

EVEN
MORE

fun with
luametateX
and context

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1 Introduction

After five collections of ‘articles’ about the development of Lua \TeX , Con \TeX t MkIV, LuaMeta \TeX and Con \TeX t lmtx, there is even more to tell so here is number six. Wrapping up not only serves to inform the users but for me it is also a way to get things right: if you cannot write it down it’s no good. It forces me to (re)consider interfaces and also test new code but of course it comes with no guarantees.

When writing this introduction I just finished the first chapter, about some new font stuff, as follow up on the (again) nice Con \TeX t meeting in 2019. It’s always inspiring to meet and talk with my \TeX friends and see what they’re doing. It keeps me going.

Some chapters end up in user group journals first so they will be added once they have been published and are available. The advantage is that these are then copy-edited. Many texts, also in previous development updates, got better because Karl Berry checked them thoroughly for TUGboat, for which I’m grateful.

Hopefully, this document serves a purpose.

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PRAGMA ADE, Hasselt NL
Started in October 2019

2 T_EX and Pi

First in TUGboat.

3 Modern Type 3 fonts

First in TUGboat.

4 ThreeSix, Don Knuths first colorfont?

After the his new book comes out.

5 Normalization

What I describe here was long due. I delayed it because when enabled it had best also be used and I need to (check and) adapt some code to it in order to profit from it. So, if used at all, it will take some time to have an effect on the ConT_EXt code base. But first some background information.

When T_EX builds a paragraph it splits the current text stream (that makes up the paragraph) into lines where each line becomes an horizontal box. In LuaT_EX, this process is split into distinctive steps, contrary to regular T_EX where the splitting is combined with hyphenation, ligature construction and font kerning. But what all engines have in common is that after the decision is made about what a line is, the result gets packages into the horizontal box.

The decision making is influenced by quite some factors, like:

- The indentation of the first line, driven by the presence of a box of with a certain width and no height and depth (its always there, also when the indentation is zero).
- Hanging indentation, which can happen at each corner of the paragraph, or alternatively a specific parshape.
- Left and/or right margins, aka left skip and right skip. A right skip is always present, even when zero.
- The way the last line gets aligns, aka parfill skip.
- Directional changes that need to be carries over to the next line.
- Optional protrusion of characters to the left of right of the line, something that is sensitive for directional changes.
- Expansion of characters in order to get better inter-word spacing and/or to prevent lines being too bad. There can be stretch as well as shrink but on a per line basis. Inter-character kerns can also get that treatment.
- The penalties associated to hyphenation: the pre-last line, the last two lines, a list of penalties (ϵ -T_EX), specific penalties bound to hyphenation pints (LuaT_EX).
- The wish to have more or less lines than optimal, aka looseness. I have to admit that I never use that feature.

In traditional T_EX it doesn't really matter how the resulting boxes look like, as long as the following steps can handle them, and those steps don't look into those boxes. In fact, unless you unpack a box, only the backend deals with the content. But in LuaT_EX we have callbacks that hook into several stages and *can* look into the constructed boxes. In LuaT_EX these boxes also have embedded directional information (needed by the backend) and (although that is seldom used) left or right boxed material, a features inherited from Aleph/Omega. And when messing around with the content of boxes one has to know what can be seen there. In principle the code can be reorganized a it but adding additional functionality is not that trivial because we want to stay close to the original implementation, even if it has been messed up a bit by successive additions. Eventually I might give it a try to integrate all these features a bit better, but on the other hand: it works.

In the next examples we show how the result of typesetting a paragraph looks like. We use the Sapolsky quote from the distribution. The cyan glue nodes are the left and right skip nodes, and the gray one at the end of the last line represents the parfill skip. The magenta ones at the edge are baseline skips. An indentation is shown in gray too. As experiment we have four normalization levels but in the end only the highest level makes sense, simply because normalization makes no sense unless one consistently normalizes all. We just keep the granularity because it makes it possible to explain what gets done.

normalization 0, sample-1

```
\parindent = 20pt  
\leftskip = 40pt  
\rightskip = 50pt  
\hangindent = 0pt  
\hangafter = 0
```

Agriculture is a fairly recent human invention, and in many ways it was one of the great stupid moves of all time. Hunter-gatherers have thousands of wild sources of food to subsist on. Agriculture changed that all, generating an overwhelming reliance on a few dozen domesticated food sources, making you extremely vulnerable to the next famine, the next locust infestation, the next potato blight. Agriculture allowed for stockpiling of surplus resources and thus, inevitably, the unequal stockpiling of them — stratification of society and the invention of classes. Thus, it allowed for the invention of poverty. I think that the punch line of the primate-human difference is that when humans invented poverty, they came up with a way of subjugating the low-ranking like nothing ever seen before in the primate world.

normalization 0, sample-2

```
\parindent = 0pt  
\leftskip = 0pt  
\rightskip = 0pt  
\hangindent = -20pt  
\hangafter = -3
```

Agriculture is a fairly recent human invention, and in many ways it was one of the great stupid moves of all time. Hunter-gatherers have thousands of wild sources of food to subsist on. Agriculture changed that all, generating an overwhelming reliance on a few dozen domesticated food sources, making you extremely vulnerable to the next famine, the next locust infestation, the next potato blight. Agriculture allowed for stockpiling of surplus resources and thus, inevitably, the unequal stockpiling of them — stratification of society and the invention of classes. Thus, it allowed for the invention of poverty. I think that the punch line of the primate-human difference is that when humans invented poverty, they came up with a way of subjugating the low-ranking like nothing ever seen before in the primate world.

normalization 0, sample-3

```
\parindent = 0pt  
\leftskip = 0pt  
\rightskip = 0pt  
\hangindent = 20pt  
\hangafter = 3
```

Agriculture is a fairly recent human invention, and in many ways it was one of the great stupid moves of all time. Hunter-gatherers have thousands of wild sources of food to subsist on. Agriculture changed that all, generating an overwhelming reliance on a few dozen domesticated food sources, making you extremely vulnerable to the next famine, the next locust infestation, the next potato blight. Agriculture allowed for stockpiling of surplus resources and thus, inevitably, the unequal stockpiling of them — stratification of society and the invention of classes. Thus, it allowed for the invention of poverty. I think that the punch line of the primate-human difference is that when humans invented poverty, they came up with a way of subjugating the low-ranking like nothing ever seen before in the primate world.

normalization 0, sample-4

```
\parindent = 0pt
\leftskip = 10pt
\rightskip = 30pt
\hangindent = 20pt
\hangafter = 3
```

Agriculture is a fairly recent human invention, and in many ways it was one of the great stupid moves of all time. Hunter-gatherers have thousands of wild sources of food to subsist on. Agriculture changed that all, generating an overwhelming reliance on a few dozen domesticated food sources, making you extremely vulnerable to the next famine, the next locust infestation, the next potato blight. Agriculture allowed for stockpiling of surplus resources and thus, inevitably, the unequal stockpiling of them — stratification of society and the invention of classes. Thus, it allowed for the invention of poverty. I think that the punch line of the primate-human difference is that when humans invented poverty, they came up with a way of subjugating the low-ranking like nothing ever seen before in the primate world.

You might have noticed that the right skip is always there but the left skip is absent when it is zero. As said, as long as the result is okay, it does not really matter. But . . . in LuaTeX (and therefore ConTeXt) it can have consequences because there we can kick in a callback that does something with lines. Such a callback often has to deal with these specific glues and them being optional makes for more testing. The more predictable the order is, the better. Although we can easily normalize lines (in a callback) to always have a left skip too it is also an option in the engine.

normalization 1, sample-1

```
\parindent = 20pt
\leftskip = 40pt
\rightskip = 50pt
\hangindent = 0pt
\hangafter = 0
```

Agriculture is a fairly recent human invention, and in many ways it was one of the great stupid moves of all time. Hunter-gatherers have thousands of wild sources of food to subsist on. Agriculture changed that all, generating an overwhelming reliance on a few dozen domesticated food sources, making you extremely vulnerable to the next famine, the next locust infestation, the next potato blight. Agriculture allowed for stockpiling of surplus resources and thus, inevitably, the unequal stockpiling of them — stratification of society and the invention of classes. Thus, it allowed for the invention of poverty. I think that the punch line of the primate-human difference is that when humans invented poverty, they came up with a way of subjugating the low-ranking like nothing ever seen before in the primate world.

normalization 1, sample-2

```
\parindent = 0pt
\leftskip = 0pt
\rightskip = 0pt
\hangindent = -20pt
\hangafter = -3
```

Agriculture is a fairly recent human invention, and in many ways it was one of the great stupid moves of all time. Hunter-gatherers have thousands of wild sources of food to subsist on. Agriculture changed that all, generating an overwhelming reliance on a few dozen domesticated food sources, making you extremely vulnerable to the next famine, the next locust infestation, the next potato blight. Agriculture allowed for stockpiling of surplus resources and thus, inevitably, the unequal stockpiling of them — stratification of society and the invention of classes. Thus, it allowed for the invention of poverty. I think that the punch line of the primate-human difference is that when humans invented poverty, they came up with a way of subjugating the low-ranking like nothing ever seen before in the primate world.

normalization 1, sample-3

```
\parindent = 0pt
\leftskip = 0pt
\rightskip = 0pt
\hangindent = 20pt
\hangafter = 3
```

Agriculture is a fairly recent human invention, and in many ways it was one of the great stupid moves of all time. Hunter-gatherers have thousands of wild sources of food to subsist on. Agriculture changed that all, generating an overwhelming reliance on a few dozen domesticated food sources, making you extremely vulnerable to the next famine, the next locust infestation, the next potato blight. Agriculture allowed for stockpiling of surplus resources and thus, inevitably, the unequal stockpiling of them — stratification of society and the invention of classes. Thus, it allowed for the invention of poverty. I think that the punch line of the primate-human difference is that when humans invented poverty, they came up with a way of subjugating the low-ranking like nothing ever seen before in the primate world.

normalization 1, sample-4

```
\parindent = 0pt
\leftskip = 10pt
```



```

\rightskip = 30pt
\hangindent = 20pt
\hangafter = 3

```

Agriculture is a fairly recent human invention, and in many ways it was one of the great stupid moves of all time. Hunter-gatherers have thousands of wild sources of food to subsist on. Agriculture changed that all, generating an overwhelming reliance on a few dozen domesticated food sources, making you extremely vulnerable to the next famine, the next locust infestation, the next potato blight. Agriculture allowed for stockpiling of surplus resources and thus, inevitably, the unequal stockpiling of them — stratification of society and the invention of classes. Thus, it allowed for the invention of poverty. I think that the punch line of the primate-human difference is that when humans invented poverty, they came up with a way of subjugating the low-ranking like nothing ever seen before in the primate world.

In the previous examples there are always left skips as well as right skips. It makes no sense to have an option to omit both zero left and right skips, because that again is unpredictable. But we can go further.

normalization 2, sample-1

```

\parindent = 20pt
\leftskip = 40pt
\rightskip = 50pt
\hangindent = 0pt
\hangafter = 0

```

Agriculture is a fairly recent human invention, and in many ways it was one of the great stupid moves of all time. Hunter-gatherers have thousands of wild sources of food to subsist on. Agriculture changed that all, generating an overwhelming reliance on a few dozen domesticated food sources, making you extremely vulnerable to the next famine, the next locust infestation, the next potato blight. Agriculture allowed for stockpiling of surplus resources and thus, inevitably, the unequal stockpiling of them — stratification of society and the invention of classes. Thus, it allowed for the invention of poverty. I think that the punch line of the primate-human difference is that when humans invented poverty, they came up with a way of subjugating the low-ranking like nothing ever seen before in the primate world.

normalization 2, sample-2

```

\parindent = 0pt
\leftskip = 0pt
\rightskip = 0pt
\hangindent = -20pt
\hangafter = -3

```

Agriculture is a fairly recent human invention, and in many ways it was one of the great stupid moves of all time. Hunter-gatherers have thousands of wild sources of food to subsist on. Agriculture changed that all, generating an overwhelming reliance on a few dozen domesticated food sources, making you extremely vulnerable to the next famine, the next locust infestation, the next potato blight. Agriculture allowed for stockpiling of surplus resources and thus, inevitably, the unequal stockpiling of them — stratification of society and the invention of classes. Thus, it allowed for the invention of poverty. I think that the punch line of the primate-human difference is that when humans invented poverty, they came up with a way of subjugating the low-ranking like nothing ever seen before in the primate world.

normalization 2, sample-3

```
\parindent = 0pt  
\leftskip = 0pt  
\rightskip = 0pt  
\hangindent = 20pt  
\hangafter = 3
```

Agriculture is a fairly recent human invention, and in many ways it was one of the great stupid moves of all time. Hunter-gatherers have thousands of wild sources of food to subsist on. Agriculture changed that all, generating an overwhelming reliance on a few dozen domesticated food sources, making you extremely vulnerable to the next famine, the next locust infestation, the next potato blight. Agriculture allowed for stockpiling of surplus resources and thus, inevitably, the unequal stockpiling of them, stratification of society and the invention of classes. Thus, it allowed for the invention of poverty. I think that the punch line of the primate-human difference is that when humans invented poverty, they came up with a way of subjugating the low-ranking like nothing ever seen before in the primate world.

normalization 2, sample-4

```
\parindent = 0pt  
\leftskip = 10pt  
\rightskip = 30pt  
\hangindent = 20pt  
\hangafter = 3
```

Agriculture is a fairly recent human invention, and in many ways it was one of the great stupid moves of all time. Hunter-gatherers have thousands of wild sources of food to subsist on. Agriculture changed that all, generating an overwhelming reliance on a few dozen domesticated food sources, making you extremely vulnerable to the next famine, the next locust infestation, the next potato blight. Agriculture allowed for stockpiling of surplus resources and thus, inevitably, the unequal stockpiling of them, stratification of society and the invention of classes. Thus, it allowed for the invention of poverty. I think that the punch line of the primate-human difference is that when humans invented poverty, they came up with a way of subjugating the low-ranking like nothing ever seen before in the primate world.

In these examples the indentation has been turned into a glue as well (actually it is more a kern but using a glue makes more sense). The hanging indentation however is not seen here: it is not represented by glue but instead sort of hidden in the width of the box and a shift of its content.

normalization 3, sample-1

```
\parindent = 20pt  
\leftskip = 40pt  
\rightskip = 50pt  
\hangindent = 0pt  
\hangafter = 0
```

Agriculture is a fairly recent human invention, and in many ways it was one of the great stupid moves of all time. Hunter-gatherers have thousands of wild sources of food to subsist on. Agriculture changed that all, generating an overwhelming reliance on a few dozen domesticated food sources, making you extremely vulnerable to the next famine, the next locust infestation, the next potato blight. Agriculture allowed for stockpiling of surplus resources and thus, inevitably, the unequal stockpiling of them — stratification of society and the invention of classes. Thus, it allowed for the invention of poverty. I think that the punch line of the primate-human difference is that when humans invented poverty, they came up with a way of subjugating the low-ranking like nothing ever seen before in the primate world.

normalization 3, sample-2

```
\parindent = 0pt
\leftskip = 0pt
\rightskip = 0pt
\hangindent = -20pt
\hangafter = -3
```

Agriculture is a fairly recent human invention, and in many ways it was one of the great stupid moves of all time. Hunter-gatherers have thousands of wild sources of food to subsist on. Agriculture changed that all, generating an overwhelming reliance on a few dozen domesticated food sources, making you extremely vulnerable to the next famine, the next locust infestation, the next potato blight. Agriculture allowed for stockpiling of surplus resources and thus, inevitably, the unequal stockpiling of them — stratification of society and the invention of classes. Thus, it allowed for the invention of poverty. I think that the punch line of the primate-human difference is that when humans invented poverty, they came up with a way of subjugating the low-ranking like nothing ever seen before in the primate world.

normalization 3, sample-3

```
\parindent = 0pt
\leftskip = 0pt
\rightskip = 0pt
\hangindent = 20pt
\hangafter = 3
```

Agriculture is a fairly recent human invention, and in many ways it was one of the great stupid moves of all time. Hunter-gatherers have thousands of wild sources of food to subsist on. Agriculture changed that all, generating an overwhelming reliance on a few dozen domesticated food sources, making you extremely vulnerable to the next famine, the next locust infestation, the next potato blight. Agriculture allowed for stockpiling of surplus resources and thus, inevitably, the unequal stockpiling of them — stratification of society and the invention of classes. Thus, it allowed for the invention of poverty. I think that the punch line of the primate-human difference is that when humans invented poverty, they came up with a way of subjugating the low-ranking like nothing ever seen before in the primate world.

normalization 3, sample-4

```
\parindent = 0pt
\leftskip = 10pt
```

```
\rightskip = 30pt
\hangindent = 20pt
\hangafter = 3
```

Agriculture is a fairly recent human invention, and in many ways it was one of the great stupid moves of all time. Hunter-gatherers have thousands of wild sources of food to subsist on. Agriculture changed that all, generating an overwhelming reliance on a few dozen domesticated food sources, making you extremely vulnerable to the next famine, the next locust infestation, the next potato blight. Agriculture allowed for stockpiling of surplus resources and thus, inevitably, the unequal stockpiling of them — stratification of society and the invention of classes. Thus, it allowed for the invention of poverty. I think that the punch line of the primate-human difference is that when humans invented poverty, they came up with a way of subjugating the low-ranking like nothing ever seen before in the primate world.

In the previous examples the hanging indentation is turned into left and right hang skips. These cannot be set at the T_EX end, but are injected when we instruct the normalizer to do so.

normalization 4, sample-1

```
\parindent = 20pt
\leftskip = 40pt
\rightskip = 50pt
\hangindent = 0pt
\hangafter = 0
```

Agriculture is a fairly recent human invention, and in many ways it was one of the great stupid moves of all time. Hunter-gatherers have thousands of wild sources of food to subsist on. Agriculture changed that all, generating an overwhelming reliance on a few dozen domesticated food sources, making you extremely vulnerable to the next famine, the next locust infestation, the next potato blight. Agriculture allowed for stockpiling of surplus resources and thus, inevitably, the unequal stockpiling of them — stratification of society and the invention of classes. Thus, it allowed for the invention of poverty. I think that the punch line of the primate-human difference is that when humans invented poverty, they came up with a way of subjugating the low-ranking like nothing ever seen before in the primate world.

normalization 4, sample-2

```
\parindent = 0pt
\leftskip = 0pt
\rightskip = 0pt
\hangindent = -20pt
\hangafter = -3
```

Agriculture is a fairly recent human invention, and in many ways it was one of the great stupid moves of all time. Hunter-gatherers have thousands of wild sources of food to subsist on. Agriculture changed that all, generating an overwhelming reliance on a few dozen domesticated food sources, making you extremely vulnerable to the next famine, the next locust infestation, the next potato blight. Agriculture allowed for stockpiling of surplus resources and thus, inevitably, the unequal stockpiling of them — stratification of society and the invention of classes. Thus, it allowed for the invention of poverty. I think that the punch line of the primate-human difference is that when humans invented poverty, they came up with a way of subjugating the low-ranking like nothing ever seen before in the primate world.

normalization 4, sample-3

```
\parindent = 0pt
\leftskip = 0pt
\rightskip = 0pt
\hangindent = 20pt
\hangafter = 3
```

Agriculture is a fairly recent human invention, and in many ways it was one of the great stupid moves of all time. Hunter-gatherers have thousands of wild sources of food to subsist on. Agriculture changed that all, generating an overwhelming reliance on a few dozen domesticated food sources, making you extremely vulnerable to the next famine, the next locust infestation, the next potato blight. Agriculture allowed for stockpiling of surplus resources and thus, inevitably, the unequal stockpiling of them. stratification of society and the invention of classes. Thus, it allowed for the invention of poverty. I think that the punch line of the primate-human difference is that when humans invented poverty, they came up with a way of subjugating the low-ranking like nothing ever seen before in the primate world.

normalization 4, sample-4

```
\parindent = 0pt
\leftskip = 10pt
\rightskip = 30pt
\hangindent = 20pt
\hangafter = 3
```

Agriculture is a fairly recent human invention, and in many ways it was one of the great stupid moves of all time. Hunter-gatherers have thousands of wild sources of food to subsist on. Agriculture changed that all, generating an overwhelming reliance on a few dozen domesticated food sources, making you extremely vulnerable to the next famine, the next locust infestation, the next potato blight. Agriculture allowed for stockpiling of surplus resources and thus, inevitably, the unequal stockpiling of them. stratification of society and the invention of classes. Thus, it allowed for the invention of poverty. I think that the punch line of the primate-human difference is that when humans invented poverty, they came up with a way of subjugating the low-ranking like nothing ever seen before in the primate world.

The previous examples differ from the previous set in that they push these hang related glue nodes before the left and after the right skip. As I couldn't make up my mind yet, I let LuaMetaTeX just provide both variants.

The option to keep hang related information explicitly in the line has some consequences. First of all, we now have glue and not some shift/width combination. Second, we have introduced an incompatibility: the lines now always have the proper width. You might have noticed that but we can show it more explicitly. We use two parameter sets

normalization 0, sample-5

```
\hangindent = 20pt
\hangafter = 0
```


Agriculture is a fairly recent human invention, and in many ways it was one of the great stupid moves of all time. Hunter-gatherers have thousands of wild sources of food to subsist on. Agriculture changed that all, generating an overwhelming reliance on a few dozen domesticated food sources, making you extremely vulnerable to the next famine, the next locust infestation, the next potato blight. Agriculture allowed for stockpiling of surplus resources and thus, inevitably, the unequal stockpiling of them — stratification of society and the invention of classes. Thus, it allowed for the invention of poverty. I think that the punch line of the primate-human difference is that when humans invented poverty, they came up with a way of subjugating the low-ranking like nothing ever seen before in the primate world.

normalization 4, sample-5

```
\hangindent = 20pt
\hangafter = 0
```

Agriculture is a fairly recent human invention, and in many ways it was one of the great stupid moves of all time. Hunter-gatherers have thousands of wild sources of food to subsist on. Agriculture changed that all, generating an overwhelming reliance on a few dozen domesticated food sources, making you extremely vulnerable to the next famine, the next locust infestation, the next potato blight. Agriculture allowed for stockpiling of surplus resources and thus, inevitably, the unequal stockpiling of them — stratification of society and the invention of classes. Thus, it allowed for the invention of poverty. I think that the punch line of the primate-human difference is that when humans invented poverty, they came up with a way of subjugating the low-ranking like nothing ever seen before in the primate world.

normalization 0, sample-6

```
\hangindent = -20pt
\hangafter = 0
```

Agriculture is a fairly recent human invention, and in many ways it was one of the great stupid moves of all time. Hunter-gatherers have thousands of wild sources of food to subsist on. Agriculture changed that all, generating an overwhelming reliance on a few dozen domesticated food sources, making you extremely vulnerable to the next famine, the next locust infestation, the next potato blight. Agriculture allowed for stockpiling of surplus resources and thus, inevitably, the unequal stockpiling of them — stratification of society and the invention of classes. Thus, it allowed for the invention of poverty. I think that the punch line of the primate-human difference is that when humans invented poverty, they came up with a way of subjugating the low-ranking like nothing ever seen before in the primate world.

normalization 4, sample-6

```
\hangindent = -20pt
\hangafter = 0
```

Agriculture is a fairly recent human invention, and in many ways it was one of the great stupid moves of all time. Hunter-gatherers have thousands of wild sources of food to subsist on. Agriculture changed that all, generating an overwhelming reliance on a few dozen domesticated food sources, making you extremely vulnerable to the next famine, the next locust infestation, the next potato blight. Agriculture allowed for stockpiling of surplus resources and thus, inevitably, the unequal stockpiling of them — stratification of society and the invention of classes. Thus, it allowed for the invention of poverty. I think that the punch line of the primate-human difference is that when humans invented poverty, they came up with a way of subjugating the low-ranking like nothing ever seen before in the primate world.

A not yet mention part of the normalization is that, because they are no longer of relevance, the special local par nodes have been removed. The one that starts a paragraph is turned into a normal directional node if needed, so that we get properly balanced pairs of directional nodes. It must been said that the code that does all this is a bit of a mess. We want to stay close to the original code, but we also need to deal with all these extensions, like directions, protrusion, extra boxes, etc.

Not shown here is that there is a fifth mode of operation. When we enable that level an overfull box will get a correction skip so that the right skip etc are properly aligned. How useful this is: we'll see.

Now, when I decide to keep this feature, which can be set at the Lua end to do the previously mentioned tasks, depending on a feature level ranging from zero to four, I also need to check the impact on existing ConT_EXt code, which (currently) is complicated by the fact that most is shared between MkIV and lmtx, and only LuaMetaT_EX has this normalization feature. I will probably enable it for a while locally in order to see if there are side effects. Then, when the code base gets adapted, we have to assume that normalization happens, so there is no way back.

6 Expansion

Character expansion was introduced in pdf \TeX a couple of decades ago. It is a mechanism that scales glyphs horizontally in order to reduce excessive whitespace that is needed to properly justify a paragraph. I must admit that I never use it myself but there are users who do. Although this mechanism evolved a bit, and in Lua \TeX is implemented a bit different, the basics remained the same. If you have no clue what this is about, you can just quite reading here.

A font can be set up to expand characters by a certain amount: they can shrink or stretch. This is driven by three parameters: `step`, `stretch` and `shrink`. The values are in thousands because \TeX has no float quantity. Originally these values were percentages of the width of a glyph, later they became related to the em width but in Lua \TeX we went back to the former definition.

In Con \TeX t MkIV we have an interface that works as follows:

```
\startluacode
  local classes = fonts.expansions.classes

  classes.qualitya = {
    vector  = "default",
    factor  = 1,
    stretch = 4,
    shrink  = 2,
    step    = .5,
  }

  classes.qualityb = {
    vector  = "default",
    factor  = 1,
    stretch = 8,
    shrink  = 4,
    step    = .5,
  }
\stopluacode
```

The default vector looks like this:

```
vectors['default'] = {
  [0x0041] = 0.5, -- A
  [0x0042] = 0.7, -- B
  -- and some more
}
```

The values that we pass to the engine are stretch 40, shrink 20, and step 5 for `qualitya` and stretch 80, shrink 40, and step 5 for `qualityb`, so we multiply by 10. In the engine the step is limited to 100, the stretch to 1000 and the shrink to 500. But these extremes produce quite bad results.

The expansion class is set with the `expansion` feature, as in:

```
\definefontfeature [basea] [default] [expansion=qualitya]
\definefontfeature [baseb] [default] [expansion=qualityb]
```

```
\definefont [FontA] [Serif*basea]
\definefont [FontB] [Serif*baseb]
```

In figure 6.1 we see this in action, using the following code:

```
\setupalign[verytolerant,stretch,hz] % hz triggers expansion
\dorecurse {30} { %
  {\FontB \darkred test me #1,} \FontA \dorecurse{#1}{test ##1, }%
}\par
```

test me 1, test 1, test me 2, test 1, test 2, test me 3, test 1, test 2, test 3, test me 4, test 1, test 2, test 3, test 4, test me 5, test 1, test 2, test 3, test 4, test 5, test me 6, test 1, test 2, test 3, test 4, test 5, test 6, test me 7, test 1, test 2, test 3, test 4, test 5, test 6, test 7, test me 8, test 1, test 2, test 3, test 4, test 5, test 6, test 7, test 8, test me 9, test 1, test 2, test 3, test 4, test 5, test 6, test 7, test 8, test 9, test me 10, test 1, test 2, test 3, test 4, test 5, test 6, test 7, test 8, test 9, test 10, test me 11, test 1, test 2, test 3, test 4, test 5, test 6, test 7, test 8, test 9, test 10, test 11, test me 12, test 1, test 2, test 3, test 4, test 5, test 6, test 7, test 8, test 9, test 10, test 11, test 12, test me 13, test 1, test 2, test 3, test 4, test 5, test 6, test 7, test 8, test 9, test 10, test 11, test 12, test 13, test me 14, test 1, test 2, test 3, test 4, test 5, test 6, test 7, test 8, test 9, test 10, test 11, test 12, test 13, test 14, test me 15, test 1, test 2, test 3, test 4, test 5, test 6, test 7, test 8, test 9, test 10, test 11, test 12, test 13, test 14, test 15, test me 16, test 1, test 2, test 3, test 4, test 5, test 6, test 7, test 8, test 9, test 10, test 11, test 12, test 13, test 14, test 15, test 16, test me 17, test 1, test 2, test 3, test 4, test 5, test 6, test 7, test 8, test 9, test 10, test 11, test 12, test 13, test 14, test 15, test 16, test 17, test me 18, test 1, test 2, test 3, test 4, test 5, test 6, test 7, test 8, test 9, test 10, test 11, test 12, test 13, test 14, test 15, test 16, test 17, test 18, test me 19, test 1, test 2, test 3, test 4, test 5, test 6, test 7, test 8, test 9, test 10, test 11, test 12, test 13, test 14, test 15, test 16, test 17, test 18, test 19, test me 20, test 1, test 2, test 3, test 4, test 5, test 6, test 7, test 8, test 9, test 10, test 11, test 12, test 13, test 14, test 15, test 16, test 17, test 18, test 19, test 20, test me 21, test 1, test 2, test 3, test 4, test 5, test 6, test 7, test 8, test 9, test 10, test 11, test 12, test 13, test 14, test 15, test 16, test 17, test 18, test 19, test 20, test 21, test 22, test me 23, test 1, test 2, test 3, test 4, test 5, test 6, test 7, test 8, test 9, test 10, test 11, test 12, test 13, test 14, test 15, test 16, test 17, test 18, test 19, test 20, test 21, test 22, test 23, test me 24, test 1, test 2, test 3, test 4, test 5, test 6, test 7, test 8, test 9, test 10, test 11, test 12, test 13, test 14, test 15, test 16, test 17, test 18, test 19, test 20, test 21, test 22, test 23, test 24, test 25, test me 26, test 1, test 2, test 3, test 4, test 5, test 6, test 7, test 8, test 9, test 10, test 11, test 12, test 13, test 14, test 15, test 16, test 17, test 18, test 19, test 20, test 21, test 22, test 23, test 24, test 25, test 26, test 27, test me 28, test 1, test 2, test 3, test 4, test 5, test 6, test 7, test 8, test 9, test 10, test 11, test 12, test 13, test 14, test 15, test 16, test 17, test 18, test 19, test 20, test 21, test 22, test 23, test 24, test 25, test 26, test 27, test 28, test me 29, test 1, test 2, test 3, test 4, test 5, test 6, test 7, test 8, test 9, test 10, test 11, test 12, test 13, test 14, test 15, test 16, test 17, test 18, test 19, test 20, test 21, test 22, test 23, test 24, test 25, test 26, test 27, test 28, test 29, test me 30, test 1, test 2, test 3, test 4, test 5, test 6, test 7, test 8, test 9, test 10, test 11, test 12, test 13, test 14, test 15, test 16, test 17, test 18, test 19, test 20, test 21, test 22, test 23, test 24, test 25, test 26, test 27, test 28, test 29, test 30,

Figure 6.1

There is one drawback with this method, although so far I never heard a user complain, which can be an indication of how this mechanism is used: you cannot mix fonts with different step, stretch and/or shrink. As we just did this in the example, this statement is not really true in LuaMetaTeX: there we only need to keep the step the same. This is compatible in the sense that otherwise we would quit the run, so at least

we carry on: the smallest stretch and shrink is taken. But, we do issue a warning (once) because there can be side effects! This is not that pretty a solution anyway because it depends on what font is used first.

It is for this reason that we have another option: in ConT_EXt lmtx you can define a specific expansion:

```
\defineexpansion
[myexpansion]
[step=1, % default
stretch=50,
shrink=20]
```

There is no need to have a different step than 1. In pdfT_EX instances are created per step used, but in LuaT_EX this is more fluid. There is no gain in using different steps. We just keep it for compatibility reasons. This specific expansion is enables with:

```
\setexpansion[myexpansion]
```

and the result is shown in figure 6.2. This time the set expansion wins over the one set in the font. All fonts that have the expansion feature set are treated the same. By using this method you can locally have different values.

Deep down we use some new primitives:

```
\adjustspacingstep
\adjustspacingstretch
\adjustspacingshrink
```

The step is limited to 100 (10%) and the stretch and shrink to 500 (50%) and the stretch to 1000 (100%) but these extremes are only useful for examples.

