txt file.

The modifications will be visible when Concise is restarted or the refresh button on the right hand side is pushed.

Note that editing the help this way influences the help of the distributed versions only when the jar files are rebuilt.

A PDF version of this Help can be built (or rebuilt after an edit) by running one of the scripts `makehelp` (for Linux) or `makehelp.bat` (for Windows), or alternatively by calling `java -cp Concise.jar concise.HelpGenerator`.

The generated Manual.tex and Manual.pdf files can be found in the `<concisedir>/docu` directory; the images required for the LaTex document are located in the `<concisedir>/docu/images` directory.

4 Appendix

The appendix contains implementation details, system parameters and a list of Java classes used inside Concise.

4.1 Serialization

Concise can perform a standard serialization of views to .cnv files according to the following specification, and a corresponding deserialization that recovers the view from a .cnv file (even when the SM was essentially empty before loading it).

The basic structure of a serialization is divided in several parts: the external table [4.1.1], the authority codes [4.1.2], the language codes [4.1.3], the dictionary entries [4.1.4], the view roots [4.1.5] and the semantic memory [4.1.6].

There are also some additional requirements [4.1.7] and rules which each implementation of the serialization should abide.

A simple serialization example can be found in the section Example [4.1.8].

4.1.1 External table

The external table serializes each external object like names, strings, numbers, colors etc. This part of the serialization starts with the line

* EXTERNAL TABLE *

and each following line contains an entry

id=<type;value>

where the id is a unique number identifying the external value, the type is the a three character type code of the external value (nam, str, int, dbl, etc.) and value is the string representation of the external value.

More information about external tables can be found in the Externals [2.5] Section. The currently implemented external types - divided into mutable and unique externals (explained in the External Section) - are listed in the following table. Each line of the table contains the name of the external and its serialization format `<type;value>`. Note that for the value string more explanation is given in this table as it contains formatting information and meaning(expected format) items.

********************************************************************** MUTABLE EXTERNALS **********************************************************************

18
4.1.2 Authority codes

The authority codes are used in the dictionary for assigning each name to a certain owner. This part of the serialization starts with the line

* AUTHORITY CODES *

and each following line contains an entry

aid=eid

where the aid is a unique id identifying the authority while eid, is the id of the associated external value.

4.1.3 Language codes

The language codes are used in the dictionary for assigning each name to a certain language. This part of the serialization starts with the line

* LANGUAGE CODES *

and each following line contains an entry

lid=eid

where the lid is a unique id identifying the language while eid, is the id of the associated external value.
4.1.4 Dictionary

The dictionary assigns to a triple of an external name, authority and language a new id. This part of the serialization starts with the line

* DICTIONARY ENTRIES *

and each following line contains an entry

eid,iid,aid,lid

where the iid is a unique id identifying the internal entry while eid,aid and lid are the associated external, authority and language ids.

4.1.5 View roots

This part of the serialization starts with the line

* VIEW ROOTS *

and the next line contains a list of comma separated of internal or external ids specifying the roots of the serialization.

4.1.6 Semantic memory

This part encapsulates the main part of the data and starts with the line

* SEMANTIC MEMORY *

while each following line contains an entry

handle: field1=entry1, ..., fieldn=entryn

where handle and all fieldk are internal and all entryk are internal or external ids. Each line is thus a compact representation of n sems originating from the same handle handle. For more details on sems see the section Semantic memory (2.1).

4.1.7 Requirements

Every implementation of the serialization should abide the following basic rules:
- Neither the external table nor the dictionary should contains the special name type used for defining the type of a Concise object. This special name is marked only by the reserved id 1.
- For the basic authority the name System and for the basic language the name English is reserved. Each serialization should contain these.

4.1.8 Example

Minimalist example for serialization of a single type Trailer in the type sheet TextDocument. In this example the comments start with a % sign.

* EXTERNAL TABLE *
-1=<nam;English>
-7=<nam;System>
-424=<nam;TextDocument>
-1778=<nam;Trailer>
...

* AUTHORITY CODES *
12=-7 % System
219=-424 % TextDocument
...

* LANGUAGE CODES *
120=-1 % English
...
* DICTIONARY ENTRIES *
-7,12,12,120 % System(English,System)
-1,12,12,120 % English(English,System)
-424,219,12,120 % TextDocument(English,System)
-1778,4690,219,120 % Trailer(English,TextDocument)
...
* VIEW ROOTS *
...
* SEMANTIC MEMORY *
6155:1=4690 % the type of the node #6155 is 'Trailer'
...

4.2 System parameters

---------------------------------------------------
Properties of Concise 0.9339 at 2017.09.06 at 18:53:09 CEST
---------------------------------------------------
Sources* Files:400, Lines:67238, Words:202357, Total Size:2052kb
Imports* TypeSheets:11, Views:0
Semantic Memory* Objects:54976, Sems:54217
---------------------------------------------------
Comprehensive word count reference:
Short... 7,000 to 20,000
Novella... 20,000 to 40,000
Catagory... 40,000 to 65,000
Novel... 65,000 to 90,000
Novel Plus... 90,000 to 120,000
Super Novel... 120,000+
---------------------------------------------------

4.3 External types

ExternalTypes(English,SystemTmp)::

! Exported type sheet
! ***** Type Definitions *****
UniqueExternal:
union> Abstract2DShape, Character, Color, EscapedCharacter, EscapedUniqueString, File, Font, Image, IntegerName, Name, Timer, URL, UniqueString
Color:
nothingElse>
File:
nothingElse>
EscapedUniqueString:
nothingElse>
MutableExternal:
union> Array, BigDecimal, BigInteger, Boolean, Dimension, Double, EscapedString, Integer, IntegerInterval, Matrix, Point, RealInterval, RealIntervalUnion, Rectangle, String, TextLine, Vector

21
4.4 External functions

************************************* NOTATION ****************************
! - required input parameter, <> - required in-out parameter
*****************************************************************************

->package: array
append(<>Array array, ! data)
Array append function

[Array array] = array( data0, data1, data2, data3, data4, data5, data6, data7, data8, data9,
data10, data11, data12, data13, data14, data15, data16, data17, data18, data19, data20, data21,
data22, data23, data24, data25, data26, data27, data28, data29, data30, data31, data32, data33,
data34, data35, data36, data37, data38, data39, data40, data41, data42, data43, data44, data45,
data46, data47, data48, data49, data50, data51, data52, data53, data54, data55, data56, data57,
data58, data59, data60, data61, data62, data63, data64, data65, data66, data67, data68, data69,
data70, data71, data72, data73, data74, data75, data76, data77, data78, data79, data80, data81,
data82, data83, data84, data85, data86, data87, data88, data89, data90, data91, data92, data93,
data94, data95, data96, data97, data98, data99, data100, data101, data102, data103, data104,
data105, data106, data107, data108, data109, data110, data111, data112, data113, data114, data115,
data116, data117, data118, data119, data120, data121, data122, data123, data124, data125, data126,
data127, data128, data129, data130, data131, data132, data133, data134, data135, data136, data137,
data138, data139, data140, data141, data142, data143, data144, data145, data146, data147, data148,
data149, data150, data151, data152, data153, data154, data155, data156, data157, data158, data159,
data160, data161, data162, data163, data164, data165, data166, data167, data168, data169, data170,
data171, data172, data173, data174, data175, data176, data177, data178, data179, data180, data181,
data182, data183, data184, data185, data186, data187, data188, data189, data190, data191, data192,
data193, data194, data195, data196, data197, data198, data199, data200, data201, data202, data203,
data204, data205, data206, data207, data208, data209, data210, data211, data212, data213, data214,
data215, data216, data217, data218, data219, data220, data221, data222, data223, data224, data225,
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data248, data249, data250, data251, data252, data253, data254, data255, data256, data257, data258,
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data270, data271, data272, data273, data274, data275, data276, data277, data278, data279, data280,
data281, data282, data283, data284, data285, data286, data287, data288, data289, data290, data291,
data292, data293, data294, data295, data296, data297, data298, data299, data300, data301, data302,
data303, data304, data305, data306, data307, data308, data309, data310, data311, data312, data313,
data314, data315, data316, data317, data318, data319, data320, data321, data322, data323, data324,
data325, data326, data327, data328, data329, data330, data331, data332, data333, data334, data335,
data336, data337, data338, data339, data340, data341, data342, data343, data344, data345, data346,
data347, data348, data349, data350, data351, data352, data353, data354, data355, data356, data357,
data358, data359, data360, data361, data362, data363, data364, data365, data366, data367, data368,
data369, data370, data371, data372, data373, data374, data375, data376, data377, data378, data379,
data380, data381, data382, data383, data384, data385, data386, data387, data388, data389, data390,
data391, data392, data393, data394, data395, data396, data397, data398, data399, data400, data401,
data402, data403, data404, data405, data406, data407, data408, data409, data410, data411, data412,
Array constructor function
[ data] = get(!Array array, !Integer index)
Array get function
set(<>,Array array, !Integer index, ! data)
Array set function
->package: math
[Mutable res] = add(!Mutable term1, !Mutable term2)
Type-generic addition function
[Mutable res] = and(!Mutable term1, !Mutable term2)
Boolean AND function
[Mutable res] = div(!Mutable term1, !Mutable term2)
Type-generic division function
[Mutable res] = eq(!Mutable term1, !Mutable term2)
Type-generic == comparison function
[Mutable res] = geq(!Mutable term1, !Mutable term2)
Type-generic >= comparison function
[Mutable res] = gt(!Mutable term1, !Mutable term2)
Type-generic > comparison function
[Mutable res] = leq(!Mutable term1, !Mutable term2)
Type-generic <= comparison function
[Mutable res] = lt(!Mutable term1, !Mutable term2)
Type-generic < comparison function
[Vector x] = linSol(!Matrix A, !Vector b)
Solve the linear system equation Ax=b
[Matrix res] = matAdd(!Matrix mat1, !Matrix mat2)
Add the two given matrices
[Double det] = matDet(!Matrix mat)
Compute the determinant of the given matrix
[Matrix res] = matDiv(!Matrix mat1, !Matrix mat2)
Divide the first matrix with the second
[Double dat] = matGet(!Matrix mat, !Integer row, !Integer col)
Get the given data from the given position in the given matrix
Compute the LU decomposition of the given matrix
[Matrix res] = matMul(!Matrix mat1, !Matrix mat2)
Multiply the two given matrices
matSet(<>,!Matrix mat, !Integer row, !Integer col, !Double data)
Set the given data in the given position in the given matrix
[Matrix res] = matSub(!Matrix mat1, !Matrix mat2)
Subtract the second matrix from the first
[Matrix matT] = matTran(!Matrix mat)
Transpose the given matrix
[Mutable res] = mod(!Mutable term1, !Mutable term2)
Type-generic modulo function
[Mutable res] = mul(!Mutable term1, !Mutable term2)
Type-generic multiplication function
Mutable res\[\] = neg(!Mutable term)
Type-generic negation function
Mutable res\[\] = neq(!Mutable term1, !Mutable term2)
Type-generic != comparison function
Mutable res\[\] = not(!Mutable term)
Boolean NOT function
Mutable res\[\] = or(!Mutable term1, !Mutable term2)
Boolean OR function
Mutable res\[\] = sub(!Mutable term1, !Mutable term2)
Type-generic subtraction function

->package: system
alert(! out)
The string representation of the given external is displayed in a small message window
[Boolean ok\] = confirm(! question, title)
Display a small window with optional title, containing the given question, a yes and a no button. For yes/no, true/false is returned
disp(! out)
The string representation of the given external is displayed in the console
[Boolean equal\] = equal(! ex1, ! ex2)
Compare the two given externals (as strings) and return true if they are equal
[Array outArgs\] = executeMatlabComm(!String command, !Integer outArgNum)
Execute a matlab command. The 'command' string contains the command, while the 'outArgNum' specifies the required number of output arguments. Currently only Integer, Double and String outputs and arrays of the same types are supported.
executeShellComm(!String command, String commArgs, String envVars, String workDir)
Execute a shell command. The 'command' string can contain command arguments or they can additionally be specified in 'commArg'. 'commArgs' is either empty or a list of ';' separated command arguments. Optional environment variables can be given in 'envVars' as a ';' separated list of pairs <varName>=<value>. The full path of the working directory can be optionally given in 'workDir'
[String time\] = getTime
Return the system time as a string.
[String text\] = input(! question, text, title)
Display a small input window with an optional title, the given question, an input field containing the given optional text, and an ok and a cancel button. The input text or an empty text for cancel is returned
strApp(<String s, !String s2)
Append the second string to the first.
[String res\] = strMerg(!String s, !String s2)
Merge the two strings return the result
writeFile(! out, !File file, Boolean append)
Write the string representation of the given external data to a file.

->package: text
drawImage(!File file, Integer scaleToWidth, Integer scaleToHeight, Boolean center, Boolean newLine)
Draw the image scaling it to the rectangular bounds of given width and height and having the given color
drawShape(!Abstract2DShape shape, !Integer width, !Integer height, !Color color, !Boolean fill, Boolean center, Boolean newLine)
Draw the given shape filling rectangular bounds of given width and height
and having the given color
ifNotEmpty( testarg, text)
If the first argument is empty, the second will be written in the output.
lineComments(!CharSequence commentString, !CharSequence commentSign)
Output a multi-line string as a comment, prepending the line comment sign
to each line
linearize(!Integer rootId, !CharSequence typeSheet, !CharSequence usageTarget)
Linearize a given object with a specific type sheet and usage target
resetAttribs
Reset all style attributes to their default values.
resetColor
Reset the color attribute to its default value.
resetFontSize
Reset the font size attribute to its default value.
setBold
Set the bold attribute.
setColor(!Integer red, !Integer green, !Integer blue)
Set the color attribute to the given rgb value.
setFontSize(!Integer size)
Set the font size attribute to the given value.
setItalic
Set the italic attribute.
setNonBold
Clear the bold attribute.
setNonItalic
Clear the italic attribute.
textRef(!Integer objectId, String label, Color color)
Create a text reference using the given object id and an optional label
and color
textURL(!String urlString, String label, Color color)
Create a text URL using the given string and an optional label and color
toggleBold
Toggle the bold attribute.
toggleItalic
Toggle the italic attribute.

->package: tokensource
out(!Integer tokenId, Integer valueId, Integer supplementaryId)
This function has an integer argument that is passed as a token ID to the
token source, and optionally one or two integers passed as a value.

4.5 Source Listing

main:
    CodeSheetExecuter,
    ConciseAboutBox,
    ConciseApp,
    ConciseView,
    HelpGenerator,
SystemInfo,
SystemVersion,
TypeSheetChecker,
ViewPlotGenerator
acts:
   ElementaryAct,
   ElementaryActRegistry,
   ExecutionException
acts.core:
   ConstInfo,
   Constant,
   ExternalFunction,
   Function,
   InternalFunction,
   VarConst,
   VarConstInfo,
   VarInfo,
   Variable
acts.impl:
   Ask,
   Assign,
   Call,
   Convert,
   Do,
   ForAllFields,
   Get,
   GetType,
   Goto,
   Identical,
   IsSubtypeOf,
   Resume,
   Return,
   Set,
   Supervise,
   Vcopy
acts.parser:
   ActRecordParser
acts.run:
   AbstractEnvironment,
   ElementaryActReturn,
   ExecutionResult,
   LocalEnvironment,
   RuntimeEnvironment,
   Supervisor
acts.run.action:
   EndSuperviseAction,
   EndSuperviseDialogAction,
   ExecuteActAction,
   ExecutionAction,
   JumpAction,
   LeaveLocalAction,
LoopAction,
ResumeAction,
ReturnAction,
StartSuperviseAction,
StartSuperviseDialogAction
core:
ConciseException,
ConciseVersionMismatchException,
Config,
DeserializationException,
Serializable
core.action:
Action,
ActionList,
SemAction,
SemActionUI
core.graph:
SemEdge,
SemNode,
SemNodeCollectorWalker,
SemanticGraph,
SemanticGraphEvent,
SemanticGraphExecutionWalker,
SemanticGraphListener,
SemanticGraphUISettings
core.memory:
AuthedName,
LangedAuthedName,
LangedName,
Name,
NameSequence,
Sem,
SemSequence,
SemTemplate,
SemanticIterator,
SemanticMemory,
SemanticMemoryEvent,
SemanticMemoryListener,
SimpleSem,
SingleName
develop:
ComplexRecord,
EditorRecordView,
Misc,
Record,
SemSequence,
SemanticMemory-old,
SimpleRecord
teditor:
Editor,
EditorAction,
EditorAdapter,  
EditorException,  
EditorListener,  
EditorView,  
EditorViewContainer,  
EditorViewEvent,  
EditorViewListener,  
EditorViewSelectorPanel,  
ParsableFileView  
editor.browserview:  
BrowserView  
editor.dictionaryview:  
DictionaryEditor,  
DictionaryView,  
DictionaryViewPanel,  
InflectedForm,  
MorphoHeuristicsInterpreter,  
NewTermDialog,  
TermCreator,  
TermEditorPanel  
editor.fileview:  
FileView  
editor.graphview:  
GraphItemSelectionEvent,  
GraphItemSelectionListener,  
GraphView,  
GraphViewPanel,  
GraphViewToolset  
editor.matlabview:  
MatlabConsoleView  
editor.recordtransformationsheetview:  
RecordTransformationSheetView  
editor.recordview:  
RecordEditor,  
RecordUnitTreeNode,  
RecordUnitTreeNodeEvent,  
RecordUnitTreeNodeListener,  
RecordView,  
RecordViewPanel  
editor.robustamplview:  
RobustAmplView,  
RobustAmplViewSettingsDialog  
editor.textview:  
TextView  
editor.typesheetview:  
TypeSheetView  
external:  
ExpressionEvaluator,  
External,  
ExternalConversionException,  
ExternalConverter,
ExternalConverters,
ExternalDynamicObject,
ExternalMathException,
ExternalObjectEvent,
ExternalObjectListener,
ExternalPromoter,
ExternalPromoters,
ExternalRegistry,
ExternalSelectorUI,
ExternalTable,
ExternalUI,
ExternalVisualObject,
ExternalsEditorUI,
MutableExternal,
UniqueExternal

external.convert:
ExternalBigDecimalToBigInteger,
ExternalBigDecimalToDouble,
ExternalBigDecimalToInteger,
ExternalBigDecimalToRealInterval,
ExternalBigDecimalToString,
ExternalBigIntegerToBigDecimal,
ExternalBigIntegerToDouble,
ExternalBigIntegerToInteger,
ExternalBigIntegerToRealInterval,
ExternalBigIntegerToString,
ExternalBooleanToDouble,
ExternalBooleanToInteger,
ExternalBooleanToString,
ExternalCharacterToString,
ExternalColorToString,
ExternalDimensionToString,
ExternalDoubleToBigDecimal,
ExternalDoubleToBigInteger,
ExternalDoubleToBoolean,
ExternalDoubleToDouble,
ExternalDoubleToInteger,
ExternalDoubleToMatrix,
ExternalDoubleToRealInterval,
ExternalDoubleToRealIntervalUnion,
ExternalDoubleToString,
ExternalDoubleToVector,
ExternalFileToString,
ExternalFontToString,
ExternalImageToString,
ExternalIntegerIntervalToRealInterval,
ExternalIntegerIntervalToRealIntervalUnion,
ExternalIntegerToString,
ExternalIntegerToBigDecimal,
ExternalIntegerToBigInteger,
ExternalIntegerToBoolean,
ExternalIntegerToDouble,
ExternalIntegerToIntegerInterval,
ExternalIntegerToRealInterval,
ExternalIntegerToRealIntervalUnion,
ExternalIntegerToString,
ExternalMatrixToString,
ExternalMatrixToVector,
ExternalNameToString,
ExternalPointToString,
ExternalRealIntervalToRealIntervalUnion,
ExternalRealIntervalToString,
ExternalRealIntervalUnionToRealInterval,
ExternalRealIntervalUnionToString,
ExternalRectangleToString,
ExternalStringToBigDecimal,
ExternalStringToBigInteger,
ExternalStringToBoolean,
ExternalStringToCharacter,
ExternalStringToColor,
ExternalStringToDimension,
ExternalStringToDouble,
ExternalStringToFile,
ExternalStringToFont,
ExternalStringToImage,
ExternalStringToInteger,
ExternalStringToIntegerInterval,
ExternalStringToIntgerInterval,
ExternalStringToIntegerName,
ExternalStringToMatrix,
ExternalStringToName,
ExternalStringToPoint,
ExternalStringToRealInterval,
ExternalStringToRealIntervalUnion,
ExternalStringToRectangle,
ExternalStringToTextLine,
ExternalStringToUniqueString,
ExternalStringToVector,
ExternalTextLineToString,
ExternalTimerToString,
ExternalUniqueStringToString,
ExternalVectorToMatrix,
ExternalVectorToString

external.functions:
ExternalFunArgInfo,
ExternalFunException,
ExternalFunRegistry,
ExternalFunResult,
ExternalFunction,
FunArgInfo

external.functions.array:
Append,
Array,
Get,
Set

external.functions.math:
  Add,
  And,
  Div,
  Eq,
  Geq,
  Gt,
  Leq,
  LinearSolve,
  Lt,
  MatrixAdd,
  MatrixDet,
  MatrixDiv,
  MatrixGet,
  MatrixLU,
  MatrixMul,
  MatrixSet,
  MatrixSub,
  MatrixTrans,
  Mod,
  Mul,
  Neg,
  Neq,
  Not,
  Or,
  Sub

external.functions.system:
  Alert,
  Confirm,
  Disp,
  Equal,
  ExecuteMatlabComm,
  ExecuteShellComm,
  GetSystemTime,
  Input,
  StrApp,
  StrMerg,
  WriteFile

external.functions.text:
  DrawImage,
  DrawShape,
  IfNotEmpty,
  LineComments,
  Linearize,
  ResetAttribs,
  ResetColor,
  ResetFontSize,
  SetBold,
  SetColor,
  SetFontSize,
SetItalic,
SetNonBold,
SetNonItalic,
TextConstants,
TextFun,
TextRef,
TextRefItem,
TextReturn,
TextURL,
TextURLItem,
ToggleBold,
ToggleItalic

external.functions.tokensource: Out

external.interfaces: ExternalCharSequence

external.objects:
  ExternalAbstract2DShape,
  ExternalCharacter,
  ExternalColor,
  ExternalEscapedCharacter,
  ExternalEscapedUniqueString,
  ExternalFile,
  ExternalFont,
  ExternalImage,
  ExternalIntegerName,
  ExternalName,
  ExternalTimer,
  ExternalURL,
  ExternalUniqueString,
  FontComboBox

external.promote:
  ExternalIntegerIntervalAndDoubleToRealInterval

external.values:
  AbstractExternalMatrix,
  AbstractExternalVector,
  ExternalArray,
  ExternalBigDecimal,
  ExternalBigInteger,
  ExternalBoolean,
  ExternalDimension,
  ExternalDouble,
  ExternalEscapedString,
  ExternalInteger,
  ExternalIntegerInterval,
  ExternalMatrix,
  ExternalPoint,
  ExternalRealInterval,
  ExternalRealIntervalUnion,
  ExternalRectangle,
  ExternalString,
ExternalTextLine,
ExternalVector,
IntervalUnionEditor

matlab:
MatlabConnector

parser:
ConciseTokenSource,
FormulaTokenSource,
Grammar,
GrammarException,
LatexImportException,
LatexImporter,
LiteralComparator,
Parser,
Prediction,
PredictionFilter,
Predictor,
TextParagraphIterator,
Unlexer,
XsltTransform

records:
RecordException,
RecordRoot,
RecordSheet,
RecordTransformer,
RecordUnit

session:
Dictionary,
DictionaryEntry,
Session,
SessionAuthority,
SessionConstant,
SessionConstants,
SessionLanguage,
SessionSettingSelector,
SessionSystemConstant,
SessionUI,
Workspace

test:
ActsTest,
AmplTest,
AmplTestDir,
ChemProcModTest,
CodeSheetTest,
CodeSheetTest2,
ConstantsTest,
ConvertTex2cnr,
CoreTest,
DictionaryTest,
DictionaryTestInv,
EditorTest,
ExpressionTest,
ExternalMatrixTest,
ExternalTest,
FormulaNewParserTest,
FormulaNewParserTestALA,
FormulaNewParserTestEinf,
FormulaParserTest,
GrammarTest,
GraphTest,
LatexTest,
MatlabTest,
OEdit,
OptProbTest,
ParserTest,
PgfTestJava,
PmcfgTest,
RecordTest,
RecordTransformationTest,
TextViewTest,
TypeCheckTest,
TypeSystemTest,
UsageTest,
ZoomPanelTest
types:
  TypeCheckException,
  TypeChecker,
  TypeException
types.def:
  TypeDef,
  TypeDefUI,
  TypeRestriction,
  TypeRestrictionUI
types.entries:
  TypeEntry,
  TypeEntryCollection,
  TypeEntryEquationList,
  TypeEntryNameList,
  TypeEntryOneName,
  TypeEntryRegistry,
  TypeEntryTrivial,
  TypeEntryUI,
  TypeEntryUnited
types.entries.data:
  TypeEntryData,
  TypeEntryEquationData,
  TypeEntryNameData
types.entries.impl:
  TypeEntryAll0f,
  TypeEntryArray,
  TypeEntryAtomic,
  TypeEntryComplete,
TypeEntryFixed,
TypeEntryIndex,
TypeEntryItself,
TypeEntryNothing,
TypeEntryNothingElse,
TypeEntryOneOf,
TypeEntryOnly,
TypeEntryOptional,
TypeEntrySomeOf,
TypeEntrySomeOfType,
TypeEntryTemplate,
TypeEntryUnion
types.system:
  TypeSheetParser,
  TypeSystem,
  TypeSystemImport,
  TypeSystemImports,
  TypeSystemRecordParser
types.usage:
  Disambiguator,
  Linearizer,
  LitSubst,
  LitVar,
  LitVars,
  TargetLabels,
  Usage,
  UsageConstants,
  UsageException,
  UsageTarget,
  UsageToken,
  UsageTokenArray,
  UsageTokenMap,
  UsageTokenReader,
  UsageTokenRegistry,
  UsageWalker,
  UsageWalkerAdapter,
  Usages
types.usage.atoms:
  CatVar,
  CatVarId,
  CatVarName,
  CatVarRec,
  ChrRan,
  FunArgs,
  Function,
  LineBreak,
  LitId,
  LitVal,
  Literal
types.usage.expressions:
  Alternative,
Anytimes,
ChrRanges,
Expr,
Multiple,
Once,
Optional,
RegExpr
types.usage.matches:
   Except,
   Expect,
   MatchCase,
   Maximal,
   PatternMatch,
   Taboo
users:
   User,
   UserException