luaTeX
A user's perspective

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What is luaTeX

www.luatex.org says

- luaTeX is an extended version of pdfTeX using lua as an embedded scripting language
- Main objective is to provide an open and configurable variant of TeX which is backward compatible with pdfTeX

Translation

Programming in TeX made easy

How to use lua in ConTeXt

- Call lua from TeX
  - \ctxlua{...}
  - \startluacode ... \stopluacode
- Call TeX from lua
  - tex.print(...)
  - context(...)
  - context.csname(...) experimental

Simple things
are simple

Example: Pick a random option

Encode your Name and Surname as a

```
\startluacode
  local a = {'null-terminated', 'dollar-terminated', 'Pascal'}
  context('%s string', a[math.random(1,3)])
\stopluacode
```


Example: Convert decimal to binary

Perform logical AND, OR, and XOR of the following pair of hexadecimal numbers:

```
\startluacode
  local n = math.random(10,255)
  local m = math.random(10,255)
  context("%X, %X", n, m)
\stopluacode
```

Vyatcheslav Yatskovsky on ntg-context

You can parse
input without
exploding your brain

Example: Parsing

\molecule{...} should type the chemical symbol "correctly"

```
\unexpanded\def\molecule%
  {\bgroup
   \catcode`\_=\active \uccode`\~=`\_ \uppercase{\let~\chemlow}%
   \catcode`\^=\active \uccode`\~=`\^ \uppercase{\let~\chemhigh}%
   \dostepwiserecurse {65}{90}{1}
      {\catcode \recurselevel = \active
       \uccode`\~=\recurselevel
       \uppercase{\edef~{\noexpand\finishchem
                         \rawcharacter{\recurselevel}}}}%
   \uccode `\~=`\F \uppercase{\def~{\finishchem F\fluortrue}}%
   \catcode`\-=\active \uccode`\~=`\- \uppercase{\def~{--}}%
   \domolecule }
```

Snippet from mhchem.sty by Martin Hensel

```
\def\ce#1{\mhchem@ce@xiii{\mhchem@ce@viii#1 \mhchem@END\mhchem@ENDEND}}
\def\mhchem@ce@viii#1 #2\mhchem@ENDEND{%
  \ifx\mhchem@END#2%
    \ifx\@empty#1\@empty \else
      \mhchem@ce@x#1\mhchem@END\mhchem@ENDEND%
    \fi
  \else%
    \mhchem@ce@x#1\mhchem@END\mhchem@ENDEND%
    \space\mhchem@ce@viii#2\mhchem@ENDEND%
  \fi}
    ...   ...   ...   ...   ...   ...
\def\mhchem@ce@x#1#2\mhchem@ENDEND { ... }
\def\mhchem@ce@xi#1#2\mhchem@ENDEND{ ... }
\def\mhchem@ce@xii#1\mhchem@END    { ... }
\def\mhchem@ce@xiii#1{ ... }
```

LuaTeX has an inbuilt parser

lpeg

Adapted example from Wolfgang Schuster

```
local lowercase   = lpeg.R("az")
local uppercase   = lpeg.R("AZ")

  ...   ...   ...   ...   ...   ...
local leftbrace   = lpeg.P("{")
local rightbrace  = lpeg.P("}")
local nobrace     = 1 - (leftbrace + rightbrace)
local nested      = lpeg.P { leftbrace * (csname + sign + nobrace
                                          + lpeg.V(1))^0 * rightbrace }

  ...   ...   ...   ...   ...   ...
local content     = lpeg.Cs(csname + nested + sign + any)
local subscript   = lpeg.P("_")
local superscript = lpeg.P("^")

  ...   ...   ...   ...   ...   ...
  ...   ...   ...   ...   ...   ...
```

Adapted example from Wolfgang Schuster

```
local lowhigh    = lpeg.Cc("\\lohi{%s}{%s}")
                 * subscript   * content * superscript * content / format
local highlow    = lpeg.Cc("\\hilo{%s}{%s}")
                 * superscript * content * subscript   * content / format
local low        =  ...   ...   ...
local high       =  ...   ...   ...
  ...   ...   ...   ...   ...   ...
local parser     = lpeg.Cs((csname + lowhigh + highlow +
                                              low + high + sign + any)^0)
function chemicals.molecule(str) return parser:match(str) end
```

and then

```
\def\molecule#1{\ctxlua{commands.molecule(\!!bs#1\!!es)}}
```

Example: Parsing math operators

- Does an operator have subscripts and superscripts?
- Get subscripts and superscripts from
  - `\command`
  - `\command _ {...}`
  - `\command ^ {...}`
  - `\command _ {...}`
  - `\command ^ {...} _ {...}`
  - `\command _ {...} ^ {...}`
  - `\command \limit ...`
  - `\command \nolimit ...`

Snippet from mathtools.sty by Morton Høgholm

```
\newcommand*\smashoperator[2][lr]{
  \def\MT_smop_use:NNNNN {\@nameuse{MT_smop_smash_#1:NNNNN}}
  \toks@{#2}
  \expandafter\MT_smop_get_args:wwwNnNn
    \the\toks@\@nil\@nil\@nil\@nil\@nil\@nil\@@nil
}
 ...   ...   ...   ...   ...   ...
\def\MT_smop_mathop:n {\mathop}
\def\MT_smop_limits: {\limits}
 ...   ...   ...   ...   ...   ...
\MH_new_boolean:n {smop_one}
\MH_new_boolean:n {smop_two}
 ...   ...   ...   ...   ...   ...
```

Snippet from mathtools.sty by Morton Høgholm

```
\def\MT_smop_get_args:wwwNnNn #1#2#3#4#5#6#7\@@nil{%
  \begingroup
    \def\MT_smop_arg_A: {#1} \def\MT_smop_arg_B: {#2}
    \def\MT_smop_arg_C: {#3} \def\MT_smop_arg_D: {#4}
    \def\MT_smop_arg_E: {#5} \def\MT_smop_arg_F: {#6}
    \def\MT_smop_arg_G: {#7}
      ...   ...   ...   ...   ...   ...
      ...   ...   ...   ...   ...   ...
```

Snippet from mathtools.sty by Morton Høgholm

```
    ...   ...   ...   ...   ...   ...
  \if_meaning:NN \MT_smop_arg_A: \MT_smop_mathop:n
    \if_meaning:NN \MT_smop_arg_C:\MT_smop_limits:
      \def\MT_smop_final_arg_A:{#1{#2}}%
      \if_meaning:NN \MT_smop_arg_D: \@nnil \else:
        \MH_set_boolean_T:n {smop_one}
        \MH_let:NwN \MT_smop_final_arg_B: \MT_smop_arg_D:
        \MH_let:NwN \MT_smop_final_arg_C: \MT_smop_arg_E:
        \if_meaning:NN \MT_smop_arg_F: \@nnil \else:
          \MH_set_boolean_T:n {smop_two}
          \MH_let:NwN \MT_smop_final_arg_D: \MT_smop_arg_F:
          \edef\MT_smop_final_arg_E:
            {\expandafter\MT_smop_remove_nil_vi:N \MT_smop_arg_G: }
        \fi:
    ...   ...   ...   ...   ...   ...
```

Contrast this with the previous lua parser

```
local lowhigh    = lpeg.Cc("\\lohi{%s}{%s}")
              * subscript   * content * superscript * content / format
local highlow    = lpeg.Cc("\\hilo{%s}{%s}")
              * superscript * content * subscript   * content / format
local low        = lpeg.Cc("\\low{%s}")
              * subscript   * content                         / format
local high       = lpeg.Cc("\\high{%s}")
              * superscript * content                         / format

  ...   ...   ...   ...   ...   ...
  ...   ...   ...   ...   ...   ...
local parser     = lpeg.Cs((csname + lowhigh + highlow
                           + low + high + sign + any)^0)
```

Example: Parsing – Calculator math

```
\usemodule[calcmath]
    ...
\calcmath{2/(sqrt(pi)) int(0,∞, exp(-x^2)) dx = 1}
    ...
```

$$\frac{2}{\sqrt{\pi}} \int_{\infty}^{0} e^{-x^2} dx = 1$$

Proof of concept: x-calcmath module

You can do arithmetic without using an abacus

Divide two numbers: pgfmath library > 100 LOC

```
\pgfmathdeclarefunction{divide}{2}{%
  \begingroup%
    \pgfmath@x=#1pt\relax%
    \pgfmath@y=#2pt\relax%
    \let\pgfmath@sign=\pgfmath@empty%
        \ifdim\pgfmath@y=0pt\relax%
            \pgfmath@error{You've asked me to divide `#1' by `#2', %
                but I cannot divide any number by `#2'}%
        \fi%
        \afterassignment\pgfmath@xa%
        \expandafter\c@pgfmath@counta\the\pgfmath@y\relax%
        % If y is an integer, use TeX arithmatic.
        \ifdim\pgfmath@xa=0pt\relax%
            \divide\pgfmath@x by\c@pgfmath@counta\relax%
            \edef\pgfmathresult{\pgfmath@tonumber{\pgfmath@x}}%
            \let\pgfmath@next=\pgfmathdivide@@@%
        \else%
```

Divide two numbers: pgfmath library > 100 LOC

```
% Simple long division.
\ifdim\pgfmath@x<0pt\relax%
    \def\pgfmath@sign{-}%
    \pgfmath@x=-\pgfmath@x%
\fi%
\ifdim\pgfmath@y<0pt\relax ... .... \fi%
\pgfmath@ya=\pgfmath@y%
\c@pgfmath@counta=0\relax%
\ifdim\pgfmath@x>\pgfmath@ya%
    \ifdim\pgfmath@ya<1638.4pt\relax%
        \pgfmathmultiply@dimenbyten\pgfmath@ya%
        \ifdim\pgfmath@ya>\pgfmath@x%
            \pgfmathdivide@dimenbyten\pgfmath@ya%
            \c@pgfmath@counta=0\relax%
        \else%
        ...   ...   Repeat four times ...   ...
\fi\fi\fi\fi\fi\fi\fi\fi\fi
```

Divide two numbers: pgfmath library > 100 LOC

```
            % If y < 1pt use reciprocal function.
            \ifdim\pgfmath@y<1pt\relax%
                \ifdim\pgfmath@y<.00007pt\relax%
                    \pgfmath@error{The result of `#1/#2' is too big for me}{}%
                \fi%
                \pgfmathreciprocal@{\pgfmath@tonumber{\pgfmath@y}}%
                \pgfmath@x=\pgfmathresult\pgfmath@x%
                \edef\pgfmathresult{\pgfmath@tonumber{\pgfmath@x}}%
                \let\pgfmath@next=\pgfmathdivide@@@%
            \else%
                \pgfmath@y=\pgfmath@ya%
                \def\pgfmathresult{}%
                \let\pgfmath@next=\pgfmathdivide@@%
            \fi%
        \fi%
        \pgfmath@next%
}
```

Trigonometric functions : pgfmath library

```
\pgfmathdeclarefunction{sin}{1}{%
    % Let #1 = a.b
    % Then sin(#1) \approx (1-b)*sin(a) + b*sin(a+1)
    \begingroup%
        \expandafter\pgfmath@x#1pt\relax%
        % ...   Get x to be between 0 and 180  ...
        % Now 0 <= x < 179. So split x into integer and decimal...
        \afterassignment\pgfmath@xa%
        \expandafter\c@pgfmath@counta\the\pgfmath@x\relax%
        % ...if #1 is an integer, don't do anything fancy.
        \ifdim\pgfmath@xa=0pt%
          \expandafter\pgfmath@x\csname pgfmath@cos@
          \the\c@pgfmath@counta\endcsname pt\relax%
        \else
          ...   ...   ...   ...   ...   ...
          \expandafter\advance\expandafter\pgfmath@x
          \csname pgfmath@cos@\the\c@pgfmath@counta\endcsname\pgfmath@xa%
        \fi%
    \endgroup}
```

Trigonometric functions : pgfmath library

```
\def\pgfmath@def#1#2#3{\expandafter\def\csname pgfmath@#1@#2\endcsname{#3}}
  ...   ...   ...   ...   ...   ...
\pgfmath@def{cos}{0}{1.00000}          \pgfmath@def{cos}{1}{0.99985}
\pgfmath@def{cos}{2}{0.99939}          \pgfmath@def{cos}{3}{0.99863}
  ...   ...   ...   ...   ...   ...
  ...   ...   ...   ...   ...   ...
\pgfmath@def{cos}{178}{-0.99939}       \pgfmath@def{cos}{179}{-0.99985}
\pgfmath@def{cos}{180}{-1.00000}       \pgfmath@def{cos}{181}{-0.99985}
  ...   ...   ...   ...   ...   ...
  ...   ...   ...   ...   ...   ...
  Similar tables for atan and acos
  ...   ...   ...   ...   ...   ...
  ...   ...   ...   ...   ...   ...
```

Arithmetic in luaTeX

```
\pgfmathdeclarefunction{divide}{2}%
  {\def\pgfmathresult{\ctxlua{context(#1/#2)}}}
```

```
\pgfmathdeclarefunction{sin}{1}%
  {\def\pgfmathresult{\ctxlua{context(math.sin(#1*2*pi/360))}}}
```

You can write loops without worrying about expansion

Simple loops

How can you typeset

(+)	1	2	3	4	5	6
1	2	3	4	5	6	7
2	3	4	5	6	7	8
3	4	5	6	7	8	9
4	5	6	7	8	9	10
5	6	7	8	9	10	11
6	7	8	9	10	11	12

Question on ntg-context

Natural tables in ConTeXt

```
\setupTABLE[each][each][width=2em,height=2em,align={middle,middle}]
\setupTABLE[r][1][background=color,backgroundcolor=gray]
\setupTABLE[c][1][background=color,backgroundcolor=gray]
```

```
\bTABLE
  \bTR \bTD $(+)$ \eTD \bTD 1 \eTD \bTD 2 \eTD  ... ...  \eTR
  \bTR \bTD   1   \eTD \bTD 2 \eTD \bTD 3 \eTD  ... ...  \eTR
  \bTR \bTD   2   \eTD \bTD 3 \eTD \bTD 4 \eTD  ... ...  \eTR
   ...   ...   ...   ...   ...   ...
   ...   ...   ...   ...   ...   ...
\eTABLE
```

Write a simple loop

```
start_table
start_table_row
   table_element("(+)")
    for y in [1..6] do
      table_element(y)
stop_table_row
for x in [1..6] do
  start_table_row
    table_element(x)
    for y in [1..6] do
      table_element(x+y)
    end
  stop_table_row
end
stop_table
```

Simple loops can be difficult in TeX

```
\bTABLE
 \bTR
  \bTD $(+)$ \eTD
  \dorecurse{6}
   {\bTD \recurselevel \eTD}
  \eTR
\dorecurse{6}
 {\bTR
     \bTD \recurselevel \eTD
     \edef\firstrecurselevel{\recurselevel}
  \dorecurse{6}
    {\bTD \the\numexpr\firstrecurselevel+\recurselevel \eTD}
  \eTR}
\eTABLE
```

Expansion,
expansion, expansion

Sprinkle \expandafter according to taste

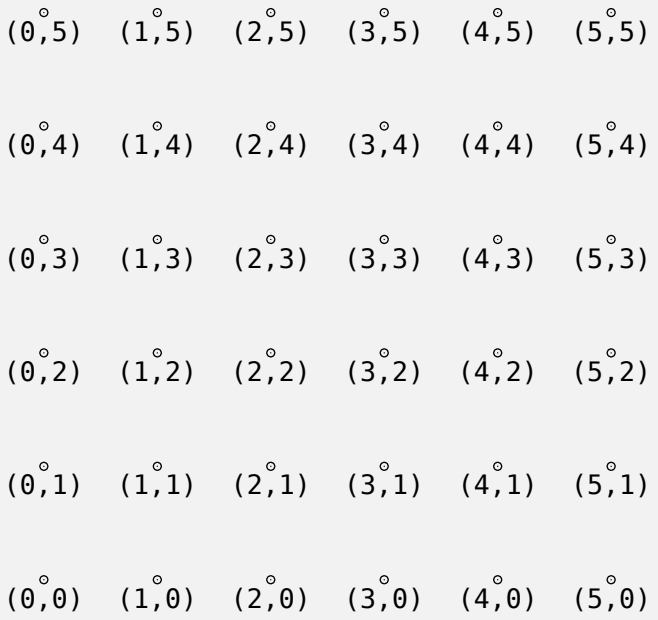
```
\bTABLE
 \bTR
  \bTD $(+)$ \eTD
  \dorecurse{6}
   {\expandafter \bTD \recurselevel \eTD}
  \eTR
\dorecurse{6}
 {\bTR
     \edef\firstrecurselevel{\recurselevel}
     \expandafter\bTD \recurselevel \eTD
  \dorecurse{6}
    {\expandafter\bTD
       \the\numexpr\firstrecurselevel+\recurselevel\relax
     \eTD}
  \eTR}
```

ConTeXt Lua Document – cld files

```
context.bTABLE()
context.bTR()
  context.bTD(); context("$(+)$"); context.eTD();
  for y = 1,6 do
    context.bTD(); context(y); context.eTD() ;
  end
context.eTR()
for x = 1,6 do
  context.bTR()
    context.bTD(); context(x); context.eTD() ;
    for y = 1,6 do
      context.bTD(); context(x+y); context.eTD() ;
    end
  context.eTR()
end
context.eTABLE()
```

Metapost : Labels in loops

Draw a grid of points with labels



Labels in loops – luaTeX to the rescue

```
\startluacode
  context.startMPcode()
  context("numeric u ; u = 2cm ;")
  for x = 0,5 do
    for y = 0,5 do
      context("drawdot(" .. x .. "*u," ..
                            y .. "*u); \n") ;
      context("label.bot(" ..
              "btex (" .. x .. "," .. y .. ") etex," ..
               "(" .. x .. "*u," .. y .. "*u)) ;")
    end
  end
  context.stopMPcode()
\stopluacode
```

You can do everything in TeX. After all, TeX is a Turing machine ... and programming in TeX is as convenient as programming a Turing machine.

Reinhard Kotucha on texhax, quoting Klaus Lagally

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luaTeX is changing this!