There are three broad “layers” between putting down ideas into a source file and
ending up with a typeset document. These layers of document writing are

1. authoring of the text with mark-up;
2. document layout design;
3. implementation (with TeX programming) of the design.

We write the text as an author, and we see the visual output of the design after the
document is generated; the TeX implementation in the middle is the glue between the
two.

\LaTeX’s greatest success has been to standardise a system of mark-up that balances
the trade-off between ease of reading and ease of writing to suit almost all forms of
technical writing. It’s other original strength was a good background in typographical
design; while the standard \LaTeX\textsuperscript{2}\epsilon classes look somewhat dated now in terms of their
visual design, their typography is generally sound. (Barring the occasional minor faults.)

However, \LaTeX\textsuperscript{2}\epsilon has always lacked a standard approach to customising the visual
design of a document. Changing the looks of the standard classes involved either:

- Creating a new version of the implementation code of the class and editing it.
- Loading one of the many packages to customise certain elements of the standard
classes.
- Loading a completely different document class, such as KOMA-Script or memoir,
  that allows easy customisation.

All three of these approaches have their drawbacks and learning curves.

The idea behind \texttt{xtemplate} is to cleanly separate the three layers introduced at the
beginning of this section, so that document authors who are not programmers can easily
change the design of their documents. \texttt{xtemplate} also makes it easier for \LaTeX programmers
to provide their own customisations on top of a pre-existing class.

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1 What is a document?

Besides the textual content of the words themselves, the source file of a document contains mark-up elements that add structure to the document. These elements include sectional divisions, figure/table captions, lists of various sorts, theorems/proofs, and so on. The list will be different for every document that can be written.

Each element can be represented logically without worrying about the formatting, with mark-up such as \section, \caption, \begin{enumerate} and so on. The output of each one of these document elements will be a typeset representation of the information marked up, and the visual arrangement and design of these elements can vary widely in producing a variety of desired outcomes.

For each type of document element, there may be design variations that contain the same sort of information but present it in slightly different ways. For example, the difference between a numbered and an unnumbered section, \section and \section*, or the difference between an itemised list or an enumerated list.

There are three distinct layers in the definition of “a document” at this level

1. semantic elements such as the ideas of sections and lists;
2. a set of design solutions for representing these elements visually;
3. specific variations for these designs that represent the elements in the document.

In the parlance of the template system, these are called object types, templates, and instances, and they are discussed below in sections 3, 4, and 6, respectively.

2 Objects, templates, and instances

By formally declaring documents to be composed of mark-up elements grouped into objects, which are interpreted and typeset with a set of templates, each of which has one or more instances with which to compose each and every semantic unit of the text, we can cleanly separate the components of document construction.

All of the structures provided by the template system are global, and do not respect \TeX grouping.

3 Object types

An object type (sometimes just “object”) is an abstract idea of a document element that takes a fixed number of arguments corresponding to the information from the document author that it is representing. A sectioning object, for example, might take three inputs: “title”, “short title”, and “label”.

Any given document class will define which object types are to be used in the document, and any template of a given object type can be used to generate an instance for the object. (Of course, different templates will produce different typeset representations, but the underlying content will be the same.)
This function defines an \langle object type \rangle taking \langle number of arguments \rangle, where the \langle object type \rangle is an abstraction as discussed above. For example,
\DeclareObjectType{sectioning}{3}
creates an object type “sectioning”, where each use of that object type will need three arguments.

4 Templates
A template is a generalised design solution for representing the information of a specified object type. Templates that do the same thing, but in different ways, are grouped together by their object type and given separate names. There are two important parts to a template:

- the parameters it takes to vary the design it is producing;
- the implementation of the design.

As a document author or designer does not care about the implementation but rather only the interface to the template, these two aspects of the template definition are split into two independent declarations, \DeclareTemplateInterface and \DeclareTemplateCode.

\DeclareTemplateInterface
\langle object type \rangle \{\langle template \rangle \} \{\langle no. of args \rangle \}
\{\langle key list \rangle \}

A \langle template \rangle interface is declared for a particular \langle object type \rangle, where the \langle number of arguments \rangle must agree with the object type declaration. The interface itself is defined by the \langle key list \rangle, which is itself a key–value list taking a specialized format:

\{key1\} : \{key type1\} ,
\{key2\} : \{key type2\} ,
\{key3\} : \{key type3\} = \{default3\} ,
\{key4\} : \{key type4\} = \{default4\} ,
...

Each \langle key \rangle name should consist of ASCII characters, with the exception of \_, = and \,. The recommended form for key names is to use lower case letters, with dashes to separate out different parts. Spaces are ignored in key names, so they can be included or missed out at will. Each \langle key \rangle must have a \langle key type \rangle, which defined the type of input that the \langle key \rangle requires. A full list of key types is given in Table 1. Each key may have a \langle default \rangle value, which will be used in by the template if the \langle key \rangle is not set explicitly. The \langle default \rangle should be of the correct form to be accepted by the \langle key type \rangle of the \langle key \rangle; this is not checked by the code.
<table>
<thead>
<tr>
<th>Key-type</th>
<th>Description of input</th>
</tr>
</thead>
<tbody>
<tr>
<td>boolean</td>
<td>true or false</td>
</tr>
<tr>
<td>choice{choices}</td>
<td>A list of pre-defined (choices)</td>
</tr>
<tr>
<td>commalist</td>
<td>A comma-separated list</td>
</tr>
<tr>
<td>function{⟨N⟩}</td>
<td>A function definition with N arguments (N from 0 to 9)</td>
</tr>
<tr>
<td>instance{⟨name⟩}</td>
<td>An instance of type ⟨name⟩</td>
</tr>
<tr>
<td>integer</td>
<td>An integer or integer expression</td>
</tr>
<tr>
<td>length</td>
<td>A fixed length</td>
</tr>
<tr>
<td>muskip</td>
<td>A math length with shrink and stretch components</td>
</tr>
<tr>
<td>real</td>
<td>A real (floating point) value</td>
</tr>
<tr>
<td>skip</td>
<td>A length with shrink and stretch components</td>
</tr>
<tr>
<td>tokenlist</td>
<td>A token list: any text or commands</td>
</tr>
</tbody>
</table>

Table 1: Key-types for defining template interfaces with \texttt{\DeclareTemplateInterface}.

\texttt{\KeyValue \{⟨key name⟩\}}

There are occasions where the default (or value) for one key should be taken from another. The \texttt{\KeyValue} function can be used to transfer this information without needing to know the internal implementation of the key:

\begin{verbatim}
\DeclareTemplateInterface { object } { template } { no. of args }
{
  key-name-1 : key-type = value ,
  key-name-2 : key-type = \KeyValue { key-name-1 },
  \ldots
}
\end{verbatim}
<table>
<thead>
<tr>
<th>Key-type</th>
<th>Description of binding</th>
</tr>
</thead>
<tbody>
<tr>
<td>boolean</td>
<td>Boolean variable, e.g. _tmpa_bool</td>
</tr>
<tr>
<td>choice</td>
<td>List of choice implementations (see Section 5)</td>
</tr>
<tr>
<td>commalist</td>
<td>Comma list, e.g. _tmpa_clist</td>
</tr>
<tr>
<td>function</td>
<td>Function taking N arguments, e.g. \use_i:nn</td>
</tr>
<tr>
<td>instance</td>
<td>Integer variable, e.g. _tmpa_int</td>
</tr>
<tr>
<td>length</td>
<td>Dimension variable, e.g. _tmpa_dim</td>
</tr>
<tr>
<td>muskip</td>
<td>Muskip variable, e.g. _tmpa_muskip</td>
</tr>
<tr>
<td>real</td>
<td>Floating-point variable, e.g. _tmpa_fp</td>
</tr>
<tr>
<td>skip</td>
<td>Skip variable, e.g. _tmpa_skip</td>
</tr>
<tr>
<td>tokenlist</td>
<td>Token list variable, e.g. _tmpa_tl</td>
</tr>
</tbody>
</table>

Table 2: Bindings required for different key types when defining template implementations with \DeclareTemplateCode. Apart from code, choice and function all of these accept the key word global to carry out a global assignment.

\DeclareTemplateCode
\DeclareTemplateCode
\{\langle object type\rangle\} \{\langle template\rangle\} \{\langle no. of args\rangle\}
\{\langle key bindings\rangle\} \{\langle code\rangle\}

The relationship between a templates keys and the internal implementation is created using the \DeclareTemplateCode function. As with \DeclareTemplateInterface, the \langle template\rangle name is given along with the \langle object type\rangle and \langle number of arguments\rangle required. The \langle key bindings\rangle argument is a key–value list which specifies the relationship between each \langle key\rangle of the template interface with an underlying\langle variable\rangle.

\langle key1\rangle = \langle variable1\rangle,
\langle key2\rangle = \langle variable2\rangle,
\langle key3\rangle = \text{global} \langle variable3\rangle,
\langle key4\rangle = \text{global} \langle variable4\rangle,
...

With the exception of the choice, code and function key types, the \langle variable\rangle here should be the name of an existing \LaTeX3 register. As illustrated, the key word “global” may be included in the listing to indicate that the \langle variable\rangle should be assigned globally. A full list of variable bindings is given in Table 2.

The \langle code\rangle argument of \DeclareTemplateCode is used as the replacement text for the template when it is used, either directly or as an instance. This may therefore accept arguments #1, #2, etc. as detailed by the \langle number of arguments\rangle taken by the object type.
In the final argument of $\texttt{\textbackslash DeclareTemplateCode}$ the assignment of keys defined by the template may be delayed by including the command $\texttt{\textbackslash AssignTemplateKeys}$. If this is not present, keys are assigned immediately before the template code. If $\texttt{\textbackslash AssignTemplateKeys}$ is present, assignment is delayed until this point. Note that the command must be directly present in the code, not placed within a nested command/macro.

5 Multiple choices

The choice key type implements multiple choice input. At the interface level, only the list of valid choices is needed:

\begin{verbatim}
\texttt{\textbackslash DeclareTemplateInterface \{ foo \} \{ bar \} \{ 0 \}}
{ key-name : choice \{ A, B, C \} }
\end{verbatim}

where the choices are given as a comma-list (which must therefore be wrapped in braces). A default value can also be given:

\begin{verbatim}
\texttt{\textbackslash DeclareTemplateInterface \{ foo \} \{ bar \} \{ 0 \}}
{ key-name : choice \{ A, B, C \} = A }
\end{verbatim}

At the implementation level, each choice is associated with code, using a nested key–value list.

\begin{verbatim}
\texttt{\textbackslash DeclareTemplateCode \{ foo \} \{ bar \} \{ 0 \}}
{ key-name =
  \{
    A = Code-A ,
    B = Code-B ,
    C = Code-C
  \}
}
{ ... }
\end{verbatim}

The two choice lists should match, but in the implementation a special unknown choice is also available. This can be used to ignore values and implement an “else” branch:

\begin{verbatim}
\texttt{\textbackslash DeclareTemplateCode \{ foo \} \{ bar \} \{ 0 \}}
{ key-name =
  \{
    A = Code-A ,
    B = Code-B ,
    C = Code-C ,
    unknown = Else-code
  \}
}
{ ... }
\end{verbatim}
The unknown entry must be the last one given, and should not be listed in the interface part of the template.

For keys which accept the values true and false both the boolean and choice key types can be used. As template interfaces are intended to prompt clarity at the design level, the boolean key type should be favoured, with the choice type reserved for keys which take arbitrary values.

6 Instances

After a template is defined it still needs to be put to use. The parameters that it expects need to be defined before it can be used in a document. Every time a template has parameters given to it, an instance is created, and this is the code that ends up in the document to perform the typesetting of whatever pieces of information are input into it.

For example, a template might say “here is a section with or without a number that might be centred or left aligned and print its contents in a certain font of a certain size, with a bit of a gap before and after it” whereas an instance declares “this is a section with a number, which is centred and set in 12pt italic with a 10pt skip before and a 12pt skip after it”. Therefore, an instance is just a frozen version of a template with specific settings as chosen by the designer.

\DeclareInstance { sectioning } { section-num } { basic }
{
    numbered = true ,
    justification = center ,
    font = \normalsize\itshape ,
    before-skip = 10pt ,
    after-skip = 12pt ,
}

Of course, the key names here are entirely imaginary, but illustrate the general idea of fixing some settings.

\IfInstanceExistT \IfInstanceExistF \IfInstanceExistTF

Tests if the named instance of a object type exists, and then inserts the appropriate code into the input stream.

\DeclareInstanceCopy

Copies the values for instance1 for an object type to instance2.
7 Document interface

After the instances have been chosen, document commands must be declared to use those instances in the document. \texttt{UseInstance} calls instances directly, and this command should be used internally in document-level mark-up.

\begin{verbatim}
\texttt{UseInstance} \texttt{UseInstance} \\
\{\langle object type\rangle\} \{\langle instance\rangle\} \{\langle arguments\rangle\}
\end{verbatim}

Uses an \langle instance\rangle of the \langle object type\rangle, which will require \langle arguments\rangle as determined by the number specified for the \langle object type\rangle. The \langle instance\rangle must have been declared before it can be used, otherwise an error is raised.

\begin{verbatim}
\texttt{UseTemplate} \texttt{UseTemplate} \\
\{\langle object type\rangle\} \{\langle template\rangle\} \\
\{\langle settings\rangle\} \{\langle arguments\rangle\}
\end{verbatim}

Uses the \langle template\rangle of the specified \langle object type\rangle, applying the \langle settings\rangle and absorbing \langle arguments\rangle as detailed by the \langle object type\rangle declaration. This in effect is the same as creating an instance using \texttt{DeclareInstance} and immediately using it with \texttt{UseInstance}, but without the instance having any further existence. It is therefore useful where a template needs to be used once.

This function can also be used as the argument to \texttt{instance} key types:

\begin{verbatim}
\texttt{DeclareInstance} \{ object \} \{ template \} \{ instance \} \\
{ \texttt{instance-key} = \texttt{UseTemplate} \{ object2 \} \{ template2 \} \{ \langle settings\rangle\} }
\end{verbatim}

8 Changing existing definitions

Template parameters may be assigned specific defaults for instances to use if the instance declaration doesn’t explicit set those parameters. In some cases, the document designer will wish to edit these defaults to allow them to “cascade” to the instances. The alternative would be to set each parameter identically for each instance declaration, a tedious and error-prone process.

\begin{verbatim}
\texttt{EditTemplateDefaults} \texttt{EditTemplateDefaults} \\
\{\langle object type\rangle\} \{\langle template\rangle\} \{\langle new defaults\rangle\}
\end{verbatim}

Edits the \langle defaults\rangle for a \langle template\rangle for an \langle object type\rangle. The \langle new defaults\rangle, given as a key-value list, replace the existing defaults for the \langle template\rangle. This means that the change will apply to instances declared after the editing, but that instances which have already been created are unaffected.

\begin{verbatim}
\texttt{EditInstance} \texttt{EditInstance} \\
\{\langle object type\rangle\} \{\langle instance\rangle\} \{\langle new values\rangle\}
\end{verbatim}

Edits the \langle values\rangle for an \langle instance\rangle for an \langle object type\rangle. The \langle new values\rangle, given as a key-value list, replace the existing values for the \langle instance\rangle. This function is complementary to \texttt{EditTemplateDefaults}: \texttt{EditInstance} changes a single instance while leaving the template untouched.
9 When template parameters should be frozen

A class designer may be inheriting templates declared by someone else, either third-party code or the \LaTeX kernel itself. Sometimes these templates will be overly general for the purposes of the document. The user should be able to customise parts of the template instances, but otherwise be restricted to only those parameters allowed by the designer.

\texttt{\textbackslash\DeclareRestrictedTemplate} \texttt{\{object type\}} \texttt{\{parent template\}} \texttt{\{new template\}} \texttt{\{parameters\}}

Creates a copy of the \texttt{\{parent template\}} for the \texttt{\{object type\}} called \texttt{\{new template\}}. The key–value list of \texttt{\{parameters\}} applies in the \texttt{\{new template\}} and cannot be changed when creating an instance.

10 \textit{Ad hoc} adjustment of templates

\texttt{\textbackslash\SetTemplateKeys} \texttt{\{object type\}} \texttt{\{template\}} \texttt{\{keyvals\}}

At point of use it may be useful to apply changes to individual instances. This is supported as each template key is made available for adjustment using \texttt{\SetTemplateKeys}.

For example, after

\texttt{\textbackslash\DeclareObjectType\{MyObj\}\{0\}}
\texttt{\textbackslash\DeclareTemplateInterface\{MyObj\}\{TemplateA\}\{0\}}
\texttt{\{akey: tokenlist, bkey: function\{2\}\}}
\texttt{\textbackslash\DeclareTemplateCode\{MyObj\}\{TemplateA\}\{0\}}
\texttt{\{akey = SomeTokens, bkey = \texttt{\textbackslash func:nn}, \}}

the template keys could be adjusted in an \textit{ad hoc} fashion using

\texttt{\SetTemplateKeys\{MyObj\}\{TemplateA\}}
\texttt{\{akey = OtherTokens, bkey = \texttt{\textbackslash AltFunc:nn}\}}

11 Getting information about templates and instances

\texttt{\ShowInstanceValues} \texttt{\ShowInstanceValues \{object type\} \{instance\}}

Shows the \texttt{\values} for an \texttt{\instance} of the given \texttt{\object type} at the terminal.
\ShowTemplateCode \ShowTemplateCode \{\langle object type\rangle\} \{\langle template\rangle\}

Shows the \texttt{\langle code\rangle} of a \langle template\rangle for an \langle object type\rangle in the terminal.

\ShowTemplateDefaults \ShowTemplateDefaults \{\langle object type\rangle\} \{\langle template\rangle\}

Shows the \texttt{\langle default\rangle} values of a \langle template\rangle for an \langle object type\rangle in the terminal.

\ShowTemplateInterface \ShowTemplateInterface \{\langle object type\rangle\} \{\langle template\rangle\}

Shows the \texttt{\langle keys\rangle} and associated \texttt{\langle key types\rangle} of a \langle template\rangle for an \langle object type\rangle in the terminal.

\ShowTemplateVariables \ShowTemplateVariables \{\langle object type\rangle\} \{\langle template\rangle\}

Shows the \texttt{\langle variables\rangle} and associated \texttt{\langle keys\rangle} of a \langle template\rangle for an \langle object type\rangle in the terminal. Note that \texttt{\langle code\rangle} and \texttt{\langle choice\rangle} keys do not map directly to variables but to arbitrary code. For \texttt{\langle choice\rangle} keys, each valid choice is shown as a separate entry in the list, with the key name and choice separated by a space, for example:

Template 'example' of object type 'example' has variable mapping:
  > demo unknown => \def \demo {?}
  > demo c => \def \demo {c}
  > demo b => \def \demo {b}
  > demo a => \def \demo {a}.

would be shown for a choice key \texttt{demo} with valid choices \texttt{a}, \texttt{b} and \texttt{c}, plus code for an unknown branch.

12 Collections

The implementation of templates includes a concept termed “collections”. The idea is that by activating a collection, a set of instances can rapidly be set up. An example use case would be collections for \texttt{frontmatter}, \texttt{mainmatter} and \texttt{backmatter} in a book. This mechanism is currently implemented by the commands \texttt{\DeclareCollectionInstance}, \texttt{\EditCollectionInstance} and \texttt{\UseCollection}. However, while the idea of switchable instances is a useful one, the team feel that collections are not the correct way to achieve this, at least with the current approach. As such, the collection functions should be regarded as deprecated: they remain available to support existing code, but will be removed when a better mechanism is developed.

\ShowCollectionInstanceValues \ShowInstanceValues \{\langle collection\rangle\} \{\langle object type\rangle\} \{\langle instance\rangle\}

Shows the \texttt{\langle values\rangle} for an \langle instance\rangle within a \langle collection\rangle of the given \langle object type\rangle at the terminal. As for other collection commands, this should be regarded as deprecated.

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