

new minivas

in luametateX

Introduction

Here I will discuss some of the new primitives in LuaTeX and LuaMetaTeX, the later being a successor that permits the ConTeXt folks to experiment with new features. The order is arbitrary. When you compare LuaTeX with pdfTeX, there are actually quite some differences. Some primitives that pdfTeX introduced have been dropped in LuaTeX because they can be done better in Lua. Others have been promoted to core primitives that no longer have a pdf prefix. Then there are lots of new primitives, some introduce new concepts, some are a side effect of for instance new math font technologies, and then there are those that are handy extensions to the macro language. The LuaMetaTeX engine drops quite some primitives, like those related to pdfTeX specific font or backend features. It also adds some new primitives, mostly concerning the macro language.

We also discuss the primitives that fit into the macro programming scope that are present in traditional TeX and ϵ -TeX but there are for sure better of descriptions out there already. Primitives that relate to typesetting, like those controlling math, fonts, boxes, attributes, directions, catcodes, Lua (functions) etc are not discussed here.

There are for instance primitives to create aliases to low level registers like counters and dimensions, as well as other (semi-numeric) quantities like characters, but normally these are wrapped into high level macros so that definitions can't clash too much. Numbers, dimensions etc can be advanced, multiplied and divided and there is a simple expression mechanism to deal with them. These are not discussed here.

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In this document the section titles that discuss the original \TeX and $\varepsilon\text{\TeX}$ primitives have a different color those explaining the $\text{\textcolor{blue}{LuaTeX}}$ and $\text{\textcolor{blue}{LuaMetaTeX}}$ primitives.

1 \afterassignment

The token following `\afterassignment`, a traditional \TeX primitive, is saved and gets injected (and then expanded) after a following assignment took place.

```
\afterassignment !\def\MyMacro {}\quad
\afterassignment !\let\MyMacro ?\quad
\afterassignment !\scratchcounter 123\quad
\afterassignment !%
\afterassignment ?\advance\scratchcounter by 1
```

The `\afterassignments` are not accumulated, the last one wins:

! ! ! ?

2 \afterassigned

The `\afterassignment` primitive stores a token to be injected (and thereby expanded) after an assignment has happened. Unlike `\aftergroup`, multiple calls are not accumulated, and changing that would be too incompatible. This is why we have `\afterassigned`, which can be used to inject a bunch of tokens. But in order to be consistent this one is also not accumulative.

```
\afterassigned{done}%
\afterassigned{{\bf done}}%
\scratchcounter=123
```

results in: **done** being typeset.

3 \aftergroup

The traditional \TeX `\aftergroup` primitive stores the next token and expands that after the group has been closed.

Multiple `\aftergroups` are combined:

```
before{ ! \aftergroup a\aftergroup f\aftergroup t\aftergroup e\aftergroup r}
```

before ! after

4 \aftergrouped

The in itself powerful `\aftergroup` primitives works quite well, even if you need to do more than one thing: you can either use it multiple times, or you can define a macro that does multiple things and apply that after the group. However, you can avoid that by using this primitive which takes a list of tokens.

```
regular
\bgroup
\aftergrouped{regular}%
\bf bold
\egroup
```

Because it happens after the group, we're no longer typesetting in bold.

regular **bold** regular

5 \atendofgroup

The token provided will be injected just before the group ends. Because these tokens are collected, you need to be aware of possible interference between them. However, normally this is managed by the macro package.

```
\bgroup
\atendofgroup\unskip
\atendofgroup )%
( but it works okay
\egroup
```

Of course these effects can also be achieved by combining (extra) grouping with `\aftergroup` calls, so this is more a convenience primitives than a real necessity: (but it works okay), as proven here.

6 \atendofgrouped

This is the multi token variant of `\atendofgroup`. Of course the next example is somewhat naive when it comes to spacing and so, but it shows the purpose.

```
\bgroup
\atendofgrouped{\bf QED}%
\atendofgrouped{ (indeed)}%
This sometimes looks nicer.
\egroup
```

Multiple invocations are accumulated: This sometimes looks nicer. **QED (indeed)**.

7 \toksapp

One way to append something to a token list is the following:

```
\scratchtoks\expandafter{\the\scratchtoks more stuff}
```

This works all right, but it involves a copy of what is already in `\scratchtoks`. This is seldom a real issue unless we have large token lists and many appends. This is why LuaTeX introduced:

```
\toksapp\scratchtoks{more stuff}
\toksapp\scratchtoksone\scratchtokstwo
```

At some point, when working on LuaMetaTeX, I realized that primitives like this one and the next appenders and prependers to be discussed were always on the radar of Taco and me. Some were even implemented in what we called eetex: extended ϵ -TeX, and we even found back the prototypes, dating from pre-pdfTeX times.

8 \etoksapp

A variant of `\toksapp` is the following: it expands the to be appended content.

```
\def\temp{more stuff}
\etoksapp\scratchtoks{some \temp}
```

9 \tokspre

Where appending something is easy because of the possible `\expandafter` trickery a prepend would involve more work, either using temporary token registers and/or using a mixture of the (no)expansion added by ε -T_EX, but all are kind of inefficient and cumbersome.

```
\tokspre\scratchtoks{less stuff}
\tokspre\scratchtoksone\scratchtokstwo
```

This prepends the token list that is provided.

10 \etokspre

A variant of `\tokspre` is the following: it expands the to be prepended content.

```
\def\temp{less stuff}
\etokspre\scratchtoks{a bit \temp}
```

11 \gtoksapp

This is the global variant of `\toksapp`.

12 \xtoksapp

This is the global variant of `\etoksapp`.

13 \gtokspre

This is the global variant of `\tokspre`.

14 \xtokspre

This is the global variant of `\etokspre`.

15 \csname

This original T_EX primitive starts the construction of a control sequence reference. It does a lookup and when no sequence with than name is found, it will create a hash entry and defaults its meaning to `\relax`.

```
\csname letters and other characters\endcsname
```

16 \endcsname

This primitive is used in combination with `\csname`, `\ifcsname` and `\begincsname` where its end the scanning for the to be constructed control sequence token.

17 \begincsname

The next code creates a control sequence token from the given serialized tokens:

```
\csname mymacro\endcsname
```

When `\mymacro` is not defined a control sequence will be created with the meaning `\relax`. A side effect is that a test for its existence might fail because it now exists. The next sequence will *not* create an control sequence:

```
\begincsname mymacro\endcsname
```

This actually is kind of equivalent to:

```
\ifcsname mymacro\endcsname
  \csname mymacro\endcsname
\fi
```

18 \lastnamedcs

The example code in the previous section has some redundancy, in the sense that there to be looked up control sequence name `mymacro` is assembled twice. This is no big deal in a traditional eight bit T_EX but in a Unicode engine multi-byte sequences demand some more processing (although it is unlikely that control sequences have many multi-byte utf8 characters).

```
\ifcsname mymacro\endcsname
  \csname mymacro\endcsname
\fi
```

Instead we can say:

```
\ifcsname mymacro\endcsname
  \lastnamedcs
\fi
```

Although there can be some performance benefits another advantage is that it uses less tokens and parsing. It might even look nicer.

19 \futureexpand

This primitive can be used as an alternative to a `\futurelet` approach, which is where the name comes from.¹

```
\def\variantone<#1>{(#1)}
\def\varianttwo#1{[#1]}
\futureexpand<\variantone\varianttwo<one>
\futureexpand<\variantone\varianttwo{two}
```

So, the next token determines which of the two variants is taken:

¹ In the engine primitives that have similar behavior are grouped in commands that are then dealt with together, code wise.

(one) [two]

Because we look ahead there is some magic involved: spaces are ignored but when we have no match they are pushed back into the input. The next variant demonstrates this:

```
\def\variantone<#1>{(#1)}
\def\varianttwo{}
\def\temp{\futureexpand<\variantone\varianttwo}
[\temp <one>]
[\temp {two}]
[\expandafter\temp\space <one>]
[\expandafter\temp\space {two}]
```

This gives us:

[(one)] [two] [(one)] [two]

20 \futureexpandis

We assume that the previous section is read. This variant will not push back spaces, which permits a consistent approach i.e. the user can assume that macro always gobbles the spaces.

```
\def\variantone<#1>{(#1)}
\def\varianttwo{}
\def\temp{\futureexpandis<\variantone\varianttwo}
[\temp <one>]
[\temp {two}]
[\expandafter\temp\space <one>]
[\expandafter\temp\space {two}]
```

So, here no spaces are pushed back. This is in the name of this primitive means ‘ignore spaces’, but having that added to the name would have made the primitive even more verbose (after all, we also don’t have `\expandeddef` but `\edef` and no `\globalexpandeddef` but `\xdef`).

[(one)] [two] [(one)] [two]

21 \futureexpandisap

This primitive is like the one in the previous section but also ignores par tokens, so `isap` means ‘ignore spaces and paragraphs’.

22 \expandafter

This original \TeX primitive stores the next token, does a one level expansion of what follows it, which actually can be an not expandable token, and reinjects the stored token in the input. Like:

```
\expandafter\let\csname my weird macro name\endcsname{m w m n}
```

Without `\expandafter` the `\csname` primitive would have been let to the left brace (effectively then a begin group). Actually in this particular case the control sequence with the weird name is injected

and when it didn't yet exist it will get the meaning `\relax` so we sort of have two assignments in a row then.

23 `\expandafterspaces`

This is a gobbler: the next token is reinjected after following spaces have been read. Here is a simple example:

```
[\expandafterspaces 1 2]
[\expandafterspaces 3
4]
[\expandafterspaces 5
6]
```

We get this typeset: [12] [34] [5

6], because a newline normally is configured to be a space (and leading spaces in a line are normally being ignored anyway).

24 `\expandafterpars`

Here is another gobbler: the next token is reinjected after following spaces and par tokens have been read. So:

```
[\expandafterpars 1 2]
[\expandafterpars 3
4]
[\expandafterpars 5
6]
```

gives us: [12] [34] [56], because empty lines are like `\par` and therefore ignored.

25 `\expandtoken`

This primitive creates a token with a specific combination of catcode and character code. Because it assumes some knowledge of \TeX we can show it using some `\expandafter` magic:

```
\expandafter\let\expandafter\temp\expandtoken 11 `X \meaning\temp\crlf
\expandafter\let\expandafter\temp\expandtoken 12 `X \meaning\temp\crlf
```

The meanings are:

the letter X

the character X

Using other catcodes is possible but the results of injecting them into the input directly (or here by injecting `\temp`) can be unexpected because of what \TeX expects. You can get messages you normally won't get, for instance about unexpected alignment interference, which is a side effect of \TeX using some catcode/character combinations as signals and there is no reason to change those internals. That said:

```

\edef\tempA{\expandtoken 9 `X} \meaning\tempA\crlf
\edef\tempB{\expandtoken 10 `X} \meaning\tempB\crlf
\edef\tempC{\expandtoken 11 `X} \meaning\tempC\crlf
\edef\tempD{\expandtoken 12 `X} \meaning\tempD

```

are all valid and from the meaning you cannot really deduce what's in there:

```

macro:->X
macro:->X
macro:->X
macro:->X

```

But you can be assured that:

```

[AB: \ifx\tempA\tempB Y\else N\fi]
[AC: \ifx\tempA\tempC Y\else N\fi]
[AD: \ifx\tempA\tempD Y\else N\fi]
[BC: \ifx\tempB\tempC Y\else N\fi]
[BD: \ifx\tempB\tempD Y\else N\fi]
[CD: \ifx\tempC\tempD Y\else N\fi]

```

makes clear that they're different: [AB: Y] [AC: Y] [AD: Y] [BC: Y] [BD: Y] [CD: Y], and in case you wonder, the characters with catcode 10 are spaces, while those with code 9 are ignored.

26 \expandcstoken

The rationale behind this primitive is that when we `\let` a single token like a character it is hard to compare that with something similar, stored in a macro. This primitive pushes back a single token alias created by `\let` into the input.

```

\let\tempA + \meaning\tempA \crlf
\let\tempB X \meaning\tempB \crlf
\let\tempC $ \meaning\tempC \par

\edef\temp      {\tempA} \doifelse{\temp}{+}{Y}{N} \meaning\temp \crlf
\edef\temp      {\tempB} \doifelse{\temp}{X}{Y}{N} \meaning\temp \crlf
\edef\temp      {\tempC} \doifelse{\temp}{X}{Y}{N} \meaning\temp \par

\edef\temp{\expandcstoken\tempA} \doifelse{\temp}{+}{Y}{N} \meaning\temp \crlf
\edef\temp{\expandcstoken\tempB} \doifelse{\temp}{X}{Y}{N} \meaning\temp \crlf
\edef\temp{\expandcstoken\tempC} \doifelse{\temp}{$}{Y}{N} \meaning\temp \par

\doifelse{\expandcstoken\tempA}{+}{Y}{N}
\doifelse{\expandcstoken\tempB}{X}{Y}{N}
\doifelse{\expandcstoken\tempC}{$}{Y}{N} \par

```

The meaning of the `\let` macros shows that we have a shortcut to a character with (in this case) catcode letter, other (here 'other character' gets abbreviated to 'character'), math shift etc.

```

the character +
the letter X
math shift character $

```

```
N macro:->\tempA
N macro:->\tempB
N macro:->\tempC
```

```
Y macro:->+
Y macro:->X
Y macro:->$
```

```
Y Y Y
```

Here we use the ConT_EXt macro `\doifelse` which can be implemented in different ways, but the only property relevant to the user is that the expanded content of the two arguments is compared.

27 `\expand`

Normally a protected macro will not be expanded inside for instance an `\edef` but there is a way out:²

```
\edef\temp      {\doifelse{a}{b}{c}{d}} \meaning\temp \crlf
\edef\temp{\expand\doifelse{a}{b}{c}{d}} \meaning\temp
```

In the second case, the `\doifelse` command is expanded, but keep in mind that this only makes sense when the body of such a macro is expandable. This is the case in ConT_EXt lmtx, but not in MkIV.

```
macro:->\doifelse {a}{b}{c}{d}
macro:->d
```

28 `\ignorespaces`

This traditional T_EX primitive signals the scanner to ignore the following spaces, if any. We mention it because we show a companion in the next section.

29 `\ignorepars`

This is a variant of `\ignorespaces`: following spaces *and* `\par` equivalent tokens are ignored, so for instance:

```
one + \ignorepars
two = \ignorepars \par
three
```

renders as: one + two = three. Traditionally T_EX has been sensitive to `\par` tokens in some of its building blocks. This has to do with the fact that it could indicate a runaway argument which in the times of slower machines and terminals was best to catch early. In LuaMetaT_EX we no longer have long macros and the mechanisms that are sensitive can be told to accept `\par` tokens (and ConT_EXt set them such that this is the case).

² This primitive is dedicated to Hans vd Meer who was playing with the unprotected version of `\doifelse` and wondered about the reason for it not being expandable in the first place.

30 \ignorearguments

This primitive will quit argument scanning and start expansion of the body of a macro. The number of grabbed arguments can be tested as follows:

```
\def\MyMacro[#1][#2][#3]%
  {\ifarguments zero\or one\or two\or three \else hm\fi}

\MyMacro          \ignorearguments \quad
\MyMacro          [1]\ignorearguments \quad
\MyMacro          [1][2]\ignorearguments \quad
\MyMacro [1][2][3]\ignorearguments \crlf
```

zero one two three

Todo: explain optional delimiters.

31 \lastarguments

```
\def\MyMacro #1{\the\lastarguments (#1) } \MyMacro{1} \crlf
\def\MyMacro #1#2{\the\lastarguments (#1) (#2)} \MyMacro{1}{2} \crlf
\def\MyMacro#1#2#3{\the\lastarguments (#1) (#2) (#3)} \MyMacro{1}{2}{3} \crlf

\def\MyMacro #1{(#1) \the\lastarguments} \MyMacro{1} \crlf
\def\MyMacro #1#2{(#1) (#2) \the\lastarguments} \MyMacro{1}{2} \crlf
\def\MyMacro#1#2#3{(#1) (#2) (#3) \the\lastarguments} \MyMacro{1}{2}{3} \crlf
```

The value of `\lastarguments` can only be trusted in the expansion until another macro is seen and expanded. For instance in these examples, as soon as a character (like the left parenthesis) is seen, horizontal mode is entered and `\everypar` is expanded which in turn can involve macros. You can see that in the second block (that is: unless we changed `\everypar` in the meantime).

1(1)
2(1) (2)
3(1) (2) (3)

(1) 0
(1) (2) 2
(1) (2) (3) 3

32 \scantokens

Just forget about this ε -TeX primitive, just take the one in the next section.

33 \scantextokens

This primitive scans the input as if it comes from a file. In the next examples the `\detokenize` primitive turns tokenized code into verbatim code that is similar to what is read from a file.

```
\edef\whatever{\detokenize{This is {\bf bold} and this is not.}}
```

```

\detokenize {This is {\bf bold} and this is not.}\crlf
\scantextokens{This is {\bf bold} and this is not.}\crlf
\scantextokens{\whatever}\crlf
\scantextokens\expandafter{\whatever}

```

This primitive does not have the end-of-file side effects of its precursor `\scantokens`.

This is `{\bf bold}` and this is not.

This is **bold** and this is not.

This is `{\bf bold}` and this is not.

This is **bold** and this is not.

34 \number

This \TeX primitive serializes the next token into a number, assuming that it is indeed a number, like

```

\number`A
\number65
\number\scratchcounter

```

For counters and such the `\the` primitive does the same, but when you're not sure if what follows is a verbose number or (for instance) a counter the `\number` primitive is a safer bet, because `\the 65` will not work.

35 \string

We mention this original primitive because of the one in the next section. It expands the next token or control sequence as if it was just entered, so normally a control sequence becomes a backslash followed by characters and a space.

36 \csstring

This primitive returns the name of the control sequence given without the leading escape character (normally a backslash). Of course you could strip that character with a simple helper but this is more natural.

```

\csstring\mymacro

```

We get the name, not the meaning: `mymacro`.

37 \unexpanded

This is an ε - \TeX enhancement. The content will not be expanded in a context where expansion is happening, like in an `\edef`. In \ConTeXt you need to use `\normalunexpanded` because we already had a macro with that name.

```

\def\A{!}
\def\B{?}

\edef\C{\A\B}           \meaning\C \crlf

```

```
\edef\C{\normalunexpanded{\A}\B} \meaning\C \crlf
```

```
macro:->!?
```

```
macro:->\A ?
```

38 \detokenize

This ε -TeX primitive turns the content of the provides list will become characters, kind of verbatim.

```
\expandafter\let\expandafter\temp\detokenize{1} \meaning\temp \crlf
```

```
\expandafter\let\expandafter\temp\detokenize{A} \meaning\temp \crlf
```

```
the character 1
```

```
the character A
```

39 \expanded

This primitive complements the two expansion related primitives mentioned in the previous two sections. This time the content will be expanded and then pushed back into the input. Protected macros will not be expanded, so you can use this primitive to expand the arguments in a call. In ConTeXt you need to use `\normalexpanded` because we already had a macro with that name. We give some examples:

```
\def\A{!}
```

```
\def\B#1{\string#1} \B{\A} \crlf
```

```
\def\B#1{\string#1} \normalexpanded{\noexpand\B{\A}} \crlf
```

```
\normalprotected\def\B#1{\string#1} \B{\A} \crlf
```

```
\A
```

```
!
```

```
\A
```

40 \immediateassignment

Assignments are not expandable which means that you cannot define fully expandable macros that have assignments. But, there is a way out of this:

```
\scratchcounter = 10
```

```
\edef\whatever{%
```

```
  (\the\scratchcounter)
```

```
  \immediateassignment\scratchcounter\numexpr\scratchcounter+10\relax
```

```
  \immediateassignment\advance\scratchcounter -5
```

```
  (\the\scratchcounter)
```

```
}
```

```
\meaning\whatever
```

Don't expect miracles: you can't mix-in content or unexpandable tokens as they will either show up or quit the scanning.

```
macro:->(10) (15)
```

41 \immediateassigned

This is the multi-token variant of the primitive mentioned in the previous section.

```
\scratchcounter = 10
\edef\whatever{%
  (\the\scratchcounter)
  \immediateassigned{
    \scratchcounter\numexpr\scratchcounter+10\relax
    \advance\scratchcounter -5
  }%
  (\the\scratchcounter)
}
\meaning\whatever
```

The results are the same as in the previous section:

macro:->(10) (15)

42 \if

This traditional T_EX conditional checks if two character codes are the same. In order to understand unexpanded results it is good to know that internally T_EX groups primitives in a way that serves the implementation. Each primitive has a command code and a character code, but only for real characters the name character code makes sense. This condition only really tests for character codes when we have a character, in all other cases, the result is true.

```
\def\A{A}\def\B{B} \chardef\C=`C \chardef\D=`D \def\AA{AA}

[\if AA YES \else NOP \fi] [\if AB YES \else NOP \fi]
[\if \A\B YES \else NOP \fi] [\if \A\A YES \else NOP \fi]
[\if \C\D YES \else NOP \fi] [\if \C\C YES \else NOP \fi]
[\if \count\dimen YES \else NOP \fi] [\if \AA\A YES \else NOP \fi]
```

The last example demonstrates that the tokens get expanded, which is why we get the extra A:

[YES] [NOP] [NOP] [YES] [YES] [YES] [YES] [AYES]

43 \ifcat

Another traditional T_EX primitive: what happens with what gets read in depends on the catcode of a character, think of characters marked to start math mode, or alphabetic characters (letters) versus other characters (like punctuation).

```
\def\A{A}\def\B{,} \chardef\C=`C \chardef\D=` , \def\AA{AA}

[\ifcat $! YES \else NOP \fi] [\ifcat () YES \else NOP \fi]
[\ifcat AA YES \else NOP \fi] [\ifcat AB YES \else NOP \fi]
[\ifcat \A\B YES \else NOP \fi] [\ifcat \A\A YES \else NOP \fi]
[\ifcat \C\D YES \else NOP \fi] [\ifcat \C\C YES \else NOP \fi]
[\ifcat \count\dimen YES \else NOP \fi] [\ifcat \AA\A YES \else NOP \fi]
```

Close reading is needed here:

```
[NOP ] [ YES ] [ YES ] [ YES ] [NOP ] [YES ] [YES ] [YES ] [YES ] [AYES ]
```

This traditional T_EX condition as well as the one in the previous section are hardly used in ConT_EXt, if only because they expand what follows and we seldom need to compare characters.

44 \ifnum

This is a frequently used conditional: it compares two numbers where a number is anything that can be seen as such.

```
\scratchcounter=65 \chardef\A=65
```

```
\ifnum65=`A      YES \else NOP\fi
\ifnum\scratchcounter=65 YES \else NOP\fi
\ifnum\scratchcounter=\A YES \else NOP\fi
```

Unless a number is an unexpandable token it ends with a space or `\relax`, so when you end up in the true branch, you'd better check if T_EX could determine where the number ends.

```
YES YES YES
```

45 \ifdim

Dimensions can be compared with this traditional T_EX primitive.

```
\scratchdimen=1pt \scratchcounter=65536
```

```
\ifdim\scratchdimen=\scratchcounter sp YES \else NOP\fi
\ifdim\scratchdimen=1 pt YES \else NOP\fi
```

The units are mandated:

```
YES YES
```

46 \ifodd

One reason for this condition to be around is that in a double sided layout we need test for being on an odd or even page. It scans for a number the same way as other primitives,

```
\ifodd65 YES \else NO\fi &
\ifodd`B YES \else NO\fi .
```

So: YES & NO.

47 \ifvmode

This traditional conditional checks we are in (internal) vertical mode.

48 \ifhmode

This traditional conditional checks we are in (restricted) horizontal mode.

49 `\ifmmode`

This traditional conditional checks we are in (inline or display) math mode mode.

50 `\ifinner`

This traditional one can be confusing. It is true when we are in restricted horizontal mode (a box), internal vertical mode (a box), or inline math mode.

```
test \ifhmode \ifinner INNER\fi HMODE\fi\crlf
\hbox{test \ifhmode \ifinner INNER \fi HMODE\fi} \crlf

\ifvmode \ifinner INNER\fi VMODE \fi\crlf
\ vbox{\ifvmode \ifinner INNER \fi VMODE\fi} \crlf
\ vbox{\ifinner INNER \ifvmode VMODE \fi \fi} \crlf
```

Watch the last line: because we typeset `INNER` we enter horizontal mode:

```
test HMODE
test INNER HMODE

VMODE
INNER VMODE
INNER
```

51 `\ifvoid`

This traditional conditional checks if a given box register or internal box variable has any content.

52 `\ifhbox`

This traditional conditional checks if a given box register or internal box variable represents a horizontal box,

53 `\ifvbox`

This traditional conditional checks if a given box register or internal box variable represents a vertical box,

54 `\ifx`

We use this traditional \TeX conditional a lot in $\text{Con}\text{\TeX}$ t. Contrary to `\if` the two tokens that are compared are not expanded. This makes it possible to compare the meaning of two macros. Depending on the need, these macros can have their content expanded or not. A different number of parameters results in false.

Control sequences are identical when they have the same command code and character code. Because a `\let` macro is just a reference, both let macros are the same and equal to `\relax`:

```
\let\one\relax \let\two\relax
```

The same is true for other definitions that result in the same (primitive) or meaning encoded in the character field (think of `\chardefs` and so).

55 \ifeof

This traditional conditional checks if current pointer into the the file bound to the given index is past the end of file. The read and write channels are not really used in ConT_EXt: in MkII we only had one file for all multi-pass data, and in MkIV all file related stuff is dealt with in LuaT_EX.

56 \iftrue

Here we have a traditional T_EX conditional that is always true (therefore the same is true for any macro that is `\let` to this primitive).

57 \iffalse

Here we have a traditional T_EX conditional that is always false (therefore the same is true for any macro that is `\let` to this primitive).

58 \ifcase

This numeric T_EX conditional takes a counter (literal, register, shortcut to a character, internal quantity) and goes to the branch that matches.

```
\ifcase 3 zero\or one\or two\or three\or four\else five or more\fi
```

Indeed: three equals three. In later sections we will see some LuaMetaT_EX primitives that behave like an `\ifcase`.

59 \ifdefined

In traditional T_EX checking for a macro to exist was a bit tricky and therefore ε -T_EX introduced a convenient conditional. We can do this:

```
\ifx\MyMacro\undefined ... \else ... \fi
```

but that assumes that `\undefined` is indeed undefined. Another test often seen was this:

```
\expandafter\ifx\csname MyMacro\endcsname\relax ... \else ... \fi
```

Instead of comparing with `\undefined` we need to check with `\relax` because the control sequence is defined when not yet present and defaults to `\relax`. This is not pretty.

60 \ifcsname

This is an ε -T_EX conditional that complements the one on the previous section:

```
\expandafter\ifx\csname MyMacro\endcsname\relax ... \else ... \fi
\ifcsname MyMacro\endcsname ... \else ... \fi
```

Here the first one has the side effect of defining the macro and defaulting it to `\relax`, while the second one doesn't do that. Just think of checking a few million different names: the first one will deplete the hash table and probably string space too.

In LuaMetaTeX the construction stops when there is no letter or other character seen (TeX expands on the go so expandable macros are dealt with). Instead of an error message, the match is simply false and all tokens till the `\endcsname` are gobbled.

61 \iffontchar

This is an ε -TeX conditional. It takes a font identifier and a character number. In modern fonts simply checking could not be enough because complex font features can swap in other ones and their index can be anything. Also, a font mechanism can provide fallback fonts and characters, so don't rely on this one too much. It just reports true when the font passed to the frontend has a slot filled.

62 \ifincsname

This conditional is sort of obsolete and can be used to check if we're inside a `\csname` or `\ifcsname` construction. It's not used in ConTeXt.

63 \ifabsnum

This test will negate negative numbers before comparison, as in:

```
\def\TestA#1{\ifnum #1<100 too small\orelse\ifnum #1>200 too large\else okay\fi}
\def\TestB#1{\ifabsnum#1<100 too small\orelse\ifabsnum#1>200 too large\else okay\fi}

\TestA {10}\quad\TestA {150}\quad\TestA {210}\crlf
\TestB {10}\quad\TestB {150}\quad\TestB {210}\crlf
\TestB {-10}\quad\TestB {-150}\quad\TestB {-210}\crlf
```

Here we get the same result each time:

```
too small  okay  too large
too small  okay  too large
too small  okay  too large
```

64 \ifabsdim

This test will negate negative dimensions before comparison, as in:

```
\def\TestA#1{\ifdim #1<2pt too small\orelse\ifdim #1>4pt too large\else okay\fi}
\def\TestB#1{\ifabsdim#1<2pt too small\orelse\ifabsdim#1>4pt too large\else okay\fi}

\TestA {1pt}\quad\TestA {3pt}\quad\TestA {5pt}\crlf
\TestB {1pt}\quad\TestB {3pt}\quad\TestB {5pt}\crlf
\TestB {-1pt}\quad\TestB {-3pt}\quad\TestB {-5pt}\crlf
```

So we get this:

```
too small  okay  too large
too small  okay  too large
too small  okay  too large
```

65 \ifchknum

In ConTeXt there are quite some cases where a variable can have a number or a keyword indicating a symbolic name of a number or maybe even some special treatment. Checking if a valid number is given is possible to some extend, but a native checker makes much sense too. So here is one:

```
\ifchknum oeps\or okay\else error\fi\quad
\ifchknum 12 \or okay\else error\fi\quad
\ifchknum 12pt\or okay\else error\fi
```

The result is as expected:

```
error  okay  okay
```

66 \ifchkdim

A variant on the checker in the previous section is a dimension checker:

```
\ifchkdim oeps\or okay\else error\fi\quad
\ifchkdim 12 \or okay\else error\fi\quad
\ifchkdim 12pt\or okay\else error\fi
```

We get:

```
error  error  okay
```

67 \ifcmpnum

This conditional compares two numbers and the resulting `\ifcase` reflects their relation:

```
[1 2 : \ifcmpnum 1 2 less\or equal\or more\fi]\quad
[1 1 : \ifcmpnum 1 1 less\or equal\or more\fi]\quad
[2 1 : \ifcmpnum 2 1 less\or equal\or more\fi]
```

This gives:

```
[1 2 : less] [1 1 : equal] [2 1 : more]
```

68 \ifcmpdim

This conditional compares two dimensions and the resulting `\ifcase` reflects their relation:

```
[1pt 2pt : \ifcmpdim 1pt 2pt less\or equal\or more\fi]\quad
[1pt 1pt : \ifcmpdim 1pt 1pt less\or equal\or more\fi]\quad
[2pt 1pt : \ifcmpdim 2pt 1pt less\or equal\or more\fi]
```

This gives:

```
[1pt 2pt : less] [1pt 1pt : equal] [2pt 1pt : more]
```

69 \ifnumval

This conditional is a variant on `\ifchknun`. This time we get some more detail about the value:

```
[-12 : \ifnumval -12\or negative\or zero\or positive\else error\fi]\quad
[0 : \ifnumval 0\or negative\or zero\or positive\else error\fi]\quad
[12 : \ifnumval 12\or negative\or zero\or positive\else error\fi]\quad
[oeps : \ifnumval oeps\or negative\or zero\or positive\else error\fi]
```

This gives:

```
[-12 : negative] [0 : zero] [12 : positive] [oeps : error]
```

70 \ifdimval

This conditional is a variant on `\ifchkdim` and provides some more detailed information about the value:

```
[-12pt : \ifdimval-12pt\or negative\or zero\or positive\else error\fi]\quad
[0pt : \ifdimval 0pt\or negative\or zero\or positive\else error\fi]\quad
[12pt : \ifdimval 12pt\or negative\or zero\or positive\else error\fi]\quad
[oeps : \ifdimval oeps\or negative\or zero\or positive\else error\fi]
```

This gives:

```
[-12pt : negative] [0pt : zero] [12pt : positive] [oeps : error]
```

71 \iftok

When you want to compare two arguments, the usual way to do this is the following:

```
\edef\tempA{#1}
\edef\tempb{#2}
\ifx\tempA\tempB
    the same
\else
    different
\fi
```

This works quite well but the fact that we need to define two macros can be considered a bit of a nuisance. It also makes macros that use this method to be not so called ‘fully expandable’. The next one avoids both issues:

```
\iftok{#1}{#2}
    the same
\else
    different
```

\fi

Instead of direct list you can also pass registers, so given:

```
\scratchtoks{a}%
\toks0{a}%
```

This:

```
\iftok 0 \scratchtoks      Y\else N\fi\space
\iftok{a}\scratchtoks      Y\else N\fi\space
\iftok\scratchtoks\scratchtoks Y\else N\fi
```

gives: Y Y Y.

72 \ifcstok

A variant on the primitive mentioned in the previous section is one that operates on lists and macros:

```
\def\{a} \def\{b} \def\{c}
```

This:

```
\ifcstok\{a}\{b} Y\else N\fi\space
\ifcstok\{a}\{c} Y\else N\fi\space
\ifcstok\{a}\{c} Y\else N\fi\space
\ifcstok\{a}\{c} Y\else N\fi
```

will give us: N Y Y Y.

73 \ifcondition

The conditionals in \TeX are hard coded as primitives and although it might look like `\newif` creates one, it actually just defined three macros.

```
\newif\ifMyTest
\meaning\MyTesttrue \crlf
\meaning\MyTestfalse \crlf
\meaning\ifMyTest    \crlf \MyTesttrue
\meaning\ifMyTest    \crlf
```

```
macro:->\let \ifMyTest \iftrue
macro:->\let \ifMyTest \iffalse
\iffalse
\iftrue
```

This means that when you say:

```
\ifMytest ... \else ... \fi
```

You actually have one of:

```
\iftrue ... \else ... \fi
```

```
\iffalse ... \else ... \fi
```

and because these are proper conditions nesting them like:

```
\ifnum\scratchcounter > 0 \ifMyTest A\else B\fi \fi
```

will work out well too. This is not true for macros, so for instance:

```
\scratchcounter = 1  
\unexpanded\def\ifMyTest{\iftrue}  
\ifnum\scratchcounter > 0 \ifMyTest A\else B\fi \fi
```

will make a run fail with an error (or simply loop forever, depending on your code). This is where **\ifcondition** enters the picture:

```
\def\MyTest{\iftrue} \scratchcounter0  
\ifnum\scratchcounter > 0  
    \ifcondition\MyTest A\else B\fi  
\else  
    x  
\fi
```

This primitive is seen as a proper condition when T_EX is in “fast skipping unused branches” mode but when it is expanding a branch, it checks if the next expanded token is a proper tests and if so, it deals with that test, otherwise it fails. The main condition here is that the **\MyTest** macro expands to a proper true or false test, so, a definition like:

```
\def\MyTest{\ifnum\scratchcounter<10 }
```

is also okay. Now, is that neat or not?

74 **\iffrozen**

This conditional checks if a control sequence is frozen:

```
is \iffrozen\MyMacro \else not \fi frozen
```

75 **\ifprotected**

This conditional checks if a control sequence is protected:

```
is \ifprotected\MyMacro \else not \fi protected
```

76 **\ifusercmd**

This conditional checks if a control sequence is not one of the primitives:

```
is \ifusercmd\MyMacro \else not \fi a primitive
```

It is not always possible to determine this but it should work okay for regular macros, register allocations and character definitions.

77 `\ifempty`

This conditional checks if a control sequence is empty:

is `\ifempty\MyMacro \else` not `\fi` empty

It is basically a shortcut of:

is `\ifx\MyMacro\empty \else` not `\fi` empty

with:

```
\def\empty{}
```

Of course this is not empty at all:

```
\def\notempty#1{}
```

78 `\ifboolean`

This tests a number (register or equivalent) and any nonzero value represents true, which is nicer than using an `\unless \ifcase`.

79 `\ifmathparameter`

This is an `\ifcase` where the value depends on if the given math parameter is zero, (0), set (1), or unset (2).

```
\ifmathparameter\Umathpuncnclosespacing\displaystyle
  zero      \or
  nonzero   \or
  unset     \fi
```

80 `\ifmathstyle`

This is a variant of `\ifcase` where the number is one of the seven possible styles: display, text, cramped text, script, cramped script, script script, cramped script script.

```
\ifmathstyle
  display
\or
  text
\or
  cramped text
\else
  normally smaller than text
\fi
```

81 `\ifarguments`

This is a variant of `\ifcase` where the selector is the number of arguments picked up. For example:


```
\def\MyMacro#1#2#3{\ifarguments\0\or1\or2\or3\else ?\fi} \MyMacro{A}{B}{C}
\def\MyMacro#1#0#3{\ifarguments\0\or1\or2\or3\else ?\fi} \MyMacro{A}{B}{C}
\def\MyMacro#1#-#2{\ifarguments\0\or1\or2\or3\else ?\fi} \MyMacro{A}{B}{C}\crlf
```

Watch the non counted, ignored, argument in the last case. Normally this test will be used in combination with `\ignorearguments`.

3 3 2

82 \ifhastok

This conditional looks for occurrences in token lists where each argument has to be a proper list.

```
\def\scratchtoks{x}

\ifhastoks{yz} {xyz} Y\else N\fi\quad
\ifhastoks\scratchtoks {xyz} Y\else N\fi
```

We get:

Y Y

83 \ifhastoks

This test compares two token lists. When a macro is passed it's meaning gets used.

```
\def\x {x}
\def\xyz{xyz}

(\ifhastoks {x} {xyz}Y\else N\fi)\quad
(\ifhastoks {\x} {xyz}Y\else N\fi)\quad
(\ifhastoks \x {xyz}Y\else N\fi)\quad
(\ifhastoks {y} {xyz}Y\else N\fi)\quad
(\ifhastoks {yz} {xyz}Y\else N\fi)\quad
(\ifhastoks {yz} {\xyz}Y\else N\fi)
```

(Y) (N) (Y) (Y) (Y) (N)

84 \ifhasxtoks

This primitive is like the one in the previous section but this time the given lists are expanded.

```
\def\x {x}
\def\xyz{\x yz}

(\ifhasxtoks {x} {xyz}Y\else N\fi)\quad
(\ifhasxtoks {\x} {xyz}Y\else N\fi)\quad
(\ifhasxtoks \x {xyz}Y\else N\fi)\quad
(\ifhasxtoks {y} {xyz}Y\else N\fi)\quad
(\ifhasxtoks {yz} {xyz}Y\else N\fi)\quad
(\ifhasxtoks {yz} {\xyz}Y\else N\fi)
```

(Y) (Y) (Y) (Y) (Y) (Y)

This primitive has some special properties.

```
\edef\+{\expandtoken 9 `+}
```

```
\ifhasxtoks {xy} {xyz}Y\else N\fi\quad
```

```
\ifhasxtoks {x\+y} {xyz}Y\else N\fi
```

Here the first argument has a token that has category code ‘ignore’ which means that such a character will be skipped when seen. So the result is:

Y Y

This permits checks like these:

```
\edef\,{\expandtoken 9 `,}
```

```
\ifhasxtoks{\,x\,} {,x,y,z,}Y\else N\fi\quad
```

```
\ifhasxtoks{\,y\,} {,x,y,z,}Y\else N\fi\quad
```

```
\ifhasxtoks{\,z\,} {,x,y,z,}Y\else N\fi\quad
```

```
\ifhasxtoks{\,x\,} {,xy,z,}Y\else N\fi
```

I admit that it needs a bit of a twisted mind to come up with this, but it works ok:

Y Y Y N

85 \else

This traditional primitive is part of the condition testing mechanism. When a condition matches, T_EX will continue till it sees an `\else` or `\or` or `\orelse` (to be discussed later). It will then do a fast skipping pass till it sees an `\fi`.

86 \or

This traditional primitive is part of the condition testing mechanism and relates to an `\ifcase` test (or a similar test to be introduced in later sections). Depending on the value, T_EX will do a fast scanning till the right `\or` is seen, then it will continue expanding till it sees a `\or` or `\else` or `\orelse` (to be discussed later). It will then do a fast skipping pass till it sees an `\fi`.

87 \fi

This traditional primitive is part of the condition testing mechanism and ends a test. So, we have:

```
\ifsomething ... \else ... \fi
```

```
\ifsomething ... \or ... \or ... \else ... \fi
```

```
\ifsomething ... \orelse \ifsomething ... \else ... \fi
```

```
\ifsomething ... \or ... \orelse \ifsomething ... \else ... \fi
```

The `\orelse` is new in LuaMetaT_EX and a continuation like we find in other programming languages (see later section).

88 \unless

This ε -TeX prefix will negate the test (when applicable).

```
\ifx\one\two YES\else NO\fi
\unless\ifx\one\two NO\else YES\fi
```

This primitive is hardly used in ConTeXt and we probably could get rid of these few cases.

89 \orelse

This primitive provides a convenient way to flatten your conditional tests. So instead of

```
\ifnum\scratchcounter<-10
  too small
\else\ifnum\scratchcounter>10
  too large
\else
  just right
\fi\fi
```

You can say this:

```
\ifnum\scratchcounter<-10
  too small
\orelse\ifnum\scratchcounter>10
  too large
\else
  just right
\fi
```

You can mix tests and even the case variants will work in most cases³

```
\ifcase\scratchcounter      zero
\or                          one
\or                          two
\orelse\ifnum\scratchcounter<10 less than ten
\else                        ten or more
\fi
```

Performance wise there are no real benefits although in principle there is a bit less housekeeping involved than with nested checks. However you might like this:

```
\ifnum\scratchcounter<-10
  \expandafter\toosmall
\orelse\ifnum\scratchcounter>10
  \expandafter\toolarge
\else
  \expandafter\justright
```

³ I just play safe because there are corner cases that might not work yet.

`\fi`

over:

```
\ifnum\scratchcounter<-10
  \expandafter\toosmall
\else\ifnum\scratchcounter>10
  \expandafter\expandafter\expandafter\toolarge
\else
  \expandafter\expandafter\expandafter\justright
\fi\fi
```

or the more ConT_EXt specific:

```
\ifnum\scratchcounter<-10
  \expandafter\toosmall
\else\ifnum\scratchcounter>10
  \doubleexpandafter\toolarge
\else
  \doubleexpandafter\justright
\fi\fi
```

But then, some T_EXies like complex and obscure code and throwing away working old code that took ages to perfect and get working and also showed that one masters T_EX might hurt.

90 \futurelet

The original T_EX primitive `\futurelet` can be used to create an alias to a next token, push it back into the input and then expand a given token.

```
\let\MySpecialToken[
\def\DoWhatever{\ifx\NextToken\MySpecialToken YES\else NOP\fi : }
\futurelet\NextToken\DoWhatever [A]\crlf
\futurelet\NextToken\DoWhatever (A)
```

This is typically the kind of primitive that most users will never use because it expects a sane follow up handler (here `\DoWhatever`) and therefore is related to user interfacing.

YES: [A]

NOP: (A)

91 \futuredef

We elaborate on the example of using `\futurelet` in the previous section. Compare that one with the next:

```
\def\MySpecialToken{[]
\def\DoWhatever{\ifx\NextToken\MySpecialToken YES\else NOP\fi : }
\futurelet\NextToken\DoWhatever [A]\crlf
\futurelet\NextToken\DoWhatever (A)
```

This time we get:

NOP: [A]

NOP: (A)

It is for that reason that we now also have `\futuredef`:

```
\def\MySpecialToken{[]
\def\DoWhatever{\ifx\NextToken\MySpecialToken YES\else NOP\fi : }
\futuredef\NextToken\DoWhatever [A]\crlf
\futuredef\NextToken\DoWhatever (A)
```

So we're back to what we want:

YES: [A]

NOP: (A)

92 \letcharcode

Assigning a meaning to an active character can sometimes be a bit cumbersome; think of using some documented uppercase magic that one tends to forget as it's used only a few times and then never looked at again. So we have this:

```
{\letcharcode 65 1 \catcode 65 13 A : \meaning A}\crlf
{\letcharcode 65 2 \catcode 65 13 A : \meaning A}\crlf
```

here we define A as an active character with meaning 1 in the first line and 2 in the second.

1 : the character 1

2 : the character 2

Normally one will assign a control sequence:

```
{\letcharcode 66 \bf \catcode 66 13 {B bold}: \meaning B}\crlf
{\letcharcode 73 \it \catcode 73 13 {I italic}: \meaning I}\crlf
```

Of course `\bf` and `\it` are ConT_EXt specific commands:

bold: protected macro:->\ifmmode \mathbf \else \normalbf \fi

italic: protected macro:->\ifmmode \mathit \else \normalit \fi

93 \global

This is one of the original prefixes that can be used when we define a macro of change some register.

```
\bgroup
  \def\MyMacroA{a}
\global\def\MyMacroB{a}
  \gdef\MyMacroC{a}
\egroup
```

The macro defined in the first line is forgotten when the groups is left. The second and third definition are both global and these definitions are retained.

94 `\long`

This original prefix gave the macro being defined the property that it could not have `\par` (or the often equivalent empty lines) in its arguments. It was mostly a protection against a forgotten right curly brace, resulting in a so called run-away argument. That mattered on a paper terminal or slow system where such a situation should be caught early. In LuaTeX it was already optional, and in LuaMetaTeX we dropped this feature completely (so that we could introduce others).

95 `\outer`

An outer macro is one that can only be used at the outer level. This property is no longer supported. Like `\long`, the `\outer` prefix is now an no-op (and we don't expect this to have unfortunate side effects).

96 `\protected`

A protected macro is one that doesn't get expanded unless it is time to do so. For instance, inside an `\edef` it just stays what it is. It often makes sense to pass macros as-is to (multi-pass) file (for tables of contents).

In ConTeXt we use either `\normalprotected` or `\unexpanded` because the later was the command we used to achieve the same results before ε -TeX introduced this protection primitive.

97 `\frozen`

You can define a macro as being frozen:

```
\frozen\def\MyMacro{...}
```

When you redefine this macro you get an error:

```
! You can't redefine a frozen macro.
```

This is a prefix like `\global` and it can be combined with other prefixes.⁴

98 `\letfrozen`

You can explicitly freeze an unfrozen macro:

```
\def\MyMacro{...}
\letfrozen\MyMacro
```

A redefinition will now give:

```
! You can't redefine a frozen macro.
```

⁴ The `\outer` and `\long` prefixes are no-ops in LuaMetaTeX and LuaTeX can be configured to ignore them.

99 \unletfrozen

A frozen macro cannot be redefined: you get an error. But as nothing in T_EX is set in stone, you can do this:

```
\frozen\def\MyMacro{...}
\unletfrozen\MyMacro
```

and `\MyMacro` is no longer protected from overloading. It is still undecided to what extent ConT_EXt will use this feature.

100 \letprotected

Say that you have these definitions:

```

\def \MyMacroA{alpha}
\normalprotected \def \MyMacroB{beta}
\edef \MyMacroC{\MyMacroA\MyMacroB}
\letprotected \MyMacroA
\edef \MyMacroD{\MyMacroA\MyMacroB}
\meaning \MyMacroC\crlf
\meaning \MyMacroD
```

We use `\normalprotected` because when the ε -T_EX `\protected` primitive showed up we already had that name in use. The typeset meaning in this example is:

```
macro:->alpha\MyMacroB
macro:->\MyMacroA \MyMacroB
```

101 \unletprotected

The complementary operation of `\letprotected` can be used to unprotect a macro, so that it gets expandable.

```

\def \MyMacroA{alpha}
\normalprotected \def \MyMacroB{beta}
\edef \MyMacroC{\MyMacroA\MyMacroB}
\unletprotected \MyMacroB
\edef \MyMacroD{\MyMacroA\MyMacroB}
\meaning \MyMacroC\crlf
\meaning \MyMacroD
```

Compare this with the example in the previous section:

```
macro:->alpha\MyMacroB
macro:->alphabeta
```

102 \beginlocalcontrol

Once T_EX is initialized it will enter the main loop. In there certain commands trigger a function that itself can trigger further scanning and functions. In LuaMetaT_EX we can have local main loops and

we can either enter it from the Lua end (which we don't discuss here) or at the T_EX end using this primitive.

```
\scratchcounter100

\edef\whatever{
  a
  \beginlocalcontrol
    \advance\scratchcounter 10
  b
  \endlocalcontrol
  \beginlocalcontrol
    c
  \endlocalcontrol
  d
  \advance\scratchcounter 10
}

\the\scratchcounter
\whatever
\the\scratchcounter
```

A bit of close reading probably gives an impression of what happens here:

```
b c

110 a d 120
```

The local loop can actually result in material being injected in the current node list. However, where normally assignments are not taking place in an `\edef`, here they are applied just fine. Basically we have a local T_EX job, be it that it shares all variables with the parent loop.

103 \endlocalcontrol

See previous section.

104 \alignmark

When you have the `#` not set up as macro parameter character `cq`. align mark, you can use this primitive instead. The same rules apply with respect to multiple such tokens in (nested) macros and alignments.

105 \aligntab

When you have the `&` not set up as align tab, you can use this primitive instead. The same rules apply with respect to multiple such tokens in (nested) macros and alignments.

Rationale

Some words about the why and how it came. One of the early adopters of ConT_EXt was Taco Hoekwater and we spent numerous trips to T_EX meetings all over the globe. He was also the only one I knew who had read the T_EX sources. Because ConT_EXt has always been on the edge of what is possible and at that time we both used it for rather advanced rendering, we also ran into the limitations. I'm not talking of T_EX features here. Naturally old school T_EX is not really geared for dealing with images of all kind, colors in all kind of color spaces, highly interactive documents, input methods like xml, etc. The nice thing is that it offers some escapes, like specials and writes and later execution of programs that opened up lots of possibilities, so in practice there were no real limitations to what one could do. But coming up with a consistent and extensible (multi lingual) user interface was non trivial, because it had an impact in memory usage and performance. A lot could be done given some programming, as ConT_EXt MkII proves, but it was not always pretty under the hood. The move to LuaT_EX and MkIV transferred some action to Lua, and because LuaT_EX effectively was a ConT_EXt related project, we could easily keep them in sync.

Our traveling together, meeting several times per year, and eventually email and intense LuaT_EX developments (lots of Skype sessions) for a couple of years, gave us enough opportunity to discuss all kind of nice features not present in the engine. The previous century we discussed lots of them, rejected some, stayed with others, and I admit that forgot about most of the arguments already. Some that we did was already explored in eetex, some of those ended up in LuaT_EX, and eventually what we have in LuaMetaT_EX can be seen as the result of years of programming in T_EX, improving macros, getting more performance and efficiency out of existing ConT_EXt code and inspiration that we got out of the ConT_EXt community, a demanding lot, always willing to experiment with us.

Once I decided to work on LuaMetaT_EX and bind its source to the ConT_EXt distribution so that we can be sure that it won't get messed up and might interfere with the ConT_EXt expectations, some more primitives saw their way into it. It is very easy to come up with all kind of bells and whistles but it is equally easy to hurt performance of an engine and what might go unnoticed in simple tests can really affect a macro package that depends on stability. So, what I did was mostly looking at the ConT_EXt code and wondering how to make some of the low level macros look more natural, also because I know that there are users who look into these sources. We spend a lot of time making them look consistent and nice and the nicer the better. Getting a better performance was seldom an argument because much is already as fast as can be so there is not that much to gain, but less clutter in tracing was an argument for some new primitives. Also, the fact that we soon might need to fall back on our phones to use T_EX a smaller memory footprint and less byte shuffling also was a consideration. The LuaMetaT_EX memory footprint is somewhat smaller than the LuaT_EX footprint. By binding LuaMetaT_EX to ConT_EXt we can also guarantee that the combinations works as expected.

I'm aware of the fact that ConT_EXt is in a somewhat unique position. First of all it has always been kind of cutting edge so its users are willing to experiment. There are users who immediately update and run tests, so bugs can and will be fixed fast. Already for a long time the community has a convenient infrastructure for updating and the build farm for generating binaries (also for other engines) is running smoothly.

Then there is the ConT_EXt user interface that is quite consistent and permits extensions with staying backward compatible. Sometimes users run into old manuals or examples and then complain that ConT_EXt is not compatible but that then involves obsolete technology: we no longer need font and input encodings and font definitions are different for OpenType fonts. We always had an abstract backend model, but nowadays pdf is kind of dominant and drives a lot of expectations. So, some of the MkII commands are gone and MkIV has some more. Also, as MetaPost evolved that department

in ConT_EXt also evolved. Think of it like cars: soon all are electric so one cannot expect a hole to poor in some fluid but gets a (often incompatible) plug instead. And buttons became touch panels. There is no need to use much force to steer or brake. Navigation is different, as are many controls. And do we need to steer ourselves a decade from now?

So, just look at T_EX and ConT_EXt in the same way. A system from the nineties in the previous century differs from one three decades later. Demands differ, input differs, resources change, editing and processing moves on, and so on. Manuals, although still being written are seldom read from cover to cover because online searching replaced them. And who buys books about programming? So LuaMetaT_EX, while still being T_EX also moves on, as do the way we do our low level coding. This makes sense because the original T_EX ecosystem was not made with a huge and complex macro package in mind, that just happened. An author was supposed to make a style for each document. An often used argument for using another macro package over ConT_EXt was that the later evolved and other macro packages would work the same forever and not change from the perspective of the user. In retrospect those arguments were somewhat strange because the world, computers, users etc. do change. Standards come and go, as do software politics and preferences. In many aspects the T_EX community is not different from other large software projects, operating system wars, library devotees, programming language addicts, paradigm shifts. But, don't worry, if you don't like LuaMetaT_EX and its new primitives, just forget about them. The other engines will be there forever and are a safe bet, although LuaT_EX already stirred up the pot I guess. But keep in mind that new features in the latest greatest ConT_EXt version will more and more rely on LuaMetaT_EX being used; after all that is where it's made for. And this manual might help understand its users why, where and how the low level code differs between MkII, MkIV and lmtx.

Can we expect more new primitives than the ones introduced here? Given the amount of time I spend on experimenting and considering what made sense and what not, the answer probably is "no", or at least "not that much". As in the past no user ever requested the kind of primitives that were added, I don't expect users to come up with requests in the future either. Of course, those more closely related to ConT_EXt development look at it from the other end. Because it's there where the low level action really is, demands might still evolve.

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