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 / LuaTEX package 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 article is based on a question asked on tex.stackexchange.com by Will Robertson: A big list of every keyval package. CTAN also provides an overview page on the subject of Key-Val: packages with key-value argument systems.

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{
  lk = require('luakeys')()
}
\newcommand{\helloworld}[2][]{
  \directlua{
    local keys = lk.parse('\luaescapestring{\unexpanded{#1}}')
    lk.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 `luakeys.sty` file loads the Lua module into the global variable `luakeys`.

```
\documentclass{article}
\usepackage{luakeys}
\begin{document}
  \directlua{
    local lk = luakeys.new()
    local keys = lk.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`

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

```
\input luakeys.tex
\directlua{
  local lk = luakeys.new()
  local keys = lk.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

Luakeys exports only one function that must be called to access the public API. The Lua module exports this functions and tables:

```
local luakeys = require('luakeys')()
local new = luakeys.new
local version = luakeys.version
local parse = luakeys.parse
local define = luakeys.define
local opts = luakeys.opts
local error_messages = luakeys.error_messages
local render = luakeys.render
local stringify = luakeys.stringify
```

```
local debug = luakeys.debug
local save = luakeys.save
local get = luakeys.get
local is = luakeys.is
local utils = luakeys.utils
```

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.

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

3.2 Options to configure the `parse` function

The `parse` function can be called with an options table. This options are supported: accumulated_result, 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

```
local opts = {
  -- Result table that is filled with each call of the parse function.
  accumulated_result = accumulated_result,

  -- 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,
}
```

3.3 Table "`opts`"

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 }
```

To avoid interactions with other packages that also use `luakeys` and set the options globally, it is recommended to use the `get_private_instance()` function (**??**) to load the package.

3.3.1 Option “accumulated_result”

Strictly speaking, this is not an option. The `accumulated_result` “option” can be used to specify a result table that is filled with each call of the `parse` function.

```
local result = {}

luakeys.parse('key1=one', { accumulated_result = result })
assert.are.same({ key1 = 'one' }, result)

luakeys.parse('key2=two', { accumulated_result = result })
assert.are.same({ key1 = 'one', key2 = 'two' }, result)

luakeys.parse('key1=1', { accumulated_result = result })
assert.are.same({ key1 = 1, key2 = 'two' }, result)
```

3.3.2 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	3.3.2
group_begin	3.3.10
group_end	3.3.11
list_separator	3.3.14
quotation_begin	3.3.17
quotation_end	3.3.18

3.3.3 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.

```lua
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.

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

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

3.3.4 Option "`debug`"

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

```latex
\documentclass{article}
\usepackage{luakeys}
\begin{document}
\directlua{
  lk = luakeys.new()
  lk.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`.

3.3.5 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.

```lua
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`.

3.3.6 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`.

3.3.7 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`.

3.3.8 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' }
```

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

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

See section 3.3.19 for the corresponding option.

3.3.9 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.

```lua
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.

```lua
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.

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

You can also combine several types of formatting.

```lua
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`.

3.3.10 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 3.3.2.

3.3.11 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 3.3.2.

3.3.12 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 }
```

3.3.13 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 3.5.13)
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.

3.3.14 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 3.3.2.

3.3.15 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`.

3.3.16 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`.

3.3.17 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 3.3.2.

3.3.18 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 3.3.2.

3.3.19 Option “true_aliases”

See section 3.3.8.

3.3.20 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 3.1). 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.

```lua
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, description, 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.

```lua
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:
    -- any, boolean, dimension, integer, number, string, list
    data_type = 'string',

    -- To provide a default value for each naked key individually.
    default = true,

    -- Can serve as a comment.
    description = 'Describe your key-value pair.',

    -- 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%d$',

    -- The name of the key, can be omitted
    name = 'key',

    -- Convert opposite (naked) keys
```

```
    -- into a boolean value and store this boolean under a target key:
    --   show -> opposite_keys = true
    --   hide -> opposite_keys = false
    -- Short form: opposite_keys = { 'show', 'hide' }
    opposite_keys = { [true] = 'show', [false] = 'hide' },

    -- Pick a value by its data type:
    -- 'any', 'string', 'number', 'dimension', 'integer', 'boolean'.
    pick = false, -- 'false' disables the picking.

    -- A function whose return value is passed to the key.
    process = function(value, input, result, unknown)
      return value
    end,

    -- To enforce that a key must be specified.
    required = true,

    -- To build nested key-value pair definitions.
    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 ...

```
-- 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.

```
-- 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.

```
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:
    --- 'luakeys error [E004]: 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'`, `'list'`. 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
```

```lua
  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 (3.3.5) 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 “description”

This attribute is currently not processed further. It can serve as a comment.

3.5.7 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!'
```

3.5.8 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:
    -- 'luakeys error [E009]: 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 "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 }
```

Opposing key pairs can be specified in a short form, namely as a list: The opposite key, which represents the true value, must be specified first in this list, followed by the false value.

```
local parse = luakeys.define({
  visibility = { opposite_keys = { 'show', 'hide' } },
})
```

3.5.12 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: string, number, dimension, integer, boolean, any. 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' }
```

3.5.13 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:

```lua
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:

```lua
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:

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

```lua
    parse('key=1') -- throws error message: 'luakeys error [E019]: Unknown keys:
    ↪  "unknown_key=true,"'
```

3.5.14 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.

```lua
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: 'luakeys error [E012]: 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: 'luakeys error [E012]: Missing required key
      ↪  "important2"!'
```

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

```
      parse2('unimportant')
      -- throws error message: 'luakeys error [E012]: Missing required key
      ↪  "important1"!'
```

3.5.15 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. Some 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.list(value): boolean"

```
-- true
equal(luakeys.is.list({ 'one', 'two', 'three' }), true)
equal(luakeys.is.list({ [1] = 'one', [2] = 'two', [3] = 'three' }),
  true)

-- false
equal(luakeys.is.list({ one = 'one', two = 'two', three = 'three' }),
  false)
equal(luakeys.is.list('one,two,three'), false)
equal(luakeys.is.list('list'), false)
equal(luakeys.is.list(nil), false)
```

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

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

3.11 Table "utils"

The `utils` table bundles some auxiliary functions.

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

---table
local merge_tables = utils.merge_tables
local clone_table = utils.clone_table
local remove_from_table = utils.remove_from_table
local get_table_keys = utils.get_table_keys
local get_table_size = utils.get_table_size
local get_array_size = utils.get_array_size

---error
```

```
local throw_error_message = utils.throw_error_message
local throw_error_code = utils.throw_error_code

local scan_oarg = utils.scan_oarg

---ansi_color
local colorize = utils.ansi_color.colorize
local red = utils.ansi_color.red
local green = utils.ansi_color.green
local yellow = utils.ansi_color.yellow
local blue = utils.ansi_color.blue
local magenta = utils.ansi_color.magenta
local cyan = utils.ansi_color.cyan

---log
local set_log_level = utils.log.set_log_level
local err = utils.log.error
local warn = utils.log.warn
local info = utils.log.info
local verbose = utils.log.verbose
local debug = utils.log.debug
```

3.11.1 Function "`utils.merge_tables(target, source, overwrite): table`"

The function `merge_tables` merges two tables into the first specified table. It copies keys from the 'source' table into the 'target' table. It returns the target table.

If the `overwrite` parameter is set to `true`, values in the target table are overwritten.

```
local result = luakeys.utils.merge_tables({ key = 'target' }, {
  key = 'source',
  key2 = 'new',
}, true)
luakeys.debug(result) -- { key = 'source', key2 = 'new' }
```

Give the parameter `overwrite` the value `false` to overwrite values in the target table.

```
local result2 = luakeys.utils.merge_tables({ key = 'target' }, {
  key = 'source',
  key2 = 'new',
}, false)
luakeys.debug(result2) -- { key = 'target', key2 = 'new' }
```

3.11.2 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 lk = luakeys.new()
    local oarg = lk.utils.scan_oarg('[', ']')
    if oarg then
      local keys = lk.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_dimensions=true]{
  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 `\LuakeysGetClassOptions` macro. `\LuakeysGetClassOptions` is an alias for

`\luaescapestring{\@raw@classoptionslist}`.

```
\NeedsTeXFormat{LaTeX2e}
\ProvidesClass{test-class}[2022/05/26 Test class to access the class options]
\DeclareOption*{} % suppresses the warning: LaTeX Warning: Unused global option(s):
\ProcessOptions\relax
\RequirePackage{luakeys}

\directlua{
  lk = luakeys.new()
}

% Using the macro \LuakeysGetClassOptions
\directlua{
  lk.debug(lk.parse('\LuakeysGetClassOptions'))
}

% Low level approach
\directlua{
  lk.debug(lk.parse('\luaescapestring{\@raw@classoptionslist}'))
}

\LoadClass{article}
```

```
\documentclass[test={key1,key2}]{test-class}

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

5.3 Process package options

The options of a LaTeX package can be accessed via the `\LuakeysGetPackageOptions` macro. `\LuakeysGetPackageOptions` is an alias for

`\luaescapestring{\@ptionlist{\@currname.\@currext}}`.

```
\NeedsTeXFormat{LaTeX2e}
\ProvidesPackage{test-package}[2022/11/27 Test package to access the package
↪  options]
\DeclareOption*{} % suppresses the error message: ! LaTeX Error: Unknown option
```

```
\ProcessOptions\relax
\RequirePackage{luakeys}

\directlua{
  lk = luakeys.new()
}

% Using the macro \LuakeysGetPackageOptions
\directlua{
  lk.debug(lk.parse('\LuakeysGetPackageOptions'))
}

% Low level approach
\directlua{
  lk.debug(lk.parse('\luaescapestring{\@ptionlist{\@currname.\@currext}}'))
}
```

```
\documentclass{article}
\usepackage[test={key1,key2}]{test-package}
\begin{document}
This document uses the package "test-package".
\end{document}
```

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:

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

6.1 For plain TeX: luakeys-debug.tex

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

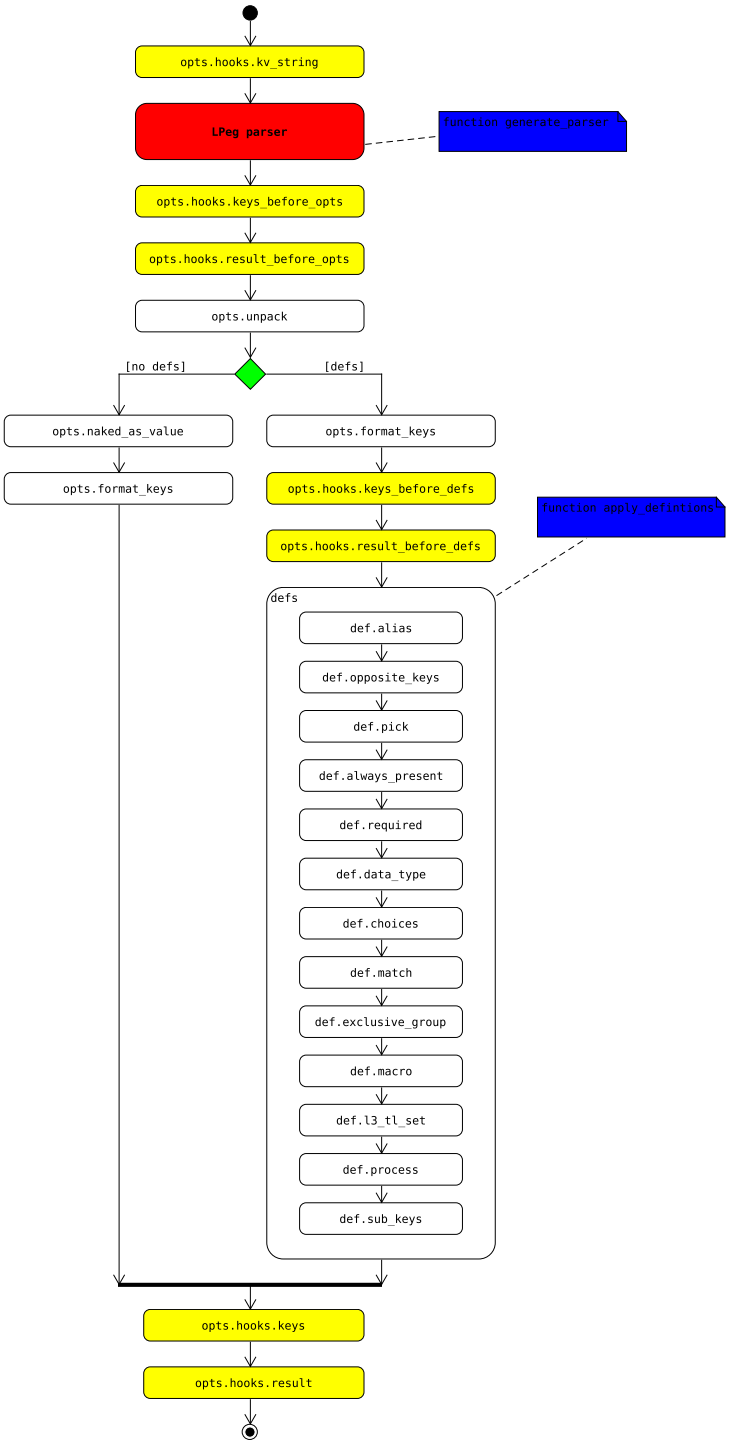
```
\input luakeys-debug.tex
\luakeysdebug{one,two,three}
\bye
```

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 2021-2023 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
  ---Dummy functions for the tests.
  tex = {
    sp = function(input)
      return 1234567
    end,
  }

  token = {
    set_macro = function(csname, content, global)
    end,
  }
end

local utils = (function()
  ---
  ---Merge two tables into the first specified table.
  ---The `merge_tables` function copies keys from the `source` table
  ---to the `target` table. It returns the target table.
  ---
  ---https://stackoverflow.com/a/1283608/10193818
  ---
  ---@param target table # The target table where all values are copied.
  ---@param source table # The source table from which all values are copied.
  ---@param overwrite? boolean # Overwrite the values in the target table if they
  ↪  are present (default true).
  ---
  ---@return table target The modified target table.
  local function merge_tables(target, source, overwrite)
    if overwrite == nil then
      overwrite = true
    end
    for key, value in pairs(source) do
      if type(value) == 'table' and type(target[key] or false) ==
        'table' then
        merge_tables(target[key] or {}, source[key] or {}, overwrite)
```

```
      elseif (not overwrite and target[key] == nil) or
        (overwrite and target[key] ~= value) then
        target[key] = value
      end
    end
    return target
  end

  ---
  ---Clone a table, i.e. make a deep copy of the source table.
  ---
  ---http://lua-users.org/wiki/CopyTable
  ---
  ---@param source table # The source table to be cloned.
  ---
  ---@return table # A deep copy of the source table.
  local function clone_table(source)
    local copy
    if type(source) == 'table' then
      copy = {}
      for orig_key, orig_value in next, source, nil do
        copy[clone_table(orig_key)] = clone_table(orig_value)
      end
      setmetatable(copy, clone_table(getmetatable(source)))
    else ---number, string, boolean, etc
      copy = source
    end
    return copy
  end

  ---
  ---Remove an element from a table.
  ---
  ---@param source table
  ---@param value any
  ---
  ---@return any|nil
  local function remove_from_table(source, value)
    for index, v in pairs(source) do
      if value == v then
        source[index] = nil
        return value
      end
    end
  end

  ---
  ---@param source table
  ---
  ---@return table # An array table with the sorted key names.
  local function get_table_keys(source)
    local keys = {}
    for key in pairs(source) do
      table.insert(keys, key)
    end
    table.sort(keys)
    return keys
  end

  ---
  ---Get the size of a table `{ one = 'one', 'two', 'three' }` = 3.
  ---
```

```lua
---@param value 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.
local function get_table_size(value)
  local count = 0
  if type(value) == 'table' then
    for _ in pairs(value) do
      count = count + 1
    end
  end
  return count
end

---
---Get the size of an array like table, for example `{ 'one', 'two',
---'three' }` = 3.
---
---@param value 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.
local function get_array_size(value)
  local count = 0
  if type(value) == 'table' then
    for _ in ipairs(value) do
      count = count + 1
    end
  end
  return count
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.
local function scan_oarg(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()
```

```
177         return convert_token(t), t
178       end
179
180       local char, t = get_next_char()
181       if char == initial_delimiter then
182         local oarg = {}
183         char = get_next_char()
184         while char ~= end_delimiter do
185           table.insert(oarg, char)
186           char = get_next_char()
187         end
188         return table.concat(oarg, '')
189       else
190         token.put_next(t)
191       end
192     end
193
194     ---
195     ---Throw a single error message.
196     ---
197     ---@param message string
198     ---@param help? table
199     local function throw_error_message(message, help)
200       if type(tex.error) == 'function' then
201         tex.error(message, help)
202       else
203         error(message)
204       end
205     end
206
207     ---
208     ---Throw an error by specifying an error code.
209     ---
210     ---@param error_messages table
211     ---@param error_code string
212     ---@param args? table
213     local function throw_error_code(error_messages,
214       error_code,
215       args)
216       local template = error_messages[error_code]
217
218       ---
219       ---@param message string
220       ---@param a table
221       ---
222       ---@return string
223       local function replace_args(message, a)
224         for key, value in pairs(a) do
225           if type(value) == 'table' then
226             value = table.concat(value, ', ')
227           end
228           message = message:gsub('@' .. key,
229             '"' .. tostring(value) .. '"')
230         end
231         return message
232       end
233
234       ---
235       ---@param list table
236       ---@param a table
237       ---
238       ---@return table
```

```
239       local function replace_args_in_list(list, a)
240         for index, message in ipairs(list) do
241           list[index] = replace_args(message, a)
242         end
243         return list
244       end
245
246       ---
247       ---@type string
248       local message
249       ---@type table
250       local help = {}
251
252       if type(template) == 'table' then
253         message = template[1]
254         if args ~= nil then
255           help = replace_args_in_list(template[2], args)
256         else
257           help = template[2]
258         end
259       else
260         message = template
261       end
262
263       if args ~= nil then
264         message = replace_args(message, args)
265       end
266
267       message = 'luakeys error [' .. error_code .. ']: ' .. message
268
269       for _, help_message in ipairs({
270         'You may be able to find more help in the documentation:',
271         'http://mirrors.ctan.org/macros/luatex/generic/luakeys/luakeys-doc.pdf',
272         'Or ask a question in the issue tracker on Github:',
273         'https://github.com/Josef-Friedrich/luakeys/issues',
274       }) do
275         table.insert(help, help_message)
276       end
277
278       throw_error_message(message, help)
279     end
280
281     local function visit_tree(tree, callback_func)
282       if type(tree) ~= 'table' then
283         throw_error_message(
284           'Parameter "tree" has to be a table, got: ' ..
285             tostring(tree))
286       end
287       local function visit_tree_recursive(tree,
288         current,
289         result,
290         depth,
291         callback_func)
292         for key, value in pairs(current) do
293           if type(value) == 'table' then
294             value = visit_tree_recursive(tree, value, {}, depth + 1,
295               callback_func)
296           end
297
298           key, value = callback_func(key, value, depth, current, tree)
299
300           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

    ---@alias ColorName
    ↪  'black'|'red'|'green'|'yellow'|'blue'|'magenta'|'cyan'|'white'|'reset'
    ---@alias ColorMode 'bright'|'dim'

    ---
    ---Small library to surround strings with ANSI color codes.
    --
    ---[SGR (Select Graphic Rendition)
    ↪  Parameters](https://en.wikipedia.org/wiki/ANSI_escape_code#SGR_(Select_Graphic_Rendition)_parameters)
    ---
    ---__attributes__
    ---
    ---| color      |code|
    ---|------------|----|
    ---| reset      |  0 |
    ---| clear      |  0 |
    ---| bright     |  1 |
    ---| dim        |  2 |
    ---| underscore |  4 |
    ---| blink      |  5 |
    ---| reverse    |  7 |
    ---| hidden     |  8 |
    ---
    ---__foreground__
    ---
    ---| color      |code|
    ---|------------|----|
    ---| black      | 30 |
    ---| red        | 31 |
    ---| green      | 32 |
    ---| yellow     | 33 |
    ---| blue       | 34 |
    ---| magenta    | 35 |
    ---| cyan       | 36 |
    ---| white      | 37 |
    ---
    ---__background__
    ---
    ---| color      |code|
    ---|------------|----|
    ---| onblack    | 40 |
    ---| onred      | 41 |
    ---| ongreen    | 42 |
    ---| onyellow   | 43 |
    ---| onblue     | 44 |
```

```
---| onmagenta  | 45 |
---| oncyan     | 46 |
---| onwhite    | 47 |
local ansi_color = (function()

  ---
  ---@param code integer
  ---
  ---@return string
  local function format_color_code(code)
    return string.char(27) .. '[' .. tostring(code) .. 'm'
  end

  ---
  ---@private
  ---
  ---@param color ColorName # A color name.
  ---@param mode? ColorMode
  ---@param background? boolean # Colorize the background not the text.
  ---
  ---@return string
  local function get_color_code(color, mode, background)
    local output = ''
    local code

    if mode == 'bright' then
      output = format_color_code(1)
    elseif mode == 'dim' then
      output = format_color_code(2)
    end

    if not background then
      if color == 'reset' then
        code = 0
      elseif color == 'black' then
        code = 30
      elseif color == 'red' then
        code = 31
      elseif color == 'green' then
        code = 32
      elseif color == 'yellow' then
        code = 33
      elseif color == 'blue' then
        code = 34
      elseif color == 'magenta' then
        code = 35
      elseif color == 'cyan' then
        code = 36
      elseif color == 'white' then
        code = 37
      else
        code = 37
      end
    else
      if color == 'black' then
        code = 40
      elseif color == 'red' then
        code = 41
      elseif color == 'green' then
        code = 42
      elseif color == 'yellow' then
        code = 43
```

```lua
    elseif color == 'blue' then
      code = 44
    elseif color == 'magenta' then
      code = 45
    elseif color == 'cyan' then
      code = 46
    elseif color == 'white' then
      code = 47
    else
      code = 40
    end
  end
  return output .. format_color_code(code)
end

---
---@param text any
---@param color ColorName # A color name.
---@param mode? ColorMode
---@param background? boolean # Colorize the background not the text.
---
---@return string
local function colorize(text, color, mode, background)
  return string.format('%s%s%s',
    get_color_code(color, mode, background), text,
    get_color_code('reset'))
end

return {
  colorize = colorize,

  ---
  ---@param text any
  ---
  ---@return string
  red = function(text)
    return colorize(text, 'red')
  end,

  ---
  ---@param text any
  ---
  ---@return string
  green = function(text)
    return colorize(text, 'green')
  end,

  ---@return string
  yellow = function(text)
    return colorize(text, 'yellow')
  end,

  ---
  ---@param text any
  ---
  ---@return string
  blue = function(text)
    return colorize(text, 'blue')
  end,

  ---
  ---@param text any
```

```lua
      ---
      ---@return string
      magenta = function(text)
        return colorize(text, 'magenta')
      end,

      ---
      ---@param text any
      ---
      ---@return string
      cyan = function(text)
        return colorize(text, 'cyan')
      end,
    }
  end)()

  ---
  ---A small logging library.
  ---
  ---Log levels:
  ---
  ---* 0: silent
  ---* 1: error
  ---* 2: warn
  ---* 3: info
  ---* 4: verbose
  ---* 5: debug
  ---
  local log = (function()
    ---@private
    local opts = { level = 0 }

    ---@private
    local function print_message(message, ...)
      print(string.format(message, ...))
    end

    ---
    ---Set the log level.
    ---
    ---@param level 0|'silent'|1|'error'|2|'warn'|3|'info'|4|'verbose'|5|'debug'
    local function set_log_level(level)
      if type(level) == 'string' then
        if level == 'silent' then
          opts.level = 0
        elseif level == 'error' then
          opts.level = 1
        elseif level == 'warn' then
          opts.level = 2
        elseif level == 'info' then
          opts.level = 3
        elseif level == 'verbose' then
          opts.level = 4
        elseif level == 'debug' then
          opts.level = 5
        else
          throw_error_message(string.format('Unknown log level: %s',
            level))
        end
      else
        if level > 5 or level < 0 then
          throw_error_message(string.format(
```

```
547               'Log level out of range 0-5: %s', level))
548           end
549           opts.level = level
550         end
551
552       end
553
554       ---
555       ---Log at level 1 (error).
556       ---
557       ---The other log levels are: 0 (silent), 1 (error), 2 (warn), 3 (info), 4
          ↪  (verbose), 5 (debug).
558       ---
559       ---@param message string
560       ---@param ... any
561       local function error(message, ...)
562         if opts.level >= 1 then
563           print_message(message, ...)
564         end
565       end
566
567       ---
568       ---Log at level 2 (warn).
569       ---
570       ---The other log levels are: 0 (silent), 1 (error), 2 (warn), 3 (info), 4
          ↪  (verbose), 5 (debug).
571       ---
572       ---@param message string
573       ---@param ... any
574       local function warn(message, ...)
575         if opts.level >= 2 then
576           print_message(message, ...)
577         end
578       end
579
580       ---
581       ---Log at level 3 (info).
582       ---
583       ---The other log levels are: 0 (silent), 1 (error), 2 (warn), 3 (info), 4
          ↪  (verbose), 5 (debug).
584       ---
585       ---@param message string
586       ---@param ... any
587       local function info(message, ...)
588         if opts.level >= 3 then
589           print_message(message, ...)
590         end
591       end
592
593       ---
594       ---Log at level 4 (verbose).
595       ---
596       ---The other log levels are: 0 (silent), 1 (error), 2 (warn), 3 (info), 4
          ↪  (verbose), 5 (debug).
597       ---
598       ---@param message string
599       ---@param ... any
600       local function verbose(message, ...)
601         if opts.level >= 4 then
602           print_message(message, ...)
603         end
604       end
```

```
605
606       ---
607       ---Log at level 5 (debug).
608       ---
609       ---The other log levels are: 0 (silent), 1 (error), 2 (warn), 3 (info), 4
          ↪  (verbose), 5 (debug).
610       ---
611       ---@param message string
612       ---@param ... any
613       local function debug(message, ...)
614         if opts.level >= 5 then
615           print_message(message, ...)
616         end
617       end
618
619       return {
620         set_log_level = set_log_level,
621         error = error,
622         warn = warn,
623         info = info,
624         verbose = verbose,
625         debug = debug,
626       }
627     end)()
628
629     return {
630       merge_tables = merge_tables,
631       clone_table = clone_table,
632       remove_from_table = remove_from_table,
633       get_table_keys = get_table_keys,
634       get_table_size = get_table_size,
635       get_array_size = get_array_size,
636       visit_tree = visit_tree,
637       scan_oarg = scan_oarg,
638       throw_error_message = throw_error_message,
639       throw_error_code = throw_error_code,
640       log = log,
641       ansi_color = ansi_color,
642     }
643   end)()
644
645   ---
646   ---Convert back to strings
647   ---@section
648   local visualizers = (function()
649
650     ---
651     ---The function `render(tbl)` reverses the function
652     ---`parse(kv_string)`. It takes a Lua table and converts this table
653     ---into a key-value string. The resulting string usually has a
654     ---different order as the input table. In Lua only tables with
655     ---1-based consecutive integer keys (a.k.a. array tables) can be
656     ---parsed in order.
657     ---
658     ---@param result table # A table to be converted into a key-value string.
659     ---
660     ---@return string # A key-value string that can be passed to a TeX macro.
661     local function render(result)
662       local function render_inner(result)
663         local output = {}
664         local function add(text)
665           table.insert(output, text)
```

```lua
      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
```

```lua

      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
        if (key and type(key) == 'number' or type(key) == 'string') then
          key = format_key(key)

          if (type(value) == 'table') then
            if (next(value)) then
              add(depth, key .. ' = ' .. start_bracket)
              add(0, stringify_inner(value, depth + 1))
              add(depth, end_bracket .. ',');
            else
              add(depth,
                key .. ' = ' .. start_bracket .. end_bracket .. ',')
            end
          else
            if (type(value) == 'string') then
              value = string.format('\'%s\'', value)
            else
              value = tostring(value)
            end

            add(depth, key .. ' = ' .. value .. ',')
          end
        end
      end

      return table.concat(output, line_break)
    end

    return start_bracket .. line_break .. stringify_inner(result, 1) ..
             line_break .. end_bracket
  end

  ---
  ---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.
  ---
  ---@param result table # A table to be printed to standard output for debugging
  ↪  purposes.
  local function debug(result)
    print('\n' .. stringify(result, false))
  end

  return { render = render, stringify = stringify, debug = debug }
end)()

local namespace = {
```

```
787     opts = {
788       accumulated_result = false,
789       assignment_operator = '=',
790       convert_dimensions = false,
791       debug = false,
792       default = true,
793       defaults = false,
794       defs = false,
795       false_aliases = { 'false', 'FALSE', 'False' },
796       format_keys = false,
797       group_begin = '{',
798       group_end = '}',
799       hooks = {},
800       invert_flag = '!',
801       list_separator = ',',
802       naked_as_value = false,
803       no_error = false,
804       quotation_begin = '"',
805       quotation_end = '"',
806       true_aliases = { 'true', 'TRUE', 'True' },
807       unpack = true,
808     },
809
810     hooks = {
811       kv_string = true,
812       keys_before_opts = true,
813       result_before_opts = true,
814       keys_before_def = true,
815       result_before_def = true,
816       keys = true,
817       result = true,
818     },
819
820     attrs = {
821       alias = true,
822       always_present = true,
823       choices = true,
824       data_type = true,
825       default = true,
826       description = true,
827       exclusive_group = true,
828       l3_tl_set = true,
829       macro = true,
830       match = true,
831       name = true,
832       opposite_keys = true,
833       pick = true,
834       process = true,
835       required = true,
836       sub_keys = true,
837     },
838
839     error_messages = {
840       E001 = {
841         'Unknown parse option: @unknown!',
842         { 'The available options are:', '@opt_names' },
843       },
844       E002 = {
845         'Unknown hook: @unknown!',
846         { 'The available hooks are:', '@hook_names' },
847       },
848       E003 = 'Duplicate aliases @alias1 and @alias2 for key @key!',
```

```
849       E004 = 'The value @value does not exist in the choices: @choices',
850       E005 = 'Unknown data type: @unknown',
851       E006 = 'The value @value of the key @key could not be converted into the data
          ↪  type @data_type!',
852       E007 = 'The key @key belongs to the mutually exclusive group @exclusive_group
          ↪  and another key of the group named @another_key is already present!',
853       E008 = 'def.match has to be a string',
854       E009 = 'The value @value of the key @key does not match @match!',
855
856       E011 = 'Wrong data type in the "pick" attribute: @unknown. Allowed are:
          ↪  @data_types.',
857       E012 = 'Missing required key @key!',
858       E013 = 'The key definition must be a table! Got @data_type for key @key.',
859       E014 = {
860         'Unknown definition attribute: @unknown',
861         { 'The available attributes are:', '@attr_names' },
862       },
863       E015 = 'Key name couldn't be detected!',
864       E017 = 'Unknown style to format keys: @unknown! Allowed styles are: @styles',
865       E018 = 'The option "format_keys" has to be a table not @data_type',
866       E019 = 'Unknown keys: @unknown',
867
868       ---Input / parsing error
869       E021 = 'Opposite key was specified more than once: @key!',
870       E020 = 'Both opposite keys were given: @true and @false!',
871       ---Config error (wrong configuration of luakeys)
872       E010 = 'Usage: opposite_keys = { "true_key", "false_key" } or { [true] =
          ↪  "true_key", [false] = "false_key" } ',
873       E023 = {
874         'Don't use this function from the global luakeys table. Create a new instance
            ↪  using e. g.: local lk = luakeys.new()',
875         {
876           'This functions should not be used from the global luakeys table:',
877           'parse()',
878           'save()',
879           'get()',
880         },
881       },
882     },
883   }
884
885   ---
886   ---@return table # The public interface of the module.
887   local function main()
888
889     ---The default options.
890     local default_opts = utils.clone_table(namespace.opts)
891
892     local error_messages = utils.clone_table(namespace.error_messages)
893
894     ---
895     ---@param error_code string
896     ---@param args? table
897     local function throw_error(error_code, args)
898       utils.throw_error_code(error_messages, error_code, args)
899     end
900
901     ---
902     ---Normalize the parse options.
903     ---
904     ---@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('E001', {
        unknown = key,
        opt_names = utils.get_table_keys(namespace.opts),
      })
    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_opts[name]
    end
  end

  for hook in pairs(opts.hooks) do
    if namespace.hooks[hook] == nil then
      throw_error('E002', {
        unknown = hook,
        hook_names = utils.get_table_keys(namespace.hooks),
      })
    end
  end
  return opts
end

local l3_code_cctab = 10

---
---Parser / Lpeg related
---@section

---Generate the PEG parser using Lpeg.
---
---Explanations of some LPeg notation forms:
---
---* `patt ^ 0` = `expression *`
---* `patt ^ 1` = `expression +`
---* `patt ^ -1` = `expression ?`
---* `patt1 * patt2` = `expression1 expression2`: Sequence
---* `patt1 + patt2` = `expression1 / expression2`: Ordered choice
---
---* [TUGboat article: Parsing complex data formats in LuaTEX with LPEG](https://tug.or-g/TUGboat/tb40-2/tb125menke-Patterndf)
---
---@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`).
---@param opts? table # Whether the dimensions should be converted to scaled points (by default `false`).
---
---@return userdata # The parser.
local function generate_parser(initial_rule, opts)
  if type(opts) ~= 'table' then
```

```
964         opts = normalize_opts(opts)
965       end
966
967       local Variable = lpeg.V
968       local Pattern = lpeg.P
969       local Set = lpeg.S
970       local Range = lpeg.R
971       local CaptureGroup = lpeg.Cg
972       local CaptureFolding = lpeg.Cf
973       local CaptureTable = lpeg.Ct
974       local CaptureConstant = lpeg.Cc
975       local CaptureSimple = lpeg.C
976
977       ---Optional whitespace
978       local white_space = Set(' \t\n\r')
979
980       ---Match literal string surrounded by whitespace
981       local ws = function(match)
982         return white_space ^ 0 * Pattern(match) * white_space ^ 0
983       end
984
985       local line_up_pattern = function(patterns)
986         local result
987         for _, pattern in ipairs(patterns) do
988           if result == nil then
989             result = Pattern(pattern)
990           else
991             result = result + Pattern(pattern)
992           end
993         end
994         return result
995       end
996
997       ---
998       ---Convert a dimension to an normalized dimension string or an
999       ---integer in the scaled points format.
1000      ---
1001      ---@param input string
1002      ---
1003      ---@return integer|string # A dimension as an integer or a dimension string.
1004      local capture_dimension = function(input)
1005        ---Remove all whitespaces
1006        input = input:gsub('%s+', '')
1007        ---Convert the unit string into lowercase.
1008        input = input:lower()
1009        if opts.convert_dimensions then
1010          return tex.sp(input)
1011        else
1012          return input
1013        end
1014      end
1015
1016      ---
1017      ---Add values to a table in two modes:
1018      ---
1019      ---Key-value pair:
1020      ---
1021      ---If `arg1` and `arg2` are not nil, then `arg1` is the key and `arg2` is the
1022      ---value of a new table entry.
1023      ---
1024      ---Indexed value:
1025      ---
```

```
---If `arg2` is nil, then `arg1` is the value and is added as an indexed
---(by an integer) value.
---
---@param result table # The result table to which an additional key-value pair
↪  or value should to be added
---@param arg1 any # The key or the value.
---@param arg2? any # Always the value.
---
---@return table # The result table to which an additional key-value pair or
↪  value has been added.
local add_to_table = function(result, arg1, arg2)
  if arg2 == nil then
    local index = #result + 1
    return rawset(result, index, arg1)
  else
    return rawset(result, arg1, arg2)
  end
end

-- LuaFormatter off
return Pattern({
  [1] = initial_rule,

  ---list_item*
  list = CaptureFolding(
    CaptureTable('') * Variable('list_item')^0,
    add_to_table
  ),

  ---'{' list '}'
  list_container =
    ws(opts.group_begin) * Variable('list') * ws(opts.group_end),

  ---( list_container / key_value_pair / value ) ','?
  list_item =
    CaptureGroup(
      Variable('list_container') +
      Variable('key_value_pair') +
      Variable('value')
    ) * ws(opts.list_separator)^-1,

  ---key '=' (list_container / value)
  key_value_pair =
    (Variable('key') * ws(opts.assignment_operator)) *
    ↪  (Variable('list_container') + Variable('value')),

  ---number / string_quoted / string_unquoted
  key =
    Variable('number') +
    Variable('string_quoted') +
    Variable('string_unquoted'),

  ---boolean !value / dimension !value / number !value / string_quoted !value /
  ↪  string_unquoted
  ---!value -> Not-predicate -> * -Variable('value')
  value =
    Variable('boolean') * -Variable('value') +
    Variable('dimension') * -Variable('value') +
    Variable('number') * -Variable('value')  +
    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/we
        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 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,

    list = function(value)
      if type(value) ~= 'table' then
        return false
      end

      for k, _ in pairs(value) do
        if type(k) ~= 'number' then
          return false
        end
      end
      return true
    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
```

```
1267          return true
1268        end
1269
1270        local function find_value(search_key, def)
1271          if input[search_key] ~= nil then
1272            local value = input[search_key]
1273            input[search_key] = nil
1274            return value
1275            ---naked keys: values with integer keys
1276          elseif utils.remove_from_table(input, search_key) ~= nil then
1277            return get_default_value(def)
1278          end
1279        end
1280
1281        local apply = {
1282          alias = function(value, key, def)
1283            if type(def.alias) == 'string' then
1284              def.alias = { def.alias }
1285            end
1286            local alias_value
1287            local used_alias_key
1288            ---To get an error if the key and an alias is present
1289            if value ~= nil then
1290              alias_value = value
1291              used_alias_key = key
1292            end
1293            for _, alias in ipairs(def.alias) do
1294              local v = find_value(alias, def)
1295              if v ~= nil then
1296                if alias_value ~= nil then
1297                  throw_error('E003', {
1298                    alias1 = used_alias_key,
1299                    alias2 = alias,
1300                    key = key,
1301                  })
1302                end
1303                used_alias_key = alias
1304                alias_value = v
1305              end
1306            end
1307            if alias_value ~= nil then
1308              return alias_value
1309            end
1310          end,
1311
1312          always_present = function(value, key, def)
1313            if value == nil and def.always_present then
1314              return get_default_value(def)
1315            end
1316          end,
1317
1318          choices = function(value, key, def)
1319            if value == nil then
1320              return
1321            end
1322            if def.choices ~= nil and type(def.choices) == 'table' then
1323              local is_in_choices = false
1324              for _, choice in ipairs(def.choices) do
1325                if value == choice then
1326                  is_in_choices = true
1327                end
1328              end
```

```
            if not is_in_choices then
              throw_error('E004', { value = value, choices = def.choices })
            end
          end
        end,

        data_type = function(value, key, def)
          if value == nil then
            return
          end
          if def.data_type ~= nil then
            local converted
            ---boolean
            if def.data_type == 'boolean' then
              if value == 0 or value == '' or not value then
                converted = false
              else
                converted = true
              end
              ---dimension
            elseif def.data_type == 'dimension' then
              if is.dimension(value) then
                converted = value
              end
              ---integer
            elseif def.data_type == 'integer' then
              if is.number(value) then
                local n = tonumber(value)
                if type(n) == 'number' and n ~= nil then
                  converted = math.floor(n)
                end
              end
              ---number
            elseif def.data_type == 'number' then
              if is.number(value) then
                converted = tonumber(value)
              end
              ---string
            elseif def.data_type == 'string' then
              converted = tostring(value)
              ---list
            elseif def.data_type == 'list' then
              if is.list(value) then
                converted = value
              end
            else
              throw_error('E005', { data_type = def.data_type })
            end
            if converted == nil then
              throw_error('E006', {
                value = value,
                key = key,
                data_type = def.data_type,
              })
            else
              return converted
            end
          end
        end,

        exclusive_group = function(value, key, def)
          if value == nil then
```

```
      return
    end
    if def.exclusive_group ~= nil then
      if exclusive_groups[def.exclusive_group] ~= nil then
        throw_error('E007', {
          key = key,
          exclusive_group = def.exclusive_group,
          another_key = exclusive_groups[def.exclusive_group],
        })
      else
        exclusive_groups[def.exclusive_group] = key
      end
    end
  end,

  l3_tl_set = function(value, key, def)
    if value == nil then
      return
    end
    if def.l3_tl_set ~= nil then
      tex.print(l3_code_cctab,
        '\\tl_set:Nn \\g_' .. def.l3_tl_set .. '_tl')
      tex.print('{' .. value .. '}')
    end
  end,

  macro = function(value, key, def)
    if value == nil then
      return
    end
    if def.macro ~= nil then
      token.set_macro(def.macro, value, 'global')
    end
  end,

  match = function(value, key, def)
    if value == nil then
      return
    end
    if def.match ~= nil then
      if type(def.match) ~= 'string' then
        throw_error('E008')
      end
      local match = string.match(value, def.match)
      if match == nil then
        throw_error('E009', {
          value = value,
          key = key,
          match = def.match:gsub('%%', '%%%%'),
        })
      else
        return match
      end
    end
  end,

  opposite_keys = function(value, key, def)
    if def.opposite_keys ~= nil then
      local function get_value(key1, key2)
        local opposite_name
        if def.opposite_keys[key1] ~= nil then
          opposite_name = def.opposite_keys[key1]
```

```
            elseif def.opposite_keys[key2] ~= nil then
              opposite_name = def.opposite_keys[key2]
            end
            return opposite_name
          end
          local true_key = get_value(true, 1)
          local false_key = get_value(false, 2)
          if true_key == nil or false_key == nil then
            throw_error('E010')
          end

          ---@param value string
          local function remove_values(value)
            local count = 0
            while utils.remove_from_table(input, value) do
              count = count + 1
            end
            return count
          end

          local true_count = remove_values(true_key)
          local false_count = remove_values(false_key)

          if true_count > 1 then
            throw_error('E021', { key = true_key })
          end

          if false_count > 1 then
            throw_error('E021', { key = false_key })
          end

          if true_count > 0 and false_count > 0 then
            throw_error('E020',
              { ['true'] = true_key, ['false'] = false_key })
          end

          return true_count == 1 or false_count == 0
        end
      end,

      process = function(value, key, def)
        if value == nil then
          return
        end
        if def.process ~= nil and type(def.process) == 'function' then
          return def.process(value, input_root, output, unknown)
        end
      end,

      pick = function(value, key, def)
        if def.pick then
          local pick_types

          ---Allow old deprecated attribut pick = true
          if def.pick == true then
            pick_types = { 'any' }
          elseif type(def.pick) == 'table' then
            pick_types = def.pick
          else
            pick_types = { def.pick }
          end

```

```
      ---Check if the pick attribute is valid
      for _, pick_type in ipairs(pick_types) do
        if type(pick_type) == 'string' and is[pick_type] == nil then
          throw_error('E011', {
            unknown = tostring(pick_type),
            data_types = {
              'any',
              'boolean',
              'dimension',
              'integer',
              'number',
              'string',
            },
          })
        end
      end

      ---The key has already a value. We leave the function at this
      ---point to be able to check the pick attribute for errors
      ---beforehand.
      if value ~= nil then
        return value
      end

      for _, pick_type in ipairs(pick_types) do
        for i, v in pairs(input) do
          ---We can not use ipairs here. `ipairs(t)` iterates up to the
          ---first absent index. Values are deleted from the `input`
          ---table.
          if type(i) == 'number' then
            local picked_value = nil
            if is[pick_type](v) then
              picked_value = v
            end

            if picked_value ~= nil then
              input[i] = nil
              return picked_value
            end
          end
        end
      end
    end,

    required = function(value, key, def)
      if def.required ~= nil and def.required and value == nil then
        throw_error('E012', { key = key })
      end
    end,

    sub_keys = function(value, key, def)
      if def.sub_keys ~= nil then
        local v
        ---To get keys defined with always_present
        if value == nil then
          v = {}
        elseif type(value) == 'string' then
          v = { value }
        elseif type(value) == 'table' then
          v = value
        end
```

```
            v = apply_definitions(def.sub_keys, opts, v, output[key],
              unknown, add_to_key_path(key_path, key), input_root)
            if utils.get_table_size(v) > 0 then
              return v
            end
          end
        end,
      }

      ---standalone values are removed.
      ---For some callbacks and the third return value of parse, we
      ---need an unchanged raw result from the parse function.
      input = utils.clone_table(input)
      if output == nil then
        output = {}
      end
      if unknown == nil then
        unknown = {}
      end
      if key_path == nil then
        key_path = {}
      end

      for index, def in pairs(defs) do
        ---Find key and def
        local key
        ---`{ key1 = { }, key2 = { } }`
        if type(def) == 'table' and def.name == nil and type(index) ==
          'string' then
          key = index
          ---`{ { name = 'key1' }, { name = 'key2' } }`
        elseif type(def) == 'table' and def.name ~= nil then
          key = def.name
          ---Definitions as strings in an array: `{ 'key1', 'key2' }`
        elseif type(index) == 'number' and type(def) == 'string' then
          key = def
          def = { default = get_default_value({}) }
        end

        if type(def) ~= 'table' then
          throw_error('E013', { data_type = tostring(def), key = index }) ---key is
          ↪  nil
        end

        for attr, _ in pairs(def) do
          if namespace.attrs[attr] == nil then
            throw_error('E014', {
              unknown = attr,
              attr_names = utils.get_table_keys(namespace.attrs),
            })
          end
        end

        if key == nil then
          throw_error('E015')
        end

        local value = find_value(key, def)

        for _, def_opt in ipairs({
          'alias',
          'opposite_keys',
```

```
        'pick',
        'always_present',
        'required',
        'data_type',
        'choices',
        'match',
        'exclusive_group',
        'macro',
        'l3_tl_set',
        'process',
        'sub_keys',
      }) do
        if def[def_opt] ~= nil then
          local tmp_value = apply[def_opt](value, key, def)
          if tmp_value ~= nil then
            value = tmp_value
          end
        end
      end

      output[key] = value
    end

    if utils.get_table_size(input) > 0 then
      ---Move to the current unknown table.
      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 options.
  ---
  ---@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 = utils.clone_table(result)

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

        if opts.debug then
          print('After the execution of the hook: ' .. name)
          visualizers.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('E017', {
                  unknown = style,
                  styles = { '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 = utils.visit_tree(result, callbacks.unpack)
      end

      if not opts.naked_as_value and opts.defs == false then
        result = utils.visit_tree(result, callbacks.process_naked)
      end

      if opts.format_keys then
        if type(opts.format_keys) ~= 'table' then
          throw_error('E018', { data_type = type(opts.format_keys) })
        end
        result = utils.visit_tree(result, callbacks.format_key)
      end

      if opts.invert_flag then
        result = utils.visit_tree(result, callbacks.apply_invert_flag)
      end

      return result
    end
    result = apply_opts(result, opts)

    ---All unknown keys are stored in this table
    local unknown = nil
    if type(opts.defs) == 'table' then
      apply_hooks('before_defs')
      result, unknown = apply_definitions(opts.defs, opts, result, {},
        {}, {}, utils.clone_table(result))
    end

    apply_hooks()

    if opts.defaults ~= nil and type(opts.defaults) == 'table' then
      utils.merge_tables(result, opts.defaults, false)
    end

    if opts.debug then
      visualizers.debug(result)
```

```
    end

    if opts.accumulated_result ~= nil and type(opts.accumulated_result) ==
      'table' then
      utils.merge_tables(opts.accumulated_result, result, true)
    end

    ---no_error
    if not opts.no_error and type(unknown) == 'table' and
      utils.get_table_size(unknown) > 0 then
      throw_error('E019', { unknown = visualizers.render(unknown) })
    end
    return result, unknown, raw
  end

  ---
  ---A table to store parsed key-value results.
  local result_store = {}

  return {
    new = main,

    version = { 0, 12, 0 },

    ---@see parse
    parse = parse,

    define = function(defs, opts)
      return function(kv_string, inner_opts)
        local options

        if inner_opts ~= nil and opts ~= nil then
          options = utils.merge_tables(opts, inner_opts)
        elseif inner_opts ~= nil then
          options = inner_opts
        elseif opts ~= nil then
          options = opts
        end

        if options == nil then
          options = {}
        end

        options.defs = defs

        return parse(kv_string, options)
      end
    end,

    ---@see default_opts
    opts = default_opts,

    error_messages = error_messages,

    ---@see visualizers.render
    render = visualizers.render,

    ---@see visualizers.stringify
    stringify = visualizers.stringify,

    ---@see visualizers.debug
    debug = visualizers.debug,
```

```
1884
1885        ---
1886        ---The function `save(identifier, result): void` saves a result (a
1887        ---table from a previous run of `parse`) under an identifier.
1888        ---Therefore, it is not necessary to pollute the global namespace to
1889        ---store results for the later usage.
1890        ---
1891        ---@param identifier string # The identifier under which the result is saved.
1892        ---
1893        ---@param result table # A result to be stored and that was created by the
            ↪  key-value parser.
1894        save = function(identifier, result)
1895          result_store[identifier] = result
1896        end,
1897
1898        ---The function `get(identifier): table` retrieves a saved result
1899        ---from the result store.
1900        ---
1901        ---@param identifier string # The identifier under which the result was saved.
1902        ---
1903        ---@return table
1904        get = function(identifier)
1905          ---if result_store[identifier] == nil then
1906          ---  throw_error('No stored result was found for the identifier \'' ..
              ↪  identifier .. '\'')
1907          ---end
1908          return result_store[identifier]
1909        end,
1910
1911        is = is,
1912
1913        utils = utils,
1914
1915        ---
1916        ---Exported but intentionally undocumented functions
1917        ---
1918
1919        namespace = utils.clone_table(namespace),
1920
1921        ---
1922        ---This function is used in the documentation.
1923        ---
1924        ---@param from string # A key in the namespace table, either `opts`, `hook` or
            ↪  `attrs`.
1925        print_names = function(from)
1926          local names = utils.get_table_keys(namespace[from])
1927          tex.print(table.concat(names, ', '))
1928        end,
1929
1930        print_default = function(from, name)
1931          tex.print(tostring(namespace[from][name]))
1932        end,
1933
1934        ---
1935        ---@param exported_table table
1936        depublish_functions = function(exported_table)
1937          local function warn_global_import()
1938            throw_error('E023')
1939          end
1940
1941          exported_table.parse = warn_global_import
1942          exported_table.define = warn_global_import
```

```
        exported_table.save = warn_global_import
        exported_table.get = warn_global_import
      end,
    }

end

return main
```

8.2 luakeys.tex

```
%% luakeys.tex
%% Copyright 2021-2023 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{
  if luakeys == nil then
    luakeys = require('luakeys')()
    luakeys.depublish_functions(luakeys)
  end
}
```

8.3 luakeys.sty

```
%% luakeys.sty
%% Copyright 2021-2023 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}[2023/01/05 v0.12.0 Parsing key-value options using Lua.]
\directlua{
  if luakeys == nil then
    luakeys = require('luakeys')()
    luakeys.depublish_functions(luakeys)
  end
}

\def\LuakeysGetPackageOptions{\luaescapestring{\@ptionlist{\@currname.\@currext}}}

\def\LuakeysGetClassOptions{\luaescapestring{\@raw@classoptionslist}}
```

8.4 luakeys-debug.tex

```
%% luakeys-debug.tex
%% Copyright 2021-2023 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')()
}

\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 2021-2023 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}[2023/01/05 v0.12.0 Debug package for luakeys.]

\input luakeys-debug.tex
```

Change History