

# Semantic Markup for Mathematical Statements<sup>\*</sup>

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## Abstract

The `statements` package is part of the  $\text{\LaTeX}$  collection, a version of  $\text{\TeX}/\text{\LaTeX}$  that allows to markup  $\text{\TeX}/\text{\LaTeX}$  documents semantically without leaving the document format, essentially turning  $\text{\TeX}/\text{\LaTeX}$  into a document format for mathematical knowledge management (MKM).

This package provides semantic markup facilities for mathematical statements like Theorems, Lemmata, Axioms, Definitions, etc. in  $\text{\LaTeX}$  files. This structure can be used by MKM systems for added-value services, either directly from the  $\text{\LaTeX}$  sources, or after translation.

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# 1 Introduction

The motivation for the `statements` package is very similar to that for semantic macros in the `modules` package: We want to annotate the structural semantic properties of statements in the source, but present them as usual in the formatted documents. In contrast to the case for mathematical objects, the repertoire of mathematical statements and their structure is more or less fixed.

This structure can be used by MKM systems for added-value services, either directly from the  $\text{\S}$ TeX sources, or after translation. Even though it is part of the  $\text{\S}$ TeX collection, it can be used independently, like its sister package `sproofs`.

$\text{\S}$ TeX [Koh08; sTeX] is a version of  $\text{\TeX}$ / $\text{\LaTeX}$  that allows to markup  $\text{\TeX}$ / $\text{\LaTeX}$  documents semantically without leaving the document format, essentially turning  $\text{\TeX}$ / $\text{\LaTeX}$  into a document format for mathematical knowledge management (MKM). Currently the OMDOC format [Koh06] is directly supported.

## 2 The User Interface

The `statements` package supplies a semantically oriented infrastructure for marking up mathematical statements: fragments of natural language that state properties of mathematical objects, e.g. axioms, definitions, or theorems. The `statement` package provides an infrastructure for marking up the semantic relations between statements for the OMDOC transformation and uses the `ntheorem` package [MS] for formatting (i.e. transformation to PDF).

### 2.1 Package Options

`showmeta` The `statements` package takes a single option: `showmeta`. If this is set, then the metadata keys are shown (see [Koh12a] for details and customization options).

### 2.2 Statements

All the statements are marked up as environments, that take a `KeyVal` argument that allows to annotate semantic information. Generally, we distinguish two forms of statements:

**block statements** have explicit discourse markers that delimit their content in the surrounding text, e.g. the boldface word “**Theorem:**” as a start marker and a little line-end box as an end marker of a proof.

**flow statements** do not have explicit markers, they are interspersed with the surrounding text.

`display=` Since they have the same semantic status, they must both be marked up, but styled differently. We distinguish between these two presentational forms with the `display` key, which is allowed on all statement environments. If it has the value `block` (the default), then the statement will be presented in a paragraph of its

own, have explicit discourse markers for its begin and end, possibly numbering, etc. If it has the value `flow`, then no extra presentation will be added the semantic information is invisible to the reader. Another key that is present on all statement environments in the `id` key it allows to identify the statement with a name and to reference it with the semantic referencing infrastructure provided by the `sref` package [Koh12c].

### 2.2.1 Axioms and Assertions

**assertion** The `assertion` environment is used for marking up statements that can be justified from previously existing knowledge (usually marked with the monikers “Theorem”, “Lemma”, “Proposition”, etc. in mathematical vernacular). The environment `assertion` is used for all of them, and the particular subtype of assertion is given in the `type` key. So instead of `\begin{Lemma}` we have to write `\begin{assertion}[type=lemma]` (see Example 1 for an example).

```
\begin{assertion}[id=sum-over-odds,type=lemma]
  $\sum_{i=1}^n 2i-1=n^2$
\end{assertion}
```

will lead to the result

**Lemma 2.1**  $\sum_{i=1}^n 2i - 1 = n^2$

**Example 1:** Semantic Markup for a Lemma in a `module` context

Whether we will see the keyword “Lemma” will depend on the value of the optional `display` key. In all of the `assertion` environments, the presentation expectation is that the text will be presented in italic font. The presentation (keywords, spacing, and numbering) of the `assertion` environment is delegated to a theorem styles from the `ntheorem` environment. For an assertion of type  $\langle type \rangle$  the `assertion` environment calls the `ST $\langle type \rangle$ AssEnv` environment provided by the `statements` package; see Figure 2 for a list of provided assertion types. Their formatting can be customized by redefining the `ST $\langle type \rangle$ AssEnv` environment via the `\renewtheorem` command from the `ntheorem` package; see [MS] for details.

**axiom** The `axiom` environment is similar to `assertion`, but the content has a different ontological status: axioms are assumed without (formal) justification, whereas assertions are expected to be justified from other assertions, axioms or definitions. This environment relegates the formatting to the `STaxiomEnv` environment, which can be redefined for configuration.

### 2.2.2 Symbols

**symboldec** The `symboldec` environment can be used for declaring concepts and symbols. Note the the `symdef` forms from the `modules` package will not do this automatically (but the `definition` environment and the `\inlinedef` macro will for all the definienda; see below). The `symboldec` environment takes an optional keywords argument

Value	Explanation
<b>theorem, proposition</b>	an important assertion with a proof
Note that the meaning of <b>theorem</b> (in this case the existence of a proof) is not enforced by OMDoc applications. It can be appropriate to give an assertion the <b>theorem</b> , if the author knows of a proof (e.g. in the literature), but has not formalized it in OMDoc yet.	
<b>lemma</b>	a less important assertion with a proof
The difference of importance specified here is even softer than the other ones, since e.g. reusing a mathematical paper as a chapter in a larger monograph, may make it necessary to downgrade a theorem (e.g. the main theorem of the paper) and give it the status of a lemma in the overall work.	
<b>corollary</b>	a simple consequence
An assertion is sometimes marked as a corollary to some other statement, if the proof is considered simple. This is often the case for important theorems that are simple to get from technical lemmata.	
<b>postulate, conjecture</b>	an assertion without proof or counter-example
Conjectures are assertions, whose semantic value is not yet decided, but which the author considers likely to be true. In particular, there is no proof or counter-example.	
<b>false-conjecture</b>	an assertion with a counter-example
A conjecture that has proven to be false, i.e. it has a counter-example. Such assertions are often kept for illustration and historical purposes.	
<b>obligation, assumption</b>	an assertion on which a proof of another depends
These kinds of assertions are convenient during the exploration of a mathematical theory. They can be used and proven later (or assumed as an axiom).	
<b>observation</b>	if everything else fails
This type is the catch-all if none of the others applies.	

**Example 2:** Types of Mathematical Assertions

with the keys `id`, `role`, `title` and `name`. The first is for general identification, the `role` specifies the OPENMATH/OMDOC role, which is one of `object`, `type`, `sort`, `binder`, `attribution`, `application`, `constant`, `semantic-attribution`, and `error` (see the OMDOC specification for details). The `name` key specifies the OPENMATH name of the symbol, it should coincide with the control sequence introduced by the corresponding `\symdef` (if one is present). The `title` key is for presenting the title of this symbol as in other statements. Usually, `axiom` and `symboldec` environments are used together as in Figure 3.

### 2.2.3 Types

In many cases, we can give additional information for symbols in the form of type assignments.  $\TeX$  does not fix a type system, but allows types to be arbitrary mathematical objects that they can be defined in (imported) modules. The

`\symtype` `\symtype` macro can be used to assign a type to a symbol:

```
\symtype[\keys]{\sym}{\type}
```

assigns the type  $\langle type \rangle$  to a symbol with name  $\langle sym \rangle$ . For instance

```
\symtype[id=plus-nat.type,system=sts]{plus}{\fntype{\Nat,\Nat}\Nat}
```

assigns the type  $\mathbb{N} \times \mathbb{N} \rightarrow \mathbb{N}$  (in the `sts` type system) to the symbol `plus`. This states (type assignments are statements epistemologically) that addition is a binary function on natural numbers. The `\symtype` macro supports the keys `id` (for identifiers) and `system` for the type system.

Often, type assignments occur in informal context, where the type assignment is given by a natural language sentence or phrase. For this, the `statements` package supplies the `typedec` environment and the `\inlinetypedec` macro. Both take an optional keyval argument followed by the type. The phrase/sentence is the body of the `typedec` environment and the last argument of the `\inlinetypedec` macro. The symbol name is given in via the `for` key. For convenience, the macro

`typedec`  
`\inlinetypedec`

`\thedectype`

`\thedectype` is bound to the type. So we can use

```
\begin{typedec}[for=plus,id=plus-nat.type]{\fntype{\Nat,\Nat}\Nat}
  $+:\thedectype$ is a binary function on $\Nat$
\end{typedec}
```

instead of the `\symtype` above in an informal setting.

### 2.2.4 Definitions, and Definienda

`definition` The `definition` environment is used for marking up mathematical definitions. Its peculiarity is that it defines (i.e. gives a meaning to) new mathematical concepts or objects. These are identified by the `\definiendum` macro, which is used as `\definiendum[\sysname]{\text}`. Here,  $\langle text \rangle$  is the text that is to be emphasized in the presentation and the optional  $\langle sysname \rangle$  is a system name of the symbol defined (for reference via `\termref`, see Section 2.3). If  $\langle sysname \rangle$  is not

```

\symdef{zero}{0}
\begin{symboldec}[name=zero,title=The number zero,type=constant]
  The number zero, it is used as the base case of the inductive definition
  of natural numbers via the Peano Axioms.
\end{symboldec}

\symdef{succ}[1]{\prefix{s}{#1}}
\begin{symboldec}[name=succ,title=The Successor Function,type=application]
  The successor function, it is used for the step case of the inductive
  definition of natural numbers via the Peano Axioms.
\end{symboldec}

\symdef{NaturalNumbers}{\mathbb{N}}
\begin{symboldec}[name=succ,title=The Natural Numbers,type=constant]
  The natural numbers inductively defined via the Peano Axioms.
\end{symboldec}

\begin{axiom}[id=peano.P1,title=P1]
  $\text{\texttt{zero}}$ is a natural number.
\end{axiom}
...
\begin{axiom}[id=peano.P5,title=P5]
  Any property $P$ such $P(\text{\texttt{zero}})$ and $P(\text{\texttt{succ}}\{k\})$ whenever $P(k)$
  holds for all $n$ in $\text{\texttt{NaturalNumbers}}$
\end{axiom}

```

will lead to the result

**Symbol zero: (The number zero)**

The number zero, it is used as the base case of the inductive definition of natural numbers via the Peano Axioms.

**Symbol succ: (The Successor Function)**

The successor function, it is used for the step case of the inductive definition of natural numbers via the Peano Axioms.

**Symbol succ: (The Natural Numbers)**

The natural numbers inductively defined via the Peano Axioms.

**Axiom 2.2 (P1)** 0 is a natural number.

...

**Axiom 2.6 (P5)** Any property  $P$  such  $P(0)$  and  $P(s(k))$  whenever  $P(k)$  holds for all  $n$  in  $\mathbb{N}$

**Example 3:** Semantic Markup for the Peano Axioms

given, then  $\langle text \rangle$  is used as a system name instead, which is usually sufficient for most situations.

```

\symdef{one}{1}
\begin{definition}[id=one.def,for=one]
  $\notatiendum[one]{\one}$ is the successor of $\zero$
  (formally: $\one\colon=\succ\zero$)
\end{definition}

```

will lead to the result

**Definition 2.7** 1 is the successor of 0 (formally:  $1 := s(0)$ )

**Example 4:** A Definition based on Figure 3

**defin**

**\defii**

**\defiii**

**\adefi**

**\adefii**

**\adefiii**

The `\defi{ $\langle word \rangle$ }` macro combines the functionality of the `\definiendum` macro with index markup from the `omdoc` package [Koh12b]: use `\defi[ $\langle name \rangle$ ]{ $\langle word \rangle$ }` to markup a definiendum  $\langle word \rangle$  with system name  $\langle name \rangle$  that appear in the index — in other words in almost all definitions of single-word concepts. We also have the variants `\defii` and `\defiii` for (adjectivized) two-word compounds. Finally, the variants `\adefi`, `\adefii`, and `\adefiii` have an additional first argument that allows to specify an alternative text; see Figure 5

source	system name	result	index
<code>\defin{concept}</code>	concept	concept	concept
<code>\defin[csymbol]{concept}</code>	csymbol	concept	concept
<code>\definalt[csymbol]{concepts}{concept}</code>	csymbol	concepts	concept
<code>\twindex{concept}{group}</code>	concept-group	concept group	concept group, group - , concept
<code>\atwindex{small}{concept}{group}</code>	small-concept-group	small concept group	small concept group, concept group - , small

**Example 5:** Some definienda with Index

Note that the `\definiendum`, `\defi`, `\defii`, and `\defiii` macros can only be used inside the definitional situation, i.e. in a `definition` or `symboldec` environment or a `\inlinedef` macro. If you find yourself in a situation where you want to use it outside, you will most likely want to wrap the appropriate text fragment in a `\begin{definition}[display=flow] ...` and `\end{definition}`. For instance,

we could continue the example in Figure 3 with the `definition` environment in Figure 4.

`\inlinedef` Sometimes we define mathematical concepts in passing, e.g. in a phrase like “... $s(o)$  which we call **one**.”. For this we cannot use the `definition` environment, which presupposes that its content gives all that is needed to understand the definition. But we do want to make use of the infrastructure introduced for the `definition` environment. In this situation, we just wrap the phrase in an `\inlinedef` macro that makes them available. The `\inlinedef` macro accepts the same `id` and `for` keys in its optional argument, and additionally the `verbalizes` key which can be used to point to a full definition of the concept somewhere else.

Note that definienda can only be referenced via a `\term` element, if they are only allowed inside a named module, i.e. a `module` environment with a name given by the `id=` key or the `theory=` key on is specified on the definitional environment.

### 2.2.5 Examples

`example` The `example` environment is a generic statement environment, except that the `for` key should be given to specify the identifier what this is an example for. The `example` environment also expects a `type` key to be specified, so that we know whether this is an example or a counterexample.

`\inlineex` The `\inlineex` is analogous to `\inlinedef`, only that it is used for inline examples, e.g. “...mammals, e.g. goats”. Note that we have used an inline example for an inline example.

As examples need to import foreign vocabularies (those used to construct the example), the example environment provides the `\usevocab` command, a special variant of `\importmodule` that is only available in the `example` environment and the argument of `\inlineex`.

## 2.3 Cross-Referencing Symbols and Concepts

If we have defined a concept with the `\definiendum` macro, then we can mark up other occurrences of the term as referring to this concept. Note that this process cannot be fully automatized yet, since that would need advanced language technology to get around problems of disambiguation, inflection, and non-contiguous phrases<sup>1</sup>. Therefore, the `\termref` can be used to make this information explicit.

`\termref` It takes the keys

- `cdbase` to specify a URI (a path actually, since  $\text{\LaTeX}$  cannot load from URIs) where the module can be found.
- `cd` to specify the module in which the term is defined. If the `cd` key is not given, then the current module is assumed. If no `cdbase` is specified (this is the usual case), then the CD has to be imported via a `\importmodule` from the `modules` package [KGA12].

---

<sup>1</sup>We do have a program that helps annotate larger text collections spotting the easy cases; see <http://kwarc.info/projects/stex> and look for the program `termin`.



`name` to specify the name of the definiendum (which is given in the body of the `\definiendum` or the optional argument). If the `name` key is not specified, then argument of the `\termref` macro is used.

`role` is currently unused.

`\termref[cd=<cd>,name=<name>]{<text>}` will just typeset the link text `<text>` with (if the `hyperref` package is loaded) a hyperlink to the definition in module `<cd>` that defines the concept `<name>`, e.g. that contains `\defi[<name>]{<text>}`.

Just as the `\definiendum` macro has the convenience variants `\defi`, `\defii` and `\defiii`, the `\termref` has variants `\trefi`, `\trefii`, and `\trefiii` that take two and three arguments for the parts of the compositum. In the same module, concepts that are marked up by `\defi{<name>}` in the definition can be referenced by `\trefi{<name>}`. Here the link text is just `<name>`. Concepts defined via `\defii{<first>}{<second>}` can be referenced by `\trefii{<first>}{<second>}` (with link text “`<first> <second>`”) and analogously for `\defiii` and `\trefiii`. Finally, we have variants `\atrefi`, `\atrefii`, and `\atrefiii` with alternative link text. For instance `\atrefii{<text>}{<first>}{<second>}` references a concept introduced by `\defii{<first>}{<second>}` but with link text `<text>`. Of course, if the system identifier is given explicitly in the optional argument of the definition form, as in `\defii[<name>]{<first>}{<second>}`, then the terms are referenced by `\trefi{<name>}`.

For referencing terms outside the current module, the module name can be specified in the first optional argument of the `\*tref*` macros. To specify the `cdbase`, we have to resort to the `\termref` macro with the `keyval` arguments.

Note that the `\termref` treatment above is natural for “concepts” declared by the `\termdef` macro from the `modules` package [KGA12]. Concepts are natural language names for mathematical objects. For “symbols”, i.e. symbolic identifiers for mathematical objects used in mathematical formulae, we use the `\symdef` macro from the `modules` package. Sometimes, symbols also have an associated natural language concept, and we want to use the symbol name to reference it (instead of specifying `cd` and `name` which is more inconvenient). For this the `\symref` `statements` package supplies the `\symref` macro. Like `\termref`, and invocation of `\symref{<cseq>}{<text>}` will just typeset `<text>` with a hyperlink to the relevant definition (i.e. the one that has the declaration `for=<cseq>` in the metadata argument.)

`\symref`

`\term`

The `\term` macro<sup>1</sup> is a variant of the `\termref` macro that marks up a phrase as a (possible) term reference, which does not have a link *yet*. This macro is a convenient placeholder for authoring, where a `\termref` annotation is (currently) too tedious or the link target has not been authored yet. It facilitates lazy flexiformalization workflows, where definitions for mathematical concepts are supplied or marked up by need (e.g. after a `grep` shows that the number of `\term` annotations of a concept is above a threshold). Editors or active documents can also support the `\term` macro like a wiki-like dangling link: a click on `\term{<phrase>}` could generate a new editor buffer with a stub definition (an `definition` environment

<sup>1</sup>EdNOTE: MK: Do we also need a symbol macro in analogy to `symref`?

EdN:2

with `\definiendum` macro and appropriate metadata).<sup>2</sup>

### 3 Configuration of the Presentation

`\defemph` The `\defemph` macro is a configuration hook that allows to specify the style of presentation of the definiendum. By default, it is set to `\bf` as a fallback, since we can be sure that this is always available. It can be customized by redefinition: For instance `\renewcommand{\defemph}[1]{\emph{#1}}`, changes the default behavior to italics.

`\termemph` The `\termemph` macro does the same for the style for `\termref`, it is empty by default. Note the term might carry an implicit hyper-reference to the defining occurrence and that the presentation engine might mark this up, changing this behavior.

`\stdMemph` The `\stdMemph` macro does the same for the style for the markup of the discourse markers like “Theorem”. If it is not defined, it is set to `\bf`; that allows to preset this in the class file.<sup>3</sup>

EdN:3

Some authors like to lowercase the semantic references, i.e. use “axiom 2.6” instead of the default “Axiom 2.6” to refer to the last axiom in Figure 3. This can be achieved by redefining the `\STpresent` macro, which is applied to the keyword of the `ST*Env` theorem environments.<sup>4</sup>

`\STpresent`

EdN:4

Finally, we provide configuration hooks in Figure 6 for the statement types provided by the `statement` package. These are mainly intended for package authors building on `statements`, e.g. for multi-language support.<sup>5</sup>

EdN:5

### 4 Limitations

In this section we document known limitations. If you want to help alleviate them, please feel free to contact the package author. Some of them are currently discussed in the `TeX` TRAC [sTeX].

1. none reported yet

### 5 The Implementation

The `statements` package generates two files: the `LATEX` package (all the code between `<*package>` and `</package>`) and the `LATEXML` bindings (between `<*ltxml>` and `</ltxml>`). We keep the corresponding code fragments together, since the documentation applies to both of them and to prevent them from getting out of sync.

<sup>2</sup>EdNOTE: MK: we probably need multi-part variants for `*tref*`

<sup>3</sup>EdNOTE: function declarations

<sup>4</sup>EdNOTE: this does not quite work as yet, since `STpresent` is applied when the label is written. But we would really like to have it applied when the reference is constructed. But for that we need to split the label into keyword and number in package `sref`.

<sup>5</sup>EdNOTE: we might want to develop an extension `statements-babel` in the future.

Environment	configuration macro	value
STtheoremAssEnv	\st@theorem@kw	Theorem
STlemmaAssEnv	\st@lemma@kw	Lemma
STpropositionAssEnv	\st@proposition@kw	Proposition
STcorollaryAssEnv	\st@corollary@kw	Corollary
STconjectureAssEnv	\st@conjecture@kw	Conjecture
STfalseconjectureAssEnv	\st@falseconjecture@kw	Conjecture (false)
STpostulateAssEnv	\st@postulate@kw	Postulate
STobligationAssEnv	\st@obligation@kw	Obligation
STassumptionAssEnv	\st@assumption@kw	Assumption
STobservationAssEnv	\st@observation@kw	Observation
STexampleEnv	\st@example@kw	Example
STaxiomEnv	\st@axiom@kw	Axiom
STdefinitionEnv	\st@definition@kw	Definition
STnotationEnv	\st@notation@kw	Notation

**Example 6:** Configuration Hooks for statement types

## 5.1 Package Options

We declare some switches which will modify the behavior according to the package options. Generally, an option xxx will just set the appropriate switches to true (otherwise they stay false). First we have the general options

```

1 <*package>
2 \DeclareOption{showmeta}{\PassOptionsToPackage{\CurrentOption}{metakeys}}
3 \DeclareOption*{\PassOptionsToPackage{\CurrentOption}{omdoc}}

```

Finally, we need to declare the end of the option declaration section to L<sup>A</sup>T<sub>E</sub>X.

```

4 \ProcessOptions
5 </package>

```

The next measure is to ensure that some S<sup>T</sup>E<sup>X</sup> packages are loaded: `omdoc` for the statement keys, `modules` since we need module identifiers for referencing. Furthermore, we need the `ntheorem` package for presenting statements. For L<sup>A</sup>-T<sub>E</sub>XML, we also initialize the package inclusions, there we do not need `ntheorem`, since the XML does not do the presentation.

```

6 <*package>
7 \RequirePackage{omtext}
8 \RequirePackage{modules}
9 \RequirePackage[hyperref]{ntheorem}
10 \theoremstyle{plain}
11 </package>
12 <*ltxml>
13 # -*- PERL -*-
14 package LaTeXML::Package::Pool;
15 use strict;
16 use LaTeXML::Package;
17 RequirePackage('omtext');

```

```
18 RequirePackage('modules');
19 </ltxml>
```

Now, we define an auxiliary function that lowercases strings

```
20 <*ltxml>
21 sub lowercase {my ($string) = @_; $string ? return lc(ToString($string)) : return('')}##$
22 sub dashed { join('-',map($_->toString,@_));}##$
23 </ltxml>
```

Sometimes it is necessary to fallback to symbol names in order to generate xml:id attributes. For this purpose, we define an auxiliary function which ensures the name receives a unique NCName equivalent.<sup>6</sup>

```
24 <*ltxml>
25 sub makeNCName {
26   my ($name) = @_;
27   my $ncname=$name;
28   $ncname=~s/\s/_/g; #Spaces to underscores
29   $ncname="_$ncname" if $ncname!~/^(\w|_)/; #Ensure start with letter or underscore
30   ##More to come...
31   $ncname;
32 }
33 </ltxml>
```

The following functions are strictly utility functions that makes our life easier later on

```
34 <*ltxml>
35 sub simple_wrapper {
36   #Deref if array reference
37   my @input;
38   foreach (@_) {
39     if (ref $_ && $_ =~ /ARRAY/ && $_ !~ /LaTeXML/) {
40       @input=(@input,@$_);
41     } else
42       { push (@input,$_); }
43   }
44   return '' if (!@input);
45   @input = map(split(/\s*,\s*/,ToString($_)),@input);
46   my $output=join(" ",@input);
47   $output=~s/^(^)|[\{\}]/g; #remove leading space and list separator brackets
48   $output||'';
49 }
50 sub hash_wrapper{
51   #Deref if array reference
52   my @input;
53   foreach (@_) {
54     if (ref $_ && $_ =~ /ARRAY/ && $_ !~ /LaTeXML/) {
55       @input=(@input,@$_);
56     } else
```

---

<sup>6</sup>EDNOTE: Hard to be unique here, e.g. the names "foo\_bar" and "foo bar" would receive the same xml:id attributes... of course we can devise a more complex scheme for the symbol replacement.

```

57     { push (@input,$_); }
58   }
59   return '' if (!@input);
60   @input = map(split(/\s*,\s*/,ToString($_)),@input);
61   my $output=join(".sym #",@input);
62   $output=~s/(\.sym )|[\{\}]/g; #remove leading space and list separator brackets
63   "$output"||'';
64 }##$
65 \</ltxml>

```

## 5.2 Statements

\STpresent

```

66 <*package>
67 \providecommand\STpresent[1]{#1}
68 </package>

```

\define@statement@env

We define a meta-macro that allows us to define several variants of statements. Upon beginning this environment, we first set the `KeyVal` attributes, then we decide whether to print the discourse marker based on the value of the `display` key, then (given the right Options were set), we show the semantic annotations, and finally initialize the environment using the appropriate macro. Upon ending the environment, we just run the respective termination macro.

```

69 <*package>
70 \def\define@statement@env#1{%
71 \newenvironment{#1}[1][\metasetkeys{omtext}{#1}\sref@target%
72 \ifx\omtext@display\st@flow\else%
73 \ifx\omtext@title\@empty\begin{ST#1Env}\else\begin{ST#1Env}[\omtext@title]\fi%
74 \ifx\sref@id\@empty\else\label{#1.\sref@id}\fi
75 \csname st@#1@initialize\endcsname\fi% display
76 \ifx\sref@id\@empty\sref@label{id{here}}\else%
77 \sref@label{id{\STpresent{\csname ST#1EnvKeyword\endcsname}~\@currentlabel}}\fi%
78 \ignorespaces}
79 {\csname st@#1@terminate\endcsname\ifx\omtext@display\st@flow\else\end{ST#1Env}\fi%
80 \omtext@post@skip}}
81 </package>

```

assertion

```

82 <*package>
83 \newenvironment{assertion}[1][\metasetkeys{omtext}{#1}\sref@target%
84 \ifx\omtext@display\st@flow\else%
85 \ifx\omtext@title\@empty\begin{ST\omtext@type AssEnv}%
86 \else\begin{ST\omtext@type AssEnv}[\omtext@title]\fi\fi%
87 \ifx\omtext@type\@empty\sref@label{id{here}}\else%
88 \sref@label{id{\STpresent{\csname ST\omtext@type AssEnvKeyword\endcsname}~\@currentlabel}}\fi}
89 {\ifx\omtext@display\st@flow\else\end{ST\omtext@type AssEnv}\fi}
90 </package>
91 <*ltxml>
92 DefStatement('assertion' OptionalKeyVals:omtext',

```

```

93  "<omdoc:assertion "
94  .  "?&KeyVal(#1,'id')(xml:id='&KeyVal(#1,'id')')() "
95  .  "?&KeyVal(#1,'theory')(theory='&KeyVal(#1,'theory')')() "
96  .  "type='&lowercase(&KeyVal(#1,'type'))'>"
97  .  "?&KeyVal(#1,'title')(<dc:title>&KeyVal(#1,'title')</dc:title>())"
98  .  "<omdoc:CMP>#body"
99  . "</omdoc:assertion>\n");
100 </ltxml>

```

`\st*@kw` We configure the default keywords for the various theorem environments.

```

101 <*package>
102 \def\st@theorem@kw{Theorem}
103 \def\st@lemma@kw{Lemma}
104 \def\st@proposition@kw{Proposition}
105 \def\st@corollary@kw{Corollary}
106 \def\st@conjecture@kw{Conjecture}
107 \def\st@falseconjecture@kw{Conjecture (false)}
108 \def\st@postulate@kw{Postulate}
109 \def\st@obligation@kw{Obligation}
110 \def\st@assumption@kw{Assumption}
111 \def\st@observation@kw{Observation}

```

Then we configure the presentation of the theorem environments

```

112 \theorembodyfont{\itshape}
113 \theoremheaderfont{\normalfont\bfseries}

```

and then we finally define the theorem environments in terms of the statement keywords defined above. They are all numbered together with the section counter.

`ST*AssEnv`

```

114 \newtheorem{STtheoremAssEnv}{\st@theorem@kw}[section]
115 \newtheorem{STlemmaAssEnv}[STtheoremAssEnv]{\st@lemma@kw}
116 \newtheorem{STpropositionAssEnv}[STtheoremAssEnv]{\st@proposition@kw}
117 \newtheorem{STcorollaryAssEnv}[STtheoremAssEnv]{\st@corollary@kw}
118 \newtheorem{STconjectureAssEnv}[STtheoremAssEnv]{\st@conjecture@kw}
119 \newtheorem{STfalseconjectureAssEnv}[STtheoremAssEnv]{\st@falseconjecture@kw}
120 \newtheorem{STpostulateAssEnv}[STtheoremAssEnv]{\st@postulate@kw}
121 \newtheorem{STobligationAssEnv}[STtheoremAssEnv]{\st@obligation@kw}
122 \newtheorem{STassumptionAssEnv}[STtheoremAssEnv]{\st@assumption@kw}
123 \newtheorem{STobservationAssEnv}[STtheoremAssEnv]{\st@observation@kw}
124 </package>

```

EdN:7

example 7

```

125 <*package>
126 \let\usevocab=\usemodule
127 \let\usemhvocab=\usemhmodule
128 \def\st@example@initialize{}\def\st@example@terminate{}

```

---

<sup>7</sup>EDNOTE: need to do something clever for the OMDoc representation of examples, in particular, the usevocab should only be defined in example

```

129 \define@statement@env{example}
130 \def\st@example@kw{Example}
131 \theorembodyfont{\upshape}
132 \newtheorem{STexampleEnv}[STtheoremAssEnv]{\st@example@kw}
133 \end{package}
134 \end{ltxml}
135 DefMacro('usevocab','usemodule');
136 DefMacro('usemhvocab','usemhmodule');
137 DefStatement('{example} OptionalKeyVals:omtext',
138     "<omdoc:example "
139     . "?&KeyVal(#1,'id')(xml:id='&KeyVal(#1,'id')')() "
140     . "?&KeyVal(#1,'for')(for='&hash_wrapper(&KeyVal(#1,'for'))')()>"
141     . "?&KeyVal(#1,'title')(<dc:title>&KeyVal(#1,'title')</dc:title>())"
142     . "#body"
143     . "</omdoc:example>\n");
144 \end{ltxml}

```

axiom

```

145 \end{package}
146 \def\st@axiom@initialize{}\def\st@axiom@terminate{}
147 \define@statement@env{axiom}
148 \def\st@axiom@kw{Axiom}
149 \theorembodyfont{\upshape}
150 \newtheorem{STaxiomEnv}[STtheoremAssEnv]{\st@axiom@kw}
151 \end{package}
152 \end{ltxml}
153 DefStatement('{axiom} OptionalKeyVals:omtext',
154     "<omdoc:axiom "
155     . "?&KeyVal(#1,'id')(xml:id='&KeyVal(#1,'id')')()>"
156     . "?&KeyVal(#1,'title')(<dc:title>&KeyVal(#1,'title')</dc:title>())"
157     . "<omdoc:CMP>#body"
158     . "</omdoc:axiom>\n");
159 \end{ltxml}

```

symboldec We use \symdef@type from the modules package as the visual cue.

```

160 \end{package}
161 \srefaddidkey{symboldec}
162 \addmetakey{symboldec}{functions}
163 \addmetakey{symboldec}{role}
164 \addmetakey*{symboldec}{title}
165 \addmetakey*{symboldec}{name}
166 \addmetakey{symboldec}{subject}
167 \addmetakey*{symboldec}{display}
168 \newenvironment{symboldec}[1][\metasetkeys{symboldec}{#1}\sref@target\st@indeftrue%
169 \ifx\symboldec@display\st@flow\else\noindent\stDMemph{\symdef@type} \symboldec@name:}\fi%
170 \ifx\symboldec@title\empty~\else~(\stDMemph{\symboldec@title})\par\fi{}
171 \end{package}
172 \end{ltxml}
173 DefStatement('{symboldec} OptionalKeyVals:symboldec',
174     "<omdoc:symbol "

```

```

175 .   "?&KeyVal{#1,'id'}(xml:id='&KeyVal{#1,'id'}')'"
176 .   "(xml:id='&makeNCName(&KeyVal{#1,'name'})).def.sym')"
177 .   "name='&KeyVal{#1,'name'}'>"
178 .   "?&KeyVal{#1,'title'}(<dc:title>&KeyVal{#1,'title'}</dc:title>())"
179 .   "<dc:description>#body"
180 .   "</omdoc:symbol>\n");
181 </ltxml>

```

### 5.2.1 Types

EdN:8

\symtype 8

```

182 <*package>
183 \srefaddidkey{symtype}
184 \addmetakey*{symtype}{system}
185 \addmetakey*{symtype}{for}
186 \newcommand\type@type{Type}
187 \newcommand\symtype[3][]{\metasetkeys{symtype}{#1}\sref@target%
188 \noindent\type@type \ifx\symtype@\empty\else (\symtype@system)\fi #2: $#3$}
189 </package>
190 <*ltxml>
191 DefConstructor('\symtype OptionalKeyVals:omtext {}{}',
192   "<omdoc:type for='#2'"
193   .   "?&KeyVal{#1,'id'}(xml:id='&KeyVal{#1,'id'}.not')()"
194   .   "?&KeyVal{#1,'system'}(xml:id='&KeyVal{#1,'system'}')()>"
195   .   "<ltx:Math><ltx:XMath>#3</ltx:XMath></ltx:Math>"
196   .   "</omdoc:type>");
197 </ltxml>

```

\inlinetypedec

```

198 <*package>
199 \newcommand\inlinetypedec[3][]{\metasetkeys{symtype}{#1}\sref@target{\def\thedectype{#2}#3}}
200 </package>
201 <*ltxml>
202 DefConstructor('\inlinetypedec OptionalKeyVals:omtext {}{}',
203   "<omdoc:type for='&KeyVal{#1,'for'}'"
204   .   "?&KeyVal{#1,'id'}(xml:id='&KeyVal{#1,'id'}.not')()"
205   .   "?&KeyVal{#1,'system'}(xml:id='&KeyVal{#1,'system'}')()>"
206   .   "<ltx:Math><ltx:XMath>#2</ltx:XMath></ltx:Math>"
207   .   "<omdoc:CMP>#body"
208   .   "</omdoc:type>");
209 </ltxml>

```

typedec We first define a theorem environment

```

210 <*package>
211 \def\st@typedec@kw{Type Declaration}
212 \theorembodyfont{\upshape}
213 \newtheorem{STtypedecEnv}[STtheoremAssEnv]{\st@typedec@kw}

```

---

<sup>8</sup>EdNOTE: MK@DG; the type element should percolate up.



and then the environment itself.

```

214 \newenvironment{typedec}[2][\metasetkeys{omtext}{#1}\sref@target%
215 \def\thedectype{#2}%
216 \ifx\omtext@display\st@flow\else%
217 \ifx\omtext@title\@empty\begin{STtypedecEnv}\else\begin{STtypedecEnv}[\omtext@title]\fi%
218 \ifx\sref@id\@empty\else\label{typedec.\sref@id}\fi
219 \ifx\sref@id\@empty\sref@label@id{here}\else%
220 \sref@label@id{\STpresent{\csname STtypedecEnvKeyword\endcsname}\~\@currentlabel}\fi%
221 \ignorespaces}
222 {\ifx\omtext@display\st@flow\else\end{STtypedecEnv}\fi\omtext@post@skip}
223 \end{package}
224 \end{*ltxml}
225 DefStatement('typedec OptionalKeyVals:omtext {}',
226   "<omdoc:type for='&KeyVal{#1,'for'}">
227     "&KeyVal{#1,'id'}(xml:id='&KeyVal{#1,'id'}.not')()"
228     "&KeyVal{#1,'system'}(xml:id='&KeyVal{#1,'system'}')()>"
229     "&KeyVal{#1,'title'}(<dc:title>&KeyVal{#1,'title'}</dc:title>())"
230     "<ltx:Math><ltx:XMath>#2</ltx:XMath></ltx:Math>"
231     "<omdoc:CMP>#body"
232     "</omdoc:type>");
233 \end{*ltxml}

```

**definition** The definition environment itself is quite similar to the other's but we need to set the `\st@indef` switch to suppress warnings from `\st@def@target`.

```

234 \end{package}
235 \newif\ifst@indef\st@indeffalse
236 \newenvironment{definition}[1][\metasetkeys{omtext}{#1}\sref@target\st@indeftrue%
237 \ifx\omtext@display\st@flow\else%
238 \ifx\omtext@title\@empty\begin{STdefinitionEnv}\else\begin{STdefinitionEnv}[\omtext@title]\fi%
239 \ifx\sref@id\@empty\sref@label@id{here}\else%
240 \sref@label@id{\STpresent{\csname STdefinitionEnvKeyword\endcsname}\~\@currentlabel}\fi%
241 \ignorespaces}
242 {\ifx\omtext@display\st@flow\else\end{STdefinitionEnv}\fi}
243 \def\st@definition@kw{Definition}
244 \theorembodyfont{\upshape}
245 \newtheorem{STdefinitionEnv}[STtheoremAssEnv]{\st@definition@kw}
246 \end{package}
247 \end{*ltxml}
248 sub definitionBody {
249   my ($doc, $keyvals, %props) = @_;
250   my $for = $keyvals->getValue('for') if $keyvals;
251   my $type = $keyvals->getValue('type') if $keyvals;
252   my %for_attr=();
253   if (ToString($for)) {
254     $for = ToString($for);
255     $for =~ s/{(.+)}$/1/eg;
256     foreach (split(/,\\s/, $for)) {
257       $for_attr{$_}=1;
258     }

```

```

259   if ($props{theory}) {
260     my @symbols = @{$props{defs} || []};
261     foreach my $symb(@symbols) {
262       next if $for_attr{$symb};
263       $for_attr{$symb}=1;
264       $doc->insertElement('omdoc:symbol', undef, (name=>$symb, "xml:id"=>makeNCName("$symb.def.
265     }
266   }
267   my %attrs = ();
268   $for = join(" ",(keys %for_attr));
269   $attrs{'for'} = $for if $for;
270   my $id = $keyvals->getValue('id') if $keyvals;
271   $attrs{'xml:id'} = $id if $id;
272   $attrs{'type'} = $type if $type;
273   if ($props{theory}) {
274     $doc->openElement('omdoc:definition', %attrs);
275   } else {
276     $attrs{'type'}='definition';
277     $doc->openElement('omdoc:omtext', %attrs);
278   }
279   my $title = $keyvals->getValue('title') if $keyvals;
280   if ($title) {
281     $doc->openElement('omdoc:metadata');
282     $doc->openElement('dc:title');
283     $doc->absorb($title);
284     $doc->closeElement('dc:title');}
285   $doc->openElement('omdoc:CMP');
286   $doc->absorb($props{body}) if $props{body};
287   $doc->maybeCloseElement('omdoc:CMP');
288   if ($props{theory}) {
289     $doc->closeElement('omdoc:definition');
290   } else {
291     $doc->closeElement('omdoc:omtext');
292   }
293   return; }
294 # We use the standard DefEnvironment here, since
295 # afterDigestBegins would collide otherwise
296 DefEnvironment('{definition} OptionalKeyVals:omtext', sub{definitionBody(@_)},
297   afterDigestBegin=>sub {
298     my ($stomach, $whatsit) = @_;
299     my @symbols = ();
300     $whatsit->setProperty(theory=>LookupValue('current_module'));
301     $whatsit->setProperty(defs=>\@symbols);
302     AssignValue('defs', \@symbols);
303     declareFunctions($stomach,$whatsit);
304     return; },
305   afterDigest => sub { AssignValue('defs', undef); return; });
306 </ltxml>

```

**notation** We initialize the `\def\st@notation@initialize{}` here, and extend it with func-

tionality below.

```

307 <*package>
308 \def\notemph#1{#1}
309 \def\st@notation@terminate{}
310 \def\st@notation@initialize{}
311 \define@statement@env{notation}
312 \def\st@notation@kw{Notation}
313 \theorembodyfont{\upshape}
314 \newtheorem{STnotationEnv}[STtheoremAssEnv]{\st@notation@kw}
315 </package>
316 <*xml>
317 DefStatement('notation' OptionalKeyVals:omtext',
318   "<omdoc:definition "
319   .   "?&KeyVal{#1,'id'}(xml:id='&KeyVal{#1,'id'}.not')()"
320   .   "?&KeyVal{#1,'for'}(for='&simple_wrapper(&KeyVal{#1,'for'})')()>"
321   .   "?&KeyVal{#1,'title'}(<dc:title>&KeyVal{#1,'title'}</dc:title>())"
322   .   "<omdoc:CMP>#body"
323   .   "</omdoc:definition>\n");
324 DefConstructor('\notatiendum OptionalKeyVals:notation {}',
325   "<ltx:text class='notatiendum'>#2</ltx:text>");
326 </xml>

```

`\st@def@target` the next macro is a variant of the `\sref@target` macro provided by the `sref` package specialized for the use in the `\definiendum`, `\defi`, `\defii`, and `\defiii` macros. `\st@def@target{<opt>}{<name>}` makes a target with label `sref@<opt>@<module name>@target`, if `<opt>` is non-empty, else with the label `sref@<name>@<module name>@target`. Also it generates the necessary warnings for a `definiendum`-like macro.

```

327 <*package>
328 \def\st@def@target#1#2{\def\@test{#1}%
329 \ifst@indef% if we are in a definition or such
330 \@ifundefined{mod@id}% if we are not in a module
331 {\PackageWarning{statements}{definiendum in unidentified module}\MessageBreak
332 \protect\definiendum, \protect\defi,
333 \protect\defii, \protect\defiii}\MessageBreak
334 can only be referenced when called in a module with id key}}%
335 {\edef\@cd{\ifx\omtext@theory\empty\mod@id\else\omtext@theory\fi}%
336 \edef\@name{\ifx\@test\empty{#2}\else{#1}\fi}%
337 \expandafter\sref@target@ifh{sref@\@name @\@cd @target}{}}%
338 \ifmetakeys@showmeta\metakeys@show@keys{\@cd}{name:\@name}\fi}%
339 \else% st@indef
340 \PackageError{statements}%
341 {definiendum outside definition context}\MessageBreak
342 \protect\definiendum, \protect\defi,
343 \protect\defii, \protect\defiii}\MessageBreak
344 do not make sense semantically outside a definition.\MessageBreak
345 Consider wrapping the defining phrase in a \protect\inlinedef}%
346 \fi}
347 </package>

```

The `\definiendum` and `\notatiendum` macros are very simple.

`\@termdef` This macro is experimental, it is supposed to be invoked in `\definiendum` to define a macro with the `\definiendum` text, so that can be re-used later in term assignments (see the `modules` package). But in the current context, where we rely on  $\TeX$  groupings for visibility, this does not work, since the invocations of `\definiendum` are in `definition` environments and thus one group level too low. Keeping this for future reference.

```
348 \package
349 \newcommand\@termdef[2] [] {\def\@test{#1}%
350 \ifundefined{mod@id}{\ifx\@test\empty\def\@name{#2}\else\def\@name{#1}\fi%
351 \termdef{mod@id @\@name}{#2}}
352 \package
```

`\definiendum`

```
353 \package
354 %\newcommand\definiendum[2] [] {\st@def@target{#1}{#2}\@termdef{#1}{#2}\defemph{#2}}
355 \newcommand\definiendum[2] [] {\st@def@target{#1}{#2}\defemph{#2}}
356 \package
357 \ltxml
358 DefConstructor('definiendum [] {}',
359 " <omdoc:term role='definiendum' name='#name' cd='#theory'>#2</omdoc:term>",
360 afterDigest => sub {
361 my ($stomach, $whatsit) = @_;
362 my $addr = LookupValue('defs');
363 my $name = $whatsit->getArg(1);
364 $name = $whatsit->getArg(2) unless $name;
365 $whatsit->setProperty(name=>$name->toString);
366 push(@$addr, $name->toString) if ($addr and $name);
367 $whatsit->setProperty(theory=>LookupValue('current_module'));
368 return; });#$
369 \ltxml
```

`\notatiendum` the `\notatiendum` macro also needs to be visible in the `notation` and `definition` environments

```
370 \package
371 \newcommand\notatiendum[2] [] {\notemph{#2}}
372 \package
```

We expand the L<sup>A</sup>T<sub>E</sub>XML bindings for `\defi`, `\defii` and `\defiii` into two instances one will be used for the definition and the other for indexing.

`\defi`

```
373 \package
374 \newcommand\defi[2] [] {\definiendum{#1}{#2}\omdoc@index{#1}{#2}}
375 \package
376 \ltxml
377 DefConstructor('defi [] {}',
378 " <omdoc:idx>"
```

```

379 . " <omdoc:idx>"
380 . " <omdoc:term role='definiendum' name='?#1(#1)(#2)' cd='#theory'>#2</omdoc:term>"
381 . "</omdoc:idx>"
382 . " <omdoc:ide index='default'><omdoc:idp>#2</omdoc:idp></omdoc:ide>"
383 . "</omdoc:idx>",
384 . afterDigest => sub {
385 my ($stomach, $whatsit) = @_;
386 my $addr = LookupValue('defs');
387 my $name = $whatsit->getArg(1);
388 $name = $whatsit->getArg(2) unless $name;
389 push(@$addr, $name->toString) if ($addr and $name);
390 $whatsit->setProperty(theory=>LookupValue('current_module'));#$
391 return; },
392 . alias=>'defi');
393 </ltxml>

\adefi
394 <*package>
395 \newcommand\adefi[3] [] {\def\@test{#1}%
396 \ifx\@test\@empty\definiendum[#3]{#2}%
397 \else\definiendum[#1]{#2}\omdoc@index[#1]{#3}\fi}
398 </package>
399 <*ltxml>
400 DefConstructor('\adefi[] {} {}',
401 . " <omdoc:idx>"
402 . " <omdoc:idx>"
403 . " <omdoc:term role='definiendum' name='?#1(#1)(#3)' cd='#theory'>#2</omdoc:term>"
404 . "</omdoc:idx>"
405 . " <omdoc:ide index='default'><omdoc:idp>#3</omdoc:idp></omdoc:ide>"
406 . "</omdoc:idx>",
407 . afterDigest => sub {
408 my ($stomach, $whatsit) = @_;
409 my $addr = LookupValue('defs');
410 my $name = $whatsit->getArg(1);
411 $name = $whatsit->getArg(3) unless $name;
412 push(@$addr, $name->toString) if ($addr and $name);
413 $whatsit->setProperty(theory=>LookupValue('current_module'));#$
414 return; },
415 . alias=>'adefi');
416 </ltxml>

\defii
417 <*package>
418 \newcommand\defii[3] [] {\st@def@target{#1}{#2-#3}\defemph{#2 #3}\@twin[#1]{#2}{#3}}
419 </package>
420 <*ltxml>
421 DefConstructor('\defii[] {} {}',
422 . " <omdoc:idx>"
423 . " <omdoc:idx>"
424 . " <omdoc:term role='definiendum' name='?#1(#1)(\&dashed{#2,#3})' cd='#theory'>"

```

```

425 .      "#2 #3"
426 .      "</omdoc:term>"
427 .      "</omdoc:idt>"
428 .      "<omdoc:ide index='default'>"
429 .      "<omdoc:idp>#2</omdoc:idp>"
430 .      "<omdoc:idp>#3</omdoc:idp>"
431 .      "</omdoc:ide>"
432 .      "</omdoc:idx>",
433 .      afterDigest => sub {
434 my ($stomach, $whatsit) = @_;
435 my $addr = LookupValue('defs');
436 my $name = $whatsit->getArg(1);
437 $name = $name->toString if $name;
438 $name = $whatsit->getArg(2)->toString.'-'. $whatsit->getArg(3)->toString unless $name;
439 push(@$addr, $name) if ($addr and $name);
440 $whatsit->setProperty(theory=>LookupValue('current_module'));
441 return; },
442 .      alias=>'defii');#$
443 </ltxml>

```

\adefii

```

444 <*package>
445 \newcommand\adefii[4][\def\@test{#1}%
446 \ifx\@test\empty\definiendum[#3-#4]{#2}%
447 \else\definiendum[#1]{#2}\@twin[#1]{#3}{#4}\fi}
448 </package>
449 <*ltxml>
450 DefConstructor('\adefii[]{}{}{}',
451 .      "<omdoc:idx>"
452 .      "<omdoc:idt>"
453 .      "<omdoc:term role='definiendum' name='?#1(#1)(&dashed(#3,#4))' cd='#theory'>"
454 .      "#2"
455 .      "</omdoc:term>"
456 .      "</omdoc:idt>"
457 .      "<omdoc:ide index='default'>"
458 .      "<omdoc:idp>#3</omdoc:idp>"
459 .      "<omdoc:idp>#4</omdoc:idp>"
460 .      "</omdoc:ide>"
461 .      "</omdoc:idx>",
462 .      afterDigest => sub {
463 my ($stomach, $whatsit) = @_;
464 my $addr = LookupValue('defs');
465 my $name = $whatsit->getArg(1);
466 $name = $name->toString if $name;
467 $name = $whatsit->getArg(3)->toString.'-'. $whatsit->getArg(4)->toString unless $name;
468 push(@$addr, $name) if ($addr and $name);
469 $whatsit->setProperty(theory=>LookupValue('current_module'));
470 return; },
471 .      alias=>'defii');#$
472 </ltxml>

```

\defiii

```
473 <*package>
474 \newcommand\defiii[4][\st@def@target{#1}{#2-#3-#4}\defemph{#2 #3 #4}\@atwin[#1]{#2}{#3}{#4}}
475 </package>
476 <*ltxml>
477 DefConstructor('\defiii[]{}{}{}',
478     "<omdoc:idx>"
479     . "<omdoc:idt>"
480     . "<omdoc:term role='definiendum' cd='#theory' name='?#1(#1)(\&dashed(#2,#3,#4))'>#2 #3"
481     . "</omdoc:idt>"
482     . "<omdoc:ide index='default'>"
483     . "<omdoc:idp>#2</omdoc:idp>"
484     . "<omdoc:idp>#3</omdoc:idp>"
485     . "<omdoc:idp>#4</omdoc:idp>"
486     . "</omdoc:ide>"
487     . "</omdoc:idx>",
488     afterDigest => sub {
489 my ($stomach, $whatsit) = @_;
490 my $addr = LookupValue('defs');
491 my $name = $whatsit->getArg(1);
492 $name = $name->toString if $name;
493 $name = $whatsit->getArg(2)->toString.'-'. $whatsit->getArg(3)->toString.'-'. $whatsit->getArg(4)
494 push(@$addr, $name) if ($addr and $name);
495 $whatsit->setProperty(theory=>LookupValue('current_module'));
496 return; },
497     alias=>'defiii');
498 </ltxml>
```

\adefiii

```
499 <*package>
500 \newcommand\adefiii[5][\def\@test{#1}%
501 \ifx\@test\empty\definiendum[#3-#4-#5]{#2}%
502 \else\definiendum[#1]{#2}\@atwin[#1]{#3}{#4}{#5}\fi}
503 </package>
504 <*ltxml>
505 DefConstructor('\adefiii[]{}{}{}{}',
506     "<omdoc:idx>"
507     . "<omdoc:idt>"
508     . "<omdoc:term role='definiendum' cd='#theory' name='?#1(#1)(\&dashed(#3,#4,#5))'>#2</omdoc:term"
509     . "</omdoc:idt>"
510     . "<omdoc:ide index='default'>"
511     . "<omdoc:idp>#3</omdoc:idp>"
512     . "<omdoc:idp>#4</omdoc:idp>"
513     . "<omdoc:idp>#5</omdoc:idp>"
514     . "</omdoc:ide>"
515     . "</omdoc:idx>",
516     afterDigest => sub {
517 my ($stomach, $whatsit) = @_;
518 my $addr = LookupValue('defs');
519 my $name = $whatsit->getArg(1);
```

```

520 $name = $name->toString if $name;
521 $name = $whatsit->getArg(3)->toString.'-'. $whatsit->getArg(4)->toString.'-'. $whatsit->getArg(5)
522 push(@$addr, $name) if ($addr and $name);
523 $whatsit->setProperty(theory=>LookupValue('current_module'));
524 return; },
525     alias=>'defiii');
526 </ltxml>

\inlineex
527 <*package>
528 \newcommand\inlineex[2] [] {\metasetkeys{omtext}{#1}%
529 \sref@target\sref@label{id{here}}#2}
530 </package>
531 <*ltxml>
532 DefConstructor('\inlineex OptionalKeyVals:omtext {}',
533     "<ltx:text class='example'>#2</ltx:text>");
534 </ltxml>

\inlinedef
535 <*package>
536 \newcommand\inlinedef[2] [] {\metasetkeys{omtext}{#1}\sref@target\sref@label{id{here}}\st@indeftru
537 </package>
538 <*ltxml>
539 DefConstructor('\inlinedef OptionalKeyVals:omtext {}', sub {
540 my ($document, $keyvals, $body, %props) = @_;
541 my $for = $keyvals->getValue('for') if $keyvals;
542 my %for_attr=();
543 if (ToString($for)) {
544     $for = ToString($for);
545     $for =~ s/^(.+)$/$/1/eg;
546     foreach (split(/, \s*/, $for)) {
547         $for_attr{$_}=1;
548     }
549 my @symbols = @{$props{defs} || []};
550 #Prepare for symbol insertion -insert before the parent of the closest ancestor CMP element
551 my $original_node = $document->getNode;
552 my $xc = XML::LibXML::XPathContext->new( $original_node );
553 $xc->registerNs('omdoc', 'http://omdoc.org/ns');
554 my ($statement_ancestor) = $xc->findnodes('..ancestor::omdoc:CMP/..');
555 foreach my $symb(@symbols) {
556     next if $for_attr{$symb};
557     $for_attr{$symb}=1;
558     my $symbolnode = XML::LibXML::Element->new('symbol');
559     $symbolnode->setAttribute(name=>$symb);
560     $symbolnode->setAttribute("xml:id"=>makeNCName("$symb.def.sym"));
561     $statement_ancestor->parentNode->insertBefore($symbolnode,$statement_ancestor);
562 }
563 #Restore the insertion point
564 $document->setNode($original_node);
565 my %attrs = ();

```



```

566 $for = join(" ",(keys %for_attr));
567 $attrs{'for'} = $for if $for;
568 my $id = $keyvals->getValue('id') if $keyvals;
569 $attrs{'xml:id'} = $id if $id;
570 $attrs{'class'} = 'inlinedef';
571 $document->openElement('ltx:text',%attrs);
572 $document->absorb($body);
573 $document->closeElement('ltx:text'); },
574 #Prepare 'defs' hooks for \defi and \definiendum symbol names
575 beforeDigest=>sub {
576     my @symbols = ();
577     AssignValue('defs', \@symbols); return; },
578 #Adopt collected names as 'defs' property, remove hooks
579 afterDigest=>sub {
580     my ($stomach, $whatsit) = @_;
581     my $defsref = LookupValue('defs');
582     my @defs = @$defsref;
583     $whatsit->setProperty('defs',\@defs);
584     AssignValue('defs',undef);
585 return; });#$
586 </ltxml>

```

### 5.3 Cross-Referencing Symbols and Concepts

`\termref@set` The term macro uses the `cd` and `name` keys for hyperlinking to create hyper-refs, if the `hyperref` package is loaded: We first see if the `cd` key was given, if not we define it as the local module identifier.

```

587 <*package>
588 \addmetakey*[\mod@id]{termref}{cd}
589 \addmetakey*{termref}{cdbname}
590 \addmetakey*{termref}{name}
591 \addmetakey*{termref}{role}
592 \def\termref@set#1#2{\def\termref@name{#2}\metasetkeys{termref}{#1}}

```

`\termref`

```

593 \newcommand\termref[2] [] {\metasetkeys{termref}{#1}\st@termref{#2}}
594 </package>
595 <*ltxml>
596 DefConstructor('\termref OptionalKeyVals:termref {}',
597     "<omdoc:term "
598     . " ?&KeyVal{#1,'cdbname'}(cdbname='&KeyVal{#1,'cdbname'}')() "
599     . " cd='?&KeyVal{#1,'cd'}(&KeyVal{#1,'cd'})(#module)' "
600     . " name='&KeyVal{#1,'name'}'>"
601     . "#2"
602     . "</omdoc:term>",
603     afterDigest=>sub{$_[1]->setProperty(module=>LookupValue('current_module'))});
604 </ltxml>%$

```

The next macro is where the actual work is done.

`\st@termref` If the `cdbase` is given, then we make a hyper-reference, otherwise we punt to `\mod@termref`, which can deal with the case where the `cdbase` is given by the imported `cd`.

```
605 <*package>
606 \newcommand\st@termref[1]{\ifx\termref@name\@empty\def\termref@name{#1}\fi%
607 \ifx\termref@cdbase\@empty\mod@termref\termref@cd\termref@name{#1}%
608 \else\sref@href@ifh\termref@cdbase{#1}\fi}
609 </package>
```

`\tref*`

```
610 <ltxml>RawTeX('
611 <*package | ltxml>
612 \newcommand\atrefi[3][]{\def\@test{#1}\ifx\@test\@empty\termref[name=#3]{#2}\else\termref[cd=#1
613 \newcommand\atrefii[4][]{\atrefi[#1]{#2}{#3-#4}}
614 \newcommand\atrefiii[5][]{\atrefi[#1]{#2}{#3-#4-#5}}
```

`\tref*`

```
615 \newcommand\trefi[2][]{\atrefi[#1]{#2}{#2}}
616 \newcommand\trefii[3][]{\atrefi[#1]{#2 #3}{#2-#3}}
617 \newcommand\trefiii[4][]{\atrefi[#1]{#2 #3 #4}{#2-#3-#4}}
618 </package | ltxml>
619 <ltxml>');;
```

Now we care about the configuration switches, they are set to sensible values, if they are not defined already. These are just configuration parameters, which should not appear in documents, therefore we do not provide L<sup>A</sup>T<sub>E</sub>X<sub>M</sub>L bindings for them.

`\*emph`

```
620 <*package>
621 \providecommand{\termemph}[1]{#1}
622 \providecommand{\defemph}[1]{\textbf{#1}}
623 \providecommand{\stDMemph}[1]{\textbf{#1}}
624 </package>
```

EdN:9 `\term` The `\term` macro is used for wiki-style dangling links with editor support.<sup>9</sup>

```
625 <*package>
626 \newcommand\term[1]{\textcolor{blue}{\underline{#1}}}
627 </package>
628 <ltxml>
629 DefConstructor('\term{}', "<omdoc:term class='dangling-term-link'>#1</omdoc:term>");
630 </ltxml>
```

`\symref` The `\symref` macros is quite simple, since we have done all the heavy lifting in the `modules` package: we simply apply `\mod@symref@<arg1>` to `<arg2>`.

```
631 <*package>
632 \newcommand\symref[2]{\@nameuse{mod@symref@#1}{#2}}
```

---

<sup>9</sup>EdNOTE: MK: document above

```

633 </package>
634 <*!xml>
635 DefConstructor('\symref{}{}',
636               "<omdoc:term cd='&LookupValue('symdef.#1.cd')' name='&LookupValue('symdef.#1.nam
637               .   "#2"
638               . "</omdoc:term>");
639 </!xml>

```

## 5.4 Providing IDs for OMDoc Elements

To provide default identifiers, we tag all OMDoc elements that allow `xml:id` attributes by executing the `numberIt` procedure from `omdoc.sty.ltxml`.

```

640 <*!xml>
641 Tag('omdoc:assertion',afterOpen=>\&numberIt,afterClose=>\&locateIt);
642 Tag('omdoc:definition',afterOpen=>\&numberIt,afterClose=>\&locateIt);
643 Tag('omdoc:example',afterOpen=>\&numberIt,afterClose=>\&locateIt);
644 Tag('omdoc:equation',afterOpen=>\&numberIt,afterClose=>\&locateIt);
645 Tag('omdoc:axiom',afterOpen=>\&numberIt,afterClose=>\&locateIt);
646 Tag('omdoc:symbol',afterOpen=>\&numberIt,afterClose=>\&locateIt);
647 Tag('omdoc:type',afterOpen=>\&numberIt,afterClose=>\&locateIt);
648 Tag('omdoc:term',afterOpen=>\&numberIt,afterClose=>\&locateIt);
649 </!xml>

```

## 5.5 Auxiliary Functionality

```

650 <*!xml>
651 # =====
652 #   Auxiliary Functions:                                     #
653 #   =====
654 sub DefStatement {
655   my ($definition,$replacement,%properties)=@_;
656   DefEnvironment($definition,$replacement,%properties,
657                 afterDigestBegin=>\&declareFunctions,
658 );}
659
660 sub declareFunctions{
661   my ($stomach,$whatsit) = @_;
662   my $keyval = $whatsit->getArg(1);
663   my $funval = KeyVal($keyval,'functions') if KeyVal($keyval,'functions');
664   return unless $funval;
665   my @funsyms = $funval->unlist;
666   #Unread the function declarations at the Gullet
667   foreach (@funsyms) {
668     my $symb = UnTeX($_);
669     $stomach->getGullet->unread(Tokenize('\lxDeclare[role=FUNCTION]{$'.$symb.'$}')->unlist);
670   }
671   return; }#$
672 </!xml>

```

## 5.6 Deprecated Functionality

In this section we centralize old interfaces that are only partially supported any more.

`\*def*`

```

673 <ltxml>##### Deprecated functionality:
674 <ltxml>RawTeX('
675 <*package | ltxml>
676 \newcommand\defin[2] [] {\defi[#1]{#2}%
677 \PackageWarning{statements}{\protect\defin\space is deprecated, use \protect\defi\space instead
678 \newcommand\twindef[3] [] {\defii[#1]{#2}{#3}%
679 \PackageWarning{statements}{\protect\twindef\space is deprecated, use \protect\defii\space inst
680 \newcommand\atwindef[4] [] {\defiii[#1]{#2}{#3}{#4}%
681 \PackageWarning{statements}{\protect\atwindef\space is deprecated, use \protect\defiii\space in
682 \newcommand\definalt[3] [] {\adei[#1]{#2}{#3}%
683 \PackageWarning{statements}{\protect\definalt\space is deprecated, use \protect\adei\space ins
684 \newcommand\twindefalt[4] [] {\adeii[#1]{#2}{#3}{#4}%
685 \PackageWarning{statements}{\protect\twindefalt\space is deprecated, use \protect\adeii\space
686 \newcommand\atwindefalt[5] [] {\adeiii[#1]{#2}{#3}{#4}{#5}%
687 \PackageWarning{statements}{\protect\atwindefalt\space is deprecated, use \protect\adeiii\space

```

`\*def*`

```

688 \newcommand\twinref[3] [] {\trefii[#1]{#2}{#3}%
689 \PackageWarning{statements}{\protect\twinref\space is deprecated, use \protect\trefii\space ins
690 \newcommand\atwinref[4] [] {\atrefiii[#1]{#2}{#3}{#4}%
691 \PackageWarning{statements}{\protect\atwinref\space is deprecated, use \protect\trefiii\space i
692 </package | ltxml>
693 <ltxml>');

```

## 5.7 Finale

Finally, we need to terminate the file with a success mark for perl.

```

694 <ltxml>1;

```

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## References

- [KGA12] Michael Kohlhase, Deyan Ginev, and Rares Ambrus. *modules.sty: Semantic Macros and Module Scoping in sTeX*. Self-documenting L<sup>A</sup>T<sub>E</sub>X package. Comprehensive T<sub>E</sub>X Archive Network (CTAN), 2012. URL: <http://www.ctan.org/get/macros/latex/contrib/stex/modules/modules.pdf>.
- [Koh06] Michael Kohlhase. *OMDOC – An open markup format for mathematical documents [Version 1.2]*. LNAI 4180. Springer Verlag, Aug. 2006. URL: <http://omdoc.org/pubs/omdoc1.2.pdf>.
- [Koh08] Michael Kohlhase. “Using L<sup>A</sup>T<sub>E</sub>X as a Semantic Markup Format”. In: *Mathematics in Computer Science 2.2* (2008), pp. 279–304. URL: <https://svn.kwarc.info/repos/stex/doc/mcs08/stex.pdf>.
- [Koh12a] Michael Kohlhase. *metakeys.sty: A generic framework for extensible Metadata in L<sup>A</sup>T<sub>E</sub>X*. Self-documenting L<sup>A</sup>T<sub>E</sub>X package. Comprehensive T<sub>E</sub>X Archive Network (CTAN), 2012. URL: <http://www.ctan.org/tex-archive/macros/latex/contrib/stex/metakeys/metakeys.pdf>.
- [Koh12b] Michael Kohlhase. *omdoc.sty/cls: Semantic Markup for Open Mathematical Documents in L<sup>A</sup>T<sub>E</sub>X*. Self-documenting L<sup>A</sup>T<sub>E</sub>X package. Comprehensive T<sub>E</sub>X Archive Network (CTAN), 2012. URL: <http://www.ctan.org/tex-archive/macros/latex/contrib/stex/omdoc/omdoc.pdf>.
- [Koh12c] Michael Kohlhase. *sref.sty: Semantic Crossreferencing in L<sup>A</sup>T<sub>E</sub>X*. Self-documenting L<sup>A</sup>T<sub>E</sub>X package. Comprehensive T<sub>E</sub>X Archive Network (CTAN), 2012. URL: <http://www.ctan.org/tex-archive/macros/latex/contrib/stex/sref/sref.pdf>.
- [MS] Wolfgang May and Andreas Schedler. *An Extension of the L<sup>A</sup>T<sub>E</sub>X-Theorem Environment*. Self-documenting L<sup>A</sup>T<sub>E</sub>X package. URL: <http://dante.ctan.org/tex-archive/macros/latex/contrib/ntheorem/ntheorem.pdf> (visited on 01/11/2010).
- [sTeX] *Semantic Markup for L<sup>A</sup>T<sub>E</sub>X*. Project Homepage. URL: <http://trac.kwarc.info/sTeX/> (visited on 02/22/2011).