Footnotes in a multi-column layout*

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1 Introduction
The placement of footnotes in a multi-column layout always bothered me. The approach taken by \LaTeX{} (i.e., placing the footnotes separately under each column) might be all right if nearly no footnotes are present. But it looks clumsy when both columns contain footnotes, especially when they occupy different amounts of space.

In the multi-column style option [?], I used page-wide footnotes at the bottom of the page, but again the result doesn’t look very pleasant since short footnotes produce undesired gaps of white space. Of course, the main goal of this style option was a balancing algorithm for columns which would allow switching between different numbers of columns on the same page. With this feature, the natural place for footnotes seems to be the bottom of the page but looking at some of the results it seems best to avoid footnotes in such a layout entirely.

Another possibility is to turn footnotes into endnotes, i.e., printing them at the end of every chapter or the end of the entire document. But I assume everyone who has ever read a book using such a layout will agree with me, that is a pain to search back and forth, so that the reader is tempted to ignore the endnotes entirely.

When I wrote the article about “Future extensions of \TeX{}” [?] I was again dissatisfied with the outcome of the footnotes, and since article should show certain aspects of high quality typesetting, I decided to give the footnote problem a try and modified the \LaTeX{} output routine for this purpose. The layout I used was inspired by the yearbook of the Gutenberg Gesellschaft Mainz [?]. Later on, I found that it is also recommended by Jan White [?]. On the layout of footnotes I also consulted books by Jan Tschichold [?] and Manfred Simonet [?], books, I would recommend to everyone being able to read German texts.

1.1 Description of the new layout
The result of this effort is presented in this paper and the reader can judge for himself whether it was successful or not. The main idea for this layout is to assemble the footnotes of all columns on a page and place them all together at the bottom of the right column. Allowing for enough space between footnotes and text, and in addition, setting the footnotes in smaller type I decided that one could omit the footnote separator rule which is used in most publications prepared with \TeX{}. Furthermore, I decided to place the footnote markers at the baseline instead of raising them as superscripts.

All in all, I think this generates a neat layout, and surprisingly enough, the necessary changes to the \LaTeX{} output routine are nevertheless astonishingly simple.

1.2 The use of the style option
This style option might be used together with any other style option for \LaTeX{} which does not change the three internals changed by \texttt{ftnright.sty}. In most cases, it is best to use this style option as the very last option in the \texttt{documentstyle} command to make sure that its settings are not overwritten by other options.

It is unfortunate that the current \LaTeX{} has no provisions to make such changes without overwriting the internal routines. In the new \LaTeX{} implementation, we will certainly add some hooks that will make such changes more easy.

The \texttt{ftnright} option makes use of the values of \texttt{\textwidth} and \texttt{\skipfootins} (the space between text and footnotes). The values used are the ones current when \texttt{ftnright.sty} is read in. If the user wants to change either of them in the

\* The \LaTeX{} style option \texttt{ftnright} which is described in this article has the version number v1.0c dated 90/08/24. The documentation was last revised on 90/08/24.

1. You can not use column footnotes at the bottom, since the number of columns can differ on one page.

2. Please note, that this option only changed the placement of footnotes. Since this article also makes use of the \texttt{doc} option [?], that assigns tiny numbers to code lines sprinkled throughout the text, the resulting design is not perfect.

3. The standard layout in TUGboat uses the same size for footnotes and text, giving the footnotes, in my opinion, much too much prominence.

4. People who prefer the rule can add it by redefining the command \texttt{\footnoterule} [?, p. 156]. Please, note, that this command should occupy no space, so that a negative space should be used to compensate for the width of the rule used.

5. The tiny numbers or symbols, e.g., the ‘S’ in front of this footnote.

6. Of course, this is only done for the mark preceding the footnote text and not the one used within the main text where a raised number or symbol set in smaller type will help to keep the flow of thoughts, uninterrupted.

7. These are the macros \texttt{\atwocolumn}, \texttt{\makeatall} and \texttt{\atendall} as we will see below. Of course, the option will take only effect with a document style using a twocolumn layout (like \texttt{TUGboat}) or when the user additionally specifies \texttt{twocolumn} as a document style option in the \texttt{documentstyle} command.

8. The \texttt{TUGboat} option (which is currently set up as a style option instead of a document style option which it actually is) will overwrite the size used in footnotes if it follows the \texttt{ftnright} option.
preamble of his document he should call the macro \preparefootins afterwards to reinitialize the footnote algorithm, e.g.,
\setlength{\skip\footins}{0pt plus 3pt}
\addtolength{\textheight}{1in}
\preparefootins

This is necessary because the current \LaTeX\ version contains no hook at the \begin{document} command where we could force an execution of \preparefootins internally.

2 The Implementation

As usual, we start by identifying the current version of this style file in the transcript file.9

1 \vlog{Style Option: \texttt{filename}}
2 \vfileversion{\space <\filedate> (FM1)}
3 \vlog{English Documentation}
4 \vspaces@\vspaces\vspace{<\docdate> (FM1)}

To implement the layout described, above we have to distinguish between the left and the right column on a page. For this purpose \LaTeX\ maintains the switch \if@firstcolumn. When assembling material for the left (i.e., the first) column, footnotes should take up no space, since they are held over for the second column. In the second column these footnotes are combined with the ones found there and placed a suitable distance from the main text at the bottom of this column.

This means that we have to change certain parameters for the insertion \footins when we construct the second column. The right place to do this is in the \LaTeX\ macro \outputdblcol which we are going to change later on. What settings for the insertion parameters are appropriate? For setting the first column \count\footins and \skip\footins should both be zero since footnotes are held over while for the second column \count\footins should be 1000 and the \skip\footins has to be set to the desired separation between main text and footnotes.10

We will allow one column of footnotes (i.e., the right column) at most, so that \dimen\footins has to equal \textheight. In principle, it would be possible to allow for even more footnotes, but this would complicate matters enormously.11

Since a document usually starts with a left column, we have to set \count and \skip\footins on top-level to zero. For this purpose, we define a macro \preparefootins which will first save the current value of \skip\footins in a safe place. This saved value will be used later for the second column. In this way, it is possible for the user or a designer of a document style to adjust this parameter without fiddling with the code of this style file.

5 \def\preparefootins{%
6 \global\rcol@footinskip\skip\footins
7 \global\skip\footins:=0
8 \global\count\footins=0
9 \global\dimen\footins=\textheight}

We will also assign \textheight to \dimen\footins to allow the user to change this parameter in the preamble.

10 \global\dimen\footins=\textheight

It is necessary to make the assignments above \global because we are going to use this macro in the output routine which has an implicit grouping level to keep the changes made by it local.

Of course, we have to allocate the skip register that we used above:

11 \newskip/rcol@footinskip

Now we have all the necessary tools available to tackle \outputdblcol. We have to remember that when \if@firstcolumn equals \iftrue, we are currently starting to build the second column, i.e., that the first column is already assembled. Therefore, the macro will start with the following code:

12 \def/\outputdblcol/\if@firstcolumn
13 \global/\firstcolumn=false

After changing the switch, we save the first column (which was placed by preceding macros in \@outputbox) in the box register \@leftcolumn. Since we are inside the output routine, all those assignments have to be \global to take any effect.

14 \global/\setbox/\@leftcolumn/\box/\outputbox

Then, we make the footnotes visible to the page generation algorithm by setting \count\footins

9. Nico Poppeier suggested omitting the \typeout statements in the production version of the file to avoid showing all that unnecessary information to the user. While I accept his criticism as valid, I decided that this information should at least be placed into the transcript file to make it easier to detect problems arising from the use of older versions. The command \vlog is a \LaTeX\ command that will write its argument to the transcript file.

10. A value of 1000 means that there is a one-to-one relationship between the real size of the footnote and the size finally occupied by the footnote on the current page.

11. It is not possible to make \dimen\footins larger than \textheight directly, because this would result in a full left column (with text) and more than one column of footnotes. Instead, one has to make footnotes visible to the page generation algorithm again at the moment when a full column of footnotes is assembled, but we still have some space left in the first column. It is a nice enhancement, and, I suppose, it is of some value for preparing publications in certain disciplines, so here is the challenge ...
to 1000 (\textbackslash\&m is an abbreviation for this number) and \textbackslash\&skip\textbackslash\&footins to its saved value (i.e., \textbackslash\&col\textbackslash\&footins\textbackslash\&skip).

14 \textbackslash\&global\textbackslash\&count\textbackslash\&footins\textbackslash\&m
15 \textbackslash\&global\textbackslash\&skip\textbackslash\&footins\textbackslash\&col\textbackslash\&footins\textbackslash\&skip

We also have to reinsert all footnotes left over from the first column to make sure that they are reconsidered by the page generation algorithm of \LaTeX using the new values for \textbackslash\&count and \textbackslash\&skip\textbackslash\&footins. But this will be done later in the macro \textbackslash\&start\textbackslash\&column.

If we have just finished the right column, i.e., when \textbackslash\&if\textbackslash\&first\textbackslash\&column equals \textbackslash\&iffalse, we will reset the \textbackslash\&footins parameters as explained above using the utility macro \textbackslash\&prepare\textbackslash\&footins.

16 \textbackslash\&else \textbackslash\&prepare\textbackslash\&footins

Then, we compose both columns in \textbackslash\&output\textbackslash\&box, combine them with all page-wide floats for this page (\textbackslash\&combined\textbackslash\&dblfloats), attach header and footer, and ship out the result (\textbackslash\&output\textbackslash\&page). Finally we look to see whether it is possible to generate following pages consisting only of page-wide floats.\textsuperscript{12}

17 \textbackslash\&global\textbackslash\&first\textbackslash\&column\textbackslash\&true
18 \textbackslash\&setbox\textbackslash\&output\textbackslash\&box\{\textbackslash\&bbox to\textbackslash\&tex\textbackslash\&width
19 \textbackslash\&bbox to\textbackslash\&column\textbackslash\&width
20 \{\textbackslash\&bbox\{\textbackslash\&left\textbackslash\&column\textbackslash\&hs\textbackslash\&s\}\%
21 \textbackslash\&hrule\textbackslash\&width\textbackslash\&column\textbackslash\&seprule\textbackslash\&hs\textbackslash\&s
22 \textbackslash\&bbox to\textbackslash\&column\textbackslash\&width
23 \{\textbackslash\&bbox\{\textbackslash\&output\textbackslash\&box\textbackslash\&hs\textbackslash\&s\}\}\%
24 \textbackslash\&combined\textbackslash\&dblfloats\{\textbackslash\&output\textbackslash\&page
25 \textbackslash\&begin\textbackslash\&group
26 \textbackslash\&dbl\textbackslash\&float\textbackslash\&placement\{\textbackslash\&start\textbackslash\&dbl\textbackslash\&column
27 \textbackslash\&@\textbackslash\&while\textbackslash\&\textbackslash\&if\textbackslash\&col\textbackslash\&made\textbackslash\&fi
28 \{\textbackslash\&output\textbackslash\&page\{\textbackslash\&start\textbackslash\&dbl\textbackslash\&column\}\%
29 \textbackslash\&end\textbackslash\&group
30 \textbackslash\&fi\}

There is a fundamental flaw in \LaTeX's output routine for float columns and float pages: split footnotes, i.e., footnotes which are only partly typeset on the preceding page are not resolved. They are held over until \LaTeX starts a page (or column) containing text besides floats again. For our current layout, this would mean, that if \LaTeX decided to make the right column of a page a float column, footnotes from the left column would appear on a later page. A real cure for this problem would be to rewrite two-thirds of \LaTeX's output routine, so I am leaving this open for the interested reader.

But the problem shows up even if only one float is contributed to the right column since \LaTeX assumes that the whole column is usable, whereas some of it might actually be already devoted to footnotes from the left column. So we have to change the output routine at least in the part that contributes floats to the next column. The macro involved is called \textbackslash\&start\textbackslash\&column. The first thing we do is to check and see whether any deferred floats exists.

31 \textbackslash\&def\textbackslash\&start\textbackslash\&column\%
32 \textbackslash\&if\textbackslash\&\textbackslash\&if\textbackslash\&col\textbackslash\&made \textbackslash\&empty

If not, we set the switch \textbackslash\&if\textbackslash\&col\textbackslash\&made to false which says that we did not succeed in making a float column. Then, we set \textbackslash\&col\textbackslash\&room to \textbackslash\&col\textbackslash\&ht. The register \textbackslash\&col\textbackslash\&ht holds the amount of space that is available for floats, text, and footnotes in one column, i.e., it equals \textbackslash\&text\textbackslash\&height minus the space devoted to page-wide floats. \textbackslash\&col\textbackslash\&room is a similar register which holds the value \textbackslash\&col\textbackslash\&ht minus space for column floats that are already contributed to the current column. Of course, both values should be equal when we start a new column.

33 \textbackslash\&global\textbackslash\&col\textbackslash\&made\textbackslash\&false
34 \textbackslash\&global\textbackslash\&col\textbackslash\&room\textbackslash\&col\textbackslash\&ht
35 \textbackslash\&else

If there are floats waiting for a change to be processed, the situation is more difficult. In this case, we have to reduce both \textbackslash\&col\textbackslash\&ht and \textbackslash\&col\textbackslash\&room by the amount of space that will be needed for the footnotes from the left column. So we must check whether such footnotes are present. As we have not reinserted them in \textbackslash\&output\textbackslash\&dbl\textbackslash\&col, we can check the \textbackslash\&footins box.

36 \textbackslash\&if\textbackslash\&\textbackslash\&if\textbackslash\&footins\textbackslash\&else

If there are some, we measure the space that will be occupied by them. This measurement is not really exact. If we have a full column of footnotes, it will be too high, but this does matter since we need it

\textsuperscript{12} This part is copied directly from the original \LaTeX macro. Details about the used macros, their interfaces and meanings can be found in the \LaTeX source code.\cite{...}
only for an upper bound on the free space available
for floats.
37  \fntamount\ht\footins
38  \advance\fntamount\dp\footins
39  \advance\fntamount\skip\footins
40  \fi

We then reduce the \colht by this amount and
again assign \colroom the value of \colht. If no
footnotes are present, we subtract zero, so there is
no harm in doing this operation all the time.
41  \global\advance\colht-\fntamount
42  \global\advance\colroom\colht
Now, we call another internal \TeX macro that will
try to contribute floats to the next column. It will
use the register \colht when trying to build up
a float column, which is the reason for reducing
this register. If it succeeds, it will set the switch
\ifcolormade to true, otherwise, to false. If no
float column is possible, it will try to place some or
all of the deferred floats to the top or the bottom
of the next column, thereby, using and reducing the
value of the register \colroom.
43  \xstartcol

Afterwards, we have to restore the correct values for
\colht and \colroom again, but this time, they may differ, so that we have to \advance both
registers separately by \fntamount.
44  \global\advance\colht-\fntamount
45  \global\advance\colroom\fntamount
46  \fi

Now, after doing the things depending on the status of the \defcolom, we have to incorporate the
left over footnotes in the new column. First we check whether a float column was produced by
\xstartcol or not.
47  \ifcolormade
If so, we do something awful. To make use of
the \maketcol macro, which attaches footnotes to
\box 255 and places the result in the box register
\outputbox, we have to assign \outputbox (i.e.,
the result of \xstartcol) to \box 255.\footnote{13}
48  \setbox\ocont\box\outputbox
49  \maketcol
50  \else
If no float column was produced, we reinsert the
held over footnotes so that they can be reconsidered
by the page generation algorithm of \TeX. But it is
necessary to ensure that this operation is done only
when footnotes are actually present.\footnote{14}
51  \ifvoid\footins\else
52  \insert\footins{\unbox\footins}\fi
53  \fi

Of course, we also have to allocate the dimen
register. It will be automatically initialized to zero.
54  \newdim\fntamount

The other internal macro that we have to change
is \maketcol, a macro that is called whenever one
column of material is assembled and column floats
and footnotes have to be added. Again, we have
to distinguish between actions for the first and the
second column.
55  \def\maketcol{\ife\firstcolumn
For the first column, we leave the footnotes in their
box and simply save the contents of box 255 in the
box register \outputbox.
56  \setbox\outputbox\box\ocont

But if the user erroneously forgot to specify a twocol-
umn layout, we will always typeset the first column,
so that the footnotes are never printed. Therefore
we better check for this special case and output the
footnotes on a separate page in an emergency.\footnote{15}
57  \if\twocolumn \else
58  \ifvoid\footins \else
59  \latexerr
60  \{\fntright option used in one-column mode\}
61  \{\textit{I shipped out the the footnotes on an
62  extra page.}\}
63  \shipout\box\footins \fi
64  \else

When we construct the second column, we must first
check whether footnotes are actually present. If not, we
perform the same actions as before.
65  \ifvoid\footins
66  \setbox\outputbox\box\ocont
67  \else

But, if footnotes are present, it may be possible that
the whole column consists of footnotes, i.e., \box
255 is empty. In this case, there is no use in placing
any glue (\skip\footins) in front,\footnote{16} so we have to
check for this possibility.
68  \ifvoid\footins

13. In German, we call this "from the back through the chest
into the eyes".

14. Otherwise, we might get an undesired extra vertical
space coming from \skip\footins, even if there are no foot-
notes on the page.

15. Otherwise, the footnotes are held over for ever, prevent-
ing \TeX from finishing the document successfully. Instead,\TeX
will produce infinity many empty pages at the end of
the document, trying in vain to output the held over foot-
notes. This problem was found by Rainer Schöpf when we
prepared the paper for the Cork conference.

16. In fact, it would be a mistake since this glue was not
taken into account when the footnotes where assembled, so it
would produce an overfull box.
Individual footnotes are separated from each other by a more or less baseline skip of the text size. This can be specified with the following code:

\footnotesize
\global{\footnotespsep=\ht\strutbox}

Braces and \global were used to keep the switch to \footnotesize local, just in case some weird layout starts out with a different text size for some reason.

And finally, a small but nice change, to the mark at the beginning of the footnote text. We will place it at the baseline instead of raising it as a superscript. Additionally, it will get a dot as punctuation.

3 Initialisation

We defined the macro \preparefootins above, but we also have to use it to prepare typesetting the first column. As a default for the separation of footnotes and text on the second column, we use the following:

\skipfootins 10pt plus 5pt minus 3pt
\preparefootins

Of course, this value can be changed, on by the user as described in the introduction.

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17. This decision if certainly open to criticism, since there is nothing to separate. On the other hand, a rule or some other ornament in front of the footnotes is part of the design which should be used consistently throughout a document. As a last argument in favor of the rule, consider the situation where \LaTeX decided to place only floats and footnotes into the right hand column. In this case a separator again seems adequate. In this situation one can even argue that it is necessary to put in the \skipfootins.

18. It is an interesting question as to whether the current layout works well with bottom floats or not. Actually, I would prefer to place the footnotes below the bottom floats instead of above, as it is done here. At least when the floats are part of the document and not puzzles thrown in. But I was too lazy to implement it because I seldom use floats. If somebody implements this layout (some parts of this macro have to be changed) I would be interested in seeing the code and some sample results.

19. I only changed \dimen28 into \tempdima which is, besides being faster and shorter, only a cosmetic change. The use of this hardwired dimen register seems to indicate that this part of \LaTeX was written very early and left unchanged since then: an interesting fact for software archeologists.