Abstract

This article describes the use and the implementation of the \texttt{multicols} environment. This environment allows switching between one and multicolumn format on the same page. Footnotes are handled correctly (for the most part), but will be placed at the bottom of the page and not under each column. \LaTeX{}’s float mechanism, however, is partly disabled in this implementation. At the moment only page-wide floats (i.e., star-forms) can be used within the scope of the environment.

Preface to version 1.8

The 1.8 release improves on the balancing approach. If due to a limited number of break points (e.g., due to large objects) the balanced columns exceed the available vertical space, then balancing is canceled and a normal page is produced first. Some overflow is allowed (controlled by the parameter \texttt{\maxbalancingoverflow} which defaults to \texttt{12pt}). This ensures that we only cut a normal page if we get enough material carried over to next page.

Also added was support for \texttt{\enlargethispage}. This means it is now possible to request a page to be artificially enlarged or shortened. Note that if you enlarge pages by more than one line you may have to increase the \texttt{collectmore} counter value to ensure that enough material is being picked up.

This command was used on the second page of this manual to shorten it by one line, in order to get rid of a number of widow lines on the following pages.

There are also some small enhancements to the balancing algorithm including a ways to require a minimum number of rows in the result.

Finally, version 1.8 adds the command \texttt{\docolaction} to help with more complicated actions that depend on the current column. This command expects 3 arguments: code that is executed if we are in the “first” column, code to execute if we end up in any “middle” column (if there are more than two) and finally code to execute if we are in the “last” column. Thus

\begin{verbatim}
\docolaction{first}
  \{middle}\{last\}
\end{verbatim}

would typeset a different word depending the type of column this code is executed. Using it like this is probably pointless, but you can imagine applications like writing something into the nearest margin, etc.

As this feature needs at least two \LaTeX{} runs to produce correct results and as it adds to the processing complexity it is only made available if one add the option \texttt{colaction} when loading the package.
Preface to version 1.7 (right to left support)

The 1.7 release adds support for languages that are typeset right-to-left. For those languages the order of the columns on the page also need to be reversed—
something that wasn’t supported before. The next paragraph demonstrates the result (as it is typeset as if we are writing in a left-to-right language—
so read the rightmost column first). The change is initialized via \RLmulticolcolumns and returning to left-right (default) is done via \LRmulticolcolumns.

For example:
\renewcommand \footnoterule{\% \kern-3pt\hbox to\textwidth {\hskip .6\textwidth \hrulefill }\kern2.6pt}

Preface to version 1.5 + 1.6

The 1.5 release contains two major changes: multicols will now support up to 10 columns and two more tuning possibilities have been added to the balancing routine. The balancing routine now checks the badness of the resulting columns and rejects solutions that are larger than a certain threshold. At the same time multicols has been upgraded to run under \LaTeX{}2ε. Later changes to 1.5 include \columnbreak and multicols*.

For version 1.6 micro-spacing around the boxes produced by multicols has been improved to allow for baseline-grid typesetting.

1 Introduction

Switching between two-column and one-column layout is possible in \LaTeX{}, but every use of \twocolumn or \onecolumn starts a new page. Moreover, the last page of twocolumn output isn’t balanced and this often results in an empty, or nearly empty, right column. When I started to write macros for doc.sty (see “The doc-Option”, TUGboat volume 10 #2, pp. 245–273) I thought that it would be nice to place the index on the same page as the bibliography. And balancing the last page would not only look better, it also would save space; provided of course that it is also possible to start the next article on the same page. Rewriting the index environment was comparatively easy, but the next goal, designing an environment which takes care of footnotes, floats, etc., was a harder task. It took me a whole weekend\(^1\) to get together the few lines of code below and there is still a good chance that I missed something after all.

Try it and, hopefully, enjoy it; and please direct bug reports and suggestions back to Mainz.

2 The User Interface

To use the environment one simply says
\begin{multicols}{⟨number⟩}
⟨multicolumn text⟩
\end{multicols}

where ⟨number⟩ is the required number of columns and ⟨multicolumn text⟩ may contain arbitrary \LaTeX{} commands, except that floats and marginpars are not allowed in the current implementation\(^2\).

As its first action, the multicols environment measures the current page to determine whether there is enough room for some portion of multicolumn output.

\(^1\) I started with the algorithm given in the \TeX{}book on page 417. Without this help a weekend would not have been enough. (This remark was made in the documentation of the initial release, since then several hundreds more hours went into improving the original code.)

\(^2\) This is dictated by lack of time. To implement floats one has to reimplement the whole \LaTeX{} output routine.
The space between columns is controlled by the \pretolerance parameter \columnseprule. The width for the individual columns is automatically calculated from this parameter and the current \linewidth. In this article a value of 18.0pt was used.

Separation of columns with vertical rules is achieved by setting the parameter \columnseprule to some positive value. In this article a value of .4pt was used.

The color of the rules separating the columns can be specified through \columnseprulecolor. The default value is \normalcolor.

Since narrow columns tend to need adjustments in interline spacing we also provide a (skip) parameter called \multicolbaselinekip which is added to the \baselineskip parameter inside the multicols environment. Please use this parameter with care or leave it alone; it is intended only for package file designers since even small changes might produce totally unexpected changes to your document.

2.1 Balancing columns

Besides the previously mentioned parameters, some others are provided to influence the layout of the columns generated.

Paragraphing in \TeX{} is controlled by several parameters. One of the most important is called \tolerance: this controls the allowed ‘looseness’ (i.e. the amount of blank space between words). Its default value is 200 (the \TeX{} \fussy which is too small for narrow columns. On the other hand the \sloppy declaration (which sets \tolerance to 10000 = \infty) is too large, allowing really bad spacing.\footnote{Look at the next paragraph, it was set with the \sloppy declaration.}

We therefore use a \multicolpretolerance parameter for the \tolerance value inside the multicols environment. Its default value is 9999 which is less than infinity but ‘bad’ enough for most paragraphs in a multicolumn environment. Changing its value should be done outside the multicols environment. Since \tolerance is set to \multicolpretolerance at the beginning of every multicols environment one can locally overwrite this default by assigning \tolerance_{\text{desired value}}. There also exists a \multicolpretolerance parameter holding the value for \pretolerance within a multicols environment. Both parameters are usually used only by package designers.

Generation of multicolumn output can be divided into two parts. In the first part we are collecting material for a page, shipping it out, collecting material for the next page, and so on. As a second step, balancing will be done when the end of the multicols environment is reached. In the first step \TeX{} might consider more material whilst finding the final column content than it actually uses when shipping out the page. This might cause a problem if a footnote is encountered in the part of the input considered, but not used, on the current page. In this case the footnote might show up on the current page, while the footnotemark

\footnote{\footnote{This message will be generated even if there are no footnotes in this part of the text.} The reason behind this behavior is the asynchronous character of the \TeX{} \pagebuilder. However, this could be avoided by defining very complicated output routines which don’t use \TeX{} primitives like \insert but do everything by hand. This is clearly beyond the scope of a weekend problem.}
corresponding to this footnote might be set on the next one. Therefore the \multicols environment gives a warning message whenever it is unable to use all the material considered so far.

If you don’t use footnotes too often the chances of something actually going wrong are very slim, but if this happens you can help \TeX by using a \pagebreak command in the final document. Another way to influence the behavior of \TeX in this respect is given by the counter variable ‘collectmore’. If you use the \setcounter declaration to set this counter to \langle number \rangle, \TeX will consider \langle number \rangle more (or less) lines before making its final decision. So a value of –1 may solve all your problems at the cost of slightly less optimal columns.

In the second step (balancing columns) we have other bells and whistles. First of all you can say \raggedcolumns if you don’t want the bottom lines to be aligned. The default is \flushcolumns, so \TeX will normally try to make both the top and bottom baselines of all columns align.

If there is only a small amount of material available for balancing then you may end up with very few lines per column. In an extreme case there may be only one line which looks distinctly odd. In that case it might be better to have more material distributed to the earlier columns even if that means that later columns are empty or partially empty. This is controlled through the counter ‘\minrows’ (default 1). If set to a higher value then the balancing will have at least that many rows in the first column (and also all further columns until it runs out of material).

Additionally you can set another counter, the ‘unbalance’ counter, to some positive \langle number \rangle. This will make all but the right-most column \langle number \rangle of lines longer than they would normally have been. ‘Lines’ in this context refer to normal text lines (i.e. one \baselineskip apart); thus, if your columns contain displays, for example, you may need a higher \langle number \rangle to shift something from one column into another. A negative value can make sense if you have set \minrows and want to locally adjust that.

Unlike ‘collectmore,’ the ‘unbalance’ counter is reset to zero at the end of the environment so it only applies to one \multicols environment.

The two methods may be combined but I suggest using these features only when fine tuning important publications.

Two more general tuning possibilities were added with version 1.5. \TeX allows to measure the badness of a column in terms of an integer value, where 0 means optimal and any higher value means a certain amount of extra white space. 10000 is considered to be infinitely bad. (\TeX does not distinguish any further). In addition the special value 100000 means overfull (i.e., the column contains more text than could possibly fit into it).

Finally, when doing the balancing at the end, columns may become higher than the remaining available space. In that case the algorithm aborts and instead generates a normal page. However, if the amount is not too large, e.g., a line or so, then it might be better to keep everything on the same page instead of starting a new page with just one line after balancing. So the parameter \maxbalancingoverflow governs this process: only when the excess gets larger than its value balancing is aborted.
2.2 Not balancing the columns

Although this package was written to solve the problem of balancing columns, I got repeated requests to provide a version where all white space is automatically placed in the last column or columns. Since version v1.5q this now exists: if you use \texttt{multicols*} instead of the usual environment the columns on the last page are not balanced. Of course, this environment only works on top-level, e.g., inside a box one has to balance to determine a column height in absence of a fixed value.

2.3 Manually breaking columns

Another request often voiced was: “How do I tell \LaTeX{} that it should break the first column after this particular line?”. The \texttt{\pagebreak} command (which works with the two-column option of \LaTeX) is of no use here since it would end the collection phase of \texttt{multicols} and thus all columns on that page. So with version 1.5u the \texttt{\columnbreak} command was added. If used within a paragraph it marks the end of the current line as the desired breakpoint. You can observe its effect on the previous page where three lines of text have been artificially forced into the second column (resulting in some white space between paragraphs in the first column).

From version 1.9 onwards \texttt{\columnbreak} accepts an optional argument (just like \texttt{\pagebreak}) in which you can specify the desirability to break the column at that point: supported values are 0 (slightly desirable) to 4 (forced). This version also adds \texttt{\newcolumn} which forces a column break but runs the column short (comparable to \texttt{\newpage}).

2.4 Floats inside a multicols environment

Within the \texttt{multicols} environment the usual star float commands are available but their function is somewhat different as in the two-column mode of standard \LaTeX{}. Starred floats, e.g., \texttt{figure*}, denote page wide floats that are handled in a similar fashion as normal floats outside the \texttt{multicols} environment. However, they will never show up on the page where they are encountered. In other words, one can influence their placement by specifying a combination of \texttt{t, b, and/or p} in their optional argument, but \texttt{h} doesn’t work because the first possible place is the top of the next page. One should also note, that this means that their placement behavior is determined by the values of \texttt{\topfraction}, etc. rather than by \texttt{\dbl...}.

2.5 Support for right-to-left typesetting

In right-to-left typesetting the order of the columns on the page also need to be reversed, i.e., the first column has to appear on the far right and the last column on the left. This is supported through the commands \texttt{\RLmulticolcolumns} (switching to right-to-left typesetting) and \texttt{\Lmulticolcolumns} (switching to left-to-right typesetting) the latter being the default.

2.6 Warnings

Under certain circumstances the use of the \texttt{multicols} environment may result in some warnings from \TeX{} or \LaTeX{}. Here is a list of the important ones and the possible cause:

Underfull \hbox (badness ...
As the columns are often very narrow \TeX{} wasn’t able to find a good way to break the paragraph. Underfull denotes a loose line but as long as the badness value is below 10000 the result is probably acceptable.

Underfull \vbox ... while \output is active
If a column contains a character with an unusual depth, for example a ‘(’, in the bottom line then this message may show up. It usually has no significance as long as the value is not more than a few points.

\LaTeX{} Warning: I moved some lines to the next page
As mentioned above, \texttt{multicols} sometimes screws up the footnote numbering. As a precaution, whenever there is a footnote on a page where \texttt{multicols} had to leave a remainder for the following page this warning appears. Check the footnote numbering on this page. If it turns out that it is wrong, you have to manually break the page using \texttt{\newpage} or \texttt{\pagebreak[...].}

Floats and marginpars not allowed inside ‘multicols’ environment!
This message appears if you try to use the \texttt{\marginpar} command or an unstarrred version of the \texttt{figure} or \texttt{table} environment. Such floats will disappear!

Very deep columns! Grid alignment might be broken
This message can only appear if the option \texttt{grid} was chosen. In that case it will show up if a column has a very large depth so that \texttt{multicols} is unable to back up to its baseline. This is only relevant if one tries to produce
a document where all text lines are aligned at an invisible grid, something that requires careful adjustment of many parameters and macros, e.g., heading definitions.

2.7 Tracing the output

To understand the reasoning behind the decisions \TeX{} makes when processing a \texttt{multicols} environment, a tracing mechanism is provided. If you set the counter ‘\texttt{tracingmulticols}’ to a positive \langle number \rangle you then will get some tracing information on the terminal and in the transcript file:

\langle number \rangle = 1. \TeX{} will now tell you, whenever it enters or leaves a \texttt{multicols} environment, the number of columns it is working on and its decision about starting a new page before or after the environment.

\langle number \rangle = 2. In this case you also get information from the balancing routine: the heights tried for the left and right-most columns, information about shrinking if the \texttt{raggedcolumns} declaration is in force and the value of the ‘unbalance’ counter if positive.

\langle number \rangle = 3. Setting \langle number \rangle to this value will additionally trace the mark handling algorithm. It will show what marks are found, what marks are considered, etc. To fully understand this information you will probably have to read carefully through the implementation.

\langle number \rangle ≥ 4. Setting \langle number \rangle to such a high value will additionally place an \hrule into your output, separating the part of text which had already been considered on the previous page from the rest. Clearly this setting should not be used for the final output. It will also activate even more debugging code for mark handling.

3 Prefaces to older versions

3.1 Preface to version 1.4

Beside fixing some bugs as mentioned in the \texttt{multicol.bug} file this new release enhances the \texttt{multicols} environment by allowing for balancing in arbitrary contexts. It is now, for example, possible to balance text within a \texttt{multicols} or a \texttt{minipage} as shown in 2 where a \texttt{multicols} environment within a \texttt{quote} environment was used. It is now even possible to nest \texttt{multicols} environments.

The only restriction to such inner \texttt{multicols} environments (nested, or within \TeX{}’s internal vertical mode) is that such variants will produce a box with the balanced material in it, so that they can not be broken across pages or columns.

Additionally I rewrote the algorithm for balancing so that it will now produce slightly better results.

I updated the source documentation but like to apologize in advance for some ‘left over’ parts that slipped through the revision.

A note to people who like to improve the balancing algorithm of \texttt{multicols}: The balancing routine is now placed into a single macro which is called \texttt{balance@columns}. This means that one can easily try different balancing routines by rewriting this macro. The interface for it is explained in table 1. There are several improvements possible, one can think of integrating the \texttt{badness} function of \TeX{}3, define a faster algorithm for finding the right column height, etc.

If somebody thinks he/she has an enhancement I would be pleased to learn about it. But please obey the copyright notice and don’t change \texttt{multicol.dtx} directly!

3.2 Preface to version 1.2

After the article about the \texttt{multicols} environment was published in TUGboat 10#3, I got numerous requests for these macros. However, I also got a changed version of my style file, together with a letter asking me if I would include the changes to get better paragraphing results in the case of narrow lines. The main differences to my original style option were additional parameters (like \texttt{multicoladjdemerits} to be used for \texttt{adjdemerits}, etc.) which would influence the line breaking algorithm.

But actually resetting such parameters to zero or even worse to a negative value won’t give better line breaks inside the \texttt{multicols} environment. \TeX{}’s line breaking algorithm will only look at those possible line breaks which can be reached without a badness higher than the current value of \texttt{tolerance} (or \texttt{pretolerance} in the first pass). If this isn’t pos-
The macro \balance@columns that contains the code for balancing gathered material is a macro without parameters. It assumes that the material for balancing is stored in the box \mult@box which is a \vbox. It also "knows" about all parameters set up by the multicol environment, like \col@number, etc. It can also assume that \@colroom is the still available space on the current page.

When it finishes it must return the individual columns in boxes suitable for further processing with \page@sofar. This means that the left column should be stored in box register \mult@firstbox, the next in register \mult@firstbox + 2, ..., only the last one as an exception in register \mult@grightbox. Furthermore it has to set up the two macros \kept@firstmark and \kept@botmark to hold the values for the first and bottom mark as found in the individual columns. There are some helper functions defined in section 5.1 which may be used for this. Getting the marks right "by hand" is non-trivial and it may pay off to first take a look at the documentation and implementation of \balance@columns below before trying anew.

Table 1: Interface description for \balance@columns

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>\adj@demerits</td>
<td>Penalty for using forbidden floats</td>
</tr>
<tr>
<td>\emergen@stret</td>
<td></td>
</tr>
</tbody>
</table>

Possible, then, as a last resort, \TeX will produce overfull boxes. All those (and only those) possible break points will be considered and finally the sequence which results in the fewest demerits will be chosen. This means that a value of $-1000$ for \adj@demerits instructs \TeX to prefer visibly incompatible lines instead of producing better line breaks.

However, with \TeX 3.0 it is possible to get decent line breaks even in small columns by setting \emergen@stret to an appropriate value. I implemented a version which is capable of running both in the old and the new \TeX (actually it will simply ignore the new feature if it is not available). The calculation of \emergen@stret is probably incorrect. I made a few tests but of course one has to have much more experience with the new possibilities to achieve the maximum quality.

Version 1.1a had a nice feature: the penalty for using the forbidden floats was their ultimate removal from \TeXs \@freelist so that after a few \marginpars inside the multicol environment floats where disabled forever. (Thanks to Chris Rowley for pointing this out.) I removed this misbehavior and at the same time decided to allow at least floats spanning all columns, e.g., generated by the figure* environment. You can see the new functionality in table 2 which was inserted at this very point. However single column floats are still forbidden and I don’t think I will have time to tackle this problem in the near future. As an advice for all who want to try: wait for \TeX 3.0. It has a few features which will make life much easier in multi-column surroundings. Nevertheless we are working here at the edge of \TeXs capabilities, really perfect solutions would need a different approach than it was done in \TeXs page builder.

The text below is nearly unchanged, I only added documentation at places where new code was added.

4 The Implementation

We are now switching to two-column output to show the abilities of this environment (and bad layout decisions).

4.1 The documentation driver file

The next bit of code contains the documentation driver file for \TeX, i.e., the file that will produce the documentation you are currently reading. It will be extracted from this file by the docstrip program. Since this is the first code in this file one can produce the documentation simply by running \LaTeX on the .dtx file.

.1 \documentclass{ltxdoc}
.2 \begin{document}

We use the balancingshow option when loading multicol so that full tracing is produced. This has to be done before the doc package is loaded, since doc
4pt \times \#1$, i.e. the $\hsize$ isn’t used at all. But maybe there are better formulae.

\texttt{\set@floatcmds}: This is the hook for the experts who like to implement a full float mechanism for the \texttt{multicols} environment. The $\@$ in the name should signal that this might not be easy.

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\textbf{4.2 Identification and option processing}

We start by identifying the package. Since it makes use of features only available in \LaTeX\ 2ε we ensure that this format is available. (Now this is done earlier in the file.)

\begin{verbatim}
\\NeedsTeXFormat{LaTeX2e}
\ProvidesPackage{multicol}[..../../..
\version multicolumn formatting]
\end{verbatim}

Next we declare options supported by \texttt{multicol}. Two-column mode and \texttt{multicols} do not work together so we warn about possible problems. However, since you can revert to \texttt{\onecolumn} in which case \texttt{multicols} does work, we don’t make this an error.

\begin{verbatim}
\DeclareOption{twocolumn}{May not work with the twocolumn option}
\end{verbatim}

Tracing is done using a counter. However it is also possible to invoke the tracing using the options declared below.

\begin{verbatim}
\\newcounter{\c@\tracingmulticols}
\DeclareOption{errorshow}{\c@\tracingmulticols\z@}
\DeclareOption{infoshow}{\c@\tracingmulticols\@ne}
\DeclareOption{balancingshow}{\c@\tracingmulticols\tw@}
\DeclareOption{markshow}{\c@\tracingmulticols\thr@@}
\DeclareOption{debugshow}{\c@\tracingmulticols5\relax}
\end{verbatim}

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Table 2: The new commands of \texttt{multicol.sty} version 1.2. Both commands might be removed if good solutions to these open problems are found. I hope that these commands will prevent that nearly identical style files derived from this one are floating around.

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\texttt{\setemergencystretch}: This is a hook for people who like to play around. It is supposed to set the \texttt{\emergencystretch} \texttt{(dimen)} register provided in the new \TeX\ 3.0. The first argument is the number of columns and the second one is the current $\hsize$. At the moment the default definition is $4pt \times \#1$, i.e. the $\hsize$ isn’t used at all. But maybe there are better formulae.

\texttt{\set@floatcmds}: This is the hook for the experts who like to implement a full float mechanism for the \texttt{multicols} environment. The $\@$ in the name should signal that this might not be easy.

---

otherwise requires \texttt{multicols} without any options.

\begin{verbatim}
\usepackage{multicol}[1999/05/25]
\usepackage{doc}
\end{verbatim}

First we set up the page layout suitable for this article.

\begin{verbatim}
\setlength{\textwidth}{39pc}
\setlength{\textheight}{54pc}
\setlength{\parindent}{1em}
\setlength{\parskip}{0pt plus 1pt}
\setlength{\oddsidemargin}{0pc}
\setlength{\marginparwidth}{0pc}
\setlength{\topmargin}{-2.5pc}
\setlength{\headsep}{20pt}
\setlength{\columnsep}{1.5pc}
\end{verbatim}

We want a rule between columns.

\begin{verbatim}
\setlength{\columnseprule}{.4pt}
\end{verbatim}

We also want to ensure that a new \texttt{multicols} environment finds enough space at the bottom of the page.

\begin{verbatim}
\setlength{\premulticols}{6\baselineskip}
\end{verbatim}

When balancing columns we disregard solutions that are too bad. Also, if the last column is too bad we typeset it without stretch.

\begin{verbatim}
\setcounter{columnbadness}{7000}
\setcounter{finalcolumnbadness}{7000}
\end{verbatim}

The index is supposed to come out in four columns. And we don’t show macro names in the margin.

\begin{verbatim}
\let\DescribeMacro\SpecialUsageIndex
\let\DescribeEnv\SpecialEnvIndex
\renewcommand{\PrintMacroName}[1]{}
\CodelineIndex
\end{verbatim}

Line numbers are very small for this article.

\begin{verbatim}
\renewcommand{\theCodelineNo}{\scriptsize\rm\arabic{CodelineNo}}
\end{verbatim}

\begin{verbatim}
\settowidth{\MacroIndent}{\scriptsize\rm 00\ }
\end{verbatim}

\begin{verbatim}
\begin{document}
\typeout{****************************************
\*** Expect some Under- and overfull boxes.
\****************************************}
\DocInput{multicol.dtx}
\end{document}
\end{verbatim}
The next option is intended for typesetting on a \baselineskip grid. Right now it doesn’t do anything other than warn if it thinks that the grid got lost.

Next option enables the \docolaction command. As this changes the .aux file content this is not automatically enabled.

4.3 Starting and Ending the multicols Environment

As mentioned before, the multicols environment has one mandatory argument (the number of columns) and up to two optional ones. We start by reading the number of columns into the \col@number register.

If the user forgot the argument, \TeX will complain about a missing number at this point. The error recovery mechanism will then use zero, which isn’t a good choice in this case. So we should now test whether everything is okay. The minimum is two columns at the moment.

\iffnum\col@number<\tw@
\PackageWarning{multicol}{columns doesn’t seem a good idea. I therefore use two columns instead}\\
\col@number20 \fi

We have only enough box registers for twenty columns, so we need to check that the user hasn’t asked for more.

\iffnum\col@number>20
\PackageError{multicol}{Too many columns}\\
\col@number20 \fi

Within the environment we need a special version of the kernel \@footnotetext command since the original sets the \hsize to \columnwidth which is not correct in the multicols environment. Here \columnwidth refers to the width of the individual column and the footnote should be in \textwidth. Since \@footnotetext has a different definition inside a minipage environment we do not redefine it directly. Instead we locally set \columnwidth to \textwidth and call the original (current) definition stored in \orig@footnotetext. If the multicols environment is nested inside another multicols environment then the redefinition has already happened. So be better test for this situation. Otherwise, we will get a \TeX stack overflow as this would generate a self-referencing definition.

\ifx\@footnotetext\mult@footnotetext\else
\let\orig@footnotetext\@footnotetext\let\@footnotetext\mult@footnotetext\fi

Now we can safely look for the optional arguments.

The \mult@cols macro grabs the first optional argument (if any) and looks for the second one.

This argument should be a ⟨dimen⟩ denoting the minimum free space needed on the current page to start the environment. If the user didn’t supply one, we use \premulticols as a default.

After removing all arguments from the input we are able to start with \mult@cols.

First thing we do is to decide whether or not this is an unbounded multicols environment, i.e. one that may split across pages, or one that has to be typeset into a box. If we are in \TeX’s “inner” mode (e.g., inside a box already) then we have a boxed version of multicols therefore we set the \boxedmulticols switch to true. The \multics should start in vertical mode. If we are not already there we now force it
with \par since otherwise the test for “inner” mode wouldn’t show if we are in a box.

Otherwise we check \doublecol@number. This counter is zero outside a multicols environment but positive inside (this happens a little later on). In the second case we need to process the current multicols also in “boxed mode” and so change the switch accordingly.

Then we look to see if statistics are requested:

Then we measure the current page to see whether a useful portion of the multicolumn environment can be typeset. This routine might start a new page. Now we output the first argument and produce vertical space above the columns. (Note that this argument corresponds to the first optional argument of the multicols environment.) For many releases this argument was typeset at the outer level.

When the last line of a paragraph had a positive depth then this depth normally taken into account by the baselineskip calculation for the next line. However, the columns produced by a following \multicol are rigid and thus the distance from the baseline of a previous line to the first line in a \multicol would differ depending on the depth of the previous line. To account for this we add a negative space unless the depth is ~1000pt which signals something special to \TeX and is not supposed to be a real depth.
When preparing for multicolumn output several things must be done.

152 \def\prepare@multicols{%
  We start saving the current \@totalleftmargin and then resetting the \parshape in case we are inside some list environment. The correct indentation for the \multicol environment in such a case will be produced by moving the result to the right by \multicol@leftmargin later on. If we would use the value of \@totalleftmargin directly then lists inside the \multicol environment could cause a shift of the output.

153 \multicol@leftmargin\@totalleftmargin
154 \@totalleftmargin z@\parshape z@

We also set the register \doublecol@number for later use. This register should contain 2 × \col@number. This is also an indicator that we are within a \multicol environment as mentioned above.

156 \doublecol@number\col@number
157 \multiply\doublecol@number\tw@
158 \advance\doublecol@number\mult@rightbox
159 \if@boxedmulticols
160 \let l@kept@firstmark\kept@firstmark
161 \let l@kept@botmark\kept@botmark
162 \global\let l@kept@firstmark\@empty
163 \global\let l@kept@botmark\@empty
164 \else

We add an empty box to the main vertical list to ensure that we catch any insertions (held over or inserted at the top of the page). Otherwise it might happen that the \eject is discarded without calling the output routine. Inside the output routine we remove this box again. Again this code applies only if we are on the main vertical list and not within a box. However, it is not enough to turn off interline spacing, we also have to clear \topskip before adding this box, since \topskip is always inserted before the first box on a page which would leave us with an extra space of \topskip if \multicol start on a fresh sheet.

165 \nointerlineskip \{\topskip z@null\%
166 \output\%
167 \global\setbox\partial@page\vbox
168 \%

Now we have to make sure that we catch one special situation which may result in loss of text! If the user has a huge amount of vertical material within the first optional argument that is larger than \premulticols and we are near the bottom of the page then it can happen that not the \eject is triggering this special output routine but rather the
overfull main vertical list. In that case we get another breakpoint through the \eject penalty. As a result this special output routine would be called twice and the contents of \partial@page, i.e. the material before the multicols environment gets lost. There are several solutions to avoid this problem, but for now we will simply detect this and inform the user that he/she has to enlarge the \premulticols by using a suitable value for the second argument.

\begin{verbatim}
\check
\ifvoid\partial@page\else
 \PackageError{multicol}[
{Error saving partial page}]
{The part of the page before
 the multicols environment was
nearly full with the result
that starting the environment
will produce an overfull
page. Some text may be lost!
Please increase \premulticols
either generally or for this
environment by specifying a
suitable value in the second
optional argument to \multicols.}
\unvbox\partial@page
\box\last@line
\fi
\end{verbatim}

Finally we need to record the marks that are present within the \partial@page so that we can construct correct first and bottom marks later on. This is done by the following code.

\begin{verbatim}
\prep@keptmarks
\end{verbatim}

Finally we have to initialize \kept@topmark which should ideally be initialized with the mark that is current on “top” of this page. Unfortunately we can’t use \topmark because this register will not always contain what its name promises because \TeX sometimes calls the output routine for float management.\footnote{During such a call the \botmark gets globally copied to \topmark by the \TeX program.} Therefore we use the second best solution by initializing it with \firstmark. In fact, for our purpose this doesn’t matter as we use \kept@topmark only to initialize \firstmark and \botmark of a following page if we don’t find any marks on the current one.

\begin{verbatim}
\global\let\kept@topmark=\firstmark\eject
\end{verbatim}

The next thing to do is to assign a new value to \vsize. \TeX maintains the free room on the page (i.e. the page height without the space for already contributed floats) in the register \@colroom. We must subtract the height of \partial@page to put the actual free room into this variable.

\begin{verbatim}
\advance@colroom-\ht\partial@page
\end{verbatim}

Now we switch to a new \output routine which will be used to put the gathered column material together.

\begin{verbatim}
\set@mult@vsize\relax
\end{verbatim}

Finally we handle the footnote insertions. We have to multiply the magnification factor and the extra skip by the number of columns since each footnote reduces the space for every column (remember that we have page-wide footnotes). If, on the other hand, footnotes are typeset at the very end of the document, our scheme still works since \count@footins is zero then, so it will not change. To allow even further customization the setting of the \footins parameters is done in a separate macro.

\begin{verbatim}
\init@mult@footins
\end{verbatim}

For the same reason (page-wide footnotes), the (dimen) register controlling the maximum space used for footnotes isn’t changed. Having done this, we must reinsert all the footnotes which are already present (i.e. those encountered when the material saved in \partial@page was first processed). This will reduce the free space (i.e. \pagetotal) by the appropriate amount since we have changed the magnification factor, etc. above.

\begin{verbatim}
\reinsert@footnotes
\end{verbatim}

Inside multicols a \clearpage is fairly useless as we aren’t supporting floats. In fact, it can cause harm as it doesn’t know about the \partial@page and may therefore result in making columns too long. So we change that to behave like \newpage but also check if there are any deferred floats. If so, perhaps the user tried to place them through that \clearpage (but that needs to be done before starting the multicols environment).
Additionally, we advance \baselineskip by \multicolbaselineskip to allow corrections for narrow columns.

\vfill\eject

\pretolerance\multicolpretolerance

For use with the new \TeX{} we set \emergencystretch to \col@number \times 4pt. However this is only a guess so at the moment this is done in a macro \setemergencystretch which gets the current \hsize and the number of columns as arguments. Therefore users are able to figure out their own formula.

\setemergencystretch{\col@number\hsize}

Another hook to allow people adding their own extensions without making a new package is \setfloatcmds which handles any redefinitions of \LaTeX{}s internal float commands to work with the \multicol environment. At the moment it is only used to redefine \@dblfloat and \@enddblfloat.

\setfloatcmds

Additionally, we advance \baselineskip by \multicolbaselineskip to allow corrections for narrow columns.

\vfill\eject

The \hsize of the columns is given by the formula:

\linewidth = (\col@number - 1) \times \columnsep

\col@number

The formula above has changed from release to release. We now start with the current value of \linewidth so that the column width is properly calculated when we are inside a minipage or a list or some other environment. This will be achieved with:

\hsize=\linewidth + \advance=\hsize\columnsep
\advance=\hsize=\col@number\columnsep
\advance=\hsize=\divide=\hsize=\col@number

\ linewidth and \columnwidth to \hspace. In the past \columnwidth was left unchanged. This is inconsistent, but \columnwidth is used only by floats (which aren't allowed in their current implementation) and by the \footnote macro. Since we want page-wide footnotes\footnote{Therefore users are able to figure out their own formula.} this simple trick saved us from rewriting the \footnote macros. However, some applications referred to \columnwidth as the "width of the current column" to typeset displays (the \amsmath package, for example) and to allow the use of such applications together with \multicol this is now changed.

Before we change \linewidth to the new value we record its old value in some register called \full@width. This value is used later on when we package all columns together.

\full@width\linewidth
\linewidth=\hsize
\linewidth=\columnwidth

\hsize

This macro is used to set the parameters associated with footnote floats. It can be redefined by applications that require different amount of spaces when typesetting footnotes.

\def=\init@mult@footins{%
\multiply=\count=\footins=\col@number
\multiply=\skip=\footins=\col@number
\divide=\hsize=\col@number
}

Since we have to set \col@number columns on one page, each with a height of \@colroom, we have to assign \vsize = \col@number \times \@colroom in order to collect enough material before entering the \output routine again. In fact we have to add another \( (\col@number - 1) \times (\baselineskip - \topskip) \) if you think about it.

\def=\set@mult@vsize{%
\vsize=\@mult@vsize=\@mult@vsize#1%\}

\vfill\eject

\ifx=\empty\else
\PackageError{multicol}{Deferred floats not cleared}{%\MessageBreak\string\newpage\space and doesn't\MessageBreak\string\newpage}{%}
\fi

I'm not sure that I really want page-wide footnotes. But balancing of the last page can only be achieved with this approach or with a multi-path algorithm which is complicated and slow. But it's a challenge to everybody to prove me wrong! Another possibility is to reimplement a small part of the fire_up procedure in \TeX{} (the program). I think that this is the best solution if you are interested in complex page makeup, but it has the disadvantage that the resulting program cannot be called \TeX{} thereafter.

13
\advance\vsize\@colroom
\@tempdim\baselineskip
\advance\@tempdim\topskip
\@tempdim\vsize\@colroom
\@tempdim\vsize\advance\@tempdim\@tempdima
\advance\@tempdima-\topskip
\@tempdima\baselineskip
\vsize\@colroom
\advance\vsize\@tempdima
\newdimen\multicol@leftmargin
\multicol@leftmargin
Here is the dimen register we need for saving away the outer value of \@totalleftmargin.
\newdimen\multicol@leftmargin
\OMvi
In versions prior to 1.8\r the balancing at the end of the environment was done by changing
the output routine from \mult@box to \balance@column@out. As it turned out that this
has a couple of issues when the last columns should not be balanced after all (for example because they
contained several \columnbreak commands we now stay with one output routine for the environment
and only signal that we reached the end of the envi-
ronment by marking it with a special penalty that
we can check for later.
\mathchar\OMvi=10006 \% 10005 is \% \columnbreak
\endmulticols
When the end of the multicol\s environment is sensed we have to balance the gathered material. Depend-
ing on whether or not we are inside a boxed multicol different things must happen. But first we end the current paragraph with a \par command.
\edef\endmulticols{\par
\if\boxedmulticols
In boxed mode we have to close the box in which we have gathered all material for the columns. But be-
fore we do this we need to remove any space at the end of the box as we don’t want to use this in balanc-
ing. Because of the \color@endgroup\ this can’t be done later in \balance@columns as the color com-
mand will hide it.
\begin{thebibliography}{10}
\item This once caused a puzzling bug where some of the material was balanced twice, resulting in some overprints. The reason
was the \eject which was placed at the end of the contribution list. Then the page_builder was called (an explicit \penalty
will empty the contribution list), but the line with the \eject didn’t fit onto the current page. It was then reconsidered after
the output routine had ended, causing a second break after one line.
\end{thebibliography}
point we need to use \penalty not \addpenalty to ensure that a) the recent contributions are emptied and b) that the very last item on the main vertical list is a valid break point so that \TeX breaks the page in case it is overfull.

Now it’s safe to call the output routine in order to balance the columns. We do this by calling it with a special penalty.

If the \texttt{multicols} environment body was completely empty or if a multi-page \texttt{multicols} just ends at a page boundary we have the unusual case that the \texttt{\eject} will have no effect (since the main vertical list is empty)—thus no output routine is called at all. As a result the material preceding the \texttt{\multicols} \texttt{\let} will have no effect (since the main vertical list is empty)—thus no output routine is called at all. As a result the material preceding the \texttt{multicols} \texttt{\let} will get lost if we don’t put this back by hand.

After the output routine has acted we restore the kept marks to their initial value.

The output routine above will take care of the \texttt{\vsize} and reinsert the balanced columns, etc. But it can’t reinsert the \texttt{\footnotes} because we first have to restore the \texttt{\footins} parameter since we are returning to one column mode. This will be done in the next line of code; we simply close the group started in \texttt{\multicols}.

To fix an obscure bug which is the result of the current definition of the \texttt{\begin} \texttt{\ldots} \texttt{\end} macros, we check that we are still (logically speaking) in the \texttt{multicols} environment. If, for example, we forget to close some environment inside the \texttt{multicols} environment, the following \texttt{\endgroup} would be incorrectly considered to be the closing of this environment.

The output routine above will take care of the \texttt{\vsize} and reinsert the balanced columns, etc. But it can’t reinsert the \texttt{\footnotes} because we first have to restore the \texttt{\footins} parameter since we are returning to one column mode. This will be done in the next line of code; we simply close the group started in \texttt{\multicols}.

We also set the ‘\unbalance’ counter to its default. This is done globally since \TeX counters are always changed this way.\footnote{Actually, we are still in a group started by the \texttt{\begin} macro, so \texttt{\global} must be used anyway.}

Now it’s time to return any footnotes if we are in unrestricted mode. In boxed mode footnotes are kept inside, but in that case we have to write another column status into the .aux file to support \texttt{\docolaction} in case we have nested environments.

We also take a look at the amount of free space on the current page to see if it’s time for a page break. The vertical space added thereafter will vanish if \texttt{\enough@room} starts a new page.

But there is one catch. If the \texttt{\end{multicols}} is at the top of which can happen if there is a break point just before it (such as end ending environment) which was chosen. In that case we would do the next page using the internal \texttt{\vsize} for multicols collection which is a disaster. So we better catch this case. Fortunately we can detect it by looking at \texttt{\pagegoal}.

If statistics are required we finally report that we have finished everything.

Let us end this section by allocating all the registers used so far.

We also set the ‘\unbalance’ counter to its default. This is done globally since \TeX counters are always changed this way.\footnote{Actually, we are still in a group started by the \texttt{\begin} macro, so \texttt{\global} must be used anyway.}
And here are their default values:

\c@unbalance = 0
\c@collectmore = 0

To allow checking whether some macro is used within the \multicols environment the counter \col@number gets a default of 1 outside the environment.

\col@number = 1
\multicoltolerance = 9999
\multicolpretolerance = -1
\premulticols = 50pt
\postmulticols = 20pt
\multicolsep = 12pt plus 4pt minus 3pt
\multicolbaselineskip = 0pt

4.4 The output routines

We first start with some simple macros. When typesetting the page we save the columns either in the box registers 0, 2, 4, ... (locally) or 1, 3, 5, ... (globally). This is Plain \TeX policy to avoid an overflow of the save stack.

\process@cols

Therefore we define a \process@cols macro to help us in using these registers in the output routines below. It has two arguments: the first one is a number; the second one is the processing information. It loops starting with \count@ = \mult@rightbox, \count@+2, ... (to \doublecol@number). It might be easier to understand it through an example, so we define it now and explain its usage afterwards.

\def\process@cols#1#2{\count@#1\relax
\loop
\typeout{Looking at box \the\count@}
\ifvoid\count@
\setbox\count@\hbox to\hsize{}
\else
\wd\count@ \hsize\fi%
\repeat}

\page@sofar

Now we define \page@sofar to give an example of the \process@cols macro. \page@sofar should output everything prepared by the balancing routine \balance@columns.

\def\page@sofar{%
\balance@columns prepares its output in the even numbered scratch box registers. Now we output the columns gathered assuming that they are saved in the box registers 2 (left column), 4 (second column), ... However, the last column (i.e. the rightmost) should be saved in box register 0.\footnote{You will see the reason for this numbering when we look at the output routines \multi@column@out and \balance@columns@out.} First we ensure that the columns have equal width. We use \process@cols for this purpose, starting with \count@ = \mult@rightbox. Therefore \count@ loops through \mult@rightbox, \mult@rightbox + 2, ... (to \doublecol@number).

\process@cols\mult@rightbox

We have to check if the box in question is void, because the operation \wd{\number} on a void box will not change its dimension (sigh).

\ifvoid\count@
\setbox\count@\hbox to\hsize{}
\else
\wd\count@ \hsize
\fi%

Now we give some tracing information.

\def\page@sofar{
\count@\col@number \advance\count@\m@ne
\mult@info\w@% 
{Column spec: \the\full@width\space = indent + columns + sep = \the\multicol@leftmargin\space + \the\col@number\space x \the\hsize\space + \the\count@\space x \the\columnsep
%}
\ifvmode\else\errmessage{Multicol Error}\fi

Now we put all columns together in an \hbox of width \full@width (shifting it by \multicol@leftmargin to the right so that it will be placed correctly if we are within a list environment) and separating the columns with a rule if desired.
The box containing the columns has a large height and thus will always result in using \lineskip if the normal \baselineskip calculations are used. We therefore better cancel that process.

As mentioned earlier we want to have the reference point of the box we put on the page being at the baseline of the last line of the columns but we also want to ensure that the box has no depth so that any following skip is automatically starting from that baseline. We achieve this by recording the depths of all columns and then finally backing up by the maximum. (perhaps a simpler method would be to assemble the box in a register and set the depth of that box to zero (not checked).

We need a global scratch register for this; using standard \TeX conventions we choose \dimen2 and initialize it with the depth of the character “p” since that is one of the depths that compete for the maximum.

\setbox\z@\hbox{p}\global\dimen\tw@\dp\z@

If the document is written in a language that is typeset right-to-left then, of course, the multicol columns should be also typeset right-to-left. To support this we call \mc@align@columns which with execute different code depending on the typesetting direction.

\mc@align@columns

The depths of the columns depend on their last lines. To ensure that we will always get a similar look as far as the rules are concerned we force the depth to be at least the depth of a letter ‘p’ (which is what we set \dimen2 to above).

\rlap{\phantom p}

The processed material might consist of a last line with a descender in which case the \prevdepth will be non-zero. However, this material is getting reformatted now so that this value is likely to be wrong. We therefore normalize the situation by pretending that the depth is zero. However, if \page@sofar is being called inside the OR then setting \prevdepth here has no long-lasting effect, we therefore have to repeat this once we return to the main vertical list. Here we set it only for those cases where the command is used within a list and then followed by something else.

\prevdepth\z@

Now after typesetting the box we back up to its baseline by using the value stored in \dimen2 (which will hold the largest depth found on any column).

\kern-\dimen\tw@

However, in case one of the columns was unusually deep \TeX may have tried some corrective actions in which case backing up by the saved value will not bring us back to the baseline. A good indication for this is a depth of \@maxdepth though it is not an absolute proof. If the option grid is used \mc@gridwarn will expand to this, otherwise to \maxdimen in which case this warning will not show up.

By default the vertical rule between columns will be in \normalcolor.

\def\columnseprulecolor{\normalcolor}

Before we tackle the bigger output routines we define just one more macro which will help us to find our way through the mysteries later. \reinsert@footnotes will do what its name indicates: it reinserts the footnotes present in \footinbox so that they will be reprocessed by \TeX’s page builder.

Instead of actually reinserting the footnotes we insert an empty footnote. This will trigger insertion mechanism as well and since the old footnotes are still in their box and we are on a fresh page \skipfootins should be correctly taken into account.

\def\reinsert@footnotes{\ifvoid\footins\else\insert\footins{}\fi}

This curious definition is used as the space at the bottom of a column if we implement \raggedcolumns. Normally one only appends \vfill in that case but this is actually wrong for columns that are more or less full: by adding a glue at the bottom such a column doesn’t have any depth any more but without it the material would be allowed a depth of \@maxdepth. So we allow shrinking by that amount. This only makes a difference if the box would otherwise become overfull and shrinking never exceeds the specified value, so we should be fine.

\def\vfilmaxdepth{\vskip \z@ \@plus .0001fil
\@minus \@maxdepth}

Now we can’t postpone the difficulties any longer. The \multi@column@out routine will be called in two situations. Either the page is full (i.e., we
have collected enough material to generate all the required columns) or a float or marginpar or a \clearpage is sensed. In the latter case the \outputpenalty is less than \( -10000 \), otherwise the penalty which triggered the output routine is higher. Therefore it’s easy to distinguish both cases: we simply test this register.

\defmulticolumnout{
\iffnum\outputpenalty\<\@M
If this was a \clearpage, a float or a marginpar we call \speci@ls
\else
otherwise we construct the final page. For the next block of code see comments in section 7.2.

\ifvoid\colbreak@box\else
\mult@info\one{Re-adding forced
break(s) for splitting}\%
\setbox\@cclv\vbox{\
\unvbox\colbreak@box
\penalty\@Mv
\unvbox\@cclv}\
\fi

Let us now consider the normal case. We have to \vsplit the columns from the accumulated material in box \the@count. Therefore we first assign appropriate values to \splittopskip and \splitmaxdepth.

\splittopskip\topskip
\splitmaxdepth\@maxdepth

We also need to restrict \boxmaxdepth so that re-boxing is not generating boxes with arbitrary depth.

\boxmaxdepth\@maxdepth

Then we calculate the current column height (in \dimen@). Note that the height of \partial@page is already subtracted from \@colroom so we can use its value as a starter.

\dimen@\@colroom

But we must also subtract the space occupied by footnotes on the current page. Note that we have to reset the skip register to its normal value. Again, the actual action is carried out in a utility macro, so that other applications can modify it.

\divide\skip\footins\col@number
\ifvoid\footins\else
\leave@mult@footins\fi
\fi

And there is one more adjustment that we have to make: if the user has issue a \enlargethispage command then the height the \kludgeins box will be the negation of the size by which the page should be enlarged. If the star form of this command has been used then we also need to shrink the resulting column.

That local change will be reverted at the end of the output routine So for the next page the original state will be reestablished. However, in theory there is a possibility to sneak in a whole multicols environment into the running header definition. If that happens then it will also be affected by this change—too bad I think.

\ifvbox\kludgeins
\advance\dimen@\ht\kludgeins
\fi

The star form of \enlargethispage makes the width of the box greater than zero (sneaky isn’t it?).

\ifdim\wd\kludgeins\>\z@\shrinktrue\fi

Now we are able to \vsplit off all but the last column. Recall that these columns should be saved in the box registers \count, \count, ... (plus offset).

\process@cols\mult@firstbox{\
\setbox\count@\vsplit\@cclv to\dimen@
After splitting we update the kept marks.

Then the last column follows.

\setbox\mult@rightbox\vsplit\@cclv to\dimen@

Having done this we hope that box \the@count is emptied. If not, we reinsert its contents.

\ifvoid\@cclv\else
\unvbox\@cclv
\ifnum\outputpenalty\=\@M
\else
\fi
\fi

\set\keptmarks
If \raggedcolumns is in force we add a vfill at the bottom by unboxing the split box. But we need to unbox anyway to ensure that at the end of the box we do not have unwanted space. This can sneak in in certain situations, for example, if two lists follow each other and we break between them. While such space is usually zero it still has an effect because it hides depth of the last line in the column and that will result in incorrect placement.

\set\keptmarks
\setbox\count@ \vbox to\dimen@
{\unvbox\count@
 \ifshr\shrking\vfilmaxdepth\fi}\
\}%

Then the last column follows.

\setbox\mult@rightbox \vsplit\@cclv to\dimen@
\set\keptmarks
\setbox\mult@rightbox\vbox to\dimen@
{\unvbox\mult@rightbox
 \ifshr\shrking\vfilmaxdepth\fi}\

Having done this we hope that box \the@count is emptied. If not, we reinsert its contents.

\ifvoid\@cclv\else
\unvbox\@cclv
\ifnum\outputpenalty\=\@M
\else
\fi
\fi
In this case a footnote that happens to fall into the leftover bit will be typeset on the wrong page. Therefore we warn the user if the current page contains footnotes. The older versions of \texttt{multicols} produced this warning regardless of whether or not footnotes were present, resulting in many unnecessary warnings.

If the ‘\texttt{tracingmulticols}’ counter is 4 or higher we also add a rule.

We also initialize \texttt{\topmark} with \texttt{\kept@topmark}. This will make this mark okay for all middle pages of the \texttt{multicols} environment. After the page is shipped out we have to prepare the kept marks for the following page. \texttt{\kept@firstmark} and \texttt{\kept@botmark} reinitialized by setting them to \texttt{@empty}. The value of \texttt{\botmark} is then assigned to \texttt{\kept@topmark}.

Now we reset \texttt{\@colroom} to \texttt{\@colht} which is \LaTeX{}’s saved value of \texttt{\textheight}. We also have to reset the recorded position of the last \texttt{\marginpar} as well as the recorded size of in-text floats as we are now on a new page.
Then we process deferred floats waiting for their chance to be placed on the next page.

\begin{verbatim}
\process@deferreds \if\ifcolmade\else\fi\outputpage \global\@colht \process@deferreds
\end{verbatim}

If the user is interested in statistics we inform him about the amount of space reserved for floats.

\begin{verbatim}
\mult@info\@ne {Colroom:MessageBreak \the\@colht after float space removed = \the\@colroom \@gobble}
\end{verbatim}

Having done all this we must prepare to tackle the next page. Therefore we assign a new value to \vsize. New, because \partial@page is now empty and \@colroom might be reduced by the space reserved for floats.

\begin{verbatim}
\set@mult@vsize \global
\end{verbatim}

The \footins skip register will be adjusted when the output group is closed.

\begin{verbatim}
\leave@mult@footins
\end{verbatim}

This macro is used to subtract the amount of space occupied by footnotes for the current space from the space available for the current column. The space current column is stored in \dimen@. See above for the description of the default action.

\begin{verbatim}
\def\leave@mult@footins{% 
\ifnum\outputpenalty <-\@Mi 
If the document ends in the middle of a multicols environment, e.g., if the user forgot the \end{multicols}, \TeX adds a very negative penalty to the end of the galley which is intended to signal the output routine that it is time to prepare for shipping out everything remaining. Since inside multicols the output routine of \TeX is disabled sometimes we better check for this case: if we find a very negative penalty we produce an error message and run the default output routine for this case.

\begin{verbatim}
  \PackageError{multicol}{Document end inside multicols environment}{}%\@ehd\@specialoutput
\end{verbatim}

As this is the place of a forced break we now remove vertical white space just in front of it (or some of it at least) as it is quite likely that the break is not exactly in the right place, e.g., after a display environment (if \LaTeX would break here by its own it would break before the space following the display).

Thus we rebox 255 once (using \boxmaxdepth and calling \remove@discardable@items inside). The depth of 255 will then give us the depth the box would have had if it would have been a natural break. We then unbox 255 to get it into the \colbreak@box and then back up by this depth. This will position the bottom of the box at its natural baseline which is useful for balancing later on.

\begin{verbatim}
\set@mult@vsize \global 
\end{verbatim}

We left out two macros: \process@deferreds and \speci@ls.

\begin{verbatim}
\def\speci@ls{% 
\ifnum\outputpenalty <-\@Mi 
Another special case is reaching the end of the multicols environment which is signaled by -\@Mvi. If we are at this point then we have to run the balancing code (which was previously its own output routine). First we pretend that we had a normal forced breakpoint and then call \balance@column@out. The latter may be let to \multi@column@out if we are inside multicols* in which case we would get a loop if the \outputpenalty is not changed—this could be cleaned up in a better way; basically it is like this, because of the older code was using different ORs and I simply reused most of it.

\begin{verbatim}
\ifnum \outputpenalty <-\@MM \boxmaxdepth@maxdepth \setbox@cclv\vbox{% \unvbox@cclv \remove@discardable@items}% \dimen@d\dp@cclv \unvbox@cclv \kern\dimen@d \else % \reinsert@footnotes \else
\end{verbatim}

For the next block of code see comments in section 7.2.
If we encounter a float or a marginpar in the current implementation we simply warn the user that this is not allowed. Then we reinsert the page and its footnotes.

Additionally we empty the \@deferlist to avoid later error messages when the \LaTeX{} output routine is again in force. But first we have to place the boxes back onto the \@freelist. (\@elt is default is \relax so this is possible with \@@freecolumns@out)

Our next action is to (globally) empty \@deferlist and assign a new meaning to \@elt. Here \@scolelt is a macro that looks at the boxes in a list to decide whether they should be placed on the next page (i.e. on \@toplist or \@botlist) or should wait for further processing.

Now we call \@tempb which has the form

\@elt(box register)\@elt(box register)...
In that case we put the material back in box 255 so that we can cut a normal page. The curious set of \vskips we add is necessary to cancel out the \splittopskip that got added for balancing.

We also have to re-add the end of environment penalty since after this page we may want balance the remaining material.

We then call the standard multicol output routine which will produce a normal page for us (remember we are still within the OR so some part of the code in \multi@column@out is actually not doing anything—perhaps this should be cleaned up at some point). This also means that if there was an \enlargethispage present it will apply to this page as \multi@column@out will look at the status of \@kludgeins.

Because balancing made the columns too long we are sure that there will be some material remaining which was put back onto the main vertical list by \multi@column@out. This will also put the explicit \eject penalty back so the current \balance@columns@out output routine will be called again (so we better do not add another penalty or else the OR will be called twice and we may get scrambled results).

If the balancing went ok, we are in the position to apply \page@sofar. But first we have to set \vsize to a value suitable for one column output.

We also have to look at \@kludgeins and generate a new \insert in case there was one present due to an \enlargethispage command.

Then we \unvbox the \partial@page (which may be void if we are not processing the first page of this \multicol environment.

Then we return the first and bottom mark and the gathered material to the main vertical list.

We need to add a penalty at this point which allows to break at this point since calling the output routine may have removed the only permissible break point thereby “glueing” any following skip to the balanced box. In case there are any weird settings for \multicolsep etc. this could produce funny results.

As we already know, reinserting of footnotes will be done in the macro \endmulticols.

This macro now does the actual balancing.

We start by setting the kept marks by updating them with any marks from this box. This has to be done before we add a penalty of −10000 to the top of the box, otherwise only an empty box will be considered.

Then follow values assignments to get the \vsplitting right. We use the natural part of \topskip as the natural part for \splittopskip and allow for a bit of undershoot and overshoot by adding some stretch and shrink.

We also have to set \boxmaxdepth which normally allows to build boxes with arbitrary depth, but as we are building text columns we really want to restrict the depth. This is necessary as we sometimes rebox the boxes generated by \vsplitit and then the restriction posed by \splitmaxdepth gets lost.

The next step is a bit tricky: when \TeX~ assembles material in a box, the first line isn’t preceded
by interline glue, i.e. there is no parameter like \boxtopskip in \TeX. This means that the baseline of the first line in our box is at some unpredictable point depending on the height of the largest character in this line. But of course we want all columns to align properly at the baselines of their first lines. For this reason we have opened \mult@box with a \penalty -10000. This will now allow us to split off from \mult@box a tiny bit (in fact nothing since the first possible break-point is the first item in the box). The result is that \splittopskip is inserted at the top of \mult@box which is exactly what we like to achieve.

Next we try to find a suitable starting point for the calculation of the column height. It should be less than the height finally chosen, but large enough to reach this final value in only a few iterations. The formula which is now implemented will try to start with the nearest value which is a multiple of \baselineskip. The coding is slightly tricky in \TeX and there are perhaps better ways . . .

The code above sets \@tempdimena to the length of a column if we simply divide the whole box into equal pieces. To get to the next lower multiple of \baselineskip we convert this dimen to a number (the number of scaled points) then divide this by \baselineskip (also in scaled points) and then multiply this result with \baselineskip assigning the result to \dimen@. This makes \dimen@ \leq to \@tempdimena.

Next step is to correct our result by taking into account the difference between \topskip and \baselineskip. We start by adding \topskip; if this makes the result too large then we have to subtract one \baselineskip.

As a further restriction we want to see a minimum number of rows in the balanced result based on the setting of the counter \minrows. If the starting value is lower we adjust.

At the user’s request we start with a higher value (or lower, but this usually only increases the number of tries).

We type out statistics if we were asked to do so.

Now we try to find the final column height. We start by setting \vbadness to infinity (i.e. 10000) to suppress underfull box reports while we are trying to find an acceptable solution. We do not need to do it in a group since at the end of the output routine everything will be restored. The setting of the final columns will nearly always produce underfull boxes with badness 10000 so there is no point in warning the user about it.

We also allow for overfull boxes while we trying to split the columns. They can easily happen if we have objects with unusual depth.

The variable \last@try will hold the dimension used in the previous trial splitting. We initialize it with a negative value.

In order not to clutter up \TeX’s valuable main memory with things that are no longer needed, we empty all globally used box registers. This is necessary if we return to this point after an unsuccessful trial. We use \process@cols for this purpose, starting with \mult@grightbox. Note the extra braces around this macro call. They are needed since
Plain \TeX's \texttt{\loop...epeat} mechanism cannot be nested on the same level of grouping.

The contents of box \texttt{\mult@box} are now copied globally to box \texttt{\mult@grightbox}. (This will be the right-most column, as we shall see later.)

We start with the assumption that the trial will be successful. If we end up with a solution that is too bad we set \texttt{too@bad} to \texttt{true}. We also assume that all forced breaks (if any) will be used during balancing. If this is not the case we record this in \texttt{forcedbreak@leftover}.

Using \texttt{\vsplit} we extract the other columns from box register \texttt{\mult@grightbox}. This leaves box register \texttt{\mult@box} untouched so that we can start over again if this trial was unsuccessful.

After splitting we need to ensure that there isn't any space at the bottom, so we rebox once more.

After every split we check the badness of the resulting column, normally the amount of extra white in the column.

If this badness is larger than the allowed column badness we reject this solution by setting \texttt{too@bad} to \texttt{true}.

There is one subtle point here: while all other constructed boxes have a depth that is determined by \texttt{\splitmaxdepth} and/or \texttt{\boxmaxdepth} the last box will get a natural depth disregarding the original setting and the value of \texttt{\splitmaxdepth} or \texttt{\boxmaxdepth}. This means that we may end up with a very large depth in box \texttt{\mult@grightbox} which would make the result of the testing incorrect. So we change the value by unboxing the box into itself.

We also save a copy \texttt{\mult@gfirstbox} at its "natural" size for later use.

After \texttt{\process@cols} has done its job we have the following situation:

We report the height of the first column, in brackets the natural size is given.

If \texttt{\raggedcolumns} is in force older releases of this file also shrank the first column to its natural height at this point. This was done so that the first column doesn't run short compared to later columns but it is actually producing incorrect results (overprinting of text) in boundary cases, so since version v1.5q \texttt{\raggedcolumns} means allows for all columns to run slightly short.

Then we give information about the last column.

\footnote{With \TeX version 3.141 it is now possible to use \LaTeX's \texttt{\newlinechar} in the \texttt{\message} command, but people with older TeX versions will now get \texttt{'''J} instead of a new line on the screen.}
Some tracing code that we don’t compile into the production version unless asked for. It will produce huge listings of the boxes involved in balancing in the transcript file.

\begin{verbatim}
\ifnum\c@tracingmulticols>4
{\showoutput
\batchmode
\process@cols\mult@grightbox
{\showbox\count@}}%
\errorstopmode
\fi
\fi
\end{verbatim}

We check whether our trial was successful. The test used is very simple: we merely compare the first and the last column. Thus the intermediate columns may be longer than the first if \raggedcolumns is used. If the right-most column is longer than the first then we start over with a larger value for \dimen@.

\begin{verbatim}
\ifdim\ht\mult@grightbox >\dimen@% If the height of the last box is too large we mark this trial as unsuccessful.
\too@badtrue
\ifnum\c@tracingmulticols>\@ne
\typeout{Rejected: last column too large!}%
\fi
\else
To ensure that there isn’t a forced break in the last column we try to split off a box of size \maxdimen from \mult@grightbox (or rather from a copy of it). This should result in a void box after the split, unless there was a forced break somewhere within the column in which case the material after the break would have stayed in the box.

\setbox\@tempboxa\copy\mult@grightbox
\setbox\@tempboxa\vsplit\@tempboxa to\maxdimen
\ifvoid\@tempboxa Thus if \@tempboxa is void we have a valid solution. In this case we take a closer look at the last column to decide if this column should be made as long as all other columns or if it should be allowed to be shorter. For this we first have to rebox the column into a box of the appropriate height. If tracing is enabled we then display the badness for this box.

\global\setbox\mult@grightbox\vbox to\dimen@{
\unvbox\mult@grightbox}%
\ifnum\c@tracingmulticols>\@ne
\typeout{Final badness: \the\badness}%
\fi
\fi
\end{verbatim}

We then compare this badness with the allowed badness for the final column. If it does not exceed this value we use the box, otherwise we rebox it once more and add some glue at the bottom.

\begin{verbatim}
\ifnum\badness>\c@finalcolumnbadness% If the natural height of the first box is smaller than the current trial size but is larger than the previous trial size it is likely that we have missed a potentially better solution. (This could have happened if for some reason our first trial size was too high.) In that case we dismiss this trial and restart using the natural height for the next trial.
\fi
\fi
\fi
\end{verbatim}
Finally the switch `too@bad` is tested. If it was made true either earlier on or due to a rightmost column being too large we try again with a slightly larger value for `\dimen@`.

If we come out of the loop with the switch `forcedbreak@leftover` set to true then balancing has failed and we should cut a normal page. We indicate this below with `\too@badtrue` when any of the columns get too high, so we set this flag here too in order to get the same processing logic.\footnote{Should get cleaned up as we now have two different routes to reach this part of the processing.}

At that point `\dimen@` holds the height that was determined by the balancing loop. If that height for the columns turns out to be larger than the available space (which is `\@colroom`) we squeeze the columns into the space assuming that they will have enough shrinkability to allow this.\footnote{This might be wrong, since the shrinkability that accounts for the amount of material might be present only in some columns. But it is better to try then to give up directly.} However, this squeezing should only be done if we are balancing columns on the main galley and not if we are building a boxed multicoll (in the latter case the current `\@colroom` is irrelevant since the produced box might be moved anywhere at a later stage).

Then we move the contents of the odd-numbered box registers to the even-numbered ones, shrinking them if requested. We have to use `\vbox` not `\vtop` (as it was done in the first version) since otherwise the resulting boxes will have no height (\TeXbook page 81). This would mean that extra `\topskip` is added when the boxes are returned to the page-builder via `\vpage@sofar`.

When putting the final column together we want overfull information:

If the resulting box is overfull there was too much material to fit into the available space. The question though is how much? If it wasn’t more than `\maxbalancingoverflow` we accept it still to avoid getting very little material for the next page (which we would then have difficulties to balance).

Fail the balancing attempt:

Otherwise report that there is a problem but within the accepted boundary.

Finally end the `\ifnum\badness<>\@M` conditional.

Amount that balancing is allowed to overflow the available column space. We default to 12pt which means about one line in most layouts.

\newdimen\maxbalancingoverflow
\maxbalancingoverflow=12pt
4.5 The box allocations

Early releases of these macros used the first box registers 0, 2, 4,... for global boxes and 1, 3, 5,... for the corresponding local boxes. (You might still find some traces of this setup in the documentation, sigh.) This produced a problem at the moment we had more than 5 columns because then officially allocated boxes were overwritten by the algorithm. The new release now uses private box registers.

There was in fact a bug in the new implementation because at one point \LaTeX{} started to use the extended registers and so jumped from below 255 to above omitting the boxes allocated for inserts and the output page box.

So nowadays we really have to check if we get the full sequence of boxes allocated without holes (i.e., \(2 \times \text{max cols} + 1\)) and if not alter the allocation registers to start allocating after 255. This is all done quite low-level by looking directly at the values of the allocation counters.

5 New macros and hacks for version 1.2

\texttt{\emergencystretch} If we don’t use \TeX{} 3.0 \texttt{\emergencystretch} is undefined so in this case we simply add it as an unused \texttt{(dimen)} register.

\begin{verbatim}
829 \@ifundefined{emergencystretch}{\newdimen\emergencystretch}{}
\end{verbatim}

My tests showed that the following formula worked pretty well. Nevertheless the \texttt{\@setemergencystretch} macro also gets \texttt{\hsize} as second argument to enable the user to try different formulae.

\begin{verbatim}
831 \def\setemergencystretch#1#2{%\hsize\emergencystretch\#1\#2\%\multiply\emergencystretch#1}
832 \@setemergencystretch\#1\#2\%
833 \multiply\emergencystretch\#1
\end{verbatim}

\texttt{\set@floatcmds} Even if this should be used as a hook we use a @ in the name since it is more for experts.

\begin{verbatim}
834 \@def\set@floatcmds{%\hsize\emergencystretch\@dblfloat\@dbflt\%\let\@dblfloat\@dbflt
835 \let\@dblfloat\@dbflt
836 \def\end@dblfloat{\@deferlist\@currbox}
\end{verbatim}

This is cheap (deferring the floats until after the current page) but any other solution would go deep into \LaTeX{}’s output routine and I don’t like to work on it until I know which parts of the output routine have to be reimplemented anyway for \LaTeX{} 3.

\begin{verbatim}
839 \ifnum\@floatpenalty<\z@\let\@deferlist\@currbox
840 \@def\set@floatcmds{%\hsize\emergencystretch\@dblfloat\@dbflt\%\let\@dblfloat\@dbflt
841 \let\@dblfloat\@dbflt
842 \def\end@dblfloat{\@deferlist\@currbox}
843 \@cons\@deferlist\@currbox
844 \fi}
\end{verbatim}

This is cheap (deferring the floats until after the current page) but any other solution would go deep into \LaTeX{}’s output routine and I don’t like to work on it until I know which parts of the output routine have to be reimplemented anyway for \LaTeX{} 3.

We have to add the float to the \texttt{\@deferlist} because we assume that outside the \texttt{multicols} environment we are in one column mode. This is not entirely correct, I already used the \texttt{multicols} environment inside of \LaTeX{}’s \texttt{twocolumn} declaration but it will do for most applications.

\begin{verbatim}
849 \@def\set@floatcmds{%\hsize\emergencystretch\@dblfloat\@dbflt\%\let\@dblfloat\@dbflt
850 \let\@dblfloat\@dbflt
851 \def\end@dblfloat{\@deferlist\@currbox}
852 \@def\set@floatcmds{%\hsize\emergencystretch\@dblfloat\@dbflt\%\let\@dblfloat\@dbflt
853 \let\@dblfloat\@dbflt
854 \def\end@dblfloat{\@deferlist\@currbox}
855 \fi}
\end{verbatim}
5.1 Maintaining the mark registers

This section contains the routines that set the marks

\[ \text{so that they will be handled correctly. They have} \]

\[ \text{been introduced with version 1.4.} \]

\[ \text{First thing we do is to reserve three macro names} \]

\[ \text{to hold the replacement text for \TeX 's primitives} \]

\[ \text{\firstmark, \botmark and \topmark. We initialize} \]

\[ \text{the first two to be empty and \kept@topmark to} \]

\[ \text{contain two empty pair of braces. This is necessary} \]

\[ \text{since \kept@topmark is supposed to contain the last} \]

\[ \text{mark from a preceding page and in \LaTeX any “real”} \]

\[ \text{mark must contain two parts representing left and} \]

\[ \text{right mark information.} \]

\[ \text{\def\kept@topmark{{}{}}} \]

\[ \text{\let\kept@firstmark\@empty} \]

\[ \text{\let\kept@botmark\@empty} \]

\[ \text{\return@nonemptymark} \]

\[ \text{Sometimes we want to return the value of a} \]

\[ \text{“kept” mark into a \mark node on the main} \]

\[ \text{vertical list. This is done by the function} \]

\[ \text{\return@nonemptymark. As the name suggests it} \]

\[ \text{only acts if the replacement text of the kept mark is} \]

\[ \text{non-empty. This is done to avoid adding an empty} \]

\[ \text{mark when no mark was actually present. If we} \]

\[ \text{would nevertheless add such a mark it would be re-} \]

\[ \text{garded as a valid \firstmark later on.} \]

\[ \text{\def\return@nonemptymark#1#2{\ifx#2\@empty\else} \]

\[ \text{\for debugging purposes we take a look at the} \]

\[ \text{current dimensions of the box since in earlier versions} \]

\[ \text{of the code I made some mistakes in this area.} \]

\[ \text{\def\set@keptmarks}{\null}\] 17

\[ \text{17 Due to the current definition of \markright etc. it wouldn’t help to define the \protect command to prohibit expansion} \]

\[ \text{as any \protect has already vanished due to earlier expansions.} \]

\[ \text{Since the contents of the mark may be arbitrary} \]

\[ \text{\LaTeX code we better make sure that it doesn’t get} \]

\[ \text{expanded any further. (Some expansion have been} \]

\[ \text{done already during the execution of \markright or} \]

\[ \text{\markboth.) We therefore use the usual mechanism} \]

\[ \text{of a toks register to prohibit expansion.} \]

\[ \text{\def\set@keptmarks}{\null}\]
If \texttt{\@firstmark} is empty we assume that it isn’t set. This is strictly speaking not correct as we loose the ability to have marks that are explicitly empty, but for standard \LaTeX application it is sufficient. If it is non-empty we don’t change the value—within the output routines it will then be restored to \texttt{\@empty}.

\begin{verbatim}
879  \ifx\kept@firstmark\@empty
880  \else
881  \expandafter\gdef\expandafter\kept@firstmark
882  \expandafter{\splitfirstmark}
889  \fi
890 \end{verbatim}

When debugging we show the assignment but only when something actually happened.

\begin{verbatim}
883 \langle\texttt{*marktrace}\rangle
884  \ifx\kept@firstmark\@empty\else
885  \mult@info\tw@
886  \{Set kept first mark:\MessageBreak
887  \meaning\kept@firstmark%
888  \}@gobbletwo\%
889  \fi
890 \langle/\texttt{marktrace}\rangle
891 \fi
892 \fi
896 \fi
\end{verbatim}

We always try to set the bottom mark to the \texttt{\splitbotmark} but of course only when there has been a \texttt{\splitbotmark} at all. Again, we assume that an empty \texttt{\splitbotmark} means that the split off box part didn’t contain any marks at all.

\begin{verbatim}
892 \expandafter\def\expandafter\tempa
893 \expandafter{\splitbotmark}
894 \else
895 \global\let\kept@botmark\tempa
896 \fi
897 \langle\texttt{*marktrace}\rangle
898  \{Set kept bot mark:\MessageBreak
899  \meaning\kept@botmark%
900  \}@gobbletwo\%
901 \langle/\texttt{marktrace}\rangle
902 \fi
903 \def\prep@keptmarks{
904 \remove@discardable@items
905 \langle/\texttt{marktrace}\rangle
906 \prep@keptmarks
\end{verbatim}

There are situations when we may have some space at the end of a column and this macro here will attempt to get rid of it. The typical \LaTeX sequence is a series of self-canceling glues so if we remove them recursively we are usually fine.

Special care is needed with handling \texttt{\vspace*} as that corresponds to \texttt{\penalty10000, \vskip <skip>, followed by \vskip 0pt}. If we see this sequence going backwards in the vertical list we assume that this is a “desired” space. We therefore stop the recursion and reinsert the spaces.

As the multicols code sometimes add an explicit penalty at the end of a column we first attempt to remove it in case it is there.

\begin{verbatim}
907 \skip0=0pt
908 \edef\the@zero@skip{\the\skip0}
909 \def\remove@discardable@items{\unpenalty
910  \savea{\tempa}{\the\lastskip}
911 \ifx\tempa\the@zero@skip
912 \else
913 \unskip
914 \ifnum\lastpenalty=\@M
915 \vspace{\tempa} \vspace{\tempa}\relax
916 \else
917 \remove@discardable@items
918 \fi
919 \fi
920 \fi
\end{verbatim}

\texttt{\cpp@@keptmarks} The \texttt{\cpp@@keptmarks} function is used to initialize the kept marks from the contents of \texttt{\partial@page}, i.e. the box that holds everything from the top of the current page prior to starting the \texttt{multicol} environment. However, such a box is only available if we are not producing a boxed \texttt{multicol}.

\begin{verbatim}
909 \def\prep@keptmarks{}
910 \ifdef\boxedmulticol\else
911 \get@keptmarks\partial@page
912 \fi
913 \end{verbatim}
\newif\iftoo@bad
\too@badtrue\global\let\iftoo@bad\iftrue
\def\too@badfalse\global\let\iftoo@bad\iffalse
\newif\ifforcedbreak@leftover
\c@minrows=1
\newcount\c@minrows
\c@minrows=10000
\newcount\c@columnbadness
\c@columnbadness=10000
\newcount\c@finalcolumnbadness
\c@finalcolumnbadness=9999
\newdimen\last@try
\newdimen\multicolovershoot
\newdimen\multicolundershoot
\multicolovershoot=0pt \multicolundershoot=2pt
\newbox\mult@nat@firstbox
\def\mult@info#1#2{\ifnum\c@tracingmulticols>#1\GenericWarning{%\spaces\spaces}{Package multicol: #2}\fi}
\ifinner\PackageWarning{multicol}{multicols* inside a box does not make sense.\MessageBreak Going to balance anyway}\else\def\balance@columns@out\multi@column@out \penalty-\@Mvi \fi

6 Fixing the \columnwidth

If we store the current column width in \columnwidth we have to redefine the internal \@footnotetext macro to use \textwidth for the width of the footnotes rather than using the original definition.

Starting with version v1.5r this is now done in a way that the original definition is still used, except that locally \columnwidth is set to \textwidth. This solves two problems: first redefinitions of \@footnotetext done by a class will correctly survive and second if multicols is used inside a minipage environment the special definition of \@footnotetext in that environment will be picked up and not the one for the main galley (the latter would result in all footnotes getting lost in that case).

See the definition of the \multicols command further up for the exact code.

7 Further extensions

This section does contain code for extensions added to this package over time. Not all of them may be active, some might sit dormant and wait for being activated in some later release.

7.1 Not balancing the columns

This is fairly trivial to implement. we just have to disable the balancing output routine and replace it by the one that ships out the other pages.

\multicols* The code for this environment was suggested by Matthias Clasen.
\{nobalance\} \namedef{multicols*}{%
\ifinner\PackageWarning{multicol}%
\else\def\balance@columns@out\multi@column@out \penalty-\@Mvi \fi%

If we are not on the main galley, i.e., inside a box of some sort, that approach will not work since we don’t have a vertical size for the box so we better warn that we balance anyway.
\ifinner\PackageWarning{multicol}%
When ending the environment we simply end the inner \multicols environment, except that we better also stick in some stretchable vertical glue so that the last column still containing text is not vertically stretched out.

We do this as follows: first we ensure that we are back in vertical mode and then we cancel out \lastskip if it was positive (in case of a negative glue we assume that it was deliberate, for a deliberate positive glue one needs to use \vspace*). We can’t simply use \remove@discardable@items here as this only works inside boxes but we are here on the main vertical list.

Then we back up by \prevdepth but not more than \boxmaxdepth so that a baseline of the last box is now at the bottom. This way the material will align properly in case something like \vfill spreads it out after all. Finally we append \vfil to put white space at the bottom of the column, but we only do this if we aren’t anyway doing \raggedcolumns.

\columnbreak is modeled after \pagebreak except that we generate a penalty -10005.

\newcommand{\columnbreak}[1][4]{% We have to ensure that it is only used within a \multicols environment since if that penalty would be seen by the unmodified \LaTeX output routine strange things would happen.
\edef\mc@break@pen{-\ifcase#1\@m\or 3333\or 6666\or 9999\else\@Mv\fi\relax}\
\ifvmode\penalty \mc@break@pen\else\@bsphack\vadjust{\penalty \mc@break@pen}\@esphack\fi}
\newcommand{\newcolumn}{% This is modeled after \newpage but for column breaks.
\edef\mc@break@pen{\relax}
{-\ifcase#1\@m\or 3333\or 6666\or 9999\else\@Mv\fi\relax}
\ifvmode\penalty \mc@break@pen\else\@bsphack\vadjust{\penalty \mc@break@pen}\@esphack\fi}

\subsection{Manual column breaking}

The problem with manual page breaks within \multicols is the fact that during collection of material for all columns a page-forcing penalty (i.e. -10000 or higher) would stop the collecting pass which is not quite what is desired. On the other hand, using a penalty like -9999 would mean that there would be occasions where the \vsplitting operations within \multicols would ignore that penalty and still choose a different break point.

For this reason the current implementation uses a completely different approach. In a nutshell it extends the \LaTeX output routine handling by introducing an additional penalty flag (i.e., a penalty which is forcing but higher than -10000 so that the output routine can look at this value and thus knows why it has been called).

Inside the output routine we test for this value and if it appears we do two things: save the galley up to this point in a special box for later use and reduce the \vsize by the height of the material seen. This way the forcing penalty is now hidden in that box and we can restart the collection process for the remaining columns. (This is done in \speci@ls above.)

In the output routines that do the \vsplitting either for balancing or for a full page we simply combine box 255 with the saved box thus getting a single box for splitting which now contains forcing breaks in the right positions.

Increasingly lower penalty based on argument value. This is like \pagebreak but we use other penalty values are the \LaTeX defaults are rather pointless for pagination.

This is modeled after \newpage but for column breaks.
We need to guard the \vfill from disappearing.

If the \texttt{colaction} option is given we write out status
information about the last column, otherwise the
next command does nothing.

Assembling the boxes for right to left typesetting is
far more complicated. When I first tried to build a
solution for this my thinking was that all that is
necessary to do is to reverse the order of the columns.
But such an approach produces a subtle bug: If we
work this way then the first column put on the page
will be the last column of the text to read. and this
means that the order in which \TeX executes write
statements or assembles mark material will not hap-
pen in the order of the textual flow. So if, for ex-
ample each column contains a section command then
these sections will appear in reverse order in the ta-
tle of content.

For this reason some amount of gymnastics is
needed to add the columns in their natural flow.

First step is to put all rules in the right place (with-
out adding the comes which are instead represented
by a space of \texttt{\hsize}.

At this point in the code our typesetting reference
point is at the right end of the rightmost column (or
rather where that column should appear).

We are now typesetting all columns by first back-
ing up by their width (which is \texttt{\hsize}) then type-
setting the box and then backing up again, but this
time further, i.e., also across the column separation.
That will then enable us to typeset the next column
using the same approach until we are done with all
but the final column.

The approach for the final column is similar only
that we do not have to back up over any column
gap.
However we do have to move the reference point to its right place: to make the rules appear at the expected places, we should get the typesetting position to the far right again. As we at the moment at the far left we skip to the far right like this:

\hskip \textwidth

The default is left-to-right:

\LRmulticolcolumns

Macros to switch between left-right and right-left typesetting. In LR typesetting the LR@column@boxes is used to combine the columns. When typesetting right to left the RL@column@boxes is used instead.

\newcommand\RLmulticolcolumns{\let\mc@align@columns\RL@column@boxes}
\newcommand\LRmulticolcolumns{\let\mc@align@columns\LR@column@boxes}

7.4 Supporting \docolaction

Whenever we want to do something that depends on the current column we execute \docolaction. This command takes one optional and three mandatory arguments. The mandatory ones denote what to do if this is a “left”, “middle”, or “right” column and the optional one is simply there to say what to do if we don’t know (default is to use the “left” column action in that case).

We use one counter \mc@col@check@num to generate our unique label names. Each time we execute \docolaction we increment this counter to get a new name.

The generated “labels” are named \mc@col\the\mc@col@check@num and they hold as values the numbers 1, 2, or 3 denoting the current column type.

The \docolaction scans for a star and optional argument and 3 mandatory ones, but we do this in chunks (not having xparse available).
Here is the if used above:
\newif\if@docolactionstar

Because of extra data writing to the aux file the aux file will now contain something like the following after the document is processed the first time:
\relax
\mc@col@status{1}
\mc@set@col@status{1col-1}{0}
\mc@col@status{2}
\mc@set@col@status{1col-2}{0}
\mc@col@status{3}
\mc@set@col@status{1col-3}{0}
\mc@col@status{1}
\mc@col@status{2}
\mc@col@status{3}
\mc@set@col@status{1col-4}{0}

The \mc@col@status line denotes the column type and has been written out just before corresponding the column box was placed onto the page. The \mc@set@col@status lines have been written out as part of shipping the column boxes out, e.g., \mc@set@col@status{1col-1}{0} was therefore somewhere within the first column as it appears between \mc@col@status{1} and \mc@col@status{2}. The second argument in that line is the value used in the previous run (or zero if there was no previous run. We can use this to determine if a rerun is necessary.

Thus with this knowledge we can set things up to get the labels working.

\mc@col@status When the aux file is read in \mc@col@status is used to set \mc@curr@col@status:
\def\mc@col@status#1{\% \gdef\mc@curr@col@status{#1}}

\mc@set@col@status And when \mc@set@col@status is executed we can simply set up the label by associating it with the \mc@curr@col@status and ignore the second argument:
\def\mc@set@col@status#1#2{\% \global\expandafter\let\csname #1\endcsname \mc@curr@col@status}

The above definition is being used when the .aux file is read in at the beginning. At the end we need a different definition to test if another typesetting run is needed. There we compare the value used in the current run (stored in the second argument) with the value used on the next run. If those two values differ we set @tempswa to false which will trigger the “Label(s) may have changed” warning.
\AtEndDocument{\def\mc@set@col@status#1#2{\% \ifnum #2=\mc@curr@col@status\else \@tempswatrue \fi} \%}

Finally, as part of determining in which column we are, we used a switch inside \mc@col@status@write to determine if we are in the first column or not.
\newif\ifmc@firstcol
\mc@firstcoltrue
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Numbers written in italic refer to the page where the corresponding entry is described; numbers underlined refer to the code line of the definition; numbers in roman refer to the code lines where the entry is used.

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Change History

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\enough@room: Penalty 0 added to empty the contribution list. .................. 10

v1.0d
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v1.0e
General: Redefinition of description env. to use \description@margin=5pt in documentation. .................. 1
\prepare@multicols: \textwidth changed to \linewidth. .................. 13
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So this file will work with the ‘tvcolumn’ command. .......... 13

v1.0f
General: Changed \z@ to 0pt in redefinition of description. .................. 1

v1.1a
General: \multicols@sep changed to \multicol@sep. .................. 1
\flush@columns: \flushed@columns renamed to \flush@columns. .................. 21

v1.2a
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\set@float@cmds: Macro added. .......... 27
\set@emergency@stretch: Macro added. .......... 27
v1.4a
\spec@ion: Float boxes freed. 

v1.3a
\balance@columns: Changed \vtop to \bbox.  

v1.3b
\endmulticols: Do \penalty with \addpenalty  
\enough@room: Do \penalty with \addpenalty  
\multicols: Minimum of two columns  

v1.3c
\balance@columns: \global\advance left over 
from older code. 
Limit column height to \@colroom  
\endmulticols: Check closing env.  
\multicols@out: \unbox avoided.  
Check if footnotes are actually present before 
issuing a warning.  
Unnecessary code removed  
\prepare@multicols: \null inserted and 
removed in output  
\reinsert@footnotes: \unbox avoided.  

v1.3d
\unbalance: \col@number set to one  

v1.4a
General: Added support for multicol in inner 
mode  
\balance@columns: Changed to proper 
\endlinechar in \message  
\multicols: Forgotten braces added  
\multicols@out: \botmark set to 
\splitbotmark.  
\prepare@multicols: Checking for text losses. 
Conditional code for boxed mode added.  
kept marks initialized  

v1.4d
\balance@columns: New algorithm for start 
height  

v1.4e
\endmulticols: But ignore \nobreak in 
\addpenalty  
\enough@room: But ignore \nobreak in 
\addpenalty  
\multicols: Typeset optional arg inside group  
\prepare@multicols: Using  

v1.4f
\balance@columns: \on@line added to tracing 
info  
\multicols: \on@line added to tracing info  
\par added to allow for correct inner test  

v1.4g
\multicols: \global was probably wrong but 
at least unnecessary  
\multicols@out: Only change 
\kept@topmark if \kept@botmark 
non-empty  

v1.4h
General: Added mark tracing with 
tracingmulticols\geq 2  
\kept@topmark: Init to double brace pair  

v1.4i
\multicols@out: Set \kept@topmark to \botmark  
\prepare@multicols: \kept@topmark 
initialized.  
\set@mult@vsize: Setting of 
\emergencystretch on top removed.  

v1.4j
\multicols: Maximum of 5 columns (temp)  

v1.4k
\multicols: \@totalleftmargin now in 
\prepare@multicols  
\page@sofar: use \multicols@leftmargin 
instead of \@totalleftmargin  
\prepare@multicols: saved \@totalleftmargin  

v1.4m
\endmulticols: Check \partial@page being 
emptied  

v1.4n
\return@nonemptymark: Make marks robust  

v1.4o
\prepare@multicols: \topskip locally zeroed.  

v1.4p
\multicols@out: Use different \vsize 
setting  
\prepare@multicols: Code moved to 
\set@mult@vsize  
Use different \vsize setting  
\set@mult@vsize: Macro added.  

v1.5a
\balance@columns: Allow columns to come out 
a bit long or short.  
Do splitting to zero here  
Initialize \last@try  
Show natural size  
\endmulticols: Splitting off zero box moved to 
\balance@columns  
\leave@mult@footins: Macro added  
\multicols: Penalty moved to later point  
\multicols@out: Use \leave@mult@footins 
\prepare@multicols: Use \init@mult@footins  

v1.5b
\balance@columns: New box mechanism  
\LR@column@boxer: New box mechanism  
\multicols@out: New box mechanism  
\multicols: Allow 10 columns again  
\page@sofar: New box mechanism  
\prepare@multicols: Add offset to 
\doublecolnumber  

v1.5c
\balance@columns: New badness mechanism  

v1.5d
\balance@columns@out: added badness at 
output routine exit  
\endmulticols: Again use \penalty  
\multicols@out: Support \clearpage  
\spec@ion: Support \clearpage  

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v1.5d
\multicolumnout: reinit \topmark

v1.5c
\enoughroom: Assign arg to skip register to be able to output value

v1.5g
\setfloatcmds: Updated since floats have changed

v1.5h
\balance\columns: Get kept marks first
\pagessofar: Check for void boxes

v1.5i
\pagessofar: But don’t remove original code.
\setfloatcmds: Updated since floats have changed again

v1.5j
General: Apply improvement of documentation, kindly done by Robin Fairbairns.

v1.5o
\footnotetext: Redefinition added \pr/2664
\prepare@multicols: Setting of \columnwidth added again \pr/2664

v1.5p
\multicols: Redefinition of \footnotetext only within \env\pr/2689

v1.5q
\balance\columns: Do not reset
\multigfirstbox: (pr/2739) Removed setting \dimen (pr/2739)
\endmulticols: Macro added
\multitoks: And removed the group again six years later
\multicols: Macro added

v1.5r
\footnotetext: Use \footnotetext but with local change to \columnwidth
\multifirstbox: Macro removed again
\multicols: Use \footnotetext but with local change to \columnwidth

v1.5s
\specials: check for \stoppenalty \pr/2873

v1.5t
\return@nonemptymark: re-add \mark command which was commented out by mistake at some point in 1998 (pr/2978)

v1.5u
\balance\columns\out: Support \columbreak
\colbreakbox: Macro added
\columbreak: Macro added
\multitoks: Support \columbreak
\specials: Support \columbreak

v1.5v
\balance\columns: Added tracing statements for trial unsuccessful
Check last column if it contains forced break and reject trial if that is the case
\balance\columns\out: Added debug statements for column break support
\multitoks: Added debug statements for column break support
\specials: Added debug statements for column break support

v1.5w
\multicols: Make \footnotetext long to allow multi-paragraph footnotes

v1.5x
\endmulticols: Detect and fix problem if a multicols ends at the top of a page
\balance\columns: Limit column height only in unrestricted mode (pr/3212)

v1.5y
\pagessofar: Ensure that column rule has always \normalcolor
\c@finalcolumnbadness: Change wrong default for \multicolovershoot to zero (pr/3465)
\multitoks: Add a kern to cancel potential depth of previous line
\pagessofar: Suppress interline glue at this point

v1.5z
\LR@columnboxes: Preparing for adjusting \prevdepth
\multitoks: Adjust spacing
\pagessofar: Preparing for adjusting \prevdepth
\page@sofar: Different info display

v1.6a
General: New option grid
\LR@columnboxes: Preparing for adjusting \prevdepth
\multitoks: Adjust spacing
\pagessofar: Preparing for adjusting \prevdepth

v1.6b
\page@sofar: Different info display

v1.6c
\set@mult@vsize: Collect one line per column more

v1.6d
\endmulticols: Catch problem with \columbreak in last line

v1.6e
\multicols: Avoid self-referencing definition of \footnotetext (pr/3618)
\balance\columns: /colbreak guard in the wrong position
need to use \multigrightbox in the loop
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\pagessofar: Make the color of the rule a hook

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