

Output Routine Requirements for Advanced Typesetting Tasks

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Abstract

\LaTeX 's output routine is designed with fixed layout and functionality in mind. This is even true for the current state of the new output routine work by the $\LaTeX 3$ team. When typesetting things like critical editions, one may have to cater for multiple levels of marginal notes (like verse/line numbers and additional cross references), multiple and nested levels of footnotes, footnotes also carrying marginal notes, multicolumn material with synchronized page breaks and so forth and so on. It is not feasible to anticipate every possible perversion of typesetting tasks in advance.

For this reason, flexible methods of allocating the various special penalties for communicating the relevant information for such material, and for interpreting, collecting and assembling the relevant material within the context of the output routine and `minipage`-like environments are required. The implementor of such contorted layouts should then have the possibility to allocate the required levels and layers of specialities and plug them together in comparative ease.

A suitably generic core could be employed by vastly different and far more diverse typesetting tasks than just the \LaTeX base classes. With suitable generality, it might even become feasible to root different systems with different user interfaces (like `ConTeXt`) on common core mechanisms, making it easier to cross-port functionality over the various systems.

Résumé

La routine de sortie de \LaTeX a été conçue en vue d'une utilisation avec des mises en page et des fonctionnalités fixes. Ceci s'applique aussi à l'état actuel de la nouvelle routine de sortie développée par l'équipe $\LaTeX 3$. Quand on compose des documents tels que des éditions critiques, on nécessite parfois plusieurs niveaux de notes marginales, plusieurs niveaux de notes de bas de page, des notes de bas de page munies de notes marginales, du multicolonnage avec fins de page synchronisées, etc. Il est impossible de prévoir toutes les perversions typographiques possibles et imaginables, à l'avance.

Pour cette raison, on nécessite des méthodes flexibles, pour allouer les pénalités spéciales, pour communiquer l'information *ad hoc*, pour interpréter, collectionner et assembler le matériel dans le contexte de la routine de sortie et des environnements de mini-page. L'implémentateur d'une telle mise en page doit être capable d'allouer les niveaux et couches requis nécessaires et des les joindre au logiciel relativement facilement.

Un noyau raisonnablement générique peut être utilisé par un grand nombre de tâches de composition diverses et variées, bien au-delà des classes \LaTeX de base. En gardant un niveau de généralité assez haut, on pourrait même tenter d'utiliser des interfaces différentes (comme `ConTeXt`) et obtenir ainsi une compatibilité inter-systèmes.

Introduction to output routines

The output routine is one of the more mysterious pieces of \TeX . The chapter of the \TeX book discussing output routines claims that designing output routines makes one achieve the level of a “ \TeX Grandmaster”.

As is so often the case, mastery of the concept of an output routine in plain \TeX will only barely prepare you for the complexities awaiting you with \LaTeX 's variant of an output routine.

Basic operation So what is an output routine? When \TeX

is typesetting pages of continuous text, it will gather material until it can find a least-cost page break intended to make the gathered material fit the `\pagegoal` size. The gathered material will then be placed into `\box255` and the output routine stored in the token register `\output` will be processed in a group of its own. Usually it will arrange the gathered material in some way, add headers, footlines and page numbers, and ship the gathered results out in typeset form with the `\shipout` command. At the time of the `\shipout` command all `\open` and `\write` commands stored in the box shipped out are ex-

panded and written out. This is what makes it possible to have page labels corresponding to the actual page numbers at the time of shipout: the corresponding info is written to the `.aux` file at that time.

The output routine may decide to place material back on the main vertical list instead of shipping it out.

Marks One feature connected to the output routine is marks: marks can contain arbitrary tokens and are placed in the vertical list with `\mark` commands. The first and last mark on any page can be accessed as `\firstmark` and `\botmark`, respectively, when the output routine gets called. ϵ -TeX provides for more than one mark at a time if necessary. Marks can be used to gather information about what range of material has made it to the page.

Special penalties and ‘here’ points Penalties govern how infeasible to consider a page break. Negative penalties indicate good break points. Penalties of -10000 and below force an immediate page break. Those penalties don’t occur naturally, so one can use various values for signalling conditions to the output routine in so-called ‘here’ points. One possibility is to use TeX’s `\vadjust` command to insert such a special penalty right after the current line. The page will then be broken at that point and the output routine called. The output routine will then notice that it was invoked by a special penalty and will cause a corresponding special action, like placing a figure or margin note, or adjusting to a grid, or placing a line number (for that purpose, the normal interline penalty would be set to an appropriate special penalty) or a number of other possible actions. Typically, `\box255` will be just contributed back to the current vertical list in the output routine after the necessary special action has been called.

Insertions TeX has the concept of insertions that are used for floating material and things like footnotes. An insertion is a mechanism by which material associated with the main vertical list, such as footnotes or floating figures, is collected.

Insertions consist of the following items:

- A box register is where the collected insertions appear when the output routine is called. Insertions may be split or float completely to the next page. In that case the remaining material is not in the box but will be inserted for the main vertical list immediately *before* any material contributed from the output routine.
- A skip register specifies how much vertical space on the main page is consumed if at least one item from the insertion appears.
- A count register is a scale factor telling TeX how much space in the main vertical list gets eaten up by material in the insertion. For example, single column footnotes below double column text might take

twice the vertical space from the galley, margin notes might take up no space at all, and so on.

A dimension register can be set to the maximum amount of material that can be permitted from insertions of that type on a single page.

There are also parameters recorded with every single insertion, like its floating penalty (how bad is it if the insertion material does not at least start on the same page where it is referenced).

Insertions like footnotes may be split across pages, in which case the material before the split appears in the corresponding box register while the material following the split is placed into an insertion before the material that the output routine may recontribute to the main vertical list.

Examples for output routine requirements

We start off with two rather innocuous extracts from a two-language version of the Iliad (figure 1). Such two-language versions of a text will usually be set in two separate passes where each pass concerns itself with typesetting one language and after completing both passes, the results get joined into one common document by alternating the produced pages. This particular variant looks like one of the easiest ones: since we have an original text organized by verse lines, and a translation organized similarly, synchronization happens automatically.

Almost: what if we have overlong lines and need to wrap them? There are two approaches: the first one is to just put the line end somewhere else, usually in the line below. The version in figure 1(a) has to use the line above because of a verse number, so the placement also depends on the contents of the following lines. However, it can also depend on the position of page breaks: if the following line happens to be on the next page, we get more space for tacking on some line stubs and may not need to move stuff around too much. There are advantages to trying to fix stuff such things, as well as line numbers, within the scope of the output routine, but in this case it would probably be overkill.

The second approach is to synchronize the extra line needed with the translation, as seen in figure 1(b). Of course, this synchronization needs to be established in a multipass scheme: the blank lines can only be inserted after the other language has had its page set. It would actually be more convenient to have two copies of TeX running in lockstep, each reading from its own input file. Then we could save ourselves the trouble of a multipass algorithm.

Unique arrangements of standard elements The next interesting example is an excerpt (figure 2) from James Joyce’s “Finnegans Wake”. We notice a few difficulties with regard to L^ATeX’s usual operations: the footnote area has

<p>κεῖνος δ' αὖ περὶ κῆρι μακάριτατος ἔξοχον ἄλλων ὅς κέ σ' ἐέδνοιαι βρίσας οἰκόνδ' ἀγάγηται. οὐ γάρ πω τοιοῦτον ἕδον βροτῶν ὀφθαλμοῦσιν, οὔτε ἄνδρ' οὔτε γυναῖκα· σέβας μ' ἔχει εἰσορῶντα.</p>	160	<p>Aber keiner ermißt die Wonne des seligen Jünglings, Der dich gewinnt mit den reichsten Geschenken und führt dich nach Denn ich sah noch nie solch einen sterblichen Menschen, Weder Mann noch Weib! Mit Staunen erfüllt mich der Anblick!</p>	[Hause!] 160
(a) Synchronicity by arrangement			
<p>ἔχθεσθ', ἀλλ' ἔτι πού τις ἐπέσσειται ὅς κεν ἔχησι δῶματά θ' ὑπερρέφα καὶ ἀπόπροθι πίνοντας ἀγρούς· ὡς φάτο, τῆς δ' εὐνήσε γόνον, σκέθε δ' ὄσσε βόοιο.</p>		<p>Ganz verhaßt; es bleibt ihm noch einer, daß er beherrsche Dieses hohe Haus und die weiten gesegneten Felder. Also sprach sie und stillt' ihr den Gram und hemmte die Tränen.</p>	
<p>ἦ δ' ὑδρηγαμένη, καθαρὰ χροὶ εἰμαθ' ἑλοῦσα, εἰς ὑπερῶν' ἀνέβαινε σὺν ἀμφιπόλοισι γυναιξίν,</p>	760	<p>Und sie badete sich und legt' ein reines Gewand an, Ging hinauf in den Söller, von ihren Mägden begleitet,</p>	760
(b) Synchronicity by spacing			

FIG. 1: Two excerpts from the Iliad

<p><i>With his broad and hairy face, to Ireland a disgrace.</i></p> <p><i>Menly about peebles.</i></p> <p><i>Dont retch meat fat salt lard sinks down (and out).</i></p>	<p>As we there are where are we are we there from tomtittot to teetootmtotalitarian. Tea tea too oo.</p> <p>Whom will comes over. Who to caps ever. And howelse do we hook our hike to find that pint of porter place? Am shot, says the big- guard.¹</p> <p>Whence. Quick lunch by our left, wheel, to where. Long Livius Lane, mid Mezzofanti Mall, diagonising Lavatery Square, up Tycho Brache Crescent,² shouldering Berkeley Alley, querfixing Gainsborough Carfax, under Guido d'Arezzo's Gadeway, by New Livius Lane till where we whiled while we whithered. Old Vico Roundpoint. But fahr, be fear! And natural, simple, slavish, filial. The marriage of Montan wetting his moll we know, like any enthewsyass cuckling a hoyden³ in her rougey</p>	<p>UNDE ET UBI.</p> <p>SIC.</p> <p>IMAGINABLE ITINERARY THROUGH THE PARTICULAR UNIVERSAL.</p>
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¹ Rawmeash, quoshe with her girlic teangue. If old Herod with the Cormwell's eczema was to go for me like he does Snuffer whatever about his blue canaries I'd do nine months for his beaver beard.

² Mater Mary Mercerycordial of the Dripping Nipples, milk's a queer arrangement.

³ Real life behind the floodlights as shown by the best exponents of a royal divorce.

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FIG. 2: An excerpt from "Finnegans Wake"

a different text width from the main text, and we have margin notes on both borders of the text. L^AT_EX's margin notes are a pain to switch between the margins (using `\reversemarginpar`), and it happens that we only have the possibility to specify outer and inner margin notes, whereas this chapter of "Finnegans Wake" would rather require left and right notes since the notes do not switch sides on opposing pages. This kind of layout should be easier to achieve than it is currently with L^AT_EX 2_ε. In addition, we find that in "Finnegans Wake" several chapters have separate layouts, so it would be desirable to be able to switch between layouts from chapter to chapter, changing page formats and general layouts on the fly in

the middle of a document.

Critical edition In figure 3, we have an example for a critical edition. We happen to have three footnote apparatus here. The first one is from the original commentator. The second one gives text variants of the original commentary. The third apparatus gives comments of the current editor. The interesting thing is that footnote anchors of the lower footnote apparatus can occur anywhere in the material on the page before. Note that the order of footnote numbers depends on the page breaks: if a footnote is continued to the next page, and a lower level footnote is anchored within the part broken to the next page, the number and position of the lower level footnote

und müssen sie einerseits gegen die Kulturkrankheiten der Skepsis und der Anarchie sowie des naturalistischen Atheismus verteidigen, andererseits sie in die neuen intellektuellen Horizonte einstellen, den jeweils neuen ethisch-sozialen Aufgaben anpassen¹⁾. |

Zu solchen Betrachtungen leitet uns der Befund der Historie. Sie sind freilich Geschichtsphilosophie und insofern keine strenge Wissenschaft. Aber die Wissenschaft ist nicht bloß exakte Wissenschaft, sonst müßte sie auf Mathematik und Naturwissenschaft^a, etwa auch eine streng motiva-

B 78

1) Hiermit sind nur meine früheren Ausführungen über „Die Selbständigkeit der Religion“ und „Metaphysik u. Geschichte“ (Z. f. Th. u. K. VIII 1897) fortgeführt und teilweise genauer bestimmt, insofern mit dem Ideal eines Begriffes der Religion noch stärker gebrochen ist, als es dort bereits der Fall war. Im übrigen darf ich auf das neue Buch Euckens verweisen „Der Wahrheitsgehalt der Religion“ Leipzig 1901, das meinen Anschauungen überaus nahe steht. Nur^b erledigt auch Eucken „m. E. zu“ rasch das Absolut-

A 70, B 77

a In A₁ folgt: auf Anthropologie u Psychologie

b A: Nur über die Begriffe der „universalen“ und der „charakteristischen Religion“, namentlich über das Verhältnis beider würde ich eine etwas andere Darstellung wünschen. Die „universale“ Religion ähnelt zu stark dem alten Wesen und Begriff der Religion und die „charakteristische“ zu stark der Realisation des Begriffes der Religion.¹⁴⁸ Eben damit

c-c A: ziemlich

148 Religion muß nach Eucken einen „universalen Charakter“ tragen. Rudolf Eucken: Der Wahrheitsgehalt der Religion (1901), S. 209. Sie sei „aus dem Ganzen des Lebens“ erwachsen, „es handelt sich bei ihr um den Gewinn einer neuen Welt, der Welt selbständigen, sowohl der Natur als dem menschlichen Getriebe überlegenen Geisteslebens“ (S. 209). Religion sei damit „der Höhepunkt, an dem sich eine Umwandlung des ganzen Lebens vollzieht“; sie sei die „Konzentration des Ganzen“ (S. 210). Innerhalb der universalen Religion habe sich zwar eine „weltüberlegene Innerlichkeit“ (S. 331) angekündigt, da aber das „Göttliche“ sich „einstweilen nur als Gesetz und Gericht“ (S. 303) erschlossen habe, sei gleichzeitig „die eigne Erhabenheit und unsere Nichtigkeit zu stärkster Empfindung“ (S. 303) gekommen: „So droht die ganze unermessliche Lebensflut ins Leere zu verrinnen“ (S. 303). Eine Rettung komme aus der „Kraft göttlichen Lebens“, aus einer „weiter[er]n Erschließung weltüberlegener Vernunft“, wie diese „Wendung“ in den „sog. historischen oder positiven Religionen“ uns entgegengetreten sei (S. 303). Die universale Religion entwickelt sich zur charakteristischen. Eucken setzt bei dieser eine „Thathandlung der Gottheit selbst“ an, „in der [...] eine neue Art der Gemeinschaft, ein neuer Lebenskreis, eine neue Wirklichkeit gebildet wird“ (S. 332). „Daß eine solche neue Welt in unser Dasein hineinwirkt, daß ihm ein überweltliches Leben gegenwärtig ist, das bildet die Voraussetzung einer neuen Gestalt der Religion, die uns die

FIG. 3: Critical Edition with multiple footnotes

will be *after* a same level footnote anchored into the main text.

The footnote number reordering can be solved by using a `\label`-like mechanism that will get the numbers right in a multiple pass method, so we won't delve deeper here.

What is more interesting here is that we have margin

notes that are used for indicating the original pagination. Margin notes like that can occur in the main text, but they can also occur in the footnotes. Here the standard mechanisms of \LaTeX break down: as insertions, \LaTeX treats margin notes only in the main text. So what do we have to do in order to get the same treatment in the footnotes also?

There are several possibilities. One is to use `\vsplit` in order to achieve similar functionality to the output routine, in figuring out ‘here’ points placed into the footnote. So it is apparent that we would really want to have the sort of ‘here’ point processing from the output routine available also as a separate operation.

Another possibility would be to place insertion material into the footnote boxes, then rerun the output routine with the material that has been inserted from within the footnotes. This could make for some problems in a case where we have to deal with multiple columns, though: if footnotes are to be attached to each column, the amount of material for a column might change when insertions migrate out, leading to different column breaks.

So no generally useful strategy appears to suggest itself, making it obvious that any particular format should be as free as possible to choose its own order of trying to deal with that problem.

Of course, this does not address the main problem: we have here several layers of page breaking decisions, and complicated rules about just when something might be carried over or placed on the next page. There are some easily understandable rules: a footnote must begin on the same page as its reference point, all footnotes in a block must be numbered consecutively in order of vertical appearance of their reference points on the page, regardless of the logical order, and only the last footnote on one footnote block may be broken over to the next page. If a footnote is broken over to the next page, the part carried over must constitute the top part of the footnote block on the next page, even if footnotes in a level ordinarily placed before it (such as footnotes from the main text) appear in the same block.

If we have a footnote to a footnote that gets split across a page, then its top part must come at the bottom of its footnote block, whereas its bottom part must continue on the top of the footnote block of the next page. This means that subordinate footnotes must be

- kept in separate insertions from other footnotes in the block
- kept in separate insertions even from other footnotes of the same level, since their reference might fall on a different page, making other footnotes from, say, the main matter intercede.

Why do we need insertions at all, rather than handling this just with a queue of boxes, like \LaTeX ’s usual floats do? Because then \LaTeX will not attempt to split footnotes...

The details are pretty messy. Let it suffice to say that we have a complicated mess of decisions to make. It turns out that we can do this reasonably only with a multipass approach again where footnotes get shortened systematically until the material fits the page.

It becomes apparent that we want a mechanism with which we can easily specify that we want a particular box treated for ‘here’ points both for subordinate footnotes as well as margin notes, while we would not want to have to code things like attachment of margin notes more than once.

Another critical edition In figure 4, we have a typical passage from a biblical critical edition. We see footnotes in run-in paragraph form, we have verse numbers (one sort of margin notes), we have *another* level of margin notes on the outside for cross references, we have margin notes for indexing purposes on the inner side. All in all, three levels of margin notes, and we have different languages on opposite pages that have synchronized page breaks. Now the synchronization of page breaks is not possible to achieve sensibly apart from typesetting even and odd pages separately and writing information into external files for synchronization: \TeX does not offer a way for interchanging between alternating document sources. One could possibly try to make the text of one language insertions in a main text created by the other language, but this would be pretty awkward and would certainly require that the texts get interspersed. Since the texts will usually be prepared by people proficient in different languages, this would be distinctly impractical.

Synchronization, however, could be left to a separate package. It is easy enough to achieve with insertions: synchronization points could be implemented simply by creating an insertion with a fixed height. The output routine can then measure the height of the respective insertion box, corresponding to the number of synchronization points, and write it out to an external file. The number of synchronization points on a page can be strictly limited by setting the `\dimen` register of the appropriate insertion to a maximum height value.

A magazine Figure 5 provides us with a view to more complicated figure placements. Placement requirements like this are commonplace. Let us suffice here by saying that current experimental output routine work from \LaTeX_3 can accommodate most of the difficulties of placing material like that, but the work is not yet complete, and several restrictions exist that make working with this cumbersome, and the interfaces are still in a state of flux.

