The luakeys package

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```lua
local result = luakeys.parse(
  'level1={level2={naked,dim=1cm,bool=false,num=-0.001,str="lua,{}"}}',
  { convert_dimensions = true })
luakeys.debug(result)
```

Result:

```
{
  ['level1'] = {
    ['level2'] = {
      ['naked'] = true,
      ['dim'] = 1864679,
      ['bool'] = false,
      ['num'] = -0.001,
      ['str'] = 'lua,{}',
    }
  }
}
```

Contents

1 Introduction

`luakeys` is a Lua module / LuaTEXpackage that can parse key-value options like the TEX packages keyval, kvsetkeys, kvoptions, xkeyval, pgfkeys etc. `luakeys`, however, accomplishes this task by using the Lua language and doesn't rely on TEX. Therefore this package can only be used with the TEX engine LuaTEX. Since `luakeys` uses LPeg, the parsing mechanism should be pretty robust.

The TUGboat article "Implementing key–value input: An introduction" (Volume 30 (2009), No. 1) by *Joseph Wright* and *Christian Feuersänger* gives a good overview of the available key-value packages.

This package would not be possible without the article "Parsing complex data formats in LuaTEX with LPEG" (Volume 40 (2019), No. 2).

1.1 Pros of `luakeys`

- Key-value pairs can be parsed independently of the macro collection (LATEX or ConTEXt).
- Even in plain LuaTEX keys can be parsed.
- `luakeys` can handle nested lists of key-value pairs, i.e. it can handle a recursive data structure of keys.
- Keys do not have to be defined, but can they can be defined.

1.2 Cons of `luakeys`

- The package works only in combination with LuaTEX.
- You need to know two languages: TEX and Lua.

2 How the package is loaded

2.1 Using the Lua module `luakeys.lua`

The core functionality of this package is realized in Lua. So you can use `luakeys` even without using the wrapper files `luakeys.sty` and `luakeys.tex`.

```
\documentclass{article}
\directlua{
  luakeys = require('luakeys')
}

\newcommand{\helloworld}[2][]{
  \directlua{
    local keys = luakeys.parse('\luaescapestring{\unexpanded{#1}}')
    luakeys.debug(keys)
    local marg = '#2'
    tex.print(keys.greeting .. ', ' .. marg .. keys.punctuation)
  }
}
\begin{document}
\helloworld[greeting=hello,punctuation=!]{world} % hello, world!
\end{document}
```

2.2 Using the LuaLaTeX wrapper `luakeys.sty`

For example, the MiKTeX package manager downloads packages only when needed. It has been reported that this automatic download only works with this wrapper files. Probably MiKTeX is searching for an occurrence of the LaTeX macro "`\usepackage {luakeys}`". The supplied LuaLaTeX file is quite small:

```
\NeedsTeXFormat{LaTeX2e}
\ProvidesPackage{luakeys}
\directlua{luakeys = require('luakeys')}
```

It loads the Lua module into the global variable `luakeys`.

```
\documentclass{article}
\usepackage{luakeys}

\begin{document}
  \directlua{
    local keys = luakeys.parse('one,two,three', { naked_as_value = true })
    tex.print(keys[1])
    tex.print(keys[2])
    tex.print(keys[3])
  } % one two three
\end{document}
```

2.3 Using the plain LuaTeX wrapper `luakeys.tex`

Even smaller is the file `luakeys.tex`. It consists of only one line:

```
\directlua{luakeys = require('luakeys')}
```

It does the same as the LuaLaTeX wrapper and loads the Lua module `luakeys.lua` into the global variable `luakeys`.

```
\input luakeys.tex

\directlua{
  local keys = luakeys.parse('one,two,three', { naked_as_value = true })
  tex.print(keys[1])
  tex.print(keys[2])
  tex.print(keys[3])
} % one two three
\bye
```

3 Lua interface / API

The Lua module exports this functions and tables:

```
local luakeys = require('luakeys')
local version = luakeys.version
local opts = luakeys.opts
local stringify = luakeys.stringify
local define = luakeys.define
local parse = luakeys.parse
local render = luakeys.render
local debug = luakeys.debug
local save = luakeys.save
```

```
local get = luakeys.get
local is = luakeys.is
```

This documentation presents only the public functions and tables. To learn more about the private, not exported functions, please read the source code documentation, which was created with LDoc.

3.1 Lua indentifier names

The project uses a few abbreviations for variable names that are hopefully unambiguous and familiar to external readers.

Abbreviation	spelled out	Example
`kv_string`	Key-value string	`'key=value'`
`opts`	Options (for the parse function)	`{ no_error = false }`
`defs`	Definitions	
`def`	Definition	
`attr`	Attributes (of a definition)	

These unabbreviated variable names are commonly used.

`result`	The final result of all individual parsing and normalization steps.
`unknown`	A table with unknown, undefinied key-value pairs.
`raw`	The raw result of the Lpeg grammar parser.

3.2 Function "`parse(kv_string, opts): result, unknown, raw`"

The function `parse(kv_string, opts)` is the most important function of the package. It converts a key-value string into a Lua table.

```
\documentclass{article}
\usepackage{luakeys}
\begin{document}
\newcommand{\mykeyvalcmd}[2][]{
  \directlua{
    local result = luakeys.parse('#1')
    tex.print('The key "one" has the value ' .. tostring(result.one) .. '.')
  }
  marg: #2
}
\mykeyvalcmd[one=1]{test}
\end{document}
```

In plain TEX:

```
\input luakeys.tex
\def\mykeyvalcmd#1{
  \directlua{
    local result = luakeys.parse('#1')
    tex.print('The key "one" has the value ' .. tostring(result.one) .. '.')
  }
}
\mykeyvalcmd{one=1}
\bye
```

3.3 Options to configure the `parse` function

The `parse` function can be called with an options table. This options are supported: assignment_operator, convert_dimensions, debug, default, defaults, defs, false_aliases, format_keys, group_begin, group_end, hooks, invert_flag, list_separator, naked_as_value, no_error, quotation_begin, quotation_end, true_aliases, unpack

```lua
local opts = {
  -- Configure the delimiter that assigns a value to a key.
  assignment_operator = '=',

  -- Automatically convert dimensions into scaled points (1cm -> 1864679).
  convert_dimensions = false,

  -- Print the result table to the console.
  debug = false,

  -- The default value for naked keys (keys without a value).
  default = true,

  -- A table with some default values. The result table is merged with
  -- this table.
  defaults = { key = 'value' },

  -- Key-value pair definitions.
  defs = { key = { default = 'value' } },

  -- Specify the strings that are recognized as boolean false values.
  false_aliases = { 'false', 'FALSE', 'False' },

  -- lower, snake, upper
  format_keys = { 'snake' },

  -- Configure the delimiter that marks the beginning of a group.
  group_begin = '{',

  -- Configure the delimiter that marks the end of a group.
  group_end = '}',

  -- Listed in the order of execution
  hooks = {
    kv_string = function(kv_string)
      return kv_string
    end,

    -- Visit all key-value pairs recursively.
    keys_before_opts = function(key, value, depth, current, result)
      return key, value
    end,

    -- Visit the result table.
    result_before_opts = function(result)
    end,

    -- Visit all key-value pairs recursively.
    keys_before_def = function(key, value, depth, current, result)
      return key, value
    end,
```

```
    -- Visit the result table.
    result_before_def = function(result)
    end,

    -- Visit all key-value pairs recursively.
    keys = function(key, value, depth, current, result)
      return key, value
    end,

    -- Visit the result table.
    result = function(result)
    end,
  },

  invert_flag = '!',

  -- Configure the delimiter that separates list items from each other.
  list_separator = ',',

  -- If true, naked keys are converted to values:
  -- { one = true, two = true, three = true } -> { 'one', 'two', 'three' }
  naked_as_value = false,

  -- Throw no error if there are unknown keys.
  no_error = false,

  -- Configure the delimiter that marks the beginning of a string.
  quotation_begin = '"',

  -- Configure the delimiter that marks the end of a string.
  quotation_end = '"',

  -- Specify the strings that are recognized as boolean true values.
  true_aliases = { 'true', 'TRUE', 'True' },

  -- { key = { 'value' } } -> { key = 'value' }
  unpack = false,
}
```

The options can also be set globally using the exported table `opts`:

```
local result = luakeys.parse('dim=1cm') -- { dim = '1cm' }
```

```
luakeys.opts.convert_dimensions = true
local result2 = luakeys.parse('dim=1cm') -- { dim = 1234567 }
```

3.3.1 Option “assignment_operator”

The option `assignment_operator` configures the delimiter that assigns a value to a key. The default value of this option is `"="`.

The code example below demonstrates all six delimiter related options.

```
local result = luakeys.parse(
  'level1: ( key1: value1; key2: "A string;" )', {
    assignment_operator = ':',
    group_begin = '(',
    group_end = ')',
    list_separator = ';',
```

```
    quotation_begin = '"',
    quotation_end = '"',
  })
luakeys.debug(result) -- { level1 = { key1 = 'value1', key2 = 'A string;' } }
```

Delimiter options	Section
assignment_operator	3.3.1
group_begin	3.3.9
group_end	3.3.10
list_separator	3.3.13
quotation_begin	3.3.16
quotation_end	3.3.17

3.3.2 Option "convert_dimensions"

If you set the option `convert_dimensions` to `true`, `luakeys` detects the TEX dimensions and converts them into scaled points using the function `tex.sp(dim)`.

```
local result = luakeys.parse('dim=1cm', {
  convert_dimensions = true,
})
-- result = { dim = 1864679 }
```

By default the dimensions are not converted into scaled points.

```
local result = luakeys.parse('dim=1cm', {
  convert_dimensions = false,
})
-- or
result = luakeys.parse('dim=1cm')
-- result = { dim = '1cm' }
```

If you want to convert a scaled points number into a dimension string you can use the module lualibs-util-dim.lua.

```
require('lualibs')
tex.print(number.todimen(tex.sp('1cm'), 'cm', '%0.0F%s'))
```

The default value of the option "convert_dimensions" is: `false`.

3.3.3 Option "debug"

If the option `debug` is set to ture, the result table is printed to the console.

```
\documentclass{article}
\usepackage{luakeys}
\begin{document}
\directlua{
  luakeys.parse('one,two,three', { debug = true })
}
Lorem ipsum
\end{document}
```

```
This is LuaHBTeX, Version 1.15.0 (TeX Live 2022)
...
(./debug.aux) (/usr/local/texlive/texmf-dist/tex/latex/base/ts1cmr.fd)
```

```
{
  ['three'] = true,
  ['two'] = true,
  ['one'] = true,
}
 [1{/usr/
local/texlive/2022/texmf-var/fonts/map/pdftex/updmap/pdftex.map}] (./debug.aux)
)
...
Transcript written on debug.log.
```

The default value of the option "debug" is: false.

3.3.4 Option "default"

The option default can be used to specify which value naked keys (keys without a value) get. This option has no influence on keys with values.

```
local result = luakeys.parse('naked', { default = 1 })
luakeys.debug(result) -- { naked = 1 }
```

By default, naked keys get the value true.

```
local result2 = luakeys.parse('naked')
luakeys.debug(result2) -- { naked = true }
```

The default value of the option "default" is: true.

3.3.5 Option "defaults"

The option "defaults" can be used to specify not only one default value, but a whole table of default values. The result table is merged into the defaults table. Values in the defaults table are overwritten by values in the result table.

```
local result = luakeys.parse('key1=new', {
  defaults = { key1 = 'default', key2 = 'default' },
})
luakeys.debug(result) -- { key1 = 'new', key2 = 'default' }
```

The default value of the option "defaults" is: false.

3.3.6 Option "defs"

For more informations on how keys are defined, see section 3.4. If you use the defs option, you don't need to call the define function. Instead of ...

```
local parse = luakeys.define({ one = { default = 1 }, two = { default = 2 } })
local result = parse('one,two') -- { one = 1, two = 2 }
```

we can write ...

```
local result2 = luakeys.parse('one,two', {
  defs = { one = { default = 1 }, two = { default = 2 } },
}) -- { one = 1, two = 2 }
```

The default value of the option "`defs`" is: `false`.

3.3.7 Option "`false_aliases`"

The `true_aliases` and `false_aliases` options can be used to specify the strings that will be recognized as boolean values by the parser. The following strings are configured by default.

```
local result = luakeys.parse('key=yes', {
  true_aliases = { 'true', 'TRUE', 'True' },
  false_aliases = { 'false', 'FALSE', 'False' },
})
luakeys.debug(result) -- { key = 'yes' }
```

```
local result2 = luakeys.parse('key=yes', {
  true_aliases = { 'on', 'yes' },
  false_aliases = { 'off', 'no' },
})
luakeys.debug(result2) -- { key = true }
```

```
local result3 = luakeys.parse('key=true', {
  true_aliases = { 'on', 'yes' },
  false_aliases = { 'off', 'no' },
})
luakeys.debug(result3) -- { key = 'true' }
```

See section 3.3.18 for the corresponding option.

3.3.8 Option "`format_keys`"

With the help of the option `format_keys` the keys can be formatted. The values of this option must be specified in a table.

lower To convert all keys to *lowercase*, specify `lower` in the options table.

```
local result = luakeys.parse('KEY=value', { format_keys = { 'lower' } })
luakeys.debug(result) -- { key = 'value' }
```

snake To make all keys *snake case* (The words are separated by underscores), specify `snake` in the options table.

```
local result2 = luakeys.parse('snake case=value', { format_keys = {
↪  'snake' } })
luakeys.debug(result2) -- { snake_case = 'value' }
```

upper To convert all keys to *uppercase*, specify `upper` in the options table.

```
local result3 = luakeys.parse('key=value', { format_keys = { 'upper' }
↪  })
luakeys.debug(result3) -- { KEY = 'value' }
```

You can also combine several types of formatting.

```
local result4 = luakeys.parse('Snake Case=value', { format_keys = { 'lower',
↪  'snake' } })
luakeys.debug(result4) -- { snake_case = 'value' }
```

The default value of the option "`format_keys`" is: `false`.

3.3.9 Option "`group_begin`"

The option `group_begin` configures the delimiter that marks the beginning of a group. The default value of this option is `"{"`. A code example can be found in section 3.3.1.

3.3.10 Option "`group_end`"

The option `group_end` configures the delimiter that marks the end of a group. The default value of this option is `"}"`. A code example can be found in section 3.3.1.

3.3.11 Option "`invert_flag`"

If a naked key is prefixed with an exclamation mark, its default value is inverted. Instead of `true` the key now takes the value `false`.

```
local result = luakeys.parse('naked1,!naked2')
luakeys.debug(result) -- { naked1 = true, naked2 = false }
```

The `invert_flag` option can be used to change this inversion character.

```
local result2 = luakeys.parse('naked1,~naked2', { invert_flag = '~' })
luakeys.debug(result2) -- { naked1 = true, naked2 = false }
```

For example, if the default value for naked keys is set to `false`, the naked keys prefixed with the invert flat take the value `true`.

```
local result3 = luakeys.parse('naked1,!naked2', { default = false })
luakeys.debug(result3) -- { naked1 = false, naked2 = true }
```

Set the `invert_flag` option to `false` to disable this automatic boolean value inversion.

```
local result4 = luakeys.parse('naked1,!naked2', { invert_flag = false })
luakeys.debug(result4) -- { naked1 = true, ['!naked2'] = true }
```

3.3.12 Option "`hooks`"

The following hooks or callback functions allow to intervene in the processing of the `parse` function. The functions are listed in processing order. `*_before_opts` means that the hooks are executed after the LPeg syntax analysis and before the options are applied. The `*_before_defs` hooks are executed before applying the key value definitions.

1. `kv_string  = function(kv_string): kv_string`
2. `keys_before_opts  = function(key, value, depth, current, result): key, value`

3. `result_before_opts = function(result): void`
4. `keys_before_def = function(key, value, depth, current, result): key, value`
5. `result_before_def = function(result): void`
6. (`process`) (has to be definied using defs, see 3.5.12)
7. `keys = function(key, value, depth, current, result): key, value`
8. `result = function(result): void`

`kv_string` The `kv_string` hook is called as the first of the hook functions before the LPeg syntax parser is executed.

```
local result = luakeys.parse('key=unknown', {
  hooks = {
    kv_string = function(kv_string)
      return kv_string:gsub('unknown', 'value')
    end,
  },
})
luakeys.debug(result) -- { key = 'value' }
```

`keys_*` The hooks `keys_*` are called recursively on each key in the current result table. The hook function must return two values: `key`, `value`. The following example returns `key` and `value` unchanged, so the result table is not changed.

```
local result = luakeys.parse('l1={l2=1}', {
  hooks = {
    keys = function(key, value)
      return key, value
    end,
  },
})
luakeys.debug(result) -- { l1 = { l2 = 1 } }
```

The next example demonstrates the third parameter `depth` of the hook function.

```
local result = luakeys.parse('x,d1={x,d2={x}}', {
  naked_as_value = true,
  unpack = false,
  hooks = {
    keys = function(key, value, depth)
      if value == 'x' then
        return key, depth
      end
      return key, value
    end,
  },
})
luakeys.debug(result) -- { 1, d1 = { 2, d2 = { 3 } } }
```

`result_*` The hooks `result_*` are called once with the current result table as a parameter.

3.3.13 Option "list_separator"

The option `list_separator` configures the delimiter that separates list items from each other. The default value of this option is `","`. A code example can be found in section 3.3.1.

3.3.14 Option "naked_as_value"

With the help of the option `naked_as_value`, naked keys are not given a default value, but are stored as values in a Lua table.

```
local result = luakeys.parse('one,two,three')
luakeys.debug(result) -- { one = true, two = true, three = true }
```

If we set the option `naked_as_value` to `true`:

```
local result2 = luakeys.parse('one,two,three', { naked_as_value = true })
luakeys.debug(result2)
-- { [1] = 'one', [2] = 'two', [3] = 'three' }
-- { 'one', 'two', 'three' }
```

The default value of the option "`naked_as_value`" is: `false`.

3.3.15 Option "no_error"

By default the parse function throws an error if there are unknown keys. This can be prevented with the help of the `no_error` option.

```
  luakeys.parse('unknown', { defs = { 'key' } })
  -- Error message: Unknown keys: unknown,
```

If we set the option `no_error` to `true`:

```
luakeys.parse('unknown', { defs = { 'key' }, no_error = true })
-- No error message
```

The default value of the option "`no_error`" is: `false`.

3.3.16 Option "quotation_begin"

The option `quotation_begin` configures the delimiter that marks the beginning of a string. The default value of this option is `'"'` (double quotes). A code example can be found in section 3.3.1.

3.3.17 Option "quotation_end"

The option `quotation_end` configures the delimiter that marks the end of a string. The default value of this option is `'"'` (double quotes). A code example can be found in section 3.3.1.

3.3.18 Option "true_aliases"

See section 3.3.7.

3.3.19 Option "unpack"

With the help of the option `unpack`, all tables that consist of only a single naked key or a single standalone value are unpacked.

```
local result = luakeys.parse('key={string}', { unpack = true })
luakeys.debug(result) -- { key = 'string' }
```

```
local result2 = luakeys.parse('key={string}', { unpack = false })
luakeys.debug(result2) -- { key = { string = true } }
```

The default value of the option "`unpack`" is: `true`.

3.4 Function "`define(defs, opts): parse`"

The `define` function returns a `parse` function (see 3.2). The name of a key can be specified in three ways:

1. as a string.
2. as a key in a Lua table. The definition of the corresponding key-value pair is then stored under this key.
3. by the "name" attribute.

```
-- standalone string values
local defs = { 'key' }

-- keys in a Lua table
local defs = { key = {} }

-- by the "name" attribute
local defs = { { name = 'key' } }

local parse = luakeys.define(defs)
local result, unknown = parse('key=value,unknown=unknown', { no_error = true
↪  })
luakeys.debug(result) -- { key = 'value' }
luakeys.debug(unknown) -- { unknown = 'unknown' }
```

For nested definitions, only the last two ways of specifying the key names can be used.

```
local parse2 = luakeys.define({
  level1 = {
    sub_keys = { level2 = { sub_keys = { key = { } } } },
  },
}, { no_error = true })
local result2, unknown2 =
↪  parse2('level1={level2={key=value,unknown=unknown}}')
luakeys.debug(result2) -- { level1 = { level2 = { key = 'value' } } }
luakeys.debug(unknown2) -- { level1 = { level2 = { unknown = 'unknown' } } }
```

3.5 Attributes to define a key-value pair

The definition of a key-value pair can be made with the help of various attributes. The name *"attribute"* for an option, a key, a property ... (to list just a few naming possibilities) to define keys, was deliberately chosen to distinguish them from the options of the `parse` function. These attributes are allowed: alias, always_present, choices, data_type, default, exclusive_group, l3_tl_set, macro, match, name, opposite_keys, pick, process, required, sub_keys. The code example below lists all the attributes that can be used to define key-value pairs.

```
local defs = {
  key = {
    -- Allow different key names.
    -- or a single string: alias = 'k'
    alias = { 'k', 'ke' },

    -- The key is always included in the result. If no default value is
    -- definied, true is taken as the value.
    always_present = false,

    -- Only values listed in the array table are allowed.
    choices = { 'one', 'two', 'three' },

    -- Possible data types: boolean, dimension, integer, number, string
    data_type = 'string',

    default = true,

    -- The key belongs to a mutually exclusive group of keys.
    exclusive_group = 'name',

    -- > \MacroName
    macro = 'MacroName', -- > \MacroName

    -- See http://www.lua.org/manual/5.3/manual.html#6.4.1
    match = '^%d%d%d%-%d%d%-%d%d$',

    -- The name of the key, can be omitted
    name = 'key',
    opposite_keys = { [true] = 'show', [false] = 'hide' },

    -- Pick a value
    -- boolean
    pick = false,

    process = function(value, input, result, unknown)
      return value
    end,
    required = true,
    sub_keys = { key_level_2 = { } },
  }
}
```

3.5.1 Attribute "alias"

With the help of the `alias` attribute, other key names can be used. The value is always stored under the original key name. A single alias name can be specified by a string ...

```lua
-- a single alias
local parse = luakeys.define({ key = { alias = 'k' } })
local result = parse('k=value')
luakeys.debug(result) -- { key = 'value' }
```

multiple aliases by a list of strings.

```lua
-- multiple aliases
local parse = luakeys.define({ key = { alias = { 'k', 'ke' } } })
local result = parse('ke=value')
luakeys.debug(result) -- { key = 'value' }
```

3.5.2 Attribute "always_present"

The `default` attribute is used only for naked keys.

```lua
local parse = luakeys.define({ key = { default = 1 } })
local result = parse('') -- { }
```

If the attribute `always_present` is set to true, the key is always included in the result. If no default value is definied, true is taken as the value.

```lua
local parse = luakeys.define({ key = { default = 1, always_present = true } })
local result = parse('') -- { key =  1 }
```

3.5.3 Attribute "choices"

Some key values should be selected from a restricted set of choices. These can be handled by passing an array table containing choices.

```lua
local parse = luakeys.define({ key = { choices = { 'one', 'two', 'three' } }
↪  })
local result = parse('key=one') -- { key = 'one' }
```

When the key-value pair is parsed, values will be checked, and an error message will be displayed if the value was not one of the acceptable choices:

```lua
    parse('key=unknown')
    -- error message:
    --- 'The value "unknown" does not exist in the choices: one, two, three!'
```

3.5.4 Attribute "data_type"

The `data_type` attribute allows type-checking and type conversions to be performed. The following data types are supported: `'boolean'`, `'dimension'`, `'integer'`, `'number'`, `'string'`. A type conversion can fail with the three data types `'dimension'`, `'integer'`, `'number'`. Then an error message is displayed.

```lua
local function assert_type(data_type, input_value, expected_value)
  assert.are.same({ key = expected_value },
    luakeys.parse('key=' .. tostring(input_value),
      { defs = { key = { data_type = data_type } } }))
end
```

```
  assert_type('boolean', 'true', true)
  assert_type('dimension', '1cm', '1cm')
  assert_type('integer', '1.23', 1)
  assert_type('number', '1.23', 1.23)
  assert_type('string', 1.23, '1.23')
```

3.5.5 Attribute "default"

Use the `default` attribute to provide a default value for each naked key individually. With the global `default` attribute (3.3.4) a default value can be specified for all naked keys.

```
local parse = luakeys.define({
  one = {},
  two = { default = 2 },
  three = { default = 3 },
}, { default = 1, defaults = { four = 4 } })
local result = parse('one,two,three') -- { one = 1, two = 2, three = 3, four =
↪  4 }
```

3.5.6 Attribute "exclusive_group"

All keys belonging to the same exclusive group must not be specified together. Only one key from this group is allowed. Any value can be used as a name for this exclusive group.

```
local parse = luakeys.define({
  key1 = { exclusive_group = 'group' },
  key2 = { exclusive_group = 'group' },
})
local result1 = parse('key1') -- { key1 = true }
local result2 = parse('key2') -- { key2 = true }
```

If more than one key of the group is specified, an error message is thrown.

```
    parse('key1,key2') -- throws error message:
    -- 'The key "key2" belongs to a mutually exclusive group "group"
    -- and the key "key1" is already present!'
```

3.5.7 Attribute "opposite_keys"

The `opposite_keys` attribute allows to convert opposite (naked) keys into a boolean value and store this boolean under a target key. Lua allows boolean values to be used as keys in tables. However, the boolean values must be written in square brackets, e. g. `opposite_keys = { [true] = 'show', [false] = 'hide' }`. Examples of opposing keys are: `show` and `hide`, `dark` and `light`, `question` and `solution`. The example below uses the `show` and `hide` keys as the opposite key pair. If the key `show` is parsed by the `parse` function, then the target key `visibility` receives the value `true`.

```
local parse = luakeys.define({
  visibility = { opposite_keys = { [true] = 'show', [false] = 'hide' } },
})
local result = parse('show') -- { visibility = true }
```

If the key `hide` is parsed, then `false`.

```
local result = parse('hide') -- { visibility = false }
```

3.5.8 Attribute “macro”

The attribute `macro` stores the value in a TEX macro.

```
local parse = luakeys.define({
  key = {
    macro = 'MyMacro'
  }
})
parse('key=value')
```

```
\MyMacro % expands to "value"
```

3.5.9 Attribute “match”

The value of the key is first passed to the Lua function `string.match(value, match)` (http://www.lua.org/manual/5.3/manual.html#pdf-string.match) before being assigned to the key. You can therefore configure the `match` attribute with a pattern matching string used in Lua. Take a look at the Lua manual on how to write patterns (http://www.lua.org/manual/5.3/manual.html#6.4.1).

```
local parse = luakeys.define({
  birthday = { match = '^%d%d%d%d%-%d%d%-%d%d$' },
})
local result = parse('birthday=1978-12-03') -- { birthday = '1978-12-03' }
```

If the pattern cannot be found in the value, an error message is issued.

```
    parse('birthday=1978-12-XX')
    -- throws error message:
    -- 'The value "1978-12-XX" of the key "birthday"
    --  does not match "^%d%d%d%d%-%d%d%-%d%d$"!'
```

The key receives the result of the function `string.match(value, match)`, which means that the original value may not be stored completely in the key. In the next example, the entire input value is accepted:

```
local parse = luakeys.define({ year = { match = '%d%d%d%d' } })
local result = parse('year=1978') -- { year = '1978' }
```

The prefix “waste ” and the suffix “ rubbisch” of the string are discarded.

```
local result2 = parse('year=waste 1978 rubbisch') -- { year = '1978' }
```

Since function `string.match(value, match)` always returns a string, the value of the key is also always a string.

3.5.10 Attribute “name”

The `name` attribute allows an alternative notation of key names. Instead of ...

```
local parse1 = luakeys.define({
  one = { default = 1 },
  two = { default = 2 },
})
local result1 = parse1('one,two') -- { one = 1, two = 2 }
```

... we can write:

```
local parse = luakeys.define({
  { name = 'one', default = 1 },
  { name = 'two', default = 2 },
})
local result = parse('one,two') -- { one = 1, two = 2 }
```

3.5.11 Attribute "pick"

The attribute `pick` searches for a value not assigned to a key. The first value found, i.e. the one further to the left, is assigned to a key.

```
local parse = luakeys.define({ font_size = { pick = 'dimension' } })
local result = parse('12pt,13pt', { no_error = true })
luakeys.debug(result) -- { font_size = '12pt' }
```

Only the current result table is searched, not other levels in the recursive data structure.

```
local parse = luakeys.define({
  level1 = {
    sub_keys = { level2 = { default = 2 }, key = { pick = 'boolean' } },
  },
}, { no_error = true })
local result, unknown = parse('true,level1={level2,true}')
luakeys.debug(result) -- { level1 = { key = true, level2 = 2 } }
luakeys.debug(unknown) -- { true }
```

The search for values is activated when the attribute `pick` is set to a data type. These data types can be used to search for values: any, dimension, boolean, integer, string, number. Use the data type "any" to accept any value. If a value is already assigned to a key when it is entered, then no further search for values is performed.

```
local parse = luakeys.define({ font_size = { pick = 'dimension' } })
local result, unknown =
  parse('font_size=11pt,12pt', { no_error = true })
luakeys.debug(result) -- { font_size = '11pt' }
luakeys.debug(unknown) -- { '12pt' }
```

The `pick` attribute also accepts multiple data types specified in a table.

```
local parse = luakeys.define({
  key = { pick = { 'number', 'dimension' } },
})
local result = parse('string,12pt,42', { no_error = true })
luakeys.debug(result) -- { key = 42 }
local result2 = parse('string,12pt', { no_error = true })
luakeys.debug(result2) -- { key = '12pt' }
```

3.5.12 Attribute "process"

The `process` attribute can be used to define a function whose return value is passed to the key. Four parameters are passed when the function is called:

1. `value`: The current value asssociated with the key.
2. `input`: The result table cloned before the time the definitions started to be applied.
3. `result`: The table in which the final result will be saved.
4. `unknown`: The table in which the unknown key-value pairs are stored.

The following example demonstrates the `value` parameter:

```
local parse = luakeys.define({
  key = {
    process = function(value, input, result, unknown)
      if type(value) == 'number' then
        return value + 1
      end
      return value
    end,
  },
})
local result = parse('key=1') -- { key = 2 }
```

The following example demonstrates the `input` parameter:

```
local parse = luakeys.define({
  'one',
  'two',
  key = {
    process = function(value, input, result, unknown)
      value = input.one + input.two
      result.one = nil
      result.two = nil
      return value
    end,
  },
})
local result = parse('key,one=1,two=2') -- { key = 3 }
```

The following example demonstrates the `result` parameter:

```
local parse = luakeys.define({
  key = {
    process = function(value, input, result, unknown)
      result.additional_key = true
      return value
    end,
  },
})
local result = parse('key=1') -- { key = 1, additional_key = true }
```

The following example demonstrates the `unknown` parameter:

```
local parse = luakeys.define({
  key = {
    process = function(value, input, result, unknown)
      unknown.unknown_key = true
      return value
    end,
  },
})
```

```
    parse('key=1') -- throws error message: 'Unknown keys: unknown_key=true,'
```

3.5.13 Attribute "required"

The `required` attribute can be used to enforce that a specific key must be specified. In the example below, the key `important` is defined as mandatory.

```
local parse = luakeys.define({ important = { required = true } })
local result = parse('important') -- { important = true }
```

If the key `important` is missing in the input, an error message occurs.

```
    parse('unimportant')
    -- throws error message: 'Missing required key "important"!'
```

A recursive example:

```
local parse2 = luakeys.define({
  important1 = {
    required = true,
    sub_keys = { important2 = { required = true } },
  },
})
```

The `important2` key on level 2 is missing.

```
      parse2('important1={unimportant}')
      -- throws error message: 'Missing required key "important2"!'
```

The `important1` key at the lowest key level is missing.

```
      parse2('unimportant')
      -- throws error message: 'Missing required key "important1"!'
```

3.5.14 Attribute "sub_keys"

The `sub_keys` attribute can be used to build nested key-value pair definitions.

```
local result, unknown = luakeys.parse('level1={level2,unknown}', {
  no_error = true,
  defs = {
    level1 = {
      sub_keys = {
        level2 = { default = 42 }
      }
    }
  },
})
```

```
luakeys.debug(result) -- { level1 = { level2 = 42 } }
luakeys.debug(unknown) -- { level1 = { 'unknown' } }
```

3.6 Function "render(result): string"

The function `render(result)` reverses the function `parse(kv_string)`. It takes a Lua table and converts this table into a key-value string. The resulting string usually has a different order as the input table.

```
local result = luakeys.parse('one=1,two=2,three=3,')
local kv_string = luakeys.render(result)
--- one=1,two=2,tree=3,
--- or:
--- two=2,one=1,tree=3,
--- or:
--- ...
```

In Lua only tables with 1-based consecutive integer keys (a.k.a. array tables) can be parsed in order.

```
local result2 = luakeys.parse('one,two,three', { naked_as_value = true })
local kv_string2 = luakeys.render(result2) --- one,two,three, (always)
```

3.7 Function "debug(result): void"

The function `debug(result)` pretty prints a Lua table to standard output (stdout). It is a utility function that can be used to debug and inspect the resulting Lua table of the function `parse`. You have to compile your TEX document in a console to see the terminal output.

```
local result = luakeys.parse('level1={level2={key=value}}')
luakeys.debug(result)
```

The output should look like this:

```
{
  ['level1'] = {
      ['level2'] = {
        ['key'] = 'value',
    },
  }
}
```

3.8 Function "save(identifier, result): void"

The function `save(identifier, result)` saves a result (a table from a previous run of `parse`) under an identifier. Therefore, it is not necessary to pollute the global namespace to store results for the later usage.

3.9 Function "get(identifier): result"

The function `get(identifier)` retrieves a saved result from the result store.

3.10 Table “is”

In the table `is` some functions are summarized, which check whether an input corresponds to a certain data type. All functions accept not only the corresponding Lua data types, but also input as strings. For example, the string `'true'` is recognized by the `is.boolean()` function as a boolean value.

3.10.1 Function “is.boolean(value): boolean”

```
  -- true
  equal(luakeys.is.boolean('true'), true) -- input: string!
  equal(luakeys.is.boolean('True'), true) -- input: string!
  equal(luakeys.is.boolean('TRUE'), true) -- input: string!
  equal(luakeys.is.boolean('false'), true) -- input: string!
  equal(luakeys.is.boolean('False'), true) -- input: string!
  equal(luakeys.is.boolean('FALSE'), true) -- input: string!
  equal(luakeys.is.boolean(true), true)
  equal(luakeys.is.boolean(false), true)
  -- false
  equal(luakeys.is.boolean('xxx'), false)
  equal(luakeys.is.boolean('trueX'), false)
  equal(luakeys.is.boolean('1'), false)
  equal(luakeys.is.boolean('0'), false)
  equal(luakeys.is.boolean(1), false)
  equal(luakeys.is.boolean(0), false)
  equal(luakeys.is.boolean(nil), false)
end)
```

3.10.2 Function “is.dimension(value): boolean”

```
  -- true
  equal(luakeys.is.dimension('1 cm'), true)
  equal(luakeys.is.dimension('- 1 mm'), true)
  equal(luakeys.is.dimension('-1.1pt'), true)
  -- false
  equal(luakeys.is.dimension('1cmX'), false)
  equal(luakeys.is.dimension('X1cm'), false)
  equal(luakeys.is.dimension(1), false)
  equal(luakeys.is.dimension('1'), false)
  equal(luakeys.is.dimension('xxx'), false)
  equal(luakeys.is.dimension(nil), false)
```

3.10.3 Function “is.integer(value): boolean”

```
  -- true
  equal(luakeys.is.integer('42'), true) -- input: string!
  equal(luakeys.is.integer(1), true)
  -- false
  equal(luakeys.is.integer('1.1'), false)
  equal(luakeys.is.integer('xxx'), false)
```

3.10.4 Function “is.number(value): boolean”

```
  -- true
  equal(luakeys.is.number('1'), true) -- input: string!
  equal(luakeys.is.number('1.1'), true) -- input: string!
```

```
equal(luakeys.is.number(1), true)
equal(luakeys.is.number(1.1), true)
-- false
equal(luakeys.is.number('xxx'), false)
equal(luakeys.is.number('1cm'), false)
```

3.10.5 Function "is.string(value): boolean"

```
-- true
equal(luakeys.is.string('string'), true)
equal(luakeys.is.string(''), true)
-- false
equal(luakeys.is.string(true), false)
equal(luakeys.is.string(1), false)
equal(luakeys.is.string(nil), false)
```

3.10.6 Function "is.any(value): boolean"

The function `is.any(value)` always returns `true` and therefore accepts any data type.

3.11 Table "utils"

3.11.1 Function "utils.scan_oarg(initial_delimiter?, end_delimiter?): string"

Plain TEX does not know optional arguments (oarg). The function `utils.scan_oarg(initial_delimiter?, end_delimiter?): string` allows to search for optional arguments not only in LATEX but also in Plain TEX. The function uses the token library built into LuaTEX. The two parameters `initial_delimiter` and `end_delimiter` can be omitted. Then square brackets are assumed to be delimiters. For example, this Lua code `utils.scan_oarg('(', ')')` searches for an optional argument in round brackets The function returns the string between the delimiters or `nil` if no delimiters could be found. The delimiters themselves are not included in the result. After the `\directlua {}`, the macro using `utils.scan_oarg` must not expand to any characters.

```
\input luakeys.tex

\def\mycmd{\directlua{
    local oarg = luakeys.utils.scan_oarg('[', ']')
    if oarg then
      local keys = luakeys.parse(oarg)
      for key, value in pairs(keys) do
        tex.print('oarg: key: "' .. key .. '" value: "' .. value .. '";')
      end
    end
    local marg = token.scan_argument()
    tex.print('marg: "' .. marg .. '"')
  }% <- important
}

\mycmd[key=value]{marg}
% oarg: key: "key" value: "value"; marg: "marg"

\mycmd{marg without oarg}
% marg: "marg without oarg"
```

```
end
\bye
```

3.12 Table “version”

The luakeys project uses semantic versioning. The three version numbers of the semantic versioning scheme are stored in a table as integers in the order MAJOR, MINOR, PATCH. This table can be used to check whether the correct version is installed.

```
local v = luakeys.version
local version_string = v[1] .. '.' .. v[2] .. '.' .. v[3]
print(version_string) -- 0.7.0

if v[1] >= 1 and v[2] > 2 then
  print('You are using the right version.')
end
```

4 Syntax of the recognized key-value format

4.1 An attempt to put the syntax into words

A key-value pair is definied by an equal sign (`key=value`). Several key-value pairs or keys without values (naked keys) are lined up with commas (`key=value,naked`) and build a key-value list. Curly brackets can be used to create a recursive data structure of nested key-value lists (`level1={level2={key=value,naked}}`).

4.2 An (incomplete) attempt to put the syntax into the Extended Backus-Naur Form

⟨*list*⟩ ::= { ⟨*list-item*⟩ }

⟨*list-container*⟩ ::= ‘`{`’ ⟨*list*⟩ ‘`}`’

⟨*list-item*⟩ ::= (⟨*list-container*⟩ | ⟨*key-value-pair*⟩ | ⟨*value*⟩) [‘`,`’]

⟨*key-value-pair*⟩ ::= ⟨*value*⟩ ‘`=`’ (⟨*list-container*⟩ | ⟨*value*⟩)

⟨*value*⟩ ::= ⟨*boolean*⟩
| ⟨*dimension*⟩
| ⟨*number*⟩
| ⟨*string-quoted*⟩
| ⟨*string-unquoted*⟩

⟨*dimension*⟩ ::= ⟨*number*⟩ ⟨*unit*⟩

⟨*number*⟩ ::= ⟨*sign*⟩ (⟨*integer*⟩ [⟨*fractional*⟩] | ⟨*fractional*⟩)

⟨*fractional*⟩ ::= ‘`.`’ ⟨*integer*⟩

⟨*sign*⟩ ::= ‘`-`’ | ‘`+`’

⟨*integer*⟩ ::= ⟨*digit*⟩ { ⟨*digit*⟩ }

⟨*digit*⟩ ::= '0' | '1' | '2' | '3' | '4' | '5' | '6' | '7' | '8' | '9'

⟨*unit*⟩ ::= 'bp' | 'BP'
| 'cc' | 'CC'
| 'cm' | 'CM'
| 'dd' | 'DD'
| 'em' | 'EM'
| 'ex' | 'EX'
| 'in' | 'IN'
| 'mm' | 'MM'
| 'mu' | 'MU'
| 'nc' | 'NC'
| 'nd' | 'ND'
| 'pc' | 'PC'
| 'pt' | 'PT'
| 'px' | 'PX'
| 'sp' | 'SP'

⟨*boolean*⟩ ::= ⟨*boolean-true*⟩ | ⟨*boolean-false*⟩

⟨*boolean-true*⟩ ::= 'true' | 'TRUE' | 'True'

⟨*boolean-false*⟩ ::= 'false' | 'FALSE' | 'False'

... to be continued

4.3 Recognized data types

4.3.1 boolean

The strings `true`, `TRUE` and `True` are converted into Lua's boolean type `true`, the strings `false`, `FALSE` and `False` into `false`.

```
\luakeysdebug{
  lower case true = true,
  upper case true = TRUE,
  title case true = True,
  lower case false = false,
  upper case false = FALSE,
  title case false = False,
}
```

```
{
  ['lower case true'] = true,
  ['upper case true'] = true,
  ['title case true'] = true,
  ['lower case false'] = false,
  ['upper case false'] = false
  ['title case false'] = false,
}
```

4.3.2 number

```
\luakeysdebug{
  num0 = 042,
  num1 = 42,
  num2 = -42,
  num3 = 4.2,
  num4 = 0.42,
  num5 = .42,
  num6 = 0 . 42,
}
```

```
{
  ['num0'] = 42,
  ['num1'] = 42,
  ['num2'] = -42,
```

```
  ['num3'] = 4.2,
  ['num4'] = 0.42,
  ['num5'] = 0.42,
  ['num6'] = '0 . 42', -- string
}
```

4.3.3 dimension

`luakeys` tries to recognize all units used in the TEX world. According to the LuaTEX source code (source/texk/web2c/luatexdir/lua/ltexlib.c) and the dimension module of the lualibs library (lualibs-util-dim.lua), all units should be recognized.

	Description
bp	big point
cc	cicero
cm	centimeter
dd	didot
em	horizontal measure of *M*
ex	vertical measure of *x*
in	inch
mm	milimeter
mu	math unit
nc	new cicero
nd	new didot
pc	pica
pt	point
px	x height current font
sp	scaledpoint

```
\luakeysdebug[convert_dimer
  bp = 1bp,
  cc = 1cc,
  cm = 1cm,
  dd = 1dd,
  em = 1em,
  ex = 1ex,
  in = 1in,
  mm = 1mm,
  mu = 1mu,
  nc = 1nc,
  nd = 1nd,
  pc = 1pc,
  pt = 1pt,
  px = 1px,
  sp = 1sp,
}
```

```
{
  ['bp'] = 65781,
  ['cc'] = 841489,
  ['cm'] = 1864679,
  ['dd'] = 70124,
  ['em'] = 655360,
  ['ex'] = 282460,
  ['in'] = 4736286,
  ['mm'] = 186467,
  ['mu'] = 65536,
  ['nc'] = 839105,
  ['nd'] = 69925,
  ['pc'] = 786432,
  ['pt'] = 65536,
  ['px'] = 65781,
  ['sp'] = 1,
}
```

The next example illustrates the different notations of the dimensions.

```
\luakeysdebug[convert_dimensions=true]{
  upper = 1CM,
  lower = 1cm,
  space = 1 cm,
  plus = + 1cm,
  minus = -1cm,
  nodim = 1 c m,
}
```

```
{
  ['upper'] = 1864679,
  ['lower'] = 1864679,
  ['space'] = 1864679,
  ['plus'] = 1864679,
  ['minus'] = -1864679,
  ['nodim'] = '1 c m', -- string
}
```

4.3.4 string

There are two ways to specify strings: With or without double quotes. If the text have to contain commas, curly braces or equal signs, then double quotes must be used.

```
local kv_string = [[
  without double quotes = no commas and equal signs are allowed,
  with double quotes = ", and = are allowed",
  escape quotes = "a quote \" sign",
  curly braces = "curly { } braces are allowed",
]]
local result = luakeys.parse(kv_string)
luakeys.debug(result)
```

```
-- {
--   ['without double quotes'] = 'no commas and equal signs are allowed',
--   ['with double quotes'] = ', and = are allowed',
--   ['escape quotes'] = 'a quote \" sign',
--   ['curly braces'] = 'curly { } braces are allowed',
-- }
```

4.3.5 Naked keys

Naked keys are keys without a value. Using the option `naked_as_value` they can be converted into values and stored into an array. In Lua an array is a table with numeric indexes (The first index is 1).

```
\luakeysdebug[naked_as_value=true]{one,two,three}
% {
%   [1] = 'one',
%   [2] = 'two',
%   [3] = 'three',
% }
% =
% { 'one', 'two', 'three' }
```

All recognized data types can be used as standalone values.

```
\luakeysdebug[naked_as_value=true]{one,2,3cm}
% {
%   [1] = 'one',
%   [2] = 2,
%   [3] = '3cm',
% }
```

5 Examples

5.1 Extend and modify keys of existing macros

Extend the includegraphics macro with a new key named `caption` and change the accepted values of the `width` key. A number between 0 and 1 is allowed and converted into `width=0.5\linewidth`

```
local luakeys = require('luakeys')

local parse = luakeys.define({
  caption = { alias = 'title' },
  width = {
    process = function(value)
      if type(value) == 'number' and value >= 0 and value <= 1 then
        return tostring(value) .. '\\linewidth'
      end
      return value
    end,
  },
})

local function print_image_macro(image_path, kv_string)
  local caption = ''
  local options = ''
  local keys, unknown = parse(kv_string)
  if keys['caption'] ~= nil then
    caption = '\\ImageCaption{' .. keys['caption'] .. '}'
  end
  if keys['width'] ~= nil then
    unknown['width'] = keys['width']
  end
  options = luakeys.render(unknown)

  tex.print('\\includegraphics[' .. options .. ']{' .. image_path .. '}' ..
              caption)
end

return print_image_macro
```

```
\documentclass{article}
\usepackage{graphicx}
\begin{document}
\newcommand{\ImageCaption}[1]{%
  \par\textit{#1}%
}

\newcommand{\myincludegrahics}[2][]{
  \directlua{
    print_image_macro = require('extend-keys.lua')
    print_image_macro('#2', '#1')
  }
}

\myincludegrahics{test.png}

\myincludegrahics[width=0.5]{test.png}

\myincludegrahics[caption=A caption]{test.png}
```

```
\end{document}
```

5.2 Process document class options

The options of a LaTeX document class can be accessed via the `\@classoptionslist` macro. The string of the macro `\@classoptionslist` is already expanded and normalized. In addition to spaces, the curly brackets are also removed. It is therefore not possible to process nested hierarchical key-value pairs via the option.

```
\NeedsTeXFormat{LaTeX2e}
\ProvidesClass{test-class}[2022/05/26 Test class to access the class options]
\DeclareOption*{\PassOptionsToClass{\CurrentOption}{article}}
\ProcessOptions\relax
\directlua{
  luakeys = require('luakeys')
  local kv = luakeys.parse('\@classoptionslist', {
    convert_dimensions = false,
    naked_as_value = true
  })
  luakeys.debug(kv)
}
\LoadClass{article}
```

```
\documentclass[12pt,landscape]{test-class}

\begin{document}
This document uses the class "test-class".
\end{document}
```

```
{
  [1] = '12pt',
  [2] = 'landscape',
}
```

6 Debug packages

Two small debug packages are included in `luakeys`. One debug package can be used in LaTeX (luakeys-debug.sty) and one can be used in plain TeX (luakeys-debug.tex). Both packages provide only one command: `\luakeysdebug{kv-string}`

```
\luakeysdebug{one,two,three}
```

Then the following output should appear in the document:

```
{
  ['two'] = true,
  ['one'] = true,
  ['three'] = true,
}
```

6.1 For plain TeX: luakeys-debug.tex

An example of how to use the command in plain TeX:

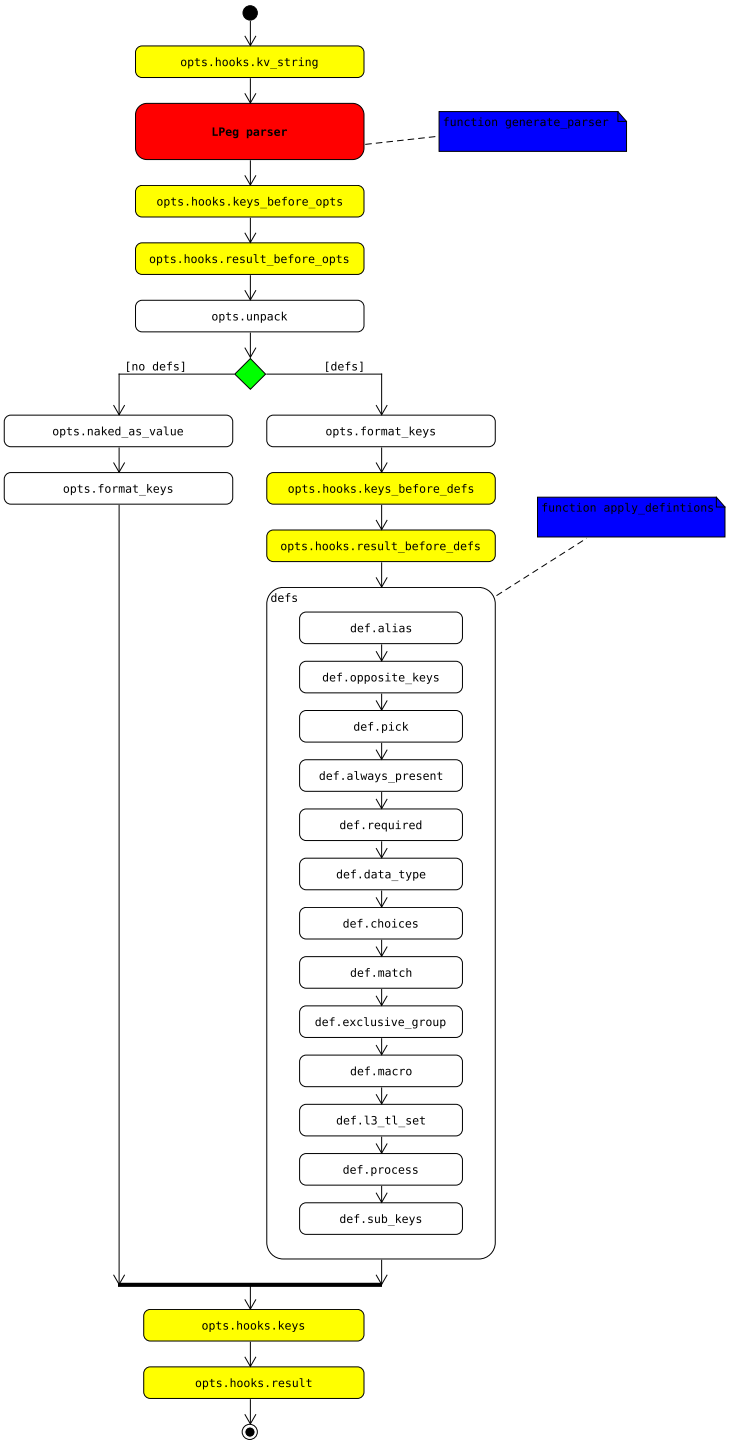
```
\input luakeys-debug.tex
\luakeysdebug{one,two,three}
\bye
```

6.2 For LaTeX: luakeys-debug.sty

An example of how to use the command in LaTeX:

```
\documentclass{article}
\usepackage{luakeys-debug}
\begin{document}
\luakeysdebug[
  unpack=false,
  convert dimensions=false
]{one,two,three}
\end{document}
```

7 Activity diagramm of the parsing process



8 Implementation

8.1 luakeys.lua

```lua
-- luakeys.lua
-- Copyright 2021-2022 Josef Friedrich
--
-- This work may be distributed and/or modified under the
-- conditions of the LaTeX Project Public License, either version 1.3c
-- of this license or (at your option) any later version.
-- The latest version of this license is in
--   http://www.latex-project.org/lppl.txt
-- and version 1.3c or later is part of all distributions of LaTeX
-- version 2008/05/04 or later.
--
-- This work has the LPPL maintenance status `maintained'.
--
-- The Current Maintainer of this work is Josef Friedrich.
--
-- This work consists of the files luakeys.lua, luakeys.sty, luakeys.tex
-- luakeys-debug.sty and luakeys-debug.tex.
--- A key-value parser written with Lpeg.
--
-- @module luakeys
local lpeg = require('lpeg')

if not tex then
  tex = {
    -- Dummy function for the tests.
    sp = function(input)
      return 1234567
    end,
  }
end

if not token then
  token = {
    set_macro = function(csname, content, global)
    end,
  }
end

--- Merge two tables in the first specified table.
--- The `merge_tables` function copies all keys from the `source` table
--- to a target table. It returns the modified target table.
---
---@see https://stackoverflow.com/a/1283608/10193818
---
---@param target table
---@param source table
---
---@return table target The modified target table.
local function merge_tables(target, source)
  for key, value in pairs(source) do
    if type(value) == 'table' then
      if type(target[key] or false) == 'table' then
        merge_tables(target[key] or {}, source[key] or {})
      elseif target[key] == nil then
        target[key] = value
      end
    elseif target[key] == nil then
      target[key] = value
```

```lua
    end
  end
  return target
end

---Clone a table.
---
---@see http://lua-users.org/wiki/CopyTable
---
---@param orig table
---
---@return table
local function clone_table(orig)
  local orig_type = type(orig)
  local copy
  if orig_type == 'table' then
    copy = {}
    for orig_key, orig_value in next, orig, nil do
      copy[clone_table(orig_key)] = clone_table(orig_value)
    end
    setmetatable(copy, clone_table(getmetatable(orig)))
  else -- number, string, boolean, etc
    copy = orig
  end
  return copy
end

local utils = {
  --- Get the size of an array like table `{ 'one', 'two', 'three' }` = 3.
  ---
  ---@param value table # A table or any input.
  ---
  ---@return number # The size of the array like table. 0 if the input is no table
  ↪  or the table is empty.
  get_array_size = function(value)
    local count = 0
    if type(value) == 'table' then
      for _ in ipairs(value) do
        count = count + 1
      end
    end
    return count
  end,

  ---Get the size of a table `{ one = 'one', 'two', 'three' }` = 3.
  ---
  ---@param value table|any # A table or any input.
  ---
  ---@return number # The size of the array like table. 0 if the input is no table
  ↪  or the table is empty.
  get_table_size = function(value)
    local count = 0
    if type(value) == 'table' then
      for _ in pairs(value) do
        count = count + 1
      end
    end
    return count
  end,

  merge_tables = merge_tables,

```

```
    clone_table = clone_table,

    remove_from_array = function(array, element)
      for index, value in pairs(array) do
        if element == value then
          array[index] = nil
          return value
        end
      end
    end,

    ---Scan for an optional argument.
    ---
    ---@param initial_delimiter? string # The character that marks the beginning of an optional argument (by default `[`).
    ---@param end_delimiter? string # The character that marks the end of an optional argument (by default `]`).
    ---
    ---@return string|nil # The string that was enclosed by the delimiters. The delimiters themselves are not returned.
    scan_oarg = function(initial_delimiter, end_delimiter)
      if initial_delimiter == nil then
        initial_delimiter = '['
      end

      if end_delimiter == nil then
        end_delimiter = ']'
      end

      local function convert_token(t)
        if t.index ~= nil then
          return utf8.char(t.index)
        else
          return '\\' .. t.csname
        end
      end

      local function get_next_char()
        local t = token.get_next()
        return convert_token(t), t
      end

      local char, t = get_next_char()
      if char == initial_delimiter then
        local oarg = {}
        char = get_next_char()
        while char ~= end_delimiter do
          table.insert(oarg, char)
          char = get_next_char()
        end
        return table.concat(oarg, '')
      else
        token.put_next(t)
      end
    end,
  }

  local namespace = {
    opts = {
      assignment_operator = '=',
      convert_dimensions = false,
      debug = false,
```

```
    default = true,
    defaults = false,
    defs = false,
    false_aliases = { 'false', 'FALSE', 'False' },
    format_keys = false,
    group_begin = '{',
    group_end = '}',
    hooks = {},
    invert_flag = '!',
    list_separator = ',',
    naked_as_value = false,
    no_error = false,
    quotation_begin = '"',
    quotation_end = '"',
    true_aliases = { 'true', 'TRUE', 'True' },
    unpack = true,
  },

  hooks = {
    kv_string = true,
    keys_before_opts = true,
    result_before_opts = true,
    keys_before_def = true,
    result_before_def = true,
    keys = true,
    result = true,
  },

  attrs = {
    alias = true,
    always_present = true,
    choices = true,
    data_type = true,
    default = true,
    exclusive_group = true,
    l3_tl_set = true,
    macro = true,
    match = true,
    name = true,
    opposite_keys = true,
    pick = true,
    process = true,
    required = true,
    sub_keys = true,
  },
}

--- The default options.
local default_options = clone_table(namespace.opts)

local function throw_error(message)
  if type(tex.error) == 'function' then
    tex.error(message)
  else
    error(message)
  end
end

--- Normalize the parse options.
---
---@param opts? table # Options in a raw format. The table may be empty or some keys
↪  are not set.
```

```lua
---
---@return table
local function normalize_opts(opts)
  if type(opts) ~= 'table' then
    opts = {}
  end
  for key, _ in pairs(opts) do
    if namespace.opts[key] == nil then
      throw_error('Unknown parse option: ' .. tostring(key) .. '!')
    end
  end
  local old_opts = opts
  opts = {}
  for name, _ in pairs(namespace.opts) do
    if old_opts[name] ~= nil then
      opts[name] = old_opts[name]
    else
      opts[name] = default_options[name]
    end
  end

  for hook in pairs(opts.hooks) do
    if namespace.hooks[hook] == nil then
      throw_error('Unknown hook: ' .. tostring(hook) .. '!')
    end
  end
  return opts
end

local l3_code_cctab = 10

--- Convert back to strings
-- @section

--- The function `render(tbl)` reverses the function
--- `parse(kv_string)`. It takes a Lua table and converts this table
--- into a key-value string. The resulting string usually has a
--- different order as the input table. In Lua only tables with
--- 1-based consecutive integer keys (a.k.a. array tables) can be
--- parsed in order.
---
---@param result table # A table to be converted into a key-value string.
---
---@return string # A key-value string that can be passed to a TeX macro.
local function render(result)
  local function render_inner(result)
    local output = {}
    local function add(text)
      table.insert(output, text)
    end
    for key, value in pairs(result) do
      if (key and type(key) == 'string') then
        if (type(value) == 'table') then
          if (next(value)) then
            add(key .. '={')
            add(render_inner(value))
            add('},')
          else
            add(key .. '={},')
          end
        else
          add(key .. '=' .. tostring(value) .. ',')
```

```
          end
        else
          add(tostring(value) .. ',')
        end
      end
      return table.concat(output)
    end
    return render_inner(result)
  end

  --- The function `stringify(tbl, for_tex)` converts a Lua table into a
  --- printable string. Stringify a table means to convert the table into
  --- a string. This function is used to realize the `debug` function.
  --- `stringify(tbl, true)` (`for_tex = true`) generates a string which
  --- can be embeded into TeX documents. The macro `\luakeysdebug{}` uses
  --- this option. `stringify(tbl, false)` or `stringify(tbl)` generate a
  --- string suitable for the terminal.
  ---
  ---@see https://stackoverflow.com/a/54593224/10193818
  ---
  ---@param result table # A table to stringify.
  ---@param for_tex? boolean # Stringify the table into a text string that can be
  ↪  embeded inside a TeX document via tex.print(). Curly braces and whites spaces
  ↪  are escaped.
  ---
  ---@return string
  local function stringify(result, for_tex)
    local line_break, start_bracket, end_bracket, indent

    if for_tex then
      line_break = '\\par'
      start_bracket = '$\\{$'
      end_bracket = '$\\}$'
      indent = '\\ \\ '
    else
      line_break = '\n'
      start_bracket = '{'
      end_bracket = '}'
      indent = '  '
    end

    local function stringify_inner(input, depth)
      local output = {}
      depth = depth or 0

      local function add(depth, text)
        table.insert(output, string.rep(indent, depth) .. text)
      end

      local function format_key(key)
        if (type(key) == 'number') then
          return string.format('[%s]', key)
        else
          return string.format('[\'%s\']', key)
        end
      end

      if type(input) ~= 'table' then
        return tostring(input)
      end

      for key, value in pairs(input) do
```

```
361         if (key and type(key) == 'number' or type(key) == 'string') then
362           key = format_key(key)
363
364           if (type(value) == 'table') then
365             if (next(value)) then
366               add(depth, key .. ' = ' .. start_bracket)
367               add(0, stringify_inner(value, depth + 1))
368               add(depth, end_bracket .. ',');
369             else
370               add(depth,
371                 key .. ' = ' .. start_bracket .. end_bracket .. ',')
372             end
373           else
374             if (type(value) == 'string') then
375               value = string.format('\'%s\'', value)
376             else
377               value = tostring(value)
378             end
379
380             add(depth, key .. ' = ' .. value .. ',')
381           end
382         end
383       end
384
385       return table.concat(output, line_break)
386     end
387
388     return start_bracket .. line_break .. stringify_inner(result, 1) ..
389              line_break .. end_bracket
390   end
391
392   --- The function `debug(result)` pretty prints a Lua table to standard
393   --   output (stdout). It is a utility function that can be used to
394   --   debug and inspect the resulting Lua table of the function
395   --   `parse`. You have to compile your TeX document in a console to
396   --   see the terminal output.
397   --
398   ---@param result table # A table to be printed to standard output for debugging
      ↪  purposes.
399   local function debug(result)
400     print('\n' .. stringify(result, false))
401   end
402
403   --- Parser / Lpeg related
404   -- @section
405
406   --- Generate the PEG parser using Lpeg.
407   ---
408   --- Explanations of some LPeg notation forms:
409   ---
410   --- * `patt ^ 0` = `expression *`
411   --- * `patt ^ 1` = `expression +`
412   --- * `patt ^ -1` = `expression ?`
413   --- * `patt1 * patt2` = `expression1 expression2`: Sequence
414   --- * `patt1 + patt2` = `expression1 / expression2`: Ordered choice
415   ---
416   --- * [TUGboat article: Parsing complex data formats in LuaTEX with
      ↪  LPEG](https://tug.org/TUGboat/tb40-2/tb125menke-Patterndf)
417   ---
418   ---@param initial_rule string # The name of the first rule of the grammar table
      ↪  passed to the `lpeg.P(attern)` function (e. g. `list`, `number`).
419   ---@param opts? table # Whether the dimensions should be converted to scaled points
      ↪  (by default `false`).
```

```
420   ---
421   ---@return userdata # The parser.
422   local function generate_parser(initial_rule, opts)
423     if type(opts) ~= 'table' then
424       opts = normalize_opts(opts)
425     end
426
427     local Variable = lpeg.V
428     local Pattern = lpeg.P
429     local Set = lpeg.S
430     local Range = lpeg.R
431     local CaptureGroup = lpeg.Cg
432     local CaptureFolding = lpeg.Cf
433     local CaptureTable = lpeg.Ct
434     local CaptureConstant = lpeg.Cc
435     local CaptureSimple = lpeg.C
436
437     -- Optional whitespace
438     local white_space = Set(' \t\n\r')
439
440     --- Match literal string surrounded by whitespace
441     local ws = function(match)
442       return white_space ^ 0 * Pattern(match) * white_space ^ 0
443     end
444
445     local line_up_pattern = function(patterns)
446       local result
447       for _, pattern in ipairs(patterns) do
448         if result == nil then
449           result = Pattern(pattern)
450         else
451           result = result + Pattern(pattern)
452         end
453       end
454       return result
455     end
456
457     --- Convert a dimension to an normalized dimension string or an
458     --- integer in the scaled points format.
459     ---
460     ---@param input string
461     ---
462     ---@return integer|string # A dimension as an integer or a dimension string.
463     local capture_dimension = function(input)
464       -- Remove all whitespaces
465       input = input:gsub('%s+', '')
466       -- Convert the unit string into lowercase.
467       input = input:lower()
468       if opts.convert_dimensions then
469         return tex.sp(input)
470       else
471         return input
472       end
473     end
474
475     --- Add values to a table in two modes:
476     --
477     -- Key-value pair:
478     --
479     -- If `arg1` and `arg2` are not nil, then `arg1` is the key and `arg2` is the
480     -- value of a new table entry.
481     --
```

```
482     -- Indexed value:
483     --
484     -- If `arg2` is nil, then `arg1` is the value and is added as an indexed
485     -- (by an integer) value.
486     --
487     ---@param result table # The result table to which an additional key-value pair or
        ↪  value should to be added
488     ---@param arg1 any # The key or the value.
489     ---@param arg2? any # Always the value.
490     ---
491     ---@return table # The result table to which an additional key-value pair or value
        ↪  has been added.
492     local add_to_table = function(result, arg1, arg2)
493       if arg2 == nil then
494         local index = #result + 1
495         return rawset(result, index, arg1)
496       else
497         return rawset(result, arg1, arg2)
498       end
499     end
500
501     -- LuaFormatter off
502     return Pattern({
503       [1] = initial_rule,
504
505       -- list_item*
506       list = CaptureFolding(
507         CaptureTable('') * Variable('list_item')^0,
508         add_to_table
509       ),
510
511       -- '{' list '}'
512       list_container =
513         ws(opts.group_begin) * Variable('list') * ws(opts.group_end),
514
515       -- ( list_container / key_value_pair / value ) ','?
516       list_item =
517         CaptureGroup(
518           Variable('list_container') +
519           Variable('key_value_pair') +
520           Variable('value')
521         ) * ws(opts.list_separator)^-1,
522
523       -- key '=' (list_container / value)
524       key_value_pair =
525         (Variable('key') * ws(opts.assignment_operator)) *
          ↪  (Variable('list_container') + Variable('value')),
526
527       -- number / string_quoted / string_unquoted
528       key =
529         Variable('number') +
530         Variable('string_quoted') +
531         Variable('string_unquoted'),
532
533       -- boolean !value / dimension !value / number !value / string_quoted !value /
          ↪  string_unquoted
534       -- !value -> Not-predicate -> * -Variable('value')
535       value =
536         Variable('boolean') * -Variable('value') +
537         Variable('dimension') * -Variable('value') +
538         Variable('number') * -Variable('value')  +
539         Variable('string_quoted') * -Variable('value') +
```

```
    Variable('string_unquoted'),

  -- for is.boolean()
  boolean_only = Variable('boolean') * -1,

  -- boolean_true / boolean_false
  boolean =
    (
      Variable('boolean_true') * CaptureConstant(true) +
      Variable('boolean_false') * CaptureConstant(false)
    ),

  boolean_true = line_up_pattern(opts.true_aliases),

  boolean_false = line_up_pattern(opts.false_aliases),

  -- for is.dimension()
  dimension_only = Variable('dimension') * -1,

  dimension = (
    Variable('tex_number') * white_space^0 *
    Variable('unit')
  ) / capture_dimension,

  -- for is.number()
  number_only = Variable('number') * -1,

  -- capture number
  number = Variable('tex_number') / tonumber,

  -- sign? white_space? (integer+ fractional? / fractional)
  tex_number =
    Variable('sign')^0 * white_space^0 *
    (Variable('integer')^1 * Variable('fractional')^0) +
    Variable('fractional'),

  sign = Set('-+'),

  fractional = Pattern('.') * Variable('integer')^1,

  integer = Range('09')^1,

  -- 'bp' / 'BP' / 'cc' / etc.
  -- https://raw.githubusercontent.com/latex3/lualibs/master/lualibs-util-dim.lua
  -- https://github.com/TeX-
  ↪  Live/luatex/blob/51db1985f5500dafd2393aa2e403fefa57d3cb76/source/texk/web2c/luatexdir/lua/ltexlib.c#
  ↪  L625
  unit =
    Pattern('bp') + Pattern('BP') +
    Pattern('cc') + Pattern('CC') +
    Pattern('cm') + Pattern('CM') +
    Pattern('dd') + Pattern('DD') +
    Pattern('em') + Pattern('EM') +
    Pattern('ex') + Pattern('EX') +
    Pattern('in') + Pattern('IN') +
    Pattern('mm') + Pattern('MM') +
    Pattern('mu') + Pattern('MU') +
    Pattern('nc') + Pattern('NC') +
    Pattern('nd') + Pattern('ND') +
    Pattern('pc') + Pattern('PC') +
    Pattern('pt') + Pattern('PT') +
    Pattern('px') + Pattern('PX') +
```

```
      Pattern('sp') + Pattern('SP'),

    -- '"' ('\"' / !'"')* '"'
    string_quoted =
      white_space^0 * Pattern(opts.quotation_begin) *
      CaptureSimple((Pattern('\\' .. opts.quotation_end) + 1 -
      ↪  Pattern(opts.quotation_end))^0) *
      Pattern(opts.quotation_end) * white_space^0,

    string_unquoted =
      white_space^0 *
      CaptureSimple(
        Variable('word_unquoted')^1 *
        (Set(' \t')^1 * Variable('word_unquoted')^1)^0) *
      white_space^0,

    word_unquoted = (1 - white_space - Set(
      opts.group_begin ..
      opts.group_end ..
      opts.assignment_operator  ..
      opts.list_separator))^1
  })
-- LuaFormatter on
end

local function visit_tree(tree, callback_func)
  if type(tree) ~= 'table' then
    throw_error('Parameter "tree" has to be a table, got: ' ..
                  tostring(tree))
  end
  local function visit_tree_recursive(tree,
    current,
    result,
    depth,
    callback_func)
    for key, value in pairs(current) do
      if type(value) == 'table' then
        value = visit_tree_recursive(tree, value, {}, depth + 1,
          callback_func)
      end

      key, value = callback_func(key, value, depth, current, tree)

      if key ~= nil and value ~= nil then
        result[key] = value
      end
    end
    if next(result) ~= nil then
      return result
    end
  end

  local result = visit_tree_recursive(tree, tree, {}, 1, callback_func)

  if result == nil then
    return {}
  end
  return result
end

local is = {
  boolean = function(value)
```

```
    if value == nil then
      return false
    end
    if type(value) == 'boolean' then
      return true
    end
    local parser = generate_parser('boolean_only')
    local result = parser:match(tostring(value))
    return result ~= nil
  end,

  dimension = function(value)
    if value == nil then
      return false
    end
    local parser = generate_parser('dimension_only')
    local result = parser:match(tostring(value))
    return result ~= nil
  end,

  integer = function(value)
    local n = tonumber(value)
    if n == nil then
      return false
    end
    return n == math.floor(n)
  end,

  number = function(value)
    if value == nil then
      return false
    end
    if type(value) == 'number' then
      return true
    end
    local parser = generate_parser('number_only')
    local result = parser:match(tostring(value))
    return result ~= nil
  end,

  string = function(value)
    return type(value) == 'string'
  end,

  any = function(value)
    return true
  end,
}

--- Apply the key-value-pair definitions (defs) on an input table in a
--- recursive fashion.
---
---@param defs table # A table containing all definitions.
---@param opts table # The parse options table.
---@param input table # The current input table.
---@param output table # The current output table.
---@param unknown table # Always the root unknown table.
---@param key_path table # An array of key names leading to the current
---@param input_root table # The root input table input and output table.
local function apply_definitions(defs,
  opts,
  input,
```

```
    output,
    unknown,
    key_path,
    input_root)
    local exclusive_groups = {}

    local function add_to_key_path(key_path, key)
      local new_key_path = {}

      for index, value in ipairs(key_path) do
        new_key_path[index] = value
      end

      table.insert(new_key_path, key)
      return new_key_path
    end

    local function get_default_value(def)
      if def.default ~= nil then
        return def.default
      elseif opts ~= nil and opts.default ~= nil then
        return opts.default
      end
      return true
    end

    local function find_value(search_key, def)
      if input[search_key] ~= nil then
        local value = input[search_key]
        input[search_key] = nil
        return value
        -- naked keys: values with integer keys
      elseif utils.remove_from_array(input, search_key) ~= nil then
        return get_default_value(def)
      end
    end

    local apply = {
      alias = function(value, key, def)
        if type(def.alias) == 'string' then
          def.alias = { def.alias }
        end
        local alias_value
        local used_alias_key
        -- To get an error if the key and an alias is present
        if value ~= nil then
          alias_value = value
          used_alias_key = key
        end
        for _, alias in ipairs(def.alias) do
          local v = find_value(alias, def)
          if v ~= nil then
            if alias_value ~= nil then
              throw_error(string.format(
                'Duplicate aliases "%s" and "%s" for key "%s"!',
                used_alias_key, alias, key))
            end
            used_alias_key = alias
            alias_value = v
          end
        end
        if alias_value ~= nil then
```

```
785           return alias_value
786         end
787       end,
788
789       always_present = function(value, key, def)
790         if value == nil and def.always_present then
791           return get_default_value(def)
792         end
793       end,
794
795       choices = function(value, key, def)
796         if value == nil then
797           return
798         end
799         if def.choices ~= nil and type(def.choices) == 'table' then
800           local is_in_choices = false
801           for _, choice in ipairs(def.choices) do
802             if value == choice then
803               is_in_choices = true
804             end
805           end
806           if not is_in_choices then
807             throw_error('The value "' .. value ..
808                         '" does not exist in the choices: ' ..
809                         table.concat(def.choices, ', ') .. '!')
810           end
811         end
812       end,
813
814       data_type = function(value, key, def)
815         if value == nil then
816           return
817         end
818         if def.data_type ~= nil then
819           local converted
820           -- boolean
821           if def.data_type == 'boolean' then
822             if value == 0 or value == '' or not value then
823               converted = false
824             else
825               converted = true
826             end
827             -- dimension
828           elseif def.data_type == 'dimension' then
829             if is.dimension(value) then
830               converted = value
831             end
832             -- integer
833           elseif def.data_type == 'integer' then
834             if is.number(value) then
835               local n = tonumber(value)
836               if type(n) == 'number' and n ~= nil then
837                 converted = math.floor(n)
838               end
839             end
840             -- number
841           elseif def.data_type == 'number' then
842             if is.number(value) then
843               converted = tonumber(value)
844             end
845             -- string
846           elseif def.data_type == 'string' then
```

```
847             converted = tostring(value)
848           else
849             throw_error('Unknown data type: ' .. def.data_type)
850           end
851           if converted == nil then
852             throw_error(
853               'The value "' .. value .. '" of the key "' .. key ..
854                 '" could not be converted into the data type "' ..
855                 def.data_type .. '"!')
856           else
857             return converted
858           end
859         end
860       end,
861
862       exclusive_group = function(value, key, def)
863         if value == nil then
864           return
865         end
866         if def.exclusive_group ~= nil then
867           if exclusive_groups[def.exclusive_group] ~= nil then
868             throw_error('The key "' .. key ..
869                         '" belongs to a mutually exclusive group "' ..
870                         def.exclusive_group .. '" and the key "' ..
871                         exclusive_groups[def.exclusive_group] ..
872                         '" is already present!')
873           else
874             exclusive_groups[def.exclusive_group] = key
875           end
876         end
877       end,
878
879       l3_tl_set = function(value, key, def)
880         if value == nil then
881           return
882         end
883         if def.l3_tl_set ~= nil then
884           tex.print(l3_code_cctab,
885             '\\tl_set:Nn \\g_' .. def.l3_tl_set .. '_tl')
886           tex.print('{' .. value .. '}')
887         end
888       end,
889
890       macro = function(value, key, def)
891         if value == nil then
892           return
893         end
894         if def.macro ~= nil then
895           token.set_macro(def.macro, value, 'global')
896         end
897       end,
898
899       match = function(value, key, def)
900         if value == nil then
901           return
902         end
903         if def.match ~= nil then
904           if type(def.match) ~= 'string' then
905             throw_error('def.match has to be a string')
906           end
907           local match = string.match(value, def.match)
908           if match == nil then
```

```
909             throw_error(
910               'The value "' .. value .. '" of the key "' .. key ..
911                 '" does not match "' .. def.match .. '"!')
912           else
913             return match
914           end
915         end
916       end,
917
918       opposite_keys = function(value, key, def)
919         if def.opposite_keys ~= nil then
920           local true_value = def.opposite_keys[true]
921           local false_value = def.opposite_keys[false]
922           if true_value == nil or false_value == nil then
923             throw_error(
924               'Usage opposite_keys = { [true] = "...", [false] = "..." }')
925           end
926           if utils.remove_from_array(input, true_value) ~= nil then
927             return true
928           elseif utils.remove_from_array(input, false_value) ~= nil then
929             return false
930           end
931         end
932       end,
933
934       process = function(value, key, def)
935         if value == nil then
936           return
937         end
938         if def.process ~= nil and type(def.process) == 'function' then
939           return def.process(value, input_root, output, unknown)
940         end
941       end,
942
943       pick = function(value, key, def)
944         if def.pick then
945           local pick_types
946
947           -- Allow old deprecated attribut pick = true
948           if def.pick == true then
949             pick_types = { 'any' }
950           elseif type(def.pick) == 'table' then
951             pick_types = def.pick
952           else
953             pick_types = { def.pick }
954           end
955
956           -- Check if the pick attribute is valid
957           for _, pick_type in ipairs(pick_types) do
958             if type(pick_type) == 'string' and is[pick_type] == nil then
959               throw_error(
960                 'Wrong data type in the "pick" attribute: ' ..
961                   tostring(pick_type) ..
962                   '. Allowed are: any, boolean, dimension, integer, number, string.')
963             end
964           end
965
966           -- The key has already a value. We leave the function at this
967           -- point to be able to check the pick attribute for errors
968           -- beforehand.
969           if value ~= nil then
970             return value
```

```
971           end
972
973           for _, pick_type in ipairs(pick_types) do
974             for i, v in pairs(input) do
975               -- We can not use ipairs here. `ipairs(t)` iterates up to the
976               -- first absent index. Values are deleted from the `input`
977               -- table.
978               if type(i) == 'number' then
979                 local picked_value = nil
980                 if is[pick_type](v) then
981                   picked_value = v
982                 end
983
984                 if picked_value ~= nil then
985                   input[i] = nil
986                   return picked_value
987                 end
988               end
989             end
990           end
991         end
992       end,
993
994       required = function(value, key, def)
995         if def.required ~= nil and def.required and value == nil then
996           throw_error(string.format('Missing required key "%s"!', key))
997         end
998       end,
999
1000      sub_keys = function(value, key, def)
1001        if def.sub_keys ~= nil then
1002          local v
1003          -- To get keys defined with always_present
1004          if value == nil then
1005            v = {}
1006          elseif type(value) == 'string' then
1007            v = { value }
1008          elseif type(value) == 'table' then
1009            v = value
1010          end
1011          v = apply_definitions(def.sub_keys, opts, v, output[key],
1012            unknown, add_to_key_path(key_path, key), input_root)
1013          if utils.get_table_size(v) > 0 then
1014            return v
1015          end
1016        end
1017      end,
1018    }
1019
1020    --- standalone values are removed.
1021    -- For some callbacks and the third return value of parse, we
1022    -- need an unchanged raw result from the parse function.
1023    input = clone_table(input)
1024    if output == nil then
1025      output = {}
1026    end
1027    if unknown == nil then
1028      unknown = {}
1029    end
1030    if key_path == nil then
1031      key_path = {}
1032    end
```

```
1033
1034    for index, def in pairs(defs) do
1035      -- Find key and def
1036      local key
1037      -- `{ key1 = { }, key2 = { } }`
1038      if type(def) == 'table' and def.name == nil and type(index) ==
1039        'string' then
1040        key = index
1041        -- `{ { name = 'key1' }, { name = 'key2' } }`
1042      elseif type(def) == 'table' and def.name ~= nil then
1043        key = def.name
1044        -- Definitions as strings in an array: `{ 'key1', 'key2' }`
1045      elseif type(index) == 'number' and type(def) == 'string' then
1046        key = def
1047        def = { default = get_default_value({}) }
1048      end
1049
1050      if type(def) ~= 'table' then
1051        throw_error('Key definition must be a table!')
1052      end
1053
1054      for attr, _ in pairs(def) do
1055        if namespace.attrs[attr] == nil then
1056          throw_error('Unknown definition attribute: ' .. tostring(attr))
1057        end
1058      end
1059
1060      if key == nil then
1061        throw_error('Key name couldn't be detected!')
1062      end
1063
1064      local value = find_value(key, def)
1065
1066      for _, def_opt in ipairs({
1067        'alias',
1068        'opposite_keys',
1069        'pick',
1070        'always_present',
1071        'required',
1072        'data_type',
1073        'choices',
1074        'match',
1075        'exclusive_group',
1076        'macro',
1077        'l3_tl_set',
1078        'process',
1079        'sub_keys',
1080      }) do
1081        if def[def_opt] ~= nil then
1082          local tmp_value = apply[def_opt](value, key, def)
1083          if tmp_value ~= nil then
1084            value = tmp_value
1085          end
1086        end
1087      end
1088
1089      output[key] = value
1090    end
1091
1092    if utils.get_table_size(input) > 0 then
1093      -- Move to the current unknown table.
1094      local current_unknown = unknown
```

```
      for _, key in ipairs(key_path) do
        if current_unknown[key] == nil then
          current_unknown[key] = {}
        end
        current_unknown = current_unknown[key]
      end

      -- Copy all unknown key-value-pairs to the current unknown table.
      for key, value in pairs(input) do
        current_unknown[key] = value
      end
    end

    return output, unknown
  end

  --- Parse a LaTeX/TeX style key-value string into a Lua table.
  ---
  ---@param kv_string string # A string in the TeX/LaTeX style key-value format as
  ↪  described above.
  ---@param opts? table # A table containing the settings:
  ---   `convert_dimensions`, `unpack`, `naked_as_value`, `converter`,
  ---   `debug`, `preprocess`, `postprocess`.
  --
  ---@return table result # The final result of all individual parsing and
  ↪  normalization steps.
  ---@return table unknown # A table with unknown, undefinied key-value pairs.
  ---@return table raw # The unprocessed, raw result of the LPeg parser.
  local function parse(kv_string, opts)
    if kv_string == nil then
      return {}, {}, {}
    end

    opts = normalize_opts(opts)

    if type(opts.hooks.kv_string) == 'function' then
      kv_string = opts.hooks.kv_string(kv_string)
    end

    local result = generate_parser('list', opts):match(kv_string)
    local raw = clone_table(result)

    local function apply_hook(name)
      if type(opts.hooks[name]) == 'function' then
        if name:match('^keys') then
          result = visit_tree(result, opts.hooks[name])
        else
          opts.hooks[name](result)
        end

        if opts.debug then
          print('After the execution of the hook: ' .. name)
          debug(result)
        end
      end
    end

    local function apply_hooks(at)
      if at ~= nil then
        at = '_' .. at
      else
        at = ''
```

```
    end
    apply_hook('keys' .. at)
    apply_hook('result' .. at)
  end

  apply_hooks('before_opts')

  --- Normalize the result table of the LPeg parser. This normalization
  --  tasks are performed on the raw input table coming directly from
  --  the PEG parser:
  --
  ---@param result table # The raw input table coming directly from the PEG parser
  ---@param opts table # Some options.
  local function apply_opts(result, opts)
    local callbacks = {
      unpack = function(key, value)
        if type(value) == 'table' and utils.get_array_size(value) == 1 and
          utils.get_table_size(value) == 1 and type(value[1]) ~= 'table' then
          return key, value[1]
        end
        return key, value
      end,

      process_naked = function(key, value)
        if type(key) == 'number' and type(value) == 'string' then
          return value, opts.default
        end
        return key, value
      end,

      format_key = function(key, value)
        if type(key) == 'string' then
          for _, style in ipairs(opts.format_keys) do
            if style == 'lower' then
              key = key:lower()
            elseif style == 'snake' then
              key = key:gsub('[^%w]+', '_')
            elseif style == 'upper' then
              key = key:upper()
            else
              throw_error('Unknown style to format keys: ' ..
                          tostring(style) ..
                          ' Allowed styles are: lower, snake, upper')
            end
          end
        end
        return key, value
      end,

      apply_invert_flag = function(key, value)
        if type(key) == 'string' and key:find(opts.invert_flag) then
          return key:gsub(opts.invert_flag, ''), not value
        end
        return key, value
      end,
    }

    if opts.unpack then
      result = visit_tree(result, callbacks.unpack)
    end

    if not opts.naked_as_value and opts.defs == false then
```

```
1217        result = visit_tree(result, callbacks.process_naked)
1218      end
1219
1220      if opts.format_keys then
1221        if type(opts.format_keys) ~= 'table' then
1222          throw_error(
1223            'The option "format_keys" has to be a table not ' ..
1224              type(opts.format_keys))
1225        end
1226        result = visit_tree(result, callbacks.format_key)
1227      end
1228
1229      if opts.invert_flag then
1230        result = visit_tree(result, callbacks.apply_invert_flag)
1231      end
1232
1233      return result
1234    end
1235    result = apply_opts(result, opts)
1236
1237    -- All unknown keys are stored in this table
1238    local unknown = nil
1239    if type(opts.defs) == 'table' then
1240      apply_hooks('before_defs')
1241      result, unknown = apply_definitions(opts.defs, opts, result, {}, {},
1242        {}, clone_table(result))
1243    end
1244
1245    apply_hooks()
1246
1247    if opts.defaults ~= nil and type(opts.defaults) == 'table' then
1248      merge_tables(result, opts.defaults)
1249    end
1250
1251    if opts.debug then
1252      debug(result)
1253    end
1254
1255    -- no_error
1256    if not opts.no_error and type(unknown) == 'table' and
1257      utils.get_table_size(unknown) > 0 then
1258      throw_error('Unknown keys: ' .. render(unknown))
1259    end
1260    return result, unknown, raw
1261  end
1262
1263  --- Store results
1264  -- @section
1265
1266  --- A table to store parsed key-value results.
1267  local result_store = {}
1268
1269  --- Exports
1270  -- @section
1271
1272  local export = {
1273    version = { 0, 10, 0 },
1274
1275    namespace = namespace,
1276
1277    ---This function is used in the documentation.
1278    ---
```

```
1279    ---@param from string # A key in the namespace table, either `opts`, `hook` or
        ↪  `attrs`.
1280    print_names = function(from)
1281      local names = {}
1282      for name in pairs(namespace[from]) do
1283        table.insert(names, name)
1284      end
1285      table.sort(names)
1286      tex.print(table.concat(names, ', '))
1287    end,
1288
1289    print_default = function(from, name)
1290      tex.print(tostring(namespace[from][name]))
1291    end,
1292
1293    --- @see default_options
1294    opts = default_options,
1295
1296    --- @see stringify
1297    stringify = stringify,
1298
1299    --- @see parse
1300    parse = parse,
1301
1302    define = function(defs, opts)
1303      return function(kv_string, inner_opts)
1304        local options
1305
1306        if inner_opts ~= nil and opts ~= nil then
1307          options = merge_tables(opts, inner_opts)
1308        elseif inner_opts ~= nil then
1309          options = inner_opts
1310        elseif opts ~= nil then
1311          options = opts
1312        end
1313
1314        if options == nil then
1315          options = {}
1316        end
1317
1318        options.defs = defs
1319
1320        return parse(kv_string, options)
1321      end
1322    end,
1323
1324    --- @see render
1325    render = render,
1326
1327    --- @see debug
1328    debug = debug,
1329
1330    --- The function `save(identifier, result): void` saves a result (a
1331    --  table from a previous run of `parse`) under an identifier.
1332    --  Therefore, it is not necessary to pollute the global namespace to
1333    --  store results for the later usage.
1334    --
1335    ---@param identifier string # The identifier under which the result is saved.
1336    --
1337    ---@param result table # A result to be stored and that was created by the
        ↪  key-value parser.
1338    save = function(identifier, result)
```

```lua
      result_store[identifier] = result
    end,

    --- The function `get(identifier): table` retrieves a saved result
    --  from the result store.
    --
    ---@param identifier string # The identifier under which the result was saved.
    ---
    ---@return table
    get = function(identifier)
      -- if result_store[identifier] == nil then
      --   throw_error('No stored result was found for the identifier \'' ..
      ↪  identifier .. '\'')
      -- end
      return result_store[identifier]
    end,

    is = is,

    utils = utils,
  }

  return export
```

8.2 luakeys.tex

```
%% luakeys.tex
%% Copyright 2021-2022 Josef Friedrich
%
% This work may be distributed and/or modified under the
% conditions of the LaTeX Project Public License, either version 1.3c
% of this license or (at your option) any later version.
% The latest version of this license is in
%   http://www.latex-project.org/lppl.txt
% and version 1.3c or later is part of all distributions of LaTeX
% version 2008/05/04 or later.
%
% This work has the LPPL maintenance status `maintained'.
%
% The Current Maintainer of this work is Josef Friedrich.
%
% This work consists of the files luakeys.lua, luakeys.sty, luakeys.tex
% luakeys-debug.sty and luakeys-debug.tex.

\directlua{luakeys = require('luakeys')}
```

8.3 luakeys.sty

```
%% luakeys.sty
%% Copyright 2021-2022 Josef Friedrich
%
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% conditions of the LaTeX Project Public License, either version 1.3c
% of this license or (at your option) any later version.
% The latest version of this license is in
%   http://www.latex-project.org/lppl.txt
% and version 1.3c or later is part of all distributions of LaTeX
% version 2008/05/04 or later.
%
% This work has the LPPL maintenance status `maintained'.
%
% The Current Maintainer of this work is Josef Friedrich.
%
% This work consists of the files luakeys.lua, luakeys.sty, luakeys.tex
% luakeys-debug.sty and luakeys-debug.tex.

\NeedsTeXFormat{LaTeX2e}
\ProvidesPackage{luakeys}[2022/12/16 0.10.0 Parsing key-value options using Lua.]
\directlua{luakeys = require('luakeys')}
```

8.4 luakeys-debug.tex

```
%% luakeys-debug.tex
%% Copyright 2021-2022 Josef Friedrich
%
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% conditions of the LaTeX Project Public License, either version 1.3c
% of this license or (at your option) any later version.
% The latest version of this license is in
%   http://www.latex-project.org/lppl.txt
% and version 1.3c or later is part of all distributions of LaTeX
% version 2008/05/04 or later.
%
% This work has the LPPL maintenance status `maintained'.
%
% The Current Maintainer of this work is Josef Friedrich.
%
% This work consists of the files luakeys.lua, luakeys.sty, luakeys.tex
% luakeys-debug.sty and luakeys-debug.tex.

\directlua
{
  luakeys = require('luakeys')
}

\def\luakeysdebug%
{%
  \directlua%
  {
    local oarg = luakeys.utils.scan_oarg()
    local marg = token.scan_argument(false)
    local opts
    if oarg then
      opts = luakeys.parse(oarg, { format_keys = { 'snake', 'lower' } })
    end
    local result = luakeys.parse(marg, opts)
    luakeys.debug(result)
    tex.print(
      '{' ..
        '\string\\tt' ..
        '\string\\parindent=0pt' ..
        luakeys.stringify(result, true) ..
      '}'
    )
  }%
}
```

8.5 luakeys-debug.sty

```
%% luakeys-debug.sty
%% Copyright 2021-2022 Josef Friedrich
%
% This work may be distributed and/or modified under the
% conditions of the LaTeX Project Public License, either version 1.3c
% of this license or (at your option) any later version.
% The latest version of this license is in
%   http://www.latex-project.org/lppl.txt
% and version 1.3c or later is part of all distributions of LaTeX
% version 2008/05/04 or later.
%
% This work has the LPPL maintenance status `maintained'.
%
% The Current Maintainer of this work is Josef Friedrich.
%
% This work consists of the files luakeys.lua, luakeys.sty, luakeys.tex
% luakeys-debug.sty and luakeys-debug.tex.

\NeedsTeXFormat{LaTeX2e}
\ProvidesPackage{luakeys-debug}[2022/12/16 0.10.0 Debug package for luakeys.]

\input luakeys-debug.tex
```

Change History