

The zref package

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Abstract

Package `zref` tries to get rid of the restriction in \LaTeX 's reference system that only two properties are supported. The package implements an extensible referencing system, where properties are handled in a more flexible way. It offers an interface for macro programmers for the access to the system and some applications that uses the new reference scheme.

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1 Introduction

Standard L^AT_EX's reference system with `\label`, `\ref`, and `\pageref` supports two properties, the appearance of the counter that is last incremented by `\refstepcounter` and the page with the `\label` command.

Unhappily L^AT_EX does not provide an interface for adding another properties. Packages such as `hyperref`, `nameref`, or `titleref` are forced to use ugly hacks to extend the reference system. These ugly hacks are one of the causes for `hyperref`'s difficulty regarding compatibility with other packages.

1.1 Standard L^AT_EX behaviour

References are created by the `\label` command:

```
\chapter{Second chapter}
\section{First section on page 7} % section 2.1
\label{myref}
```

Now L^AT_EX records the section number 2.1 and the page 7 in the reference. Internally the reference is a list with two entries:

```
\r@myref → {2.1}{7}
```

The length of the list is fixed in the L^AT_EX kernel. An interface for adding new properties is missing.

There are several tries to add new properties:

hyperref uses a list of five properties instead of the standard list with two entries. This causes many compatibility problems with L^AT_EX and other packages.

titleref stores its title data into the first entry in the list. L^AT_EX is happy because it does only see its list with two entries. The situation becomes more difficult, if more properties are added this way. Then the macros form a nested structure inside the first reference argument for the label. Expandable extractions will then become painful.

1.2 Basic idea

Some time ago Morten Høgholm sent me an experimental cross referencing mechanism as “expl3” code. His idea is:

```
\g_xref_mylabel_plist →
  \xref_dance_key{salsa}\xref_name_key{Morten}...
```

The entries have the following format:

```
\xref_{your key}_key{(some text)}
```

This approach is much more flexible:

- New properties can easily be added, just use a new key.
- The length of the list is not fixed. A reference can use a subset of the keys.
- The order of the entries does not matter.

Unhappily I am not familiar with the experimental code for L^AT_EX3 that will need some time before its first release. Thus I have implemented it as L^AT_EX 2_ε package without disturbing the existing L^AT_EX reference system.

1.3 Interfaces

The package provides a generic *interface for programmers*. Commands of this interface are prefixed by `\zref@`.

Option `user` enables the *user interface*. Here the commands are prefixed by `\z` to avoid name clashes with existing macros.

Then the packages provides some *modules*. They are applications for the reference system and can also be considered as examples how to use the reference system.

The modules can be loaded as packages. The package name is prefixed with `zref-`, for example:

```
\RequirePackage{zref-abspage}
```

This is the preferred way if the package is loaded from within other packages to avoid option clashes.

As alternative package `zref` can be used and the modules are given as options:

```
\usepackage[perpage,user]{zref}
```

2 Interface for programmers

The user interface is described in the next section 3.

2.1 Entities

Reference. Internally a reference is a list of key value pairs:

```
\Z@R@myref → \default{2.1}\page{7}
```

The generic format of a entry is:

```
\Z@R@⟨refname⟩ → \⟨propname⟩{⟨value⟩}
```

`⟨refname⟩` is the name that denoted references (the name used in `\label` and `\ref`). `⟨propname⟩` is the name of the property or key. The property key macro is never executed, it is used in parameter text matching only.

Property. Because the name of a property is used in a macro name that must survive the `.aux` file, the name is restricted to letters and ‘@’.

Property list. Often references are used for special purposes. Thus it saves memory if just the properties are used in this reference that are necessary for its purpose.

Therefore this package uses the concept of *property lists*. A property list is a set of properties. The set of properties that is used by the default `\label` command is the *main property list*.

2.2 Property list

^{exp} means that the implementation of the marked macro is expandable.

`\zref@newlist {<listname>}`

Declares a new empty property list.

`\zref@addprop {<listname>} {<propname>}`

Adds the property `<propname>` to the property list `<listname>`. The property and list must exist.

`\zref@localaddprop {<listname>} {<propname>}`

Local variant of `\zref@addprop`.

`\zref@listexists {<listname>} {<then>}`

Executes `<then>` if the property list `<listname>` exists or raise an error otherwise.

`\zref@iflistundefinedexp {<listname>} {<then>} {<else>}`

Executes `<then>` if the list exists or `<else>` otherwise.

`\zref@iflistcontainsprop {<listname>} {<propname>} {<then>} {<else>}`

Executes `<then>` if the property `<propname>` is part of property list `<listname>` or otherwise it runs the `<else>` part.

2.3 Property

`\zref@newprop * {<propname>} [<default>] {<value>}`

This command declares and configures a new property with name `<propname>`.

In case of unknown references or the property does not exist in the reference, the `<default>` is used as value. If it is not specified here, a global default is used, see `\zref@setdefault`.

The correct values of some properties are not known immediately but at page shipout time. Prominent example is the page number. These properties are declared with the star form of the command.

`\zref@setcurrent {<propname>} {<value>}`

This sets the current value of the property `<propname>`. It is a generalization of setting L^AT_EX's `\currentlabel`.

`\zref@getcurrent {<propname>} {<value>}`

This returns the current value of the property `<propname>`. The value may not be correct, especially if the property is bound to a page (start form of `\zref@newprop`) and the right value is only known at shipout time (e.g. property 'page').

`\zref@propexists {⟨propname⟩} {⟨then⟩}`

Calls $\langle then \rangle$ if the property $\langle propname \rangle$ is available or generates an error message otherwise.

`\zref@ifpropundefinedexp {⟨propname⟩} {⟨then⟩} {⟨else⟩}`

Calls $\langle then \rangle$ or $\langle else \rangle$ depending on the existence of property $\langle propname \rangle$.

2.4 Reference generation

`\zref@label {⟨refname⟩}`

This works similar to `\label`. The reference $\langle refname \rangle$ is created and put into the `.aux` file with the properties of the main property list.

`\zref@labelbylist {⟨refname⟩} {⟨listname⟩}`

Same as `\zref@label` except that the properties are taken from the specified property list $\langle listname \rangle$.

`\zref@labelbyprops {⟨refname⟩} {⟨propnameA⟩,⟨propnameB⟩,...}`

Same as `\zref@label` except that these properties are used that are given as comma separated list in the second argument.

`\zref@newlabel {⟨refname⟩} {...}`

This is the macro that is used in the `.aux` file. It is basically the same as `\newlabel` apart from the format of the data in the second argument.

2.5 Data extraction

`\zref@extractdefaultexp {⟨refname⟩} {⟨propname⟩} {⟨default⟩}`

This is the basic command that references the value of a property $\langle propname \rangle$ for the reference $\langle refname \rangle$. In case of errors such as undefined reference the $\langle default \rangle$ is used instead.

`\zref@extractexp {⟨refname⟩} {⟨propname⟩}`

The command is an abbreviation for `\zref@extractdefault`. As default the default of the property is taken, otherwise the global default.

Example for page references:

```

LATEX: \pageref{foobar}
zref:    \zref@extract{foobar}{page}
```

Both `\zref@extract` and `\zref@extractdefault` are expandable. That means, these macros can directly be used in expandable calculations, see the example file. On the other side, babel's shorthands are not supported, there are no warnings in case of undefined references.

If an user interface doesn't need expandable macros then it can use `\zref@refused` and `\zref@wrapper@babel` for its user macros.

`\zref@refused {⟨refname⟩}`

This command is not expandable. It causes the warnings if the reference `⟨refname⟩` is not defined. Use the `\zref@extract` commands inside expandable contexts and mark their use outside by `\zref@refused`, see the example file.

`\zref@ifrefundefinedexp {⟨refname⟩} {⟨then⟩} {⟨else⟩}`

A possibility to check whether a reference exists.

`\zref@ifrefcontainspropexp {⟨refname⟩} {⟨propname⟩} {⟨then⟩} {⟨else⟩}`

Test whether a reference provides a property.

2.6 Setup

`\zref@default`

Holds the global default for unknown values.

`\zref@setdefault {⟨value⟩}`

Sets the global default for unknown values. The global default is used, if a property does not specify an own default and the value for a property cannot be extracted. This can happen if the reference is unknown or the reference does not have the property.

`\zref@setmainlist {⟨value⟩}`

Sets the name of the main property list. The package sets and uses `main`.

2.7 Declared properties

Module	Property	Property list	Default
	<code>default</code>	<code>main</code>	<code><empty></code>
	<code>page</code>	<code>main</code>	<code><empty></code>
<code>abspage, totpages</code>	<code>abspage</code>	<code>main</code>	0
<code>perpage</code>	<code>pagevalue</code>	<code>perpage</code>	0
	<code>page</code>	<code>perpage</code>	<code><empty></code>
	<code>abspage</code>	<code>perpage</code>	0
<code>counter</code>	<code>counter</code>	<code>main</code>	<code><empty></code>
<code>titleref</code>	<code>title</code>	<code>main</code>	<code><empty></code>
<code>savepos</code>	<code>posx</code>	<code>savepos</code>	0
	<code>posy</code>	<code>savepos</code>	0
<code>hyperref</code>	<code>anchor</code>	<code>main</code>	<code><empty></code>
	<code>url</code>		<code><empty></code>
<code>xr</code>	<code>url</code>		<code><empty></code>

2.8 Wrapper for advanced situations

`\zref@wrapper@babel {...} {⟨name⟩}`

This macro helps to add shorthand support. The second argument is protected, then the code of the first argument is called with the protected name appended.

Examples are in the sources.

`\zref@wrapper@immediate {...}`

There are situations where a label must be written instantly to the `.aux` file, for example after the last page. If the `\zlabel` or `\label` command is put inside this wrapper, immediate writing is enabled. See the implementation for module `lastpage` for an example of its use.

`\zref@wrapper@unexpanded {...}`

Assuming someone wants to extract a value for property `bar` and store the result in a macro `\foo` without traces of the expanding macros and without expanding the value. This (theoretical?) problem can be solved by this wrapper:

```
\edef\foo{%
  \zref@wrapper@unexpanded{%
    \zref@extract{someref}{bar}%
  }%
}
```

The `\edef` forces the expansion of `\zref@extract`, but the extraction of the value is prevented by the wrapper that uses ε -TEX' `\unexpanded` for this purpose.

2.9 Counter for unique names

Some modules (`titleref` and `dotfillmin`) need unique names for automatically generated label names.

`\zref@require@unique`

This command creates the unique counter `zref@unique` if the counter does not already exist.

`\thezref@unique`

This command is used to generate unique label names.

3 User interface

3.1 Module user

The user interface for this package and its modules is enabled by `zref`'s package option `user` or package `zref-user`. The names of user commands are prefixed by `z` in order to avoid name clashes with existing macros of the same functionality. Thus the package does not disturb the traditional reference scheme, both can be used together.

The syntax descriptions contain the following markers that are intended as hints for programmers:

- | | |
|---------------------|--|
| <code>babel</code> | Babel shorthands are allowed. |
| <code>robust</code> | Robust macro. |
| <code>exp</code> | Expandable version: |
| | <ul style="list-style-type: none">• robust, unless the extracted values are fragile,• no babel shorthand support. |

The basic user interface of the package without modules are commands that mimic the standard L^AT_EX behaviour of `\label`, `\ref`, and `\pageref`:

`\zlabel {⟨refname⟩}babel`

Similar to `\label`. It generates a label with name `⟨refname⟩` in the new reference scheme.

`\zref [⟨propname⟩] {⟨refname⟩}babel`

Without optional argument similar to `\ref`, it returns the default reference property. This property is named `default`:

$$\backslash\mathrm{zref}\{x\} \equiv \backslash\mathrm{zref}[\mathrm{default}]\{x\}$$

`\zpageref {⟨refname⟩}babel`

Convenience macro, similar to `\pageref`.

$$\backslash\mathrm{zpageref}\{x\} \equiv \backslash\mathrm{zref}[\mathrm{page}]\{x\}$$

`\zrefused {⟨refname⟩}babel`

Some of the user commands in the modules are expandable. The use of such commands do not cause any undefined reference warnings, because inside of expandable contexts this is not possible. However, if there is a place outside of expandable contexts, `\refused` is strongly recommended. The reference `⟨refname⟩` is marked as used, undefined ones will generate warnings.

3.2 Module `abspage`

With the help of package `atbegshi` a new counter `abspage` with absolute page numbers is provided. Also a new property `abspage` is defined and added to the main property list. Thus you can reference the absolute page number:

```
Section \zref{foo} is on page \zpageref{foo}.
This is page \zref[abspage]{foo} of \zref[abspage]{LastPage}.
```

The example also makes use of module `lastpage`.

3.3 Module `lastpage`

Provides the functionality of package `lastpage` [3] in the new reference scheme. The label `LastPage` is put at the end of the document. You can refer the last page number with:

```
\zpageref{LastPage}
```

Since version 2008/10/01 v2.3 the module defines the list `LastPage`. In addition to the properties of the main list label `LastPage` also stores the properties of this list `LastPage`. The default of this list is empty. The list can be used by the user to add additional properties for label `LastPage`.

3.3.1 Example

```
1 *example – lastpage
2 \NeedsTeXFormat{LaTeX2e}
3 \documentclass{report}
4 %
```

```

5 \newcounter{foo}
6 \renewcommand*{\thefoo}{\Alph{foo}}
7 %
8 \usepackage{zref-lastpage,zref-user}[2008/10/01]
9 %
10 \makeatletter
11 \zref@newprop{thefoo}{\thefoo}
12 \zref@newprop{valuefoo}{\the\value{foo}}
13 \zref@newprop{chapter}{\thechapter}
14 \zref@addprop{LastPage}{thefoo}
15 \zref@addprop{LastPage}{valuefoo}
16 \zref@addprop{LastPage}{chapter}
17 \makeatother
18 %
19 \newcommand*{\foo}{%
20   \stepcounter{foo}%
21   [Current foo: \thefoo]%
22 }
23 %
24 \begin{document}
25   \chapter{First chapter}%
26   Last page is \zref{LastPage}.\%
27   Last chapter is \zref[chapter]{LastPage}.\%
28   Last foo is \zref[thefoo]{LastPage}.\%
29   Last value of foo is \zref[valuefoo]{LastPage}.\%
30   \foo
31   \chapter{Second chapter}%
32   \foo\foo\foo
33   \chapter{Last chapter}%
34   \foo
35 \end{document}
36 \</example – lastpage>

```

3.4 Module **totpages**

For the total number of pages of a document you need to know the absolute page number of the last page. Both modules **abspage** and **lastpage** are necessary and automatically enabled.

`\ztotpagesexp`

Prints the total number of pages or 0 if this number is not yet known. It expands to an explicit number and can also be used even in expandable calculations (`\numexpr`) or counter assignments.

3.5 Module **runs**

Module **runs** counts the \LaTeX runs since last `.aux` file creation and prints the number in the `.log` file.

`\zrunsexp`

Prints the total number of \LaTeX runs including the current one. It expands to an explicit number. Before `\begin{document}` the value is zero meaning the `.aux` file is not read yet. If a previous `.aux` file exists, the value found there increased by one is the new number. Otherwise `\zruns` is set to one. \LaTeX runs where the `.aux` files are not rewritten are not counted (see `\nofiles`).

3.6 Module **perpage**

With `\@addtoreset` or `\numberwithin` a counter can be reset if another counter is incremented. This do not work well if the other counter is the page counter. The page counter is incremented in the output routine that is often called asynchronous somewhere on the next page. A reference mechanism costs at least two L^AT_EX runs, but ensures correct page counter values.

`\zmakeperpage [<reset>] {<counter>}`

At the of a new page counter *<counter>* starts counting with value *<reset>* (default is 1). The macro has the same syntax and semantics as `\MakePerPage` of package `perpage` [5]. Also `perpage` of package `footmisc` [1] can easily be simulated by

```
\zmakeperpage{footnote} % \usepackage[perpage]{footmisc}
```

If footnote symbols are used, some people dislike the first symbol †. It can easily be skipped:

```
\zmakeperpage[2]{footnote}
```

`\thezpage
counter zpage`

If the formatted counter value of the counter that is reset at a new page contains the page value, then you can use `\thezpage`, the page number of the current page. Or counter `zpage` can be used, if the page number should be formatted differently from the current page number. Example:

```
\newcounter{foobar}  
\zmakeperpage{foobar}  
\renewcommand*{\thefoobar}{\thezpage-\arabic{foobar}}  
% or  
\renewcommand*{\thefoobar}{\roman{zpage}-\arabic{foobar}}
```

`\zunmakeperpage {<counter>}`

The reset mechanism for this counter is deactivated.

3.7 Module **counter**

This option just add the property `counter` to the main property list. The property stores the counter name, that was responsible for the reference. This is the property `hyperref`'s `\autoref` feature uses. Thus this property `counter` may be useful for a reimplementaion of the `autoref` feature, see the section 4 with the `todo` list.

3.8 Module **titleref**

This option makes section and caption titles available to the reference system similar to packages `titleref` or `nameref`.

`\ztitleref {<refname>}babel`

Print the section or caption title of reference *<refname>*, similar to `\nameref` or `\titleref`.

`\ztitlerefsetup {key1=value1, key2=value2, ...}`

This command allows to configure the behaviour of module `titleref`. The following keys are available:

`title=<value>`

Sets the current title.

`stripperperiod=true|false`

Follow package `nameref` that removes a last period. Default: `true`.

`expand=true|false`

Package `\titleref` expands the title first. This way garbage and dangerous commands can be removed, e.g. `\label`, `\index...`. See implementation section for more details. Default is `false`.

`cleanup={...}`

Hook to add own cleanup code, if method `expand` is used. See implementation section for more details.

3.9 Module `savepos`

This option supports a feature that pdfTeX provides (and XeTeX). pdfTeX is able to tell the current position on the page. The page position is not instantly known. First the page must be constructed by TeX's asynchronous output routine. Thus the time where the position is known is the page shipout time. Thus a reference system where the information is recorded in the first run and made available for use in the second run comes in handy.

`\zsavepos {<refname>}`

It generates a reference with name `<refname>` to the location where the command is executed.

`\zposxexp {<refname>}`
`\zposyexp {<refname>}`

Get the position as number. Unit is sp. Horizontal positions by `\zposx` increase from left to right. Vertical positions by `\zposy` from bottom to top.

Do not rely on absolute page numbers. Because of problems with the origin the numbers may differ in DVI or PDF mode of pdfTeX. Therefore work with relative values by comparisons.

Both `\zposx` and `\zposy` are expandable and can be used inside calculations (`\setcounter`, `\addtocounter`, package `calc`, `\numexpr`). However this property prevents from notifying L^AT_EX that the reference is actually used (the notifying is not expandable). Therefore you should mark the reference as used by `\zrefused`.

This module uses pdfTeX's `\pdfsavepos`, `\pdflastxpos`, and `\pdflastypos`. They are available in PDF mode and since version 1.40.0 also in DVI mode.

3.10 Module `dotfill`

`\zdotfill`

This package provides the command `\zdotfill` that works similar to `\dotfill`, but can be configured. Especially it suppresses the dots if a minimum number of dots cannot be set.

`\zdotfillsetup {key1=value1, key2=value2, ...}`

This command allows to configure the behaviour of `\zdotfill`. The following keys are available:

`min`= \langle *count value* \rangle

If the actual number of dots are smaller than \langle *count value* \rangle , then the dots are suppressed. Default: 2.

`unit`= \langle *dimen value* \rangle

The width of a dot unit is given by \langle *dimen value* \rangle . Default: 0.44em (same as the unit in `\dotfill`).

`dot`= \langle *value* \rangle

The dot itself is given by \langle *value* \rangle . Default: . (dot, same as the dot in `\dotfill`).

3.11 Module `xr`

This package provides the functionality of package `xr`, see [8]. It also supports the syntax of `xr-hyper`.

`\zexternaldocument * [\langle prefix \rangle] babel { \langle external document \rangle } [\langle url \rangle]`

See `\externaldocument` for a description of this option. The standard reference scheme and the scheme of this package use different name spaces for reference names. If the external document uses both systems. Then one import statement would put the names in one namespace and probably causing problems with multiple references of the same name. Thus the star form only looks for `\newlabel` in the `.aux` files, whereas without star only `\zref@newlabels` are used.

In the star form it tries to detect labels from `hyperref`, `titleref`, and `ntheorem`. If such an extended property from the packages before cannot be found or are empty, they are not included in the imported reference.

Warnings are given if a reference name is already in use and the item is ignored. Unknown properties will automatically be declared.

If the external references contain `anchor` properties, then we need also a url to be able to address the external file. As default the filename is taken with a default extension.

`\zxrsetup {key1=value1, key2=value2, ...}`

Currently the key `ext` is defined, this sets the url default extension.

`\zref@xr@ext`

If the \langle url \rangle is not specified in `\zref@externaldocument`, then the url will be constructed with the file name and this macro as extension. `\XR@ext` is used if `hyperref` is loaded, otherwise `pdf`.

4 ToDo

Among other things the following issues are left for future work:

- The user land macros are not checked for robustness yet. They can be fragile. If this happens, use `\protect` until a later version of this package. The `\protect` will not disturb, if the protected macro become robust in the future.
- Other applications: `autoref`, `hyperref`, ...

5 Example

```

37 <*example>
38 \documentclass{book}
39
40 \usepackage[ngerman]{babel}%
41
42 \usepackage[savepos,totpages,titleref,dotfill,counter,user]{zref}
43

```

Chapters are wrapped inside `\ChapterStart` and `\ChapterStop`. The first argument #1 of `\ChapterStart` is used to form a label id `chap:#1`. At the end of the chapter another label is set by `\zref@wrapper@immediate`, because otherwise at the end of document a deferred write would not be written, because there is no page for shipout.

Also this example shows how chapter titles can be recorded. A new property `chaptitle` is declared and added to the main property list. In `\ChapterStart` the current value of the property is updated.

```

44 \makeatletter
45 \zref@newprop{chaptitle}{}
46 \zref@addprop{main}{chaptitle}
47
48 \newcommand*{\ChapterStart}[2]{%
49   \cleardoublepage
50   \def\current@chapid{#1}%
51   \zref@setcurrent{chaptitle}{#2}%
52   \chapter{#2}%
53   \zlabel{chap:#1}%
54 }
55 \newcommand*{\ChapterStop}{%
56   \cleardoublepage
57   \zref@wrapper@immediate{%
58     \zref@labelbyprops{chapend:\current@chapid}{abspage}%
59   }%
60 }

```

`\ChapterPages` calculates and returns the number of pages of the referenced chapter.

```

61 \newcommand*{\ChapterPages}[1]{%
62   \zrefused{chap:#1}%
63   \zrefused{chapend:#1}%
64   \number\numexpr
65     \zref@extract{chapend:#1}{abspage}%
66     -\zref@extract{chap:#1}{abspage}%
67   +1\relax
68 }
69 \makeatother
70 \begin{document}

```

As exception we use `\makeatletter` here, because this is just an example file that also should show some of programmer's interface.

```

71 \makeatletter
72
73 \frontmatter
74 \zlabel{documentstart}
75
76 \begin{itemize}
77 \item
78   The frontmatter part has
79   \number\numexpr\zref@extract{chap:first}{abspage}-1\relax~pages.
80 \item
81   Chapter \zref{chap:first} has \ChapterPages{first} page(s).
82 \item

```

```

83 Section \zref{hello} is on the
84 \ifcase\numexpr
85   \zref@extractdefault{hello}{page}{0}%
86   -\zref@extractdefault{chap:first}{page}{0}%
87   +1\relax
88   ??\or first\or second\or third\or forth\fi
89   ~page inside its chapter.
90 \item
91   The document has
92   \zref[abspage]{LastPage} pages.
93   This number is \ifodd\ztotpages odd\else even\fi.
94 \item
95   The last page is labeled with \zpageref{LastPage}.
96 \item
97   The title of chapter \zref{chap:next} is ‘‘\zref[chaptitle]{chap:next}’’.
98 \end{itemize}
99
100 \tableofcontents
101
102 \mainmatter
103 \ChapterStart{first}{First chapter}
104

```

The user level commands should protect babel shorthands where possible. On the other side, expandable extracting macros are useful in calculations, see above the examples with `\numexpr`.

```

105 \section{Test}
106 \zlabel{a"o}
107 Section \zref{a"o} on page
108 \zref@wrapper@babel\zref@extract{a"o}{page}.
109
110 Text.
111 \newpage
112
113 \section{Hello World}
114 \zlabel{hello}
115
116 \ChapterStop
117
118 \ChapterStart{next}{Next chapter with \emph{umlauts}: "a"o"u"s}
119

```

Here an example follows that makes use of pdfTeX’s “savepos” feature. The position on the page is not known before the page is constructed and shipped out. Therefore the position is stored in references and are available for calculations in the next L^AT_EX compile run.

```

120 The width of the first column is
121 \the\dimexpr \zposx{secondcol}sp - \zposx{firstcol}sp\relax,\,
122 the height difference of the two baselines is
123 \the\dimexpr \zposy{firstcol}sp - \zposy{secondline}sp\relax:\,
124 \begin{tabular}{ll}
125   \zsavepos{firstcol}Hello&\zsavepos{secondcol}World\\
126   \zsavepos{secondline}Second line&foobar\\
127 \end{tabular}
128

```

With `\zrefused` L^AT_EX is notified, if the references are not yet available and L^AT_EX can generate the rerun hint.

```

129 \zrefused{firstcol}
130 \zrefused{secondcol}
131 \zrefused{secondline}
132
133 \ChapterStop

```

Test for module `\dotfill`.

```

134 \ChapterStart{dotfill}{Test for dotfill feature}
135 \newcommand*{\dfptest}[1]{%
136   #1&
137   [\makebox[#1]{\dotfill}]&
138   [\makebox[#1]{\zdotfill}]\
139 }
140 \begin{tabular}{rll}
141 & [\verb|\dotfill|] & [\verb|\zdotfill|]\
142 \dfptest{0.43em}
143 \dfptest{0.44em}
144 \dfptest{0.45em}
145 \dfptest{0.87em}
146 \dfptest{0.88em}
147 \dfptest{0.89em}
148 \dfptest{1.31em}
149 \dfptest{1.32em}
150 \dfptest{1.33em}
151 \end{tabular}
152 \ChapterStop
153 \end{document}
154 \end{example}

```

6 Implementation

6.1 Package zref

6.1.1 Identification

```

155 \<*package>
156 \NeedsTeXFormat{LaTeX2e}
157 \ProvidesPackage{zref}
158 [2009/08/07 v2.4 New reference scheme for LaTeX2e (HO)]%

```

6.1.2 Load basic module

```

159 \RequirePackage{zref-base}[2009/08/07]

```

Abort package loading if zref-base could not be loaded successfully.

```

160 \@ifundefined{ZREF@baseok}{\endinput}{}

```

6.1.3 Process options

Known modules are loaded and the release date is checked.

```

161 \def\ZREF@temp#1{%
162   \DeclareOption{#1}{%
163     \AtEndOfPackage{%
164       \RequirePackage{zref-#1}[2009/08/07]%
165     }%
166   }%
167 }
168 \ZREF@temp{abspage}
169 \ZREF@temp{counter}
170 \ZREF@temp{dotfill}
171 \ZREF@temp{hyperref}
172 \ZREF@temp{lastpage}
173 \ZREF@temp{perpage}
174 \ZREF@temp{savepos}
175 \ZREF@temp{titleref}
176 \ZREF@temp{totpages}
177 \ZREF@temp{user}
178 \ZREF@temp{xr}
179 \ProcessOptions\relax
180 \end{package}

```


6.2 Module base

6.2.1 Prefixes

This package uses the following prefixes for macro names:

`\zref@`: Macros of the programmer's interface.

`\ZREF@`: Internal macros.

`\Z@L@listname`: The properties of the list $\langle listname \rangle$.

`\Z@D@propname`: The default value for property $\langle propname \rangle$.

`\Z@E@propname`: Extract function for property $\langle propname \rangle$.

`\Z@X@propname`: Information whether a property value for property $\langle propname \rangle$ is expanded immediately or at shipout time.

`\Z@C@propname`: Current value of the property $\langle propname \rangle$.

`\Z@R@labelname`: Data for reference $\langle labelname \rangle$.

`\ZREF@org@`: Original versions of patched commands.

`\z`: For macros in user land, defined if module `user` is set.

The following family names are used for keys defined according to the `keyval` package:

`ZREF@TR`: Setup for module `titleref`.

6.2.2 Identification

```
181 <*base>
182 \NeedsTeXFormat{LaTeX2e}
183 \ProvidesPackage{zref-base}%
184 [2009/08/07 v2.4 Module base for zref (HO)]%
```

6.2.3 Utilities

`\ZREF@name` Several times the package name is used, thus we store it in `\ZREF@name`.

```
185 \def\ZREF@name{zref}
```

`\ZREF@ErrorNoLine` An error message for this package without line information is generated by `\ZREF@ErrorNoLine`

```
186 \def\ZREF@ErrorNoLine#1#2{%
187   \begingroup
188     \let\on@line\@empty
189     \PackageError\ZREF@name{#1}{#2}%
190   \endgroup
191 }
```

`\ZREF@UpdatePdfTeX` `\ZREF@UpdatePdfTeX` is used as help message text in error messages.

```
192 \def\ZREF@UpdatePdfTeX{Update pdfTeX.}
```

`\ifZREF@found` The following switch is used in list processing.

```
193 \newif\ifZREF@found
```

`\ZREF@patch` Macro `\ZREF@patch` first checks the existence of the command and safes it.

```
194 \def\ZREF@patch#1{%
195   \begingroup\expandafter\expandafter\expandafter\endgroup
196   \expandafter\ifx\csname #1\endcsname\relax
197     \expandafter\@gobble
198   \else
```

```

199 \expandafter\let\csname ZREF@org@#1\expandafter\endcsname
200 \csname #1\endcsname
201 \expandafter\@firstofone
202 \fi
203 }

```

6.2.4 Check for ε -TeX

The use of ε -TeX should be standard nowadays for L^AT_EX. We test for ε -TeX in order to use its features later.

```

204 \begingroup
205 \ifundefined{eTeXversion}{%
206   \ZREF@ErrorNoLine{%
207     Missing support for eTeX; package is abandoned%
208   }{%
209     Use a TeX compiler that support eTeX and enable eTeX %
210     in the format.%
211   }%
212 \endgroup
213 \endinput
214 }{%
215 \endgroup

216 \RequirePackage{etexcmds}[2007/09/09]
217 \ifetex@unexpanded
218 \else
219   \ZREF@ErrorNoLine{%
220     Missing e-TeX's \string\unexpanded.\MessageBreak
221     Add \string\RequirePackage\string{etexcmds\string} before %
222     \string\documentclass%
223   }{%
224     Probably you are using some package (e.g. ConTeXt) that %
225     redefines \string\unexpanded%
226   }%
227 \expandafter\endinput
228 \fi

```

6.2.5 Auxiliary file stuff

We are using some commands in the .aux files. However sometimes these auxiliary files are interpreted by L^AT_EX processes that haven't loaded this package (e.g. package xr). Therefore we provide dummy definitions.

```

229 \RequirePackage{auxhook}
230 \AddLineBeginAux{%
231   \string\providecommand\string\zref@newlabel[2]{}%
232 }

```

`\zref@newlabel` For the implementation of `\zref@newlabel` we call the same internal macro `\@newl@bel` that is used in `\newlabel`. Thus we have for free:

- `\Z@R@labelname` is defined.
- L^AT_EX's check for multiple references.
- L^AT_EX's check for changed references.

```

233 \def\zref@newlabel{%
234   \@newl@bel{\Z@R}%
235 }

```

6.2.6 Property lists

`\zref@newlist` Property lists are stored as list of property names enclosed in curly braces. `\zref@newlist` creates a new list as empty list. Assignments to property lists are global.

```

236 \def\zref@newlist#1{%
237   \zref@iflistundefined{#1}{%
238     \ifdefinable{Z@L@#1}{%
239       \global\expandafter\let\csname Z@L@#1\endcsname\@empty
240       \PackageInfo{zref}{New property list: #1}%
241     }%
242   }{%
243     \PackageError{ZREF@name}{
244       Property list ‘#1’ already exists%
245     }\@ehc
246   }%
247 }
```

`\zref@iflistundefined` `\zref@iflistundefined` checks the existence of the property list #1. If the property list is present, then #2 is executed and #3 otherwise.

```

248 \def\zref@iflistundefined#1{%
249   \expandafter\ifx\csname Z@L@#1\endcsname\relax
250   \expandafter\@firstoftwo
251   \else
252   \expandafter\@secondoftwo
253   \fi
254 }
```

`\zref@listexists` `\zref@listexists` only executes #2 if the property list #1 exists and raises an error message otherwise.

```

255 \def\zref@listexists#1{%
256   \zref@iflistundefined{#1}{%
257     \PackageError{ZREF@name}{
258       Property list ‘#1’ does not exist%
259     }\@ehc
260   }%
261 }
```

`\zref@iflistcontainsprop` `\zref@iflistcontainsprop` checks, whether a property #2 is already present in a property list #1.

```

262 \def\zref@iflistcontainsprop#1{%
263   \expandafter\ZREF@iflistcontainsprop\csname Z@L@#1\endcsname
264 }
265 \def\ZREF@iflistcontainsprop#1#2{%
266   \begingroup
267   \ZREF@foundfalse
268   \edef\y{#2}%
269   \expandafter\@tfor\expandafter\x
270   \expandafter:\expandafter=#1\do{%
271     \edef\x{\x}%
272     \ifx\x\y
273       \ZREF@foundtrue
274     \fi
275   }%
276   \expandafter\endgroup
277   \ifZREF@found
278   \expandafter\@firstoftwo
279   \else
280   \expandafter\@secondoftwo
281   \fi
282 }
```

`\zref@listforloop`

```

283 \def\zref@listforloop#1#2{%
284   \expandafter\expandafter\expandafter\@tfor
285   \expandafter\expandafter\expandafter\zref@prop
286   \expandafter\expandafter\expandafter:%
287   \expandafter\expandafter\expandafter=%
288   \csname Z@L@#1\endcsname
289   \do{%
290     #2\zref@prop
291   }%
292 }

```

`\zref@addprop` `\zref@addprop` adds the property #2 to the property list #1, if the property is not already in the list. Otherwise a warning is given.

```

293 \def\zref@addprop#1#2{%
294   \zref@listexists{#1}{%
295     \zref@propexists{#2}{%
296       \zref@iflistcontainsprop{#1}{#2}{%
297         \PackageWarning\ZREF@name{%
298           Property ‘#2’ is already in list ‘#1’%
299         }%
300       }{%
301         \expandafter\g@addto@macro\csname Z@L@#1\endcsname{{#2}}%
302       }%
303     }%
304   }%
305 }

```

`\zref@localaddprop`

```

306 \def\zref@localaddprop#1#2{%
307   \zref@listexists{#1}{%
308     \zref@propexists{#2}{%
309       \zref@iflistcontainsprop{#1}{#2}{%
310         \PackageWarning\ZREF@name{%
311           Property ‘#2’ is already in list ‘#1’%
312         }%
313       }{%
314         \expandafter\ZREF@l@addto@macro\csname Z@L@#1\endcsname{{#2}}%
315       }%
316     }%
317   }%
318 }

```

`\ZREF@l@addto@macro`

```

319 \ifetex@unexpanded
320   \def\ZREF@l@addto@macro#1#2{%
321     \global\let\ZREF@gtemp#1%
322     \g@addto@macro\ZREF@gtemp{#2}%
323     \let#1\ZREF@gtemp
324   }%
325 \else
326   \def\ZREF@l@addto@macro#1#2{%
327     \edef#1{%
328       \etex@unexpanded\expandafter{#1#2}%
329     }%
330   }%
331 \fi

```

6.2.7 Properties

`\zref@ifpropundefined` `\zref@ifpropundefined` checks the existence of the property #1. If the property is present, then #2 is executed and #3 otherwise.

```

332 \def\zref@ifpropundefined#1{%
333   \expandafter\ifx\csname Z@E@#1\endcsname\relax
334     \expandafter\@firstoftwo
335   \else
336     \expandafter\@secondoftwo
337   \fi
338 }

```

\zref@propexists Some macros rely on the existence of a property. **\zref@propexists** only executes #2 if the property #1 exists and raises an error message otherwise.

```

339 \def\zref@propexists#1{%
340   \zref@ifpropundefined{#1}{%
341     \PackageError\ZREF@name{%
342       Property ‘#1’ does not exist%
343     }\@ehc
344   }%
345 }

```

\zref@newprop A new property is declared by **\zref@newprop**, the property name *<propname>* is given in #1. The property is created and configured. If the star form is given, then the expansion of the property value is delayed to page shipout time, when the reference is written to the .aux file.

\Z@D@propname: Stores the default value for this property.

\Z@E@propname: Extract function.

\Z@X@propname: Information whether the expansion of the property value is delayed to shipout time.

\Z@C@propname: Current value of the property.

```

346 \def\zref@newprop{%
347   \ifstar{%
348     \let\ZREF@X\noexpand
349     \ZREF@newprop
350   }{%
351     \let\ZREF@X\@empty
352     \ZREF@newprop
353   }%
354 }
355 \def\ZREF@newprop#1{%
356   \PackageInfo{zref}{New property: #1}%
357   \def\ZREF@P{#1}%
358   \@ifnextchar[\ZREF@@newprop{\ZREF@@newprop[\zref@default]}%
359 }
360 \def\ZREF@@newprop[#1]{%
361   \global\@namedef{Z@D@\ZREF@P}{#1}%
362   \global\expandafter\let\csname Z@X@\ZREF@P\endcsname\ZREF@X
363   \expandafter\ZREF@@@newprop\csname\ZREF@P\endcsname
364   \zref@setcurrent\ZREF@P
365 }
366 \def\ZREF@@@newprop#1{%
367   \expandafter\gdef\csname Z@E@\ZREF@P\endcsname##1##2##3\ZREF@nil{##2}%
368 }

```

\zref@setcurrent **\zref@setcurrent** sets the current value for a property.

```

369 \def\zref@setcurrent#1{%
370   \expandafter\def\csname Z@C@#1\endcsname
371 }

```

\zref@getcurrent **\zref@getcurrent** gets the current value for a property.

```

372 \def\zref@getcurrent#1{%
373   \csname Z@C@#1\endcsname
374 }

```

6.2.8 Reference generation

`\zref@label` Label macro that uses the main property list.

```
375 \def\zref@label#1{%
376   \zref@labelbylist{#1}\ZREF@mainlist
377 }
```

`\zref@labelbylist` Label macro that stores the properties, specified in the property list #2.

```
378 \def\zref@labelbylist#1#2{%
379   \@bsphack
380   \zref@listexists{#2}{%
381     \expandafter\expandafter\expandafter\ZREF@label
382     \expandafter\expandafter\expandafter{%
383       \csname Z@L@#2\endcsname
384     }{#1}%
385   }%
386   \@esphack
387 }
```

`\zref@labelbyprops` The properties are directly specified in a comma separated list.

```
388 \def\zref@labelbyprops#1#2{%
389   \@bsphack
390   \beginngroup
391     \edef\l{#2}%
392     \toks@{}%
393     \@for\x:=#2\do{%
394       \zref@ifpropundefined{\x}{%
395         \PackageWarning\ZREF@name{%
396           Property ‘\x’ is not known%
397         }%
398       }{%
399         \toks@\expandafter\expandafter\expandafter{%
400           \expandafter\the\expandafter\toks@\expandafter{\x}%
401         }%
402       }%
403     }%
404     \expandafter\endgroup
405     \expandafter\ZREF@label\expandafter{\the\toks@}{#1}%
406   \@esphack
407 }
```

`\ifZREF@immediate` The switch `\ifZREF@immediate` tells us, whether the label should be written immediately or at page shipout time. `\ZREF@label` need to be notified about this, because it must disable the deferred execution of property values, if the label is written immediately.

```
408 \newif\ifZREF@immediate
```

`\zref@wrapper@immediate` The argument of `\zref@wrapper@immediate` is executed inside a group where `\write` is redefined by adding `\immediate` before its execution. Also `\ZREF@label` is notified via the switch `\ifZREF@immediate`.

```
409 \long\def\zref@wrapper@immediate#1{%
410   \beginngroup
411     \ZREF@immediatetrue
412     \let\ZREF@org@write\write
413     \def\write{\immediate\ZREF@org@write}%
414     #1%
415   \endgroup
416 }
```

`\ZREF@label` `\ZREF@label` writes the data in the `.aux` file. #1 contains the list of valid properties, #2 the name of the reference. In case of immediate writing, the deferred execution of property values is disabled. Also `\ZREF@label` is made expandable in this case.

```

417 \def\ZREF@label#1#2{%
418   \if@filesw
419     \begingroup
420     \ifZREF@immediate
421       \let\ZREF@org@thepage\thepage
422     \fi
423     \protected@write\@auxout{%
424       \ifZREF@immediate
425         \let\thepage\ZREF@org@thepage
426       \fi
427       \let\ZREF@temp\@empty
428       \@tfor\ZREF@P:=#1\do{%
429         \expandafter\ifx
430           \csname\ifZREF@immediate relax\else Z@X@\ZREF@P\fi\endcsname
431           \noexpand
432         \expandafter\let\csname Z@C@\ZREF@P\endcsname\relax
433       \fi
434       \toks@\expandafter{\ZREF@temp}%
435       \edef\ZREF@temp{%
436         \the\toks@
437         \expandafter\string\csname\ZREF@P\endcsname{%
438           \expandafter\noexpand\csname Z@C@\ZREF@P\endcsname
439         }%
440       }%
441     }%
442   }{%
443     \string\zref@newlabel{#2}{\ZREF@temp}%
444   }%
445   \endgroup
446 \fi
447 }
448 \def\ZREF@addtoks#1{%
449   \toks@\expandafter\expandafter\expandafter{%
450     \expandafter\the\expandafter\toks@#1%
451   }%
452 }

```

6.2.9 Reference querying and extracting

Design goal for the extracting macros is that the extraction process is full expandable. Thus these macros can be used in expandable contexts. But there are problems that cannot be solved by full expandable macros:

- In standard L^AT_EX undefined references sets a flag and generate a warning. Both actions are not expandable.
- Babel's support for its shorthand uses commands that use non-expandable assignments. However currently there is hope, that primitives are added to pdfT_EX that allows the detection of contexts. Then the shorthand can detect, if they are executed inside `\csname` and protect themselves automatically.

`\zref@ifrefundefined` If a reference #1 is undefined, then macro `\zref@ifrefundefined` calls #2 and #3 otherwise.

```

453 \def\zref@ifrefundefined#1{%
454   \expandafter\ifx\csname Z@R@#1\endcsname\relax
455     \expandafter\@firstoftwo
456   \else
457     \expandafter\@secondoftwo
458   \fi
459 }

```

`\zref@refused` The problem with undefined references is addressed by the macro `\zref@refused`. This can be used outside the expandable context. In case of an undefined reference the flag is set to notify \LaTeX and a warning is given.

```
460 \def\zref@refused#1{%
461   \zref@wrapper@babel\ZREF@refused{#1}%
462 }
```

`\ZREF@refused`

```
463 \def\ZREF@refused#1{%
464   \zref@ifrefundefined{#1}{%
465     \protect\G@refundefinedtrue
466     \@latex@warning{%
467       Reference ‘#1’ on page \thepage \space undefined%
468     }%
469   }{%}%
470 }
```

`\zref@extract` `\zref@extract` is an abbreviation for the case that the default of the property is used as default value.

```
471 \def\zref@extract#1#2{%
472   \expandafter\expandafter\expandafter\ZREF@extract
473   \expandafter\expandafter\expandafter{%
474     \csname Z@D@#2\endcsname
475   }{#1}{#2}%
476 }
477 \def\ZREF@extract#1#2#3{%
478   \zref@extractdefault{#2}{#3}{#1}%
479 }
```

`\zref@ifrefcontainsprop` `\zref@ifrefcontainsprop` looks, if the reference #1 has the property #2 and calls then #3 and #4 otherwise.

```
480 \def\zref@ifrefcontainsprop#1#2{%
481   \zref@ifrefundefined{#1}{%
482     \@secondoftwo
483   }{%
484     \expandafter\ZREF@ifrefcontainsprop
485     \csname Z@E@#2\expandafter\endcsname
486     \csname#2\expandafter\expandafter\expandafter\endcsname
487     \expandafter\expandafter\expandafter{%
488       \csname Z@R@#1\endcsname
489     }%
490   }%
491 }
492 \def\ZREF@ifrefcontainsprop#1#2#3{%
493   \expandafter\ifx\expandafter\ZREF@novalue
494   #1#3#2\ZREF@novalue\ZREF@nil\@empty
495     \expandafter\@secondoftwo
496   \else
497     \expandafter\@firstoftwo
498   \fi
499 }
500 \def\ZREF@novalue{\ZREF@NOVALUE}
```

`\zref@extractdefault` The basic extracting macro is `\zref@extractdefault` with the reference name in #1, the property in #2 and the default value in #3 in case for problems.

```
501 \def\zref@extractdefault#1#2#3{%
502   \zref@ifrefundefined{#1}{%
503     \ZREF@unexpanded{#3}%
504   }{%
505     \expandafter\expandafter\expandafter\ZREF@unexpanded
506     \expandafter\expandafter\expandafter{%
```



```

507     \csname Z@E@#2\expandafter\expandafter\expandafter\endcsname
508     \csname Z@R@#1\expandafter\endcsname
509     \csname#2\endcsname{#3}\ZREF@nil
510 }%
511 }%
512 }

```

`\zref@wrapper@unexpanded`

```

513 \long\def\zref@wrapper@unexpanded#1{%
514   \let\ZREF@unexpanded\etex@unexpanded
515   #1%
516   \let\ZREF@unexpanded\@firstofone
517 }
518 \let\ZREF@unexpanded\@firstofone

```

6.2.10 Compatibility with babel

`\zref@wrapper@babel`

```

519 \long\def\zref@wrapper@babel#1#2{%
520   \ifcsname if@safe@actives\endcsname
521     \expandafter\@firstofone
522   \else
523     \expandafter\@secondoftwo
524   \fi
525   {%
526     \if@safe@actives
527       \expandafter\@secondoftwo
528     \else
529       \expandafter\@firstoftwo
530     \fi
531     {%
532       \begingroup
533         \csname @safe@activestruel\endcsname
534         \edef\x{#2}%
535         \expandafter\endgroup
536         \expandafter\ZREF@wrapper@babel\expandafter{\x}{#1}%
537       }%
538     }{%
539       #1{#2}%
540     }%
541   }
542 \long\def\ZREF@wrapper@babel#1#2{%
543   #2{#1}%
544 }

```

6.2.11 Unique counter support

`\zref@require@unique` Generate the counter `zref@unique` if the counter does not already exist.

```

545 \def\zref@require@unique{%
546   \@ifundefined{c@zref@unique}{%
547     \begingroup
548       \let\@addtoreset\@gobbletwo
549       \newcounter{zref@unique}%
550     \endgroup

```

`\thezref@unique` `\thezref@unique` is used for automatically generated unique labelnames.

```

551     \renewcommand*{\thezref@unique}{%
552       zref@number\c@zref@unique
553     }%
554   }{}%
555 }

```

6.2.12 Setup

`\zref@setdefault` Standard L^AT_EX prints “??” in bold face if a reference is not known. `\zref@default` holds the text that is printed in case of unknown references and is used, if the default was not specified during the definition of the new property by `\ref@newprop`. The global default value can be set by `\zref@setdefault`.

```
556 \def\zref@setdefault#1{%  
557   \def\zref@default{#1}%  
558 }
```

`\zref@default` Now we initialize `\zref@default` with the same value that L^AT_EX uses for its undefined references.

```
559 \zref@setdefault{%  
560   \nfss@text{\reset@font\bfseries ??}%  
561 }
```

Main property list.

`\zref@setmainlist` The name of the default property list is stored in `\ZREF@mainlist` and can be set by `\zref@setmainlist`.

```
562 \def\zref@setmainlist#1{%  
563   \def\ZREF@mainlist{#1}%  
564 }  
565 \zref@setmainlist{main}
```

Now we create the list.

```
566 \zref@newlist\ZREF@mainlist
```

Main properties. The two properties `default` and `page` are created and added to the main property list. They store the data that standard L^AT_EX uses in its references created by `\label`.

`default` the apperance of the latest counter that is incremented by `\refstepcounter`

`page` the apperance of the page counter

```
567 \zref@newprop{default}{\@currentlabel}  
568 \zref@newprop*{page}{\thepage}  
569 \zref@addprop\ZREF@mainlist{default}  
570 \zref@addprop\ZREF@mainlist{page}
```

Mark successful loading

```
571 \let\ZREF@baseok\@empty  
572 \</base>
```

6.3 Module user

```
573 <*user>  
574 \NeedsTeXFormat{LaTeX2e}  
575 \ProvidesPackage{zref-user}%  
576 [2009/08/07 v2.4 Module user for zref (HO)]%  
577 \RequirePackage{zref-base}[2009/08/07]  
578 \@ifundefined{ZREF@baseok}{\endinput}{}
```

Module user enables a small user interface. All macros are prefixed by `\z`.

First we define the pendants to the standard L^AT_EX referencing commands `\label`, `\ref`, and `\pageref`.

`\zlabel` Similar to `\label` the macro `\zlabel` writes a reference entry in the `.aux` file. The main property list is used. Also we add the babel patch. The `\label` command can also be used inside section titles, but it must not go into the table of contents. Therefore we have to check this situation.

```

579 \newcommand*\zlabel{%
580   \ifx\label\@gobble
581     \expandafter\@gobble
582   \else
583     \expandafter\zref@wrapper@babel\expandafter\zref@label
584   \fi
585 }%

```

\zref Macro **\zref** is the corresponding macro for **\ref**. Also it provides an optional argument in order to select another property.

```

586 \newcommand*{\zref}[2][default]{%
587   \zref@propexists{#1}{%
588     \zref@wrapper@babel\ZREF@zref{#2}{#1}%
589   }%
590 }%
591 \def\ZREF@zref#1{%
592   \zref@refused{#1}%
593   \zref@extract{#1}%
594 }%

```

\zpageref For macro **\zpageref** we just call **\zref** with property **page**.

```

595 \newcommand*\zpageref{%
596   \zref[page]%
597 }%

```

\zrefused For the following expandible user macros **\zrefused** should be used to notify L^AT_EX in case of undefined references.

```

598 \newcommand*{\zrefused}{\zref@refused}%
599 </user>

```

6.4 Module **abspage**

```

600 <*abspage>
601 \NeedsTeXFormat{LaTeX2e}
602 \ProvidesPackage{zref-abspage}%
603 [2009/08/07 v2.4 Module abspage for zref (HO)]%
604 \RequirePackage{zref-base}[2009/08/07]
605 \ifundefined{ZREF@baseok}{\endinput}{}

```

Module **abspage** adds a new property **abspage** to the main property list for absolute page numbers. These are recorded by the help of package **atbegshi**.

```

606 \RequirePackage{atbegshi}%

```

The counter **abspage** must not go in the clear list of **@ckpt** that is used to set counters in **.aux** files of included T_EX files.

```

607 \begingroup
608   \let\@addtoreset\@gobbletwo
609   \newcounter{abspage}%
610 \endgroup
611 \setcounter{abspage}{0}%
612 \AtBeginShipout{%
613   \stepcounter{abspage}%
614 }%
615 \zref@newprop*{abspage}[0]{\the\c@abspage}%
616 \zref@addprop\ZREF@mainlist{abspage}%

```

Note that counter **abspage** shows the previous page during page processing. Before shipout the counter is incremented. Thus the property is correctly written with deferred writing. If the counter is written using **\zref@wrapper@immediate**, then the number is too small by one.

```

617 </abspage>

```

6.5 Module counter

```
618 <*counter>
619 \NeedsTeXFormat{LaTeX2e}
620 \ProvidesPackage{zref-counter}%
621 [2009/08/07 v2.4 Module counter for zref (HO)]%
622 \RequirePackage{zref-base}[2009/08/07]
623 \@ifundefined{ZREF@baseok}{\endinput}{}
```

For features such as `hyperref`'s `\autoref` we need the name of the counter. The property `counter` is defined and added to the main property list.

```
624 \zref@newprop{counter}{}
625 \zref@addprop{ZREF@mainlist}{counter}
```

`\refstepcounter` is the central macro where we know which counter is responsible for the reference.

```
626 \AtBeginDocument{%
627   \ZREF@patch{refstepcounter}{%
628     \def\refstepcounter#1{%
629       \zref@setcurrent{counter}{#1}%
630       \ZREF@org@refstepcounter{#1}%
631     }%
632   }%
633 }
634 </counter>
```

6.6 Module lastpage

```
635 <*lastpage>
636 \NeedsTeXFormat{LaTeX2e}
637 \ProvidesPackage{zref-lastpage}%
638 [2009/08/07 v2.4 Module lastpage for zref (HO)]%
639 \RequirePackage{zref-base}[2009/08/07]
640 \@ifundefined{ZREF@baseok}{\endinput}{}
```

The module `lastpage` implements the service of package `lastpage` by setting a reference `LastPage` at the end of the document. If module `abspage` is given, also the absolute page number is available, because the properties of the main property list are used.

```
641 \zref@newlist{LastPage}
642 \AtBeginDocument{%
643   \AtEndDocument{%
644     \if@filesw
645       \clearpage
646       \begingroup
647         \advance\c@page\m@ne
648         \toks0\expandafter\expandafter\expandafter{%
649           \expandafter\Z@L@main
650           \Z@L@LastPage
651         }%
652         \expandafter\zref@wrapper@immediate\expandafter{%
653           \expandafter\ZREF@label\expandafter{\the\toks0}{LastPage}%
654         }%
655       \endgroup
656     \fi
657   }%
658 }
659 </lastpage>
```

6.7 Module totpages

```
660 <*totpages>
661 \NeedsTeXFormat{LaTeX2e}
662 \ProvidesPackage{zref-totpages}%
663 [2009/08/07 v2.4 Module totpages for zref (HO)]%
```

```

664 \RequirePackage{zref-base}[2009/08/07]
665 \@ifundefined{ZREF@baseok}{\endinput}{}

```

The absolute page number of the last page is the total page number.

```

666 \RequirePackage{zref-abspage}[2009/08/07]
667 \RequirePackage{zref-lastpage}[2009/08/07]

```

\ztotpages Macro `\ztotpages` contains the number of pages. It can be used inside expandable calculations. It expands to zero if the reference is not yet available.

```

668 \newcommand*{\ztotpages}{%
669   \zref@extractdefault{LastPage}{abspage}{0}%
670 }

```

Also we mark the reference `LastPage` as used:

```

671 \AtBeginDocument{%
672   \zref@refused{LastPage}%
673 }
674 </totpages>

```

6.8 Module runs

This module does not use the label-reference-system. The reference changes with each \LaTeX run and would force a rerun warning always.

```

675 <*runs>
676 \NeedsTeXFormat{LaTeX2e}
677 \ProvidesPackage{zref-runs}%
678   [2009/08/07 v2.4 Module runs for zref (H0)]%

```

\zruns

```

679 \providecommand*{\zruns}{0}%
680 \AtBeginDocument{%
681   \edef\zruns{\number\numexpr\zruns+1}%
682   \begingroup
683     \def\on@line{}%
684     \PackageInfo{zref-runs}{LaTeX runs: \zruns}%
685     \if@filesw
686       \immediate\write\@mainaux{%
687         \string\gdef\string\zruns{\zruns}%
688       }%
689     \fi
690   \endgroup
691 }
692 </runs>

```

6.9 Module perpage

```

693 <*perpage>
694 \NeedsTeXFormat{LaTeX2e}
695 \ProvidesPackage{zref-perpage}%
696   [2009/08/07 v2.4 Module perpage for zref (H0)]%
697 \RequirePackage{zref-base}[2009/08/07]
698 \@ifundefined{ZREF@baseok}{\endinput}{}

```

This module resets a counter at page boundaries. Because of the asynchronous output routine page counter properties cannot be asked directly, references are necessary.

For detecting changed pages module `abspage` is loaded.

```

699 \RequirePackage{zref-abspage}[2009/08/07]

```

We group the properties for the needed references in the property list `perpage`. The property `pagevalue` records the correct value of the page counter.

```

700 \zref@newprop*{pagevalue}[0]{\number\c@page}

```

```

701 \zref@newlist{perpage}
702 \zref@addprop{perpage}{abspage}
703 \zref@addprop{perpage}{page}
704 \zref@addprop{perpage}{pagevalue}

```

The page value, known by the reference mechanism, will be stored in counter `zpage`.

```
705 \newcounter{zpage}
```

Counter `zref@unique` helps in generating unique reference names.

```
706 \zref@require@unique
```

In order to be able to reset the counter, we hook here into `\stepcounter`. In fact two nested hooks are used to allow other packages to use the first hook at the beginning of `\stepcounter`.

```

707 \let\ZREF@org@stepcounter\stepcounter
708 \def\stepcounter#1{%
709   \ifcsname @stepcounterhook@#1\endcsname
710     \csname @stepcounterhook@#1\endcsname
711   \fi
712   \ZREF@org@stepcounter{#1}%
713 }

```

`\zmakeperpage` Makro `\zmakeperpage` resets a counter at each page break. It uses the same syntax and semantics as `\MakePerPage` from package `perpage` [5]. The initial start value can be given by the optional argument. Default is one that means after the first `\stepcounter` on a new page the counter starts with one.

```

714 \newcommand*{\zmakeperpage}{%
715   \@ifnextchar[\ZREF@makeperpage@opt{\ZREF@makeperpage[\z@]}%
716 }

```

We hook before the counter is incremented in `\stepcounter`, package `perpage` afterwards. Thus a little calculation is necessary.

```

717 \def\ZREF@makeperpage@opt[#1]{%
718   \begingroup
719     \edef\x{\endgroup
720       \noexpand\ZREF@makeperpage[\number\numexpr#1-1\relax]%
721     }%
722   \x
723 }

724 \def\ZREF@makeperpage[#1]#2{%
725   \@ifundefined{@stepcounterhook@#2}{%
726     \expandafter\gdef\csname @stepcounterhook@#2\endcsname{%
727   }%
728   \expandafter\gdef\csname ZREF@perpage@#2\endcsname{%
729     \ZREF@perpage@step{#2}{#1}%
730   }%
731   \expandafter\g@addto@macro\csname @stepcounterhook@#2\endcsname{%
732     \ifcsname ZREF@perpage@#2\endcsname
733       \csname ZREF@perpage@#2\endcsname
734     \fi
735   }%
736 }

```

`\ZREF@perpage@step` The heart of this module follows.

```
737 \def\ZREF@perpage@step#1#2{%
```

First the reference is generated.

```

738   \global\advance\c@zref@unique\@ne
739   \begingroup
740     \expandafter\zref@labelbylist\expandafter{\thezref@unique}{perpage}%

```

The `\expandafter` commands are necessary, because `\ZREF@temp` is also used inside of `\zref@labelbylist`.

The evaluation of the reference follows. If the reference is not yet known, we use the page counter as approximation.

```

741 \zref@ifrefundefined\thezref@unique{%
742   \global\c@zpage=\c@page
743   \global\let\thezpage\thepage
744   \expandafter\xdef\csname ZREF@abspage@#1\endcsname{\number\c@abspage}%
745 }%
```

The reference is used to set `\thezpage` and counter `zpage`.

```

746 \global\c@zpage=\zref@extract\thezref@unique{pagevalue}\relax
747 \xdef\thezpage{\noexpand\zref@extract{\thezref@unique}{page}}%
748 \expandafter\xdef\csname ZREF@abspage@#1\endcsname{%
749   \zref@extractdefault\thezref@unique{abspage}{\number\c@abspage}%
750 }%
751 }%
```

Page changes are detected by a changed absolute page number.

```

752 \expandafter\ifx\csname ZREF@abspage@#1\expandafter\endcsname
753   \csname ZREF@currentabspage@#1\endcsname
754 \else
755   \global\csname c@#1\endcsname=#2\relax
756   \global\expandafter\let
757     \csname ZREF@currentabspage@#1\expandafter\endcsname
758     \csname ZREF@abspage@#1\endcsname
759 \fi
760 \endgroup
761 }
```

`\zunmakeperpage` Macro `\zunmakeperpage` cancels the effect of `\zmakeperpage`.

```

762 \newcommand*{\zunmakeperpage}[1]{%
763   \global\expandafter\let\csname ZREF@perpage@#1\endcsname\@undefined
764 }
765 </perpage>
```

6.10 Module `titleref`

```

766 <*titleref>
767 \NeedsTeXFormat{LaTeX2e}
768 \ProvidesPackage{zref-titleref}%
769 [2009/08/07 v2.4 Module titleref for zref (HO)]%
770 \RequirePackage{zref-base}[2009/08/07]
771 \@ifundefined{ZREF@baseok}{\endinput}{}%
```

6.10.1 Implementation

```
772 \RequirePackage{keyval}
```

This module makes section and caption titles available for the reference system. It uses some of the ideas of package `nameref` and `titleref`.

`\zref@titleref@current` Later we will redefine the section and caption macros to catch the current title and remember the value in `\zref@titleref@current`.

```
773 \let\zref@titleref@current\@empty
```

Now we can add the property `title` is added to the main property list.

```

774 \zref@newprop{title}{\zref@titleref@current}%
775 \zref@addprop{ZREF@mainlist}{title}%
```

The title strings go into the `.aux` file, thus they need some kind of protection. Package `titleref` uses a protected expansion method. The advantage is that this can be used to cleanup the string and to remove `\label`, `\index` and other macros unwanted for referencing. But there is the risk that fragile stuff can break.

Therefore package `nameref` does not expand the string. Thus the entries can safely be written to the `.aux` file. But potentially dangerous macros such as `\label` remain in the string and can cause problems when using the string in references.

`\ifzref@titleref@expand` The switch `\ifzref@titleref@expand` distinguishes between the both methods. Package `nameref`'s behaviour is achieved by setting the switch to false, otherwise `titleref`'s expansion is used. Default is false.

```
776 \newif\ifzref@titleref@expand
```

`\ZREF@titleref@hook` The hook `\ZREF@titleref@hook` allows to extend the cleanup for the expansion method. Thus unnecessary macros can be removed or dangerous commands removed. The hook is executed before the expansion of `\zref@titleref@current`.

```
777 \let\ZREF@titleref@hook\@empty
```

`\zref@titleref@cleanup` The hook should not be used directly, instead we provide the macro `\zref@titleref@cleanup` to add stuff to the hook and prevents that a previous non-empty content is not discarded accidentally.

```
778 \def\zref@titleref@cleanup#1{%
779   \begingroup
780   \toks@\expandafter{%
781     \ZREF@titleref@hook
782     #1%
783   }%
784   \expandafter\endgroup
785   \expandafter\def\expandafter\ZREF@titleref@hook\expandafter{%
786     \the\toks@
787   }%
788 }
```

`\ifzref@titleref@stripperiod` Sometimes a title contains a period at the end. Package `nameref` removes this. This behaviour is controlled by the switch `\ifzref@titleref@stripperiod` and works regardless of the setting of option `expand`. Period stripping is the default.

```
789 \newif\ifzref@titleref@stripperiod
790 \zref@titleref@stripperiodtrue
```

`\zref@titleref@setcurrent` Macro `\zref@titleref@setcurrent` sets a new current title stored in `\zref@titleref@current`. Some cleanup and expansion is performed that can be controlled by the previous switches.

```
791 \def\zref@titleref@setcurrent#1{%
792   \def\zref@titleref@current{#1}%
793   \ifzref@titleref@expand
794     \begingroup
795     \let\label\@gobble
796     \let\index\@gobble
797     \let\glossary\@gobble
798     \let\markboth\@gobbletwo
799     \let\@mkboth\@gobbletwo
800     \let\markright\@gobble
801     \let\protect\@unexpandable@protect
802     \ZREF@titleref@hook
803     \edef\x{\endgroup
804       \noexpand\def\noexpand\zref@titleref@current{%
805         \zref@titleref@current
806       }%
807     }%
808     \x
809   \fi
810   \edef\zref@titleref@current{%
811     \detokenize\expandafter{\zref@titleref@current}%
812   }%
813   \ifzref@titleref@stripperiod
814     \edef\zref@titleref@current{%
815       \expandafter\ZREF@stripperiod\zref@titleref@current
816       \@empty.\@empty\@nil
817     }%
```



```

818 \fi
819 }%

```

`\ZREF@stripperperiod` If `\ZREF@stripperperiod` is called, the argument consists of space tokens and tokens with catcode 12 (other), because of ε -TeX's `\detokenize`.

```

820 \def\ZREF@stripperperiod#1.\@empty#2\@nil{#1}%

```

6.10.2 User interface

`\ztitlerefsetup` The behaviour of module `titleref` is controlled by switches and a hook. They can be set by `\ztitlerefsetup` with a key value interface, provided by package `keyval`. Also the current title can be given explicitly by the key `title`.

```

821 \define@key{ZREF@TR}{expand}[true]{%
822   \csname zref@titleref@expand#1\endcsname
823 }%
824 \define@key{ZREF@TR}{stripperperiod}[true]{%
825   \csname zref@titleref@stripperperiod#1\endcsname
826 }%
827 \define@key{ZREF@TR}{cleanup}{%
828   \zref@titleref@cleanup{#1}%
829 }%
830 \define@key{ZREF@TR}{title}{%
831   \def\zref@titleref@current{#1}%
832 }%
833 \newcommand*{\ztitlerefsetup}{%
834   \setkeys{ZREF@TR}%
835 }%

```

`\ztitleref` The user command `\ztitleref` references the title. For safety `\label` is disabled to prevent multiply defined references.

```

836 \newcommand*{\ztitleref}{%
837   \zref@wrapper@babel\ZREF@titleref
838 }%
839 \def\ZREF@titleref#1{%
840   \begingroup
841     \zref@refused{#1}%
842     \let\label\@gobble
843     \zref@extract{#1}{title}%
844   \endgroup
845 }%

```

6.10.3 Patches for section and caption commands

The section and caption macros are patched to extract the title data.

Captions of figures and tables.

```

846 \AtBeginDocument{%
847   \ZREF@patch{caption}{%
848     \long\def\@caption#1[#2]{%
849       \zref@titleref@setcurrent{#2}%
850       \ZREF@org@@caption{#1}[{#2}]%
851     }%
852   }%

```

Section commands without star. The title version for the table of contents is used because it is usually shorter and more robust.

```

853 \ZREF@patch{@part}{%
854   \def\@part[#1]{%
855     \zref@titleref@setcurrent{#1}%
856     \ZREF@org@@part[{#1}]%
857   }%
858 }%
859 \ZREF@patch{chapter}{%

```

```

860 \def\@chapter[#1]{%
861 \zref@titleref@setcurrent{#1}%
862 \ZREF@org@chapter[{#1}]%
863 }%
864 }%
865 \ZREF@patch{@sect}{%
866 \def\@sect#1#2#3#4#5#6[#7]{%
867 \zref@titleref@setcurrent{#7}%
868 \ZREF@org@sect{#1}{#2}{#3}{#4}{#5}{#6}[{#7}]%
869 }%
870 }%

```

The star versions of the section commands.

```

871 \ZREF@patch{@spart}{%
872 \def\@spart#1{%
873 \zref@titleref@setcurrent{#1}%
874 \ZREF@org@spart{#1}%
875 }%
876 }%
877 \ZREF@patch{@schapter}{%
878 \def\@schapter#1{%
879 \zref@titleref@setcurrent{#1}%
880 \ZREF@org@schapter{#1}%
881 }%
882 }%
883 \ZREF@patch{@ssect}{%
884 \def\@ssect#1#2#3#4#5{%
885 \zref@titleref@setcurrent{#5}%
886 \ZREF@org@ssect{#1}{#2}{#3}{#4}{#5}%
887 }%
888 }%

```

Class beamer.

```

889 \@ifclassloaded{beamer}{%
890 \ZREF@patch{beamer@section}{%
891 \long\def\beamer@section[#1]{%
892 \zref@titleref@setcurrent{#1}%
893 \ZREF@org@beamer@section[{#1}]%
894 }%
895 }%
896 \ZREF@patch{beamer@subsection}{%
897 \long\def\beamer@subsection[#1]{%
898 \zref@titleref@setcurrent{#1}%
899 \ZREF@org@beamer@subsection[{#1}]%
900 }%
901 }%
902 \ZREF@patch{beamer@subsubsection}{%
903 \long\def\beamer@subsubsection[#1]{%
904 \zref@titleref@setcurrent{#1}%
905 \ZREF@org@beamer@subsubsection[{#1}]%
906 }%
907 }%
908 }{}%

```

Package titlesec.

```

909 \@ifpackageloaded{titlesec}{%
910 \ZREF@patch{ttl@sect@i}{%
911 \def\ttl@sect@i#1#2[#3]#4{%
912 \zref@titleref@setcurrent{#4}%
913 \ZREF@org@ttl@sect@i{#1}{#2}[{#3}]{#4}%
914 }%
915 }%
916 }{}%

```

Package longtable: some support for its `\caption`. However `\label` inside the caption is not supported.

```

917 \ifpackageloaded{longtable}{%
918   \ZREF@patch{LT@caption}{%
919     \def\LT@caption#1[#2]#3{%
920       \ZREF@org@LT@caption{#1}[#2][#3}%
921       \zref@titleref@setcurrent{#2}%
922     }%
923   }%
924 }{}%
```

Package listings: support for its caption.

```

925 \ifpackageloaded{listings}{%
926   \ZREF@patch{lst@MakeCaption}{%
927     \def\lst@MakeCaption{%
928       \ifx\lst@label\@empty
929       \else
930         \expandafter\zref@titleref@setcurrent\expandafter{%
931           \lst@caption
932         }%
933       \fi
934       \ZREF@org@lst@MakeCaption
935     }%
936   }%
937 }{}%
938 }
939 </titleref>
```

6.11 Module xr

```

940 <*xr>
941 \NeedsTeXFormat{LaTeX2e}
942 \ProvidesPackage{zref-xr}%
943 [2009/08/07 v2.4 Module xr for zref (HO)]%
944 \RequirePackage{zref-base}[2009/08/07]
945 \ifundefined{ZREF@baseok}{\endinput}{}
946 \RequirePackage{keyval}
```

We declare property `url`, because this is added, if a reference is imported and has not already set this field. Or if `hyperref` is used, then this property can be asked.

```
947 \zref@newprop{url}{}%
```

Most code, especially the handling of the `.aux` files are taken from David Carlisle's `xr` package. Therefore I drop the documentation for these macros here.

`\zref@xr@ext` If the URL is not specied, then assume processed file with a guessed extension. Use the setting of `hyperref` if available.

```

948 \providecommand*{\zref@xr@ext}{}%
949 \ifundefined{XR@ext}{pdf}{\XR@ext}%
950 }%
```

`\ifZREF@xr@zreflabel` The use of the star form of `\zexternaldocument` is remembered in the switch `\ifZREF@xr@zreflabel`.

```
951 \newif\ifZREF@xr@zreflabel
```

`\zexternaldocument` In its star form it looks for `\newlabel`, otherwise for `\zref@newlabel`. Later we will read `.aux` files that expects `@` to have catcode 11 (letter).

```

952 \newcommand*{\zexternaldocument}{}%
953 \begingroup
954   \csname @safe@actives@true\endcsname
955   \makeatletter
956   \ifstar{%
```

```

957     \ZREF@xr@zreflabelfalse
958     \@testopt\ZREF@xr@externaldocument{}%
959 }{%
960     \ZREF@xr@zreflabeltrue
961     \@testopt\ZREF@xr@externaldocument{}%
962 }%
963 }%

```

If the `\include` featurer was used, there can be several `.aux` files. These files are read one after another, especially they are not recursively read in order to save read registers. Thus it can happen that the read order of the `newlabel` commands differs from L^AT_EX's order using `\input`.

`\ZREF@xr@externaldocument` It reads the remaining arguments. `\newcommand` comes in handy for the optional argument.

```

964 \def\ZREF@xr@externaldocument[#1]#2{%
965     \def\ZREF@xr@prefix{#1}%
966     \let\ZREF@xr@filelist\@empty
967     \edef\ZREF@xr@file{#2.aux}%
968     \filename@parse{#2}%
969     \@testopt\ZREF@xr@graburl{#2.\zref@xr@ext}%
970 }%
971 \def\ZREF@xr@graburl[#1]{%
972     \edef\ZREF@xr@url{#1}%
973     \ZREF@xr@checkfile
974     \endgroup
975 }%

```

`\ZREF@xr@processfile` We follow `xr` here, `\IfFileExists` offers a nicer test, but we have to open the file anyway.

```

976 \def\ZREF@xr@checkfile{%
977     \openin\@inputcheck\ZREF@xr@file\relax
978     \ifeof\@inputcheck
979         \PackageWarning{zref-xr}{%
980             File '\ZREF@xr@file' not found or empty,\MessageBreak
981             labels not imported%
982         }%
983     \else
984         \PackageInfo{zref-xr}{%
985             Label \ifZREF@xr@zreflabel (zref) \fi import from '\ZREF@xr@file'%
986         }%
987         \def\ZREF@xr@found{0}%
988         \def\ZREF@xr@ignored{0}%
989         \ZREF@xr@processfile
990         \closein\@inputcheck
991         \begingroup
992             \let\on@line\@empty
993             \PackageInfo{zref-xr}{%
994                 Statistics for '\ZREF@xr@file': %
995                 \ZREF@xr@found\space found, %
996                 \ZREF@xr@ignored\space ignored%
997             }%
998         \endgroup
999     \fi
1000     \ifx\ZREF@xr@filelist\@empty
1001     \else
1002         \edef\ZREF@xr@file{\expandafter\@car\ZREF@xr@filelist\@nil}%
1003         \edef\ZREF@xr@filelist{\expandafter\@cdr\ZREF@xr@filelist\@nil}%
1004         \expandafter\ZREF@xr@checkfile
1005     \fi
1006 }%

```

\ZREF@xr@processfile

```
1007 \def\ZREF@xr@processfile{%
1008   \read\@inputcheck to\ZREF@xr@line
1009   \expandafter\ZREF@xr@processline\ZREF@xr@line..\ZREF@nil
1010   \ifeof\@inputcheck
1011   \else
1012     \expandafter\ZREF@xr@procesfile
1013   \fi
1014 }%
```

\ZREF@xr@processline The most work must be done for analyzing the arguments of \newlabel.

```
1015 \long\def\ZREF@xr@processline#1#2#3\ZREF@nil{%
1016   \def\x{#1}%
1017   \toks@{#2}%
1018   \ifZREF@xr@zreflabel
1019     \ifx\x\ZREF@xr@zref@newlabel
1020       \expandafter\ZREF@xr@process@zreflabel\ZREF@xr@line..\ZREF@nil
1021     \fi
1022   \else
1023     \ifx\x\ZREF@xr@newlabel
1024       \expandafter\ZREF@xr@process@label\ZREF@xr@line...[]\ZREF@nil
1025     \fi
1026   \fi
1027   \ifx\x\ZREF@xr@@input
1028     \edef\ZREF@xr@filelist{%
1029       \etex@unexpanded\expandafter{\ZREF@xr@filelist}%
1030       {\filename@area\the\toks@}%
1031     }%
1032   \fi
1033   \ifeof\@inputcheck
1034   \else
1035     \expandafter\ZREF@xr@processfile
1036   \fi
1037 }%
1038 \def\ZREF@xr@process@zreflabel\zref@newlabel#1#2#3\ZREF@nil{%
1039   \def\ZREF@xr@refname{Z@R@\ZREF@xr@prefix#1}%
1040   \edef\ZREF@xr@found{\the\numexpr\ZREF@xr@found+1\relax}%
1041   \def\x{#2}%
1042   \@ifundefined{\ZREF@xr@refname}{%
1043     \let\ZREF@xr@list\x
1044     \ifx\ZREF@xr@list\@empty
1045       \PackageWarningNoLine{zref-xr}{%
1046         Label ‘#1’ without properties ignored\MessageBreak
1047         in file ‘\ZREF@xr@file’%
1048       }%
1049       \edef\ZREF@xr@ignored{\the\numexpr\ZREF@xr@ignored+1\relax}%
1050     \else
1051       \expandafter\ZREF@xr@checklist\x\ZREF@nil
1052       \expandafter\global\expandafter\let
1053         \csname \ZREF@xr@refname\endcsname\x
1054     \fi
1055     \ZREF@xr@urlcheck{\ZREF@xr@prefix#1}%
1056   }{%
1057     \ZREF@xr@ignorewarning{\ZREF@xr@prefix#1}%
1058   }%
1059 }%
1060 \def\ZREF@xr@process@label\newlabel#1#2#3[#4]#5\ZREF@nil{%
1061   \def\ZREF@xr@refname{Z@R@\ZREF@xr@prefix#1}%
1062   \edef\ZREF@xr@found{\the\numexpr\ZREF@xr@found+1\relax}%
1063   \def\x{#2}%
1064   \@ifundefined{\ZREF@xr@refname}{%
1065     \expandafter\ZREF@xr@scanparams
```

```

1066 \csname\ZREF@xr@refname\expandafter\endcsname
1067 \x{}{}{}{}{}\ZREF@nil
1068 \ifx\\#4\\%
1069 \else
1070 % ntheorem knows an optional argument at the end of \newlabel
1071 \zref@ifpropundefined{thetype}%
1072 \zref@newprop{thetype}%
1073 }{}%
1074 \expandafter\g@addto@macro
1075 \csname\ZREF@xr@refname\endcsname{\thetype{#4}}%
1076 \fi
1077 \ZREF@xr@urlcheck{\ZREF@xr@prefix#1}%
1078 }{%
1079 \ZREF@xr@ignorewarning{\ZREF@xr@prefix#1}%
1080 }%
1081 }
1082 \def\ZREF@xr@zref@newlabel{\zref@newlabel}%
1083 \def\ZREF@xr@newlabel{\newlabel}%
1084 \def\ZREF@xr@@input{\@input}%

```

```

1085 \def\ZREF@xr@ignorewarning#1{%
1086   \PackageWarningNoLine{zref-xr}{%
1087     Label ‘#1’ is already in use\MessageBreak
1088     in file ‘\ZREF@xr@file’%
1089   }%
1090   \edef\ZREF@xr@ignored{\the\numexpr\ZREF@xr@ignored+1\relax}%
1091 }%

```

```

1092 \def\ZREF@xr@checklist#1#2#3\ZREF@nil{%
1093   \ifx\@undefined#1\relax
1094     \expandafter\ZREF@xr@checkkey\string#1\@nil
1095   \fi
1096   \ifx\#3\%
1097   \else
1098     \@ReturnAfterFi{%
1099       \ZREF@xr@checklist#3\ZREF@nil
1100     }%
1101   \fi
1102 }%
1103 \long\def\@ReturnAfterFi#1\fi{\fi#1}%
1104 \def\ZREF@xr@checkkey#1#2\@nil{%
1105   \zref@ifpropundefined{#2}{-%
1106     \zref@newprop{#2}{-%
1107   }-%
1108 }%

```

```

1109 \def\ZREF@xr@scanparams#1#2#3#4#5#6#7\ZREF@nil{%
1110   \global\let#1\@empty
1111   \ZREF@foundfalse
1112   \ZREF@xr@scantitleref#1#2\TR@TitleReference{}-{}\ZREF@nil
1113   \ifZREF@found
1114     \else
1115       \g@addto@macro#1{\default{#2}}%
1116     \fi
1117   % page
1118   \g@addto@macro#1{\page{#3}}%
1119   % nameref title
1120   \ifZREF@found
1121     \else

```

```

1122 \ifx\\#4\\%
1123 \else
1124 \zref@ifpropundefined{title}{%
1125 \zref@newprop{title}{}%
1126 }{}%
1127 \g@addto@macro#1{\title{#4}}%
1128 \fi
1129 \fi
1130 % anchor
1131 \ifx\\#5\\%
1132 \else
1133 \zref@ifpropundefined{anchor}{%
1134 \zref@newprop{anchor}{}%
1135 }{}%
1136 \g@addto@macro#1{\anchor{#5}}%
1137 \fi
1138 \ifx\\#6\\%
1139 \else
1140 \zref@ifpropundefined{url}{%
1141 \zref@newprop{url}{}%
1142 }{}%
1143 \g@addto@macro#1{\url{#6}}%
1144 \fi
1145 }%

```

\ZREF@xr@scantitleref

```

1146 \def\ZREF@xr@scantitleref#1#2\TR@TitleReference#3#4#5\ZREF@nil{%
1147 \ifx\\#5\\%
1148 \else
1149 \g@addto@macro#1{%
1150 \default{#3}%
1151 \title{#4}%
1152 }%
1153 \ZREF@foundtrue
1154 \fi
1155 }%

```

\ZREF@xr@urlcheck

```

1156 \def\ZREF@xr@urlcheck#1{%
1157 \zref@ifrefcontainsprop{#1}{anchor}{%
1158 \zref@ifrefcontainsprop{#1}{url}{%
1159 }{%
1160 \expandafter\g@addto@macro\csname Z@R@#1\expandafter\endcsname
1161 \expandafter{%
1162 \expandafter\url\expandafter{\ZREF@xr@url}%
1163 }%
1164 }%
1165 }{%
1166 }%
1167 }%

```

\zxrsetup Just one key for setting the default extension is currently used.

```

1168 \define@key{ZREF@XR}{ext}{%
1169 \def\zref@xr@ext{#1}%
1170 }%
1171 \newcommand*{\zxrsetup}{%
1172 \setkeys{ZREF@XR}%
1173 }%
1174 \</xr>

```

6.12 Module hyperref

```
UNFINISHED :-(
1175 <*hyperref>
1176 \NeedsTeXFormat{LaTeX2e}
1177 \ProvidesPackage{zref-hyperref}%
1178 [2009/08/07 v2.4 Module hyperref for zref (H0)]%
1179 \RequirePackage{zref-base}[2009/08/07]
1180 \@ifundefined{ZREF@baseok}{\endinput}{}
1181 \zref@newprop{anchor}[]{%
1182   \@ifundefined{@currentHref}{}{\@currentHref}%
1183 }%
1184 \zref@addprop{ZREF@mainlist}{anchor}%
1185 </hyperref>
```

6.13 Module savepos

Module `savepos` provides an interface for pdfTeX's `\pdfsavepos`, see the manual for pdfTeX.

6.13.1 Identification

```
1186 <*savepos>
1187 \NeedsTeXFormat{LaTeX2e}
1188 \ProvidesPackage{zref-savepos}%
1189 [2009/08/07 v2.4 Module savepos for zref (H0)]%
1190 \RequirePackage{zref-base}[2009/08/07]
1191 \@ifundefined{ZREF@baseok}{\endinput}{}%
```

6.13.2 Availability

First we check, whether the feature is available.

```
1192 \begingroup
1193   \@ifundefined{pdfsavepos}{%
1194     \ZREF@ErrorNoLine{%
1195       \string\pdfsavepos\space is not supported.\MessageBreak
1196       It is provided by pdfTeX (1.40) or XeTeX%
1197     }\ZREF@UpdatePdfTeX
1198   \endgroup
1199   \endinput
1200 }{}%
1201 \endgroup
```

In PDF mode we are done. However support for DVI mode was added later in version 1.40.0. In earlier versions `\pdfsavepos` is defined, but its execution raises an error. Note that XeTeX also provides `\pdfsavepos`.

```
1202 \RequirePackage{ifpdf}
1203 \ifpdf
1204 \else
1205   \begingroup\expandafter\expandafter\expandafter\endgroup
1206   \expandafter\ifx\csname pdftexversion\endcsname\relax
1207   \else
1208     \ifnum\pdftexversion<140 %
1209       \ZREF@ErrorNoLine{%
1210         \string\pdfsavepos\space is not supported in DVI mode\MessageBreak
1211         of this pdfTeX version%
1212       }\ZREF@UpdatePdfTeX
1213     \expandafter\expandafter\expandafter\endinput
1214   \fi
1215 \fi
1216 \fi
```


6.13.3 Setup

```

1217 \zref@newlist{savepos}
1218 \zref@newprop*{posx}[0]{\the\pdflastxpos}
1219 \zref@newprop*{posy}[0]{\the\pdflastypos}
1220 \zref@addprop{savepos}{posx}
1221 \zref@addprop{savepos}{posy}

```

6.13.4 User macros

`\zsavepos` The current location is stored in a reference with the given name.

```

1222 \def\zsavepos#1{%
1223   \@bsphack
1224   \if@files
1225     \pdfsavepos
1226     \zref@labelbylist{#1}{savepos}%
1227   \fi
1228   \@esphack
1229 }

```

`\zposx` The horizontal and vertical position are available by `\zposx` and `\zposy`. Do not rely on absolute positions. They differ in DVI and PDF mode of pdfTeX. Use differences instead. The unit of the position numbers is sp.

`\zposy`

```

1230 \newcommand*{\zposx}[1]{%
1231   \zref@extract{#1}{posx}%
1232 }%
1233 \newcommand*{\zposy}[1]{%
1234   \zref@extract{#1}{posy}%
1235 }%

```

Typically horizontal and vertical positions are used inside calculations. Therefore the extracting macros should be expandable and babel's patch is not applicable.

Also it is in the responsibility of the user to mark used positions by `\zrefused` in order to notify L^AT_EX about undefined references.

```

1236 \</savepos>

```

6.14 Module dotfill

```

1237 \<*dotfill>
1238 \NeedsTeXFormat{LaTeX2e}
1239 \ProvidesPackage{zref-dotfill}%
1240 [2009/08/07 v2.4 Module dotfill for zref (H0)]%
1241 \RequirePackage{zref-base}[2009/08/07]
1242 \@ifundefined{ZREF@baseok}{\endinput}{}

```

For measuring the width of `\zdotfill` we use the features provided by module `savepos`.

```

1243 \RequirePackage{zref-savepos}[2009/08/07]

```

For automatically generated label names we use the unique counter of module `base`.

```

1244 \zref@require@unique

```

Configuration is done by the key value interface of package `keyval`.

```

1245 \RequirePackage{keyval}

```

The definitions of the keys follow.

```

1246 \define@key{ZREF@DF}{unit}{%
1247   \def\ZREF@df@unit{#1}%
1248 }
1249 \define@key{ZREF@DF}{min}{%
1250   \def\ZREF@df@min{#1}%
1251 }
1252 \define@key{ZREF@DF}{dot}{%

```

```

1253 \def\ZREF@df@dot{#1}%
1254 }
Defaults are set, see user interface.
1255 \providecommand\ZREF@df@min{2}
1256 \providecommand\ZREF@df@unit{.44em}
1257 \providecommand\ZREF@df@dot{.}
\zdotfillsetup Configuration of \zdotfill is done by \zdotfillsetup.
1258 \newcommand*{\zdotfillsetup}{\setkeys{ZREF@DF}}

\zdotfill \zdotfill sets labels at the left and the right to get the horizontal position.
\zsavepos is not used, because we do not need the vertical position.
1259 \newcommand*{\zdotfill}{%
1260 \leavevmode
1261 \global\advance\c@zref@unique\@ne
1262 \begingroup
1263 \def\ZREF@temp{zref@\number\c@zref@unique}%
1264 \pdfsavepos
1265 \zref@labelbyprops{\thezref@unique L}{posx}%
1266 \setlength{\dimen@}{\ZREF@df@unit}%
1267 \zref@ifrefundefined{\thezref@unique R}{%
1268 \ZREF@dotfill
1269 }{%
1270 \ifnum\numexpr\zposx{\thezref@unique R}-\zposx{\thezref@unique L}\relax
1271 <\dimexpr\ZREF@df@min\dimen@\relax
1272 \hfill
1273 \else
1274 \ZREF@dotfill
1275 \fi
1276 }%
1277 \pdfsavepos
1278 \zref@labelbyprops{\thezref@unique R}{posx}%
1279 \endgroup
1280 \kern\z@
1281 }

\ZREF@dotfill Help macro that actually sets the dots.
1282 \def\ZREF@dotfill{%
1283 \cleaders\hb@xt@\dimen@{\hss\ZREF@df@dot\hss}\hfill
1284 }

1285 </dotfill>

```

7 Test

7.1 \zref@localaddprop

```

1286 <*test1>
1287 \NeedsTeXFormat{LaTeX2e}
1288 \nofiles
1289 \documentclass{article}
1290 \usepackage{zref-base}[2009/08/07]
1291 \usepackage{qstest}
1292 \IncludeTests{*}
1293 \LogTests{log}{*}{*}
1294
1295 \makeatletter
1296 \begin{qstest}{localaddprop}{localaddprop}
1297 \Expect*{\Z@L@main}*{\default}{page}%
1298 \zref@newprop{foobar}{F00}%
1299 \zref@newlist{alist}%
1300 \Expect*{\Z@L@alist}{*}%

```

```

1301 \begingroup
1302   \zref@localaddprop{main}{foobar}%
1303   \Expect*{\Z@L@main}{\{default\}{page}{foobar}}%
1304   \zref@localaddprop{alist}{page}%
1305   \Expect*{\Z@L@alist}{\{page\}}%
1306 \endgroup
1307 \Expect*{\Z@L@main}{\{default\}{page}}%
1308 \Expect*{\Z@L@alist}{\{}}%
1309 \end{qstest}
1310 \@@end
1311 \</test1>

```

7.2 Module runs

```

1312 \<*test — runs>
1313 \NeedsTeXFormat{LaTeX2e}
1314 \documentclass{article}
1315 \usepackage{zref-runs}[2009/08/07]
1316 \usepackage{qstest}
1317 \IncludeTests{*}
1318 \LogTests{log}{*}{*}
1319
1320 \begin{qstest}{zruns-preamble}{zruns-preamble}
1321   \Expect{0}{*\{zruns\}}%
1322 \end{qstest}
1323
1324 \AtBeginDocument{%
1325   \begin{qstest}{zruns-atbegindocument}{zruns-atbegindocument}%
1326     \Expect*{\number\ExpectRuns}{*\{zruns\}}%
1327   \end{qstest}%
1328 }
1329
1330 \begin{document}
1331 \begin{qstest}{zruns-document}{zruns-document}
1332   \Expect*{\number\ExpectRuns}{*\{zruns\}}%
1333 \end{qstest}
1334 \end{document}
1335 \</test — runs>

```

8 Installation

8.1 Download

Package. This package is available on CTAN¹:

[CTAN:macros/latex/contrib/oberdiek/zref.dtx](#) The source file.

[CTAN:macros/latex/contrib/oberdiek/zref.pdf](#) Documentation.

Bundle. All the packages of the bundle ‘oberdiek’ are also available in a TDS compliant ZIP archive. There the packages are already unpacked and the documentation files are generated. The files and directories obey the TDS standard.

[CTAN:install/macros/latex/contrib/oberdiek.tds.zip](#)

TDS refers to the standard “A Directory Structure for \TeX Files” ([CTAN:tds/tds.pdf](#)). Directories with `texmf` in their name are usually organized this way.

8.2 Bundle installation

Unpacking. Unpack the `oberdiek.tds.zip` in the TDS tree (also known as `texmf` tree) of your choice. Example (linux):

```
unzip oberdiek.tds.zip -d ~/texmf
```

¹<http://ftp.ctan.org/tex-archive/>

Script installation. Check the directory `TDS:scripts/oberdiek/` for scripts that need further installation steps. Package `attachfile2` comes with the Perl script `pdfatfi.pl` that should be installed in such a way that it can be called as `pdfatfi`. Example (linux):

```
chmod +x scripts/oberdiek/pdfatfi.pl
cp scripts/oberdiek/pdfatfi.pl /usr/local/bin/
```

8.3 Package installation

Unpacking. The `.dtx` file is a self-extracting `docstrip` archive. The files are extracted by running the `.dtx` through plain- \TeX :

```
tex zref.dtx
```

TDS. Now the different files must be moved into the different directories in your installation TDS tree (also known as `texmf` tree):

<code>zref.sty</code>	→ <code>tex/latex/oberdiek/zref.sty</code>
<code>zref-base.sty</code>	→ <code>tex/latex/oberdiek/zref-base.sty</code>
<code>zref-abspage.sty</code>	→ <code>tex/latex/oberdiek/zref-abspage.sty</code>
<code>zref-counter.sty</code>	→ <code>tex/latex/oberdiek/zref-counter.sty</code>
<code>zref-dotfill.sty</code>	→ <code>tex/latex/oberdiek/zref-dotfill.sty</code>
<code>zref-hyperref.sty</code>	→ <code>tex/latex/oberdiek/zref-hyperref.sty</code>
<code>zref-lastpage.sty</code>	→ <code>tex/latex/oberdiek/zref-lastpage.sty</code>
<code>zref-perpage.sty</code>	→ <code>tex/latex/oberdiek/zref-perpage.sty</code>
<code>zref-runs.sty</code>	→ <code>tex/latex/oberdiek/zref-runs.sty</code>
<code>zref-savepos.sty</code>	→ <code>tex/latex/oberdiek/zref-savepos.sty</code>
<code>zref-titleref.sty</code>	→ <code>tex/latex/oberdiek/zref-titleref.sty</code>
<code>zref-totpages.sty</code>	→ <code>tex/latex/oberdiek/zref-totpages.sty</code>
<code>zref-user.sty</code>	→ <code>tex/latex/oberdiek/zref-user.sty</code>
<code>zref-xr.sty</code>	→ <code>tex/latex/oberdiek/zref-xr.sty</code>
<code>zref.pdf</code>	→ <code>doc/latex/oberdiek/zref.pdf</code>
<code>zref-example.tex</code>	→ <code>doc/latex/oberdiek/zref-example.tex</code>
<code>zref-example-lastpage.tex</code>	→ <code>doc/latex/oberdiek/zref-example-lastpage.tex</code>
<code>test/zref-test1.tex</code>	→ <code>doc/latex/oberdiek/test/zref-test1.tex</code>
<code>test/zref-test-runs.tex</code>	→ <code>doc/latex/oberdiek/test/zref-test-runs.tex</code>
<code>zref.dtx</code>	→ <code>source/latex/oberdiek/zref.dtx</code>

If you have a `docstrip.cfg` that configures and enables `docstrip`'s TDS installing feature, then some files can already be in the right place, see the documentation of `docstrip`.

8.4 Refresh file name databases

If your \TeX distribution (`te \TeX` , `mik \TeX` , ...) relies on file name databases, you must refresh these. For example, `te \TeX` users run `texhash` or `mktexlsr`.

8.5 Some details for the interested

Attached source. The PDF documentation on CTAN also includes the `.dtx` source file. It can be extracted by AcrobatReader 6 or higher. Another option is `pdftk`, e.g. unpack the file into the current directory:

```
pdftk zref.pdf unpack_files output .
```

Unpacking with \LaTeX . The `.dtx` chooses its action depending on the format:

plain- \TeX : Run `docstrip` and extract the files.

\LaTeX : Generate the documentation.

If you insist on using L^AT_EX for docstrip (really, docstrip does not need L^AT_EX), then inform the autodetect routine about your intention:

```
latex \let\install=y\input{zref.dtx}
```

Do not forget to quote the argument according to the demands of your shell.

Generating the documentation. You can use both the .dtx or the .drv to generate the documentation. The process can be configured by the configuration file ltxdoc.cfg. For instance, put this line into this file, if you want to have A4 as paper format:

```
\PassOptionsToClass{a4paper}{article}
```

An example follows how to generate the documentation with pdfL^AT_EX:

```
pdflatex zref.dtx
makeindex -s gind.ist zref.idx
pdflatex zref.dtx
makeindex -s gind.ist zref.idx
pdflatex zref.dtx
```

9 References

- [1] Package footmisc, Robin Fairbairns, 2004/01/23 v5.3a.[CTAN:macros/latex/contrib/footmisc/footmisc.dtx](#)
- [2] Package hyperref, Sebastian Rahtz, Heiko Oberdiek, 2006/08/16 v6.75c.[CTAN:macros/latex/contrib/hyperref/](#)
- [3] Package lastpage, Jeff Goldberg, 1994/06/25 v0.1b.[CTAN:macros/latex/contrib/lastpage/](#)
- [4] Package nameref, Sebastian Rahtz, Heiko Oberdiek, 2006/02/12 v2.24.[CTAN:macros/latex/contrib/hyperref/nameref.dtx](#)
- [5] Package perpage, David Kastrup, 2002/12/20 v1.0.[CTAN:macros/latex/contrib/bigfoot/perpage.dtx](#)
- [6] Package titleref, Donald Arsenau, 2001/04/05 v3.1.[CTAN:macros/latex/contrib/misc/titleref.sty](#)
- [7] Package totpages, Wilhelm Müller, 1999/07/14 v1.00.[CTAN:macros/latex/contrib/totpages/](#)
- [8] Package xr, David Carlisle, 1994/05/28 v5.02.[CTAN:macros/latex/required/tools/xr.pdf](#)
- [9] Package xr-hyper, David Carlisle, 2000/03/22 v6.00beta4.[CTAN:macros/latex/contrib/hyperref/xr-hyper.sty](#)

10 History

[2006/02/20 v1.0]

- First version.

[2006/05/03 v1.1]

- Module perpage added.
- Module redesign as packages.

[2006/05/25 v1.2]

- Module `dotfillmin` added.
- Module `base`: macros `\zref@require@unique` and `\thezref@unique` added (used by modules `titleref` and `dotfillmin`).

[2006/09/08 v1.3]

- Typo fixes and English cleanup by Per Starback.

[2007/01/23 v1.4]

- Typo in macro name fixed in documentation.

[2007/02/18 v1.5]

- `\zref@getcurrent` added (suggestion of Igor Akkerman).
- Module `savepos` also supports XeTeX.

[2007/04/06 v1.6]

- Fix in modules `abspage` and `base`: Now counter `abspage` and `zref@unique` are not remembered by `\include`.
- Beamer support for module `titleref`.

[2007/04/17 v1.7]

- Package `atbegshi` replaces `everyshi`.

[2007/04/22 v1.8]

- `\zref@wrapper@babel` and `\zref@refused` are now expandable if `babel` is not used or `\if@safe@actives` is already set to true. (Feature request of Josselin Noirel)

[2007/05/02 v1.9]

- Module `titleref`: Some support for `\caption` of package `longtable`, but only if `\label` is given after `\caption`.

[2007/05/06 v2.0]

- Uses package `etexcmds` for accessing ε -TeX's `\unexpanded`.

[2007/05/28 v2.1]

- Module `titleref` supports caption of package `listings`.
- Fixes in module `titleref` for support of packages `titlesec` and `longtable`.

[2008/09/21 v2.2]

- Module `base`: `\zref@iflistcontainsprop` is documented, but a broken `\zref@listcontainsprop` implemented. Name and implementation fixed (thanks Ohad Kammar).

[2008/10/01 v2.3]

- `\zref@localaddprop` added (feature request of Ohad Kammar).
- Module `lastpage`: list ‘LastPage’ added. Label ‘LastPage’ will use the properties of this list (default is empty) along with the properties of the main list.

[2009/08/07 v2.4]

- Module `runs` added.

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