

The luaotfload package

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Abstract

This package is an adaptation of the Con \TeX t font loading system. It allows for loading OpenType fonts with an extended syntax and adds support for a variety of font features.

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1 INTRODUCTION

Font management and installation has always been painful with \TeX . A lot of files are needed for one font (*TFM*, *PFB*, *MAP*, *FD*, *VF*), and due to the 8-Bit encoding each font is limited to 256 characters. But the font world has evolved since the original \TeX , and new typographic systems have appeared, most notably the so called *smart font* technologies like OpenType fonts (*OTF*). These fonts can contain many more characters than \TeX fonts, as well as additional functionality like ligatures, old-style numbers, small capitals, etc., and support more complex writing systems like Arabic and Indic¹ scripts. OpenType fonts are widely deployed and available for all modern operating systems. As of 2013 they have become the de facto standard for advanced text layout. However, until recently the only way to use them directly in the \TeX world was with the X \TeX engine.

Unlike X \TeX , Lua \TeX has no built-in support for OpenType or technologies other than the original \TeX fonts. Instead, it provides hooks for executing Lua code during the \TeX run that allow implementing extensions for loading fonts and manipulating how input text is processed without modifying the underlying engine. This is where *luaotfload* comes into play: Based on code from Con \TeX t, it extends Lua \TeX with functionality necessary for handling OpenType fonts. Additionally, it provides means for accessing fonts known to the operating system conveniently by indexing the metadata.

¹Unfortunately, *luaotfload* doesn't support many Indic scripts right now. Assistance in implementing the prerequisites is greatly appreciated.

2 *THANKS*

Luaotfload is part of Lua_{La}TeX, the community-driven project to provide a foundation for using the \LaTeX format with the full capabilities of the LuaTeX engine. As such, the distinction between end users, contributors, and project maintainers is intentionally kept less strict, lest we unduly personalize the common effort.

Nevertheless, the current maintainers would like to express their gratitude to Khaled Hosny, Akira Kakuto, Hironori Kitagawa and Dohyun Kim. Their contributions – be it patches, advice, or systematic testing – made the switch from version 1.x to 2.2 possible. Also, Hans Hagen, the author of the font loader, made porting the code to \LaTeX a breeze due to the extra effort he invested into isolating it from the rest of ConTeXt, not to mention his assistance in the task and willingness to respond to our suggestions.

3 *LOADING FONTS*

luaotfload supports an extended font request syntax:

```
\font\foo={\langle prefix\rangle:\langle font name\rangle:\langle font features\rangle}\langle TeX font features\rangle
```

The curly brackets are optional and escape the spaces in the enclosed font name. Alternatively, double quotes serve the same purpose. A selection of individual parts of the syntax are discussed below; for a more formal description see figure ??.

3.1 *Prefix – the luaotfload Way*

In luaotfload, the canonical syntax for font requests requires a *prefix*:

```
\font\fontname=\langle prefix\rangle:\langle fontname\rangle...
```

where $\langle prefix \rangle$ is either `file:` or `name:`. It determines whether the font loader should interpret the request as a *file name* or *font name*, respectively, which again influences how it will attempt to locate the font. Examples for font names are “Latin Modern Italic”, “GFS Bodoni Rg”, and “PT Serif Caption” – they are the human readable identifiers usually listed in drop-down menus and the like. In order for fonts installed both in system locations and in your `texmf` to be accessible by font name, luaotfload must first collect the metadata included in the files. Please refer to section ?? below for instructions on how to create the database.

File names are whatever your file system allows them to be, except that that they may not contain the characters `(`, `:`, and `/`. As is obvious from the last exception, the `file:` lookup will not process paths to the font location – only those files found when generating the database are addressable this way. Continue below in the \XeTeX section if you need to load your fonts by path. The file names corresponding to the example font names above are `lmroman12-italic.otf`, `GFSBodoni.otf`, and `PTZ56F.ttf`.

3.2 *Compatibility Layer*

In addition to the regular prefixed requests, luaotfload accepts loading fonts the \XeTeX way. There are again two modes: bracketed and unbracketed. A bracketed request looks as follows.

`\font\fontname=[<path to file>]`

Inside the square brackets, every character except for a closing bracket is permitted, allowing for specifying paths to a font file. Naturally, path-less file names are equally valid and processed the same way as an ordinary `file:` lookup.

`\font\fontname= ...`

Unbracketed (or, for lack of a better word: *anonymous*) font requests resemble the conventional \TeX syntax. However, they have a broader spectrum of possible interpretations: before anything else, `luaotfload` attempts to load a traditional \TeX Font Metric (*TFM* or *OFM*). If this fails, it performs a `name:` lookup, which itself will fall back to a `file:` lookup if no database entry matches **.

Furthermore, `luaotfload` supports the slashed (shorthand) font style notation from \XTeX .

`\font\fontname=/<modifier>...`

Currently, four style modifiers are supported: `I` for italic shape, `B` for bold weight, `BI` or `IB` for the combination of both. Other “slashed” modifiers are too specific to the \XTeX engine and have no meaning in $\text{Lua}\TeX$.

3.3 Examples

3.3.1 Loading by File Name

For example, conventional *TYPE1* font can be loaded with a `file:` request like so:

```
\font\lmromanten={file:ec-lmr10} at 10pt
```

The OpenType version of Janusz Nowacki’s font *Antykwa Półtawskiego*² in its condensed variant can be loaded as follows:

```
\font\apcregular=file:antpolttltcond-regular.otf at 42pt
```

The next example shows how to load the *Porson* font digitized by the Greek Font Society using \XTeX -style syntax and an absolute path from a non-standard directory:

```
\font\gfsporson="[tmp/GFSPorson.otf]" at 12pt
```

²<http://jmn.pl/antykwa-poltawskiego/>, also available in TeX Live.

3.3.2 Loading by Font Name

The name: lookup does not depend on cryptic filenames:

```
\font\pagellaregular={name:TeX Gyre Pagella} at 9pt
```

A bit more specific but essentially the same lookup would be:

```
\font\pagellaregular={name:TeX Gyre Pagella Regular} at 9pt
```

Which fits nicely with the whole set:

```
\font\pagellaregular   = {name:TeX Gyre Pagella Regular}   at 9pt
\font\pagellaitalic    = {name:TeX Gyre Pagella Italic}     at 9pt
\font\pagellabold      = {name:TeX Gyre Pagella Bold}       at 9pt
\font\pagellabolditalic = {name:TeX Gyre Pagella Bolditalic} at 9pt

{\pagellaregular      foo bar baz\endgraf}
{\pagellaitalic       foo bar baz\endgraf}
{\pagellabold         foo bar baz\endgraf}
{\pagellabolditalic   foo bar baz\endgraf}

...
```

3.3.3 Modifiers

If the entire *Iwona* family³ is installed in some location accessible by `luaotfload`, the regular shape can be loaded as follows:

```
\font\iwona=Iwona at 20pt
```

To load the most common of the other styles, the slash notation can be employed as shorthand:

```
\font\iwonaitalic    =Iwona/I    at 20pt
\font\iwonabold      =Iwona/B    at 20pt
\font\iwonabolditalic=Iwona/BI   at 20pt
```

which is equivalent to these full names:

```
\font\iwonaitalic    ="Iwona Italic"    at 20pt
\font\iwonabold      ="Iwona Bold"      at 20pt
\font\iwonabolditalic="Iwona BoldItalic" at 20pt
```

³<http://jmn.pl/kurier-i-iwona/>, also in T_EX Live.

Font features are the second to last component in the general scheme for font requests:

```
\font\foo={ <prefix>: <font name>: <font features> } <TeX font features>
```

If style modifiers are present (X_YTeX style), they must precede **.

The element ** is a semicolon-separated list of feature tags⁴ and font options. Prepending a font feature with a + (plus sign) enables it, whereas a - (minus) disables it. For instance, the request

```
\font\test=LatinModernRoman:+clig;-kern
```

activates contextual ligatures (clig) and disables kerning (kern). Alternatively the options true or false can be passed to the feature in a key/value expression. The following request has the same meaning as the last one:

```
\font\test=LatinModernRoman:clig=true;kern=false
```

Furthermore, this second syntax is required should a font feature accept other options besides a true/false switch. For example, *stylistic alternates* (salt) are variants of given glyphs. They can be selected either explicitly by supplying the variant index (starting from one), or randomly by setting the value to, obviously, random.

```
\font\librmsaltfirst=LatinModernRoman:salt=1
```

Other font options include:

mode

luaotfload has two OpenType processing *modes*: base and node.

base mode works by mapping OpenType features to traditional T_EX ligature and kerning mechanisms. Supporting only non-contextual substitutions and kerning pairs, it is the slightly faster, albeit somewhat limited, variant. node mode works by processing T_EX's internal node list directly at the Lua end and supports a wider range of OpenType features. The downside is that the intricate operations required for node mode may slow down typesetting especially with complex fonts and it does not work in math mode.

By default luaotfload is in node mode, and base mode has to be requested where needed, e. g. for math fonts.

script

An OpenType script tag,⁵ the default value is dflt. Some fonts, including very popular ones by foundries like Adobe, do not assign features to the dflt script, in which case the script needs to be set explicitly.

⁴Cf. <http://www.microsoft.com/typography/otspec/featurelist.htm>.

⁵See <http://www.microsoft.com/typography/otspec/scripttags.htm> for a list of valid values. For scripts derived from the Latin alphabet the value latn is good choice.

language

An OpenType language system identifier,⁶ defaulting to `df1t`.

featurefile

A comma-separated list of feature files to be applied to the font. Feature files contain a textual representation of OpenType tables and extend the features of a font on fly. After they are applied to a font, features defined in a feature file can be enabled or disabled just like any other font feature. The syntax is documented in Adobe's OpenType Feature File Specification.⁷

For a demonstration of how to set a `tkrn` feature consult the file `tkrn.fea` that is part of `luaotfload`. It can be read and applied as follows:

```
\font\test=Latin Modern Roman:featurefile=tkrn.fea;+tkrn
```

color

A font color, defined as a triplet of two-digit hexadecimal *RGB* values, with an optional fourth value for transparency (where `00` is completely transparent and `FF` is opaque).

For example, in order to set text in semitransparent red:

```
\font\test={Latin Modern Roman}:color=FF0000BB
```

protrusion & expansion

These keys control microtypographic features of the font, namely *character protrusion* and *font expansion*. Their arguments are names of Lua tables that contain values for the respective features.⁸ For both, only the set `default` is predefined.

For example, to enable default protrusion⁹:

```
\font\test=LatinModernRoman:protrusion=default
```

Non-standard font features `luaotfload` adds a number of features that are not defined in the original OpenType specification, most of them aiming at emulating the behavior familiar from other \TeX engines. Currently (2013) there are three of them:

⁶Cf. <http://www.microsoft.com/typography/otspec/languagetags.htm>.

⁷Cf. http://www.adobe.com/devnet/opentype/afdko/topic_feature_file_syntax.html.

⁸For examples of the table layout please refer to the section of the file `luaotfload-fonts-ext.lua` where the default values are defined. Alternatively and with loss of information, you can dump those tables into your terminal by issuing

```
\directlua{inspect(fonts.protrusions.setups.default)
inspect(fonts.expansions.setups.default)}
```

at some point after loading `luaotfload.sty`.

⁹You also need to set `pdfprotrudechars=2` and `pdfadjustspacing=2` to activate protrusion and expansion, respectively. See the [pdf \$\TeX\$ manual](#) for details.

anum Substitutes the glyphs in the *ASCII* number range with their counterparts from eastern Arabic or Persian, depending on the value of `language`.

tlig Applies legacy T_EX ligatures:

```
“ ” ‘ ’ “ ” – —
— --- ¡ ! ‘
¿ ? ‘
```

¹⁰

itlc Computes italic correction values (active by default).

5 FONT NAMES DATABASE

As mentioned above, `luaotfload` keeps track of which fonts are available to LuaT_EX by means of a *database*. This allows referring to fonts not only by explicit filenames but also by the proper names contained in the metadata which is often more accessible to humans.¹¹

When `luaotfload` is asked to load a font by a font name, it will check if the database exists and load it, or else generate a fresh one. Should it then fail to locate the font, an update to the database is performed in case the font has been added to the system only recently. As soon as the database is updated, the resolver will try and look up the font again, all without user intervention. The goal is for `luaotfload` to act in the background and behave as unobtrusively as possible, while providing a convenient interface to the fonts installed on the system.

Generating the database for the first time may take a while since it inspects every font file on your computer. This is particularly noticeable if it occurs during a typesetting run. In any case, subsequent updates to the database will be quite fast.

5.1 `luaotfload-tool / mkluatexfontdb.lua`¹²

It can still be desirable at times to do some of these steps manually, and without having to compile a document. To this end, `luaotfload` comes with the utility `luaotfload-tool` that offers an interface to the database functionality. Being a Lua script, there are two ways to run it: either make it executable (`chmod +x` on unixoid systems) or pass it as an argument to `texlua`.¹³ Invoked with the argument `--update` it will perform a database update, scanning for fonts not indexed.

¹⁰These contain the feature set `trep` of earlier versions of `luaotfload`.

Note to X_YT_EX users: this is the equivalent of the assignment `mapping=text-tex` using X_YT_EX's input remapping feature.

¹¹The tool `otfinfo` (comes with T_EX Live), when invoked on a font file with the `-i` option, lists the variety of name fields defined for it.

¹²The script may be named just `mkluatexfontdb` in your distribution.

¹³Tests by the maintainer show only marginal performance gain by running with Luigi Scarso's `LuajitTEX`, which is probably due to the fact that most of the time is spent on file system operations.

Note: On MS Windows systems, the script can be run either by calling the wrapper application `luaotfload-tool.exe` or as `texlua.exe luaotfload-tool.lua`.

Table 1: List of paths searched for each supported operating system.

Windows	%WINDIR%\Fonts
Linux	/usr/local/etc/fonts/fonts.conf and /etc/fonts/fonts.conf
Mac	~/Library/Fonts, /Library/Fonts, /System/Library/Fonts, and /Network/Library/Fonts

```
luaotfload-tool --update
```

Adding the `--force` switch will initiate a complete rebuild of the database.

```
luaotfload-tool --update --force
```

For sake of backwards compatibility, `luaotfload-tool` may be renamed or sym-linked to `mkluatexfontdb`. Whenever it is run under this name, it will update the database first, mimicking the behavior of earlier versions of `luaotfload`.

5.2 *Search Paths*

`luaotfload` scans those directories where fonts are expected to be located on a given system. On a Linux machine it follows the paths listed in the `Fontconfig` configuration files; consult `man 5 fonts.conf` for further information. On Windows systems, the standard location is `Windows\Fonts`, while Mac OS X requires a multitude of paths to be examined. The complete list is given in table ???. Other paths can be specified by setting the environment variable `OSFONTDIR`. If it is non-empty, then search will be extended to the included directories.

5.3 *Querying from Outside*

`luaotfload-tool` also provides rudimentary means of accessing the information collected in the font database. If the option `--find=name` is given, the script will try and search the fonts indexed by `luaotfload` for a matching name. For instance, the invocation

```
luaotfload-tool --find="Iwona Regular"
```

will verify if “Iwona Regular” is found in the database and can be readily requested in a document.

If you are unsure about the actual font name, then add the `-F` (or `--fuzzy`) switch to the command line to enable approximate matching. Suppose you cannot precisely remember if the variant of `Iwona` you are looking for was “Bright” or “Light”. The query


```
luaotfload-tool -F --find="Iwona Bright"
```

will tell you that indeed the latter name is correct.

Basic information about fonts in the database can be displayed using the `-i` option (`--info`).

```
luaotfload-tool -i --find="Iwona Light Italic"
```

The meaning of the printed values is described in section 4.4 of the Lua \TeX reference manual.¹⁴

`luaotfload-tool --help` will list the available command line switches, including some not discussed in detail here. For a full documentation of `luaotfload-tool` and its capabilities refer to the manpage (`man 1 luaotfload-tool`).¹⁵

5.4 Blacklisting Fonts

Some fonts are problematic in general, or just in Lua \TeX . If you find that compiling your document takes far too long or eats away all your system's memory, you can track down the culprit by running `luaotfload-tool -v` to increase verbosity. Take a note of the *filename* of the font that database creation fails with and append it to the file `luaotfload-blacklist.cnf`.

A blacklist file is a list of font filenames, one per line. Specifying the full path to where the file is located is optional, the plain filename should suffice. File extensions (`.otf`, `.ttf`, etc.) may be omitted. Anything after a percent (%) character until the end of the line is ignored, so use this to add comments. Place this file to some location where the `kpse` library can find it, e. g. `texmf-local/tex/luatex/luaotfload` if you are running \TeX Live,¹⁶ or just leave it in the working directory of your document. `luaotfload` reads all files named `luaotfload-blacklist.cnf` it finds, so the fonts in `./luaotfload-blacklist.cnf` extend the global blacklist.

Furthermore, a filename prepended with a dash character (-) is removed from the blacklist, causing it to be temporarily whitelisted without modifying the global file. An example with explicit paths:

```
% example otf-blacklist.cnf
/Library/Fonts/GillSans.ttc % Luaotfload ignores this font.
-/Library/Fonts/Optima.ttc % This one is usable again, even if
                             % blacklisted somewhere else.
```

6 FILES FROM CON \TeX T AND LUA \TeX -FONTS

`luaotfload` relies on code originally written by Hans Hagen¹⁷ for and tested with Con \TeX t. It integrates the font loader as distributed in the Lua \TeX -Fonts package. The origi-

¹⁴In \TeX Live: `texmf-dist/doc/luatex/base/luatexref-t.pdf`.

¹⁵Or see `luaotfload-tool.rst` in the source directory.

¹⁶You may have to run `mktexlsr` if you created a new file in your `texmf` tree.

¹⁷The creator of the Con \TeX t format.

nal Lua source files have been combined using the `mtx-package` script into a single, self-contained blob. In this form the font loader has no further dependencies¹⁸ and requires only minor adaptations to integrate into `luaotfload`. The guiding principle is to let ConTeXt/LuaTeX-Fonts take care of the implementation, and update the imported code from time to time. As maintainers, we aim at importing files from upstream essentially *unmodified*, except for renaming them to prevent name clashes. This job has been greatly alleviated since the advent of LuaTeX-Fonts, prior to which the individual dependencies had to be manually spotted and extracted from the ConTeXt source code in a complicated and error-prone fashion.

Below is a commented list of the files distributed with `luaotfload` in one way or the other. See figure ?? on page ?? for a graphical representation of the dependencies. From LuaTeX-Fonts, only the file `luatex-fonts-merged.lua` has been imported as `luaotfload-merged.lua`. It is generated by `mtx-package`, a Lua source code merging tool developed by Hans Hagen.¹⁹ It houses several Lua files that can be classed in three categories.

- *Lua utility libraries*, a subset of what is provided by the `lualibs` package.

– <code>l-lua.lua</code>	– <code>l-io.lua</code>
– <code>l-lpeg.lua</code>	– <code>l-file.lua</code>
– <code>l-function.lua</code>	– <code>l-boolean.lua</code>
– <code>l-string.lua</code>	– <code>l-math.lua</code>
– <code>l-table.lua</code>	– <code>util-str.lua</code>

- The *font loader* itself. These files have been written for LuaTeX-Fonts and they are distributed along with `luaotfload`.

– <code>luatex-basics-gen.lua</code>	– <code>luatex-fonts-chr.lua</code>
– <code>luatex-basics-nod.lua</code>	– <code>luatex-fonts-lua.lua</code>
– <code>luatex-fonts-enc.lua</code>	– <code>luatex-fonts-def.lua</code>
– <code>luatex-fonts-syn.lua</code>	– <code>luatex-fonts-ext.lua</code>
– <code>luatex-fonts-tfm.lua</code>	– <code>luatex-fonts-cbk.lua</code>

- Code related to *font handling and node processing*, taken directly from ConTeXt.

– <code>data-con.lua</code>	– <code>font-map.lua</code>
– <code>font-ini.lua</code>	– <code>font-oti.lua</code>
– <code>font-con.lua</code>	– <code>font-otf.lua</code>
– <code>font-cid.lua</code>	– <code>font-otb.lua</code>

¹⁸It covers, however, to some extent the functionality of the `lualibs` package.

¹⁹`mtx-package` is part of ConTeXt and requires `mtxrun`. Run `mtxrun --script package --help` to display further information. For the actual merging code see the file `util-mrg.lua` that is part of ConTeXt.

```

- node-inj.lua                - font-def.lua
- font-ota.lua
- font-otn.lua                - font-otp.lua

```

Note that if `luaotfload` cannot locate the merged file, it will load the individual Lua libraries instead. Their names remain the same as in ConT_EXt (without the `otfl`-prefix) since we imported the relevant section of `luatex-fonts.lua` unmodified into `luaotfload.lua`. Thus if you prefer running bleeding edge code from the ConT_EXt beta, all you have to do is remove `luaotfload-merged.lua` from the search path.

Also, the merged file at some point loads the Adobe Glyph List from a Lua table that is contained in `luaotfload-glyphlist.lua`, which is automatically generated by the script `mkglyphlist`.²⁰ There is a make target `glyphs` that will create a fresh glyph list so we don't need to import it from ConT_EXt any longer.

In addition to these, `luaotfload` requires a number of files not contained in the merge. Some of these have no equivalent in LuaT_EX-Fonts or ConT_EXt, some were taken unmodified from the latter.

- `luaotfload-features.lua` - font feature handling; incorporates some of the code from `font-otc` from ConT_EXt;
- `luaotfload-lib-dir.lua` - `l-dir` from ConT_EXt; contains functionality required by `luaotfload-font-nms.lua`.
- `luaotfload-override.lua` - overrides the ConT_EXt logging functionality.
- `luaotfload-loaders.lua` - registers the OpenType font reader as handler for Postscript fonts (*PFA*, *PFB*).
- `luaotfload-database.lua` - font names database.
- `luaotfload-colors.lua` - color handling.
- `luaotfload-auxiliary.lua` - access to internal functionality for package authors (proposals for additions welcome).

7 AUXILIARY FUNCTIONS

With release version 2.2, `luaotfload` received additional functions for package authors to call from outside (see the file `luaotfload-auxiliary.lua` for details). The purpose of this addition twofold. Firstly, `luaotfload` failed to provide a stable interface to internals in the past which resulted in an unmanageable situation of different packages abusing the raw access to font objects by means of the *patch_font* callback. When the structure of the font object changed due to an update, all of these imploded and several packages had to be fixed while simultaneously providing fallbacks for earlier versions. Now the patching

²⁰See `luaotfload-font-enc.lua`. The hard-coded file name is why we have to replace the procedure that loads the file in `luaotfload-override.lua`.

is done on the luaotfload side and can be adapted with future modifications to font objects without touching the packages that depend on it. Second, some the capabilities of the font loader and the names database are not immediately relevant in luaotfload itself but might nevertheless be of great value to package authors or end users.

Note that the current interface is not yet set in stone and the development team is open to suggestions for improvements or additions.

7.1 Callback Functions

The *patch_font* callback is inserted in the wrapper luaotfload provides for the font definition callback (see below, page ??). At this place it allows manipulating the font object immediately after the font loader is done creating it. For a short demonstration of its usefulness, here is a snippet that writes an entire font object to the file `fontdump.lua`:

```
\input luaotfload.sty
\directlua{
  local dumpfile    = "fontdump.lua"
  local dump_font   = function (tfmdata)
    local data = table.serialize(tfmdata)
    io.savedata(dumpfile, data)
  end

  luatexbase.add_to_callback(
    "luaotfload.patch_font",
    dump_font,
    "my_private_callbacks.dump_font"
  )
}
\font\dumpme=name:Iwona
\bye
```

Beware: this creates a Lua file of around 150,000 lines of code, taking up 3 MB of disk space. By inspecting the output you can get a first impression of how a font is structured in LuaTeX's memory, what elements it is composed of, and in what ways it can be rearranged.

7.1.1 Compatibility with Earlier Versions

As has been touched on in the preface to this section, the structure of the object as returned by the fontloader underwent rather drastic changes during different stages of its development, and not all packages that made use of font patching have kept up with every one of it. To ensure compatibility with these as well as older versions of some packages, luaotfload sets up copies of or references to data in the font table where it used to be located. For instance, important parameters like the requested point size, the units factor, and the font name have again been made accessible from the toplevel of the table even though they were migrated to different subtables in the meantime.

7.1.2 Patches

These are mostly concerned with establishing compatibility with X_YTeX.

- *set_sscale_dimens*
Calculate `\fontdimens` 10 and 11 to emulate X_YTeX.
- *set_capheight*
Calculates `\fontdimen` 8 like X_YTeX.
- *patch_cambria_domh*
Correct some values of the font *Cambria Math*.

7.2 Package Author's Interface

As LuaTeX release 1.0 is nearing, the demand for a reliable interface for package authors increases.

7.2.1 Font Properties

Below functions mostly concern querying the different components of a font like for instance the glyphs it contains, or what font features are defined for which scripts.

- *aux.font_has_glyph* (*id* : int, *index* : int)
Predicate that returns true if the font *id* has glyph *index*.
- *aux.slot_of_name* (*name* : string)
Translates an Adobe Glyph name to the corresponding glyph slot.
- *aux.name_of_slot* (*slot* : int)
The inverse of *slot_of_name*; note that this might be incomplete as multiple glyph names may map to the same codepoint, only one of which is returned by *name_of_slot*.
- *aux.provides_script* (*id* : int, *script* : string)
Test if a font supports *script*.
- *aux.provides_language* (*id* : int, *script* : string, *language* : string)
Test if a font defines *language* for a given *script*.
- *aux.provides_feature* (*id* : int, *script* : string, *language* : string, *feature* : string)
Test if a font defines *feature* for *language* for a given *script*.
- *aux.get_math_dimension* (*id* : int, *dimension* : string)
Get the dimension *dimension* of font *id*.
- *aux.sprint_math_dimension* (*id* : int, *dimension* : string)
Same as *get_math_dimension*(), but output the value in scaled points at the TeX end.

7.2.2 Database

- *aux.scan_external_dir*(*dir* : *string*)
Include fonts in directory *dir* in font lookups without adding them to the database.

8 TROUBLESHOOTING

If you encounter problems with some fonts, please first update to the latest version of this package before reporting a bug, as luaotfload is under active development and still a moving target. The development takes place on github at <https://github.com/lualatex/luaotfload> where there is an issue tracker for submitting bug reports, feature requests and the likes requests and the likes.

Errors during database generation can be traced by increasing verbosity levels and redirecting log output to stdout:

```
luaotfload-tool -fuvvv --log=stdout
```

If this fails, the font last printed to the terminal is likely to be the culprit. Please specify it when reporting a bug, and blacklist it for the time being (see above, page ??).

A common problem is the lack of features for some OpenType fonts even when specified. This can be related to the fact that some fonts do not provide features for the `df1t` script (see above on page ??), which is the default one in this package. If this happens, assigning a noth script when the font is defined should fix it. For example with `latn`:

```
\font\test=file:MyFont.otf:script=latn;+liga;
```

Another strategy that helps avoiding problems is to not access raw LuaTeX internals directly. Some of them, even though they are dangerous to access, have not been overridden or disabled. Thus, whenever possible prefer the functions in the *aux* namespace over direct manipulation of font objects. For example, raw access to the *font.fonts* table like:

```
local somefont = font.fonts[2]
```

can render already defined fonts unusable. Instead, the function *font.getfont()* should be used because it has been replaced by a safe variant.

II Implementation

9 luaotfload.lua

This file initializes the system and loads the font loader. To minimize potential conflicts between other packages and the code imported from ConTeXt, several precautions are in order. Some of the functionality that the font loader expects to be present, like raw access to callbacks, are assumed to have been disabled by luatexbase when this file is

processed. In some cases it is possible to trick it by putting dummies into place and restoring the behavior from `luatexbase` after initialization. Other cases such as attribute allocation require that we hook the functionality from `luatexbase` into locations where they normally wouldn't be.

Anyways we can import the code base without modifications, which is due mostly to the extra effort by Hans Hagen to make `LuaTeX-Fonts` self-contained and encapsulate it, and especially due to his willingness to incorporate our suggestions.

```

1 luaotfload          = luaotfload or {}
2 local luaotfload    = luaotfload
3
4 config              = config or { }
5 config.luaotfload   = config.luaotfload or { }
6 -----luaotfload.resolver      = config.luaotfload.resolver      or "normal"
7 config.luaotfload.resolver      = config.luaotfload.resolver      or "cached"
8 config.luaotfload.definer       = config.luaotfload.definer       or "patch"
9 config.luaotfload.compatibility = config.luaotfload.compatibility or false
10 config.luaotfload.loglevel     = config.luaotfload.loglevel     or 1
11 config.luaotfload.color_callback = config.luaotfload.color_callback or "pre_line-break_filter"
12 --luaotfload.prefer_merge      = config.luaotfload.prefer_merge or true
13
14 luaotfload.module = {
15     name      = "luaotfload",
16     version   = 2.2,
17     date      = "2013/05/23",
18     description = "OpenType layout system.",
19     author    = "Elie Roux & Hans Hagen",
20     copyright  = "Elie Roux",
21     license    = "GPL v2.0"
22 }
23
24 local luatexbase    = luatexbase
25
26 local setmetatable   = setmetatable
27 local type, next     = type, next
28
29 local kpsefind_file  = kpse.find_file
30 local lfsisfile      = lfs.isfile
31
32 local add_to_callback, create_callback =
33     luatexbase.add_to_callback, luatexbase.create_callback
34 local reset_callback, call_callback =
35     luatexbase.reset_callback, luatexbase.call_callback
36
37 local dummy_function = function () end
38
39 local error, warning, info, log =
40     luatexbase.provides_module(luaotfload.module)

```

```

41
42 luaotfload.error      = error
43 luaotfload.warning    = warning
44 luaotfload.info       = info
45 luaotfload.log        = log
46

```

We set the minimum version requirement for Lua_T_EX to v0.76, because the font loader requires recent features like direct attribute indexing and *node.end_of_math()* that aren't available in earlier versions.²¹

```

47
48 local luatex_version = 76
49
50 if tex.luatexversion < luatex_version then
51     warning("LuaTeX v%.2f is old, v%.2f is recommended.",
52            tex.luatexversion/100,
53            luatex_version /100)
54     --- we install a fallback for older versions as a safety
55     if not node.end_of_math then
56         local math_t      = node.id"math"
57         local traverse_nodes = node.traverse_id
58         node.end_of_math = function (n)
59             for n in traverse_nodes(math_t, n.next) do
60                 return n
61             end
62         end
63     end
64 end
65

```

9.1 Module loading

We load the files imported from Con_T_EXt with this function. It automatically prepends the prefix `luaotfload-` to its argument, so we can refer to the files with their actual Con_T_EXt name.

```

66
67 local fl_prefix = "luaotfload" -- "luatex" for luatex-plain
68 local loadmodule = function (name)
69     require(fl_prefix .. "-" .. name)
70 end
71

```

Before _T_EXLive 2013 version, Lua_T_EX had a bug that made ofm fonts fail when called with their extension. There was a side-effect making ofm totally unloadable when `luaotfload` was present. The following lines are a patch for this bug. The utility of these lines is

²¹See Taco's announcement of v0.76: <http://comments.gmane.org/gmane.comp.tex.luatex.user/4042> and this commit by Hans that introduced those features. <http://repo.or.cz/w/context.git/commitdiff/a51f6cf6ee087046a2ae5927ed4edff0a1acec1b>.

questionable as they are not necessary since \TeX Live 2013. They should be removed in the next version.

```

72 local Cs, P, lpegmatch = lpeg.Cs, lpeg.P, lpeg.match
73
74 local p_dot, p_slash = P".", P"/"
75 local p_suffix      = (p_dot * (1 - p_dot - p_slash)^1 * P(-1)) / ""
76 local p_removesuffix = Cs((p_suffix + 1)^1)
77
78 local find_vf_file = function (name)
79     local fullname = kpsefind_file(name, "ovf")
80     if not fullname then
81         --fullname = kpsefind_file(file.removesuffix(name), "ovf")
82         fullname = kpsefind_file(lpegmatch(p_removesuffix, name), "ovf")
83     end
84     if fullname then
85         log("loading virtual font file %s.", fullname)
86     end
87     return fullname
88 end
89

```

9.2 Preparing the Font Loader

We treat the fontloader as a black box so behavior is consistent between formats. We do no longer run the intermediate wrapper file `luaotfload-fonts.lua` which we used to import from [Lua \$\text{\TeX}\$ -Plain](#). Rather, we load the fontloader code directly in the same fashion as `luatex-fonts`. How this is executed depends on the presence on the *merged font loader code*. In `luaotfload` this is contained in the file `luaotfload-merged.lua`. If this file cannot be found, the original libraries from Con \TeX t of which the merged code was composed are loaded instead. The imported font loader will call `callback.register` once while reading `font-def.lua`. This is unavoidable unless we modify the imported files, but harmless if we make it call a dummy instead. However, this problem might vanish if we decide to do the merging ourselves, like the `lua-luabooks` package does. With this step we would obtain the freedom to load our own overrides in the process right where they are needed, at the cost of losing encapsulation. The decision on how to progress is currently on indefinite hold.

```

90
91 local starttime = os.gettimeofday()
92
93 local trapped_register = callback.register
94 callback.register      = dummy_function
95

```

By default, the fontloader requires a number of *private attributes* for internal use. These must be kept consistent with the attribute handling methods as provided by `luatexbase`. Our strategy is to override the function that allocates new attributes before we initialize the font loader, making it a wrapper around `luatexbase.new_attribute`.²² The attribute

²²Many thanks, again, to Hans Hagen for making this part configurable!

identifiers are prefixed “luaotfload@” to avoid name clashes.

```
96
97 do
98     local new_attribute    = luatexbase.new_attribute
99     local the_attributes   = luatexbase.attributes
100
101     attributes = attributes or { }
102
103     attributes.private = function (name)
104         local attr    = "luaotfload@" .. name --- used to be: "otfl@"
105         local number = the_attributes[attr]
106         if not number then
107             number = new_attribute(attr)
108         end
109         return number
110     end
111 end
112
```

These next lines replicate the behavior of `luatex-fonts.lua`.

```
113
114 local context_environment = { }
115
116 local push_namespaces = function ()
117     log("push namespace for font loader")
118     local normalglobal = { }
119     for k, v in next, _G do
120         normalglobal[k] = v
121     end
122     return normalglobal
123 end
124
125 local pop_namespaces = function (normalglobal, isolate)
126     if normalglobal then
127         local _G = _G
128         local mode = "non-destructive"
129         if isolate then mode = "destructive" end
130         log("pop namespace from font loader -- " .. mode)
131         for k, v in next, _G do
132             if not normalglobal[k] then
133                 context_environment[k] = v
134                 if isolate then
135                     _G[k] = nil
136                 end
137             end
138         end
139         for k, v in next, normalglobal do
140             _G[k] = v
141         end
142         -- just to be sure:

```

```

143     setmetatable(context_environment,_G)
144   else
145     log("irrecoverable error during pop_namespace: no globals to restore")
146     os.exit()
147   end
148 end
149
150 luaotfload.context_environment = context_environment
151 luaotfload.push_namespaces     = push_namespaces
152 luaotfload.pop_namespaces     = pop_namespaces
153
154 local our_environment = push_namespaces()
155

```

The font loader requires that the attribute with index zero be zero. We happily oblige. (Cf. luatex-fonts-nod.lua.)

```

156
157 tex.attribute[0] = 0
158

```

Now that things are sorted out we can finally load the fontloader.

```

159
160 loadmodule"merged.lua"
161 ---loadmodule"font-odv.lua" --- <= Devanagari support from Context
162
163 if fonts then
164
165   if not fonts._merge_loaded_message_done_ then
166     --- a program talking first person -- HH sure believes in strong AI ...
167     log[["I am using the merged version of 'luaotfload.lua' here. If]]
168     log[[ you run into problems or experience unexpected behaviour,]]
169     log[[ and if you have ConTeXt installed you can try to delete the]]
170     log[[ file 'luaotfload-font-merged.lua' as I might then use the]]
171     log[[ possibly updated libraries. The merged version is not]]
172     log[[ supported as it is a frozen instance. Problems can be]]
173     log[[ reported to the ConTeXt mailing list.]]
174   end
175   fonts._merge_loaded_message_done_ = true
176
177 else--- the loading sequence is known to change, so this might have to
178   --- be updated with future updates!
179   --- do not modify it though unless there is a change to the merged
180   --- package!
181   loadmodule("l-lua.lua")
182   loadmodule("l-lpeg.lua")
183   loadmodule("l-function.lua")
184   loadmodule("l-string.lua")
185   loadmodule("l-table.lua")
186   loadmodule("l-io.lua")
187   loadmodule("l-file.lua")

```

```

188     loadmodule("l-boolean.lua")
189     loadmodule("l-math.lua")
190     loadmodule("util-str.lua")
191     loadmodule('luatex-basics-gen.lua')
192     loadmodule('data-con.lua')
193     loadmodule('luatex-basics-nod.lua')
194     loadmodule('font-ini.lua')
195     loadmodule('font-con.lua')
196     loadmodule('luatex-fonts-enc.lua')
197     loadmodule('font-cid.lua')
198     loadmodule('font-map.lua')
199     loadmodule('luatex-fonts-syn.lua')
200     loadmodule('luatex-fonts-tfm.lua')
201     loadmodule('font-oti.lua')
202     loadmodule('font-otf.lua')
203     loadmodule('font-otb.lua')
204     loadmodule('node-inj.lua')
205     loadmodule('font-ota.lua')
206     loadmodule('font-otn.lua')
207     loadmodule('font-otp.lua')--- since 2013-04-23
208     loadmodule('luatex-fonts-lua.lua')
209     loadmodule('font-def.lua')
210     loadmodule('luatex-fonts-def.lua')
211     loadmodule('luatex-fonts-ext.lua')
212     loadmodule('luatex-fonts-cbk.lua')
213 end --- non-merge fallback scope
214

```

Here we adjust the globals created during font loader initialization. If the second argument to *pop_namespaces()* is true this will restore the state of *_G*, eliminating every global generated since the last call to *push_namespaces()*. At the moment we see no reason to do this, and since the font loader is considered an essential part of luatex as well as a very well organized piece of code, we happily concede it the right to add to *_G* if needed.

```

215
216 pop_namespaces(our_environment, false)-- true)
217
218 log("fontloader loaded in %0.3f seconds", os.gettimeofday()-starttime)
219

```

Restore original *kpse.expand_path* function.

```

220
221 if normal_expand_path ~= nil then
222     kpse.expand_path = normal_expand_path
223     phantom_kpse      = nil
224 end
225

```

9.3 Callbacks

After the fontloader is ready we can restore the callback trap from luatexbase.

```
226
227 callback.register = trapped_register
228
```

We do our own callback handling with the means provided by luatexbase. Note: *pre_linebreak_filter* and *hpack_filter* are coupled in ConT_EXt in the concept of *node processor*.

```
229
230 add_to_callback("pre_linebreak_filter",
231               nodes.simple_font_handler,
232               "luaotfload.node_processor",
233               1)
234 add_to_callback("hpack_filter",
235               nodes.simple_font_handler,
236               "luaotfload.node_processor",
237               1)
238 add_to_callback("find_vf_file",
239               find_vf_file, "luaotfload.find_vf_file")
240
241 loadmodule"lib-dir.lua"    --- required by luaotfload-database.lua
242 loadmodule"override.lua"  --- "luat-ovr"
243
244 logs.set_loglevel(config.luaotfload.loglevel)
245
```

Now we load the modules written for luaotfload.

```
246 loadmodule"loaders.lua"    --- "font-pfb" new in 2.0, added 2011
247 loadmodule"database.lua"   --- "font-nms"
248 loadmodule"colors.lua"     --- "font-clr"
249
```

Relying on the name: resolver for everything has been the source of permanent trouble with the database. With the introduction of the new syntax parser we now have enough granularity to distinguish between the X_YT_EX emulation layer and the genuine name: and file: lookups of LuaT_EX-Fonts. Another benefit is that we can now easily plug in or replace new lookup behaviors if necessary. The name resolver remains untouched, but it calls *fonts.names.resolve()* internally anyways (see luaotfload-database.lua).

```
250
251 local request_resolvers = fonts.definers.resolvers
252 local formats           = fonts.formats
253 formats.ofm             = "type1"
254
```

luaotfload promises easy access to system fonts. Without additional precautions, this cannot be achieved by kpathsea alone, because it searches only the texmf directories by default. Although it is possible for kpathsea to include extra paths by adding them

to the OSFONTDIR environment variable, this is still short of the goal »*it just works!*«. When building the font database luaotfload scans system font directories anyways, so we already have all the information for looking sytem fonts. With the release version 2.2 the file names are indexed in the database as well and we are ready to resolve file: lookups this way. Thus we no longer need to call the kpathsea library in most cases when looking up font files, only when generating the database.

```

255
256 local resolvefile = fonts.names.crude_file_lookup
257 --local resolvefile = fonts.names.crude_file_lookup_verbose
258
259 function request_resolvers.file(specification)
260     local name = resolvefile(specification.name)
261     local suffix = file.suffix(name)
262     if formats[suffix] then
263         specification.forced = suffix
264         specification.name = file.removesuffix(name)
265     else
266         specification.name = name
267     end
268 end
269
270

```

We classify as anon: those requests that have neither a prefix nor brackets. According to Khaled²³ they are the X_YTeX equivalent of a name: request, so we will be treating them as such.

```

271
272 --request_resolvers.anon = request_resolvers.name
273

```

There is one drawback, though. This syntax is also used for requesting fonts in Type1 (TFM, OFM) format. These are essentially file: lookups and must be caught before the name: resolver kicks in, lest they cause the database to update. Even if we were to require the file: prefix for all Type1 requests, tests have shown that certain fonts still include further fonts (e. g. omlgcb.ofm will ask for omsecob.tfm) *using the old syntax*. For this reason, we introduce an extra check with an early return.

```

274
275 local type1_formats = { "tfm", "ofm", }
276
277 request_resolvers.anon = function (specification)
278     local name = specification.name
279     for i=1, #type1_formats do
280         local format = type1_formats[i]
281         if resolvers.findfile(name, format) then
282             specification.name = file.addsuffix(name, format)
283             return
284         end
285     end
286 end

```

²³<https://github.com/phi-gamma/luaotfload/issues/4#issuecomment-17090553>.

```

285     end
286     --- under some weird circumstances absolute paths get
287     --- passed to the definer; we have to catch them
288     --- before the name: resolver misinterprets them.
289     name = specification.specification
290     local exists, _ = lfs.isfile(name)
291     if exists then --- garbage; we do this because we are nice,
292                   --- not because it is correct
293         logs.names_report("log", 1, "load", "file \"%s\" exists", name)
294         logs.names_report("log", 1, "load",
295             "... overriding borked anon: lookup with path: lookup")
296         specification.name = name
297         request_resolvers.path(specification)
298         return
299     end
300     request_resolvers.name(specification)
301 end
302

```

Prior to version 2.2, luaotfload did not distinguish file: and path: lookups, causing complications with the resolver. Now we test if the requested name is an absolute path in the file system, otherwise we fall back to the file: lookup.

```

303
304 request_resolvers.path = function (specification)
305     local name      = specification.name
306     local exists, _ = lfs.isfile(name)
307     if not exists then -- resort to file: lookup
308         logs.names_report("log", 1, "load",
309             "path lookup of \"%s\" unsuccessful, falling back to file:",
310             name)
311         request_resolvers.file(specification)
312     else
313         local suffix = file.suffix(name)
314         if formats[suffix] then
315             specification.forced = suffix
316             specification.name   = file.removesuffix(name)
317         else
318             specification.name = name
319         end
320     end
321 end
322

```

We create a callback for patching fonts on the fly, to be used by other packages. It initially contains the empty function that we are going to override below.

```

323
324 create_callback("luaotfload.patch_font", "simple", dummy_function)
325

```

9.4 ConTeXt override

We provide a simplified version of the original font definition callback.

```
326
327 local read_font_file = fonts.definers.read
328
329 --- spec -> size -> id -> tfmdata
330 local patch_defined_font = function (specification, size, id)
331     local tfmdata = read_font_file(specification, size, id)
332     if type(tfmdata) == "table" and tfmdata.shared then
333         --- We need to test for the "shared" field here
334         --- or else the fontspec capheight callback will
335         --- operate on tfm fonts.
336         call_callback("luaotfload.patch_font", tfmdata)
337     end
338     return tfmdata
339 end
340
341 reset_callback("define_font")
342
```

Finally we register the callbacks.

```
343
344 local font_definer = config.luaotfload.definer
345
346 if font_definer == "generic" then
347     add_to_callback("define_font",
348         fonts.definers.read,
349         "luaotfload.define_font",
350         1)
351 elseif font_definer == "patch" then
352     add_to_callback("define_font",
353         patch_defined_font,
354         "luaotfload.define_font",
355         1)
356 end
357
358 loadmodule"features.lua"    --- contains what was "font-ltx" and "font-otc"
359 loadmodule"extralibs.lua"   --- load additional Context libraries
360 loadmodule"auxiliary.lua"   --- additional high-level functionality (new)
361
362 -- vim:tw=71:sw=4:ts=4:expandtab
363
```

10 luaotfload.sty

Classical Plain+ \TeX package initialization.

```
364 \csname ifluaotfloadloaded\endcsname
365 \let\ifluaotfloadloaded\endinput
```



```

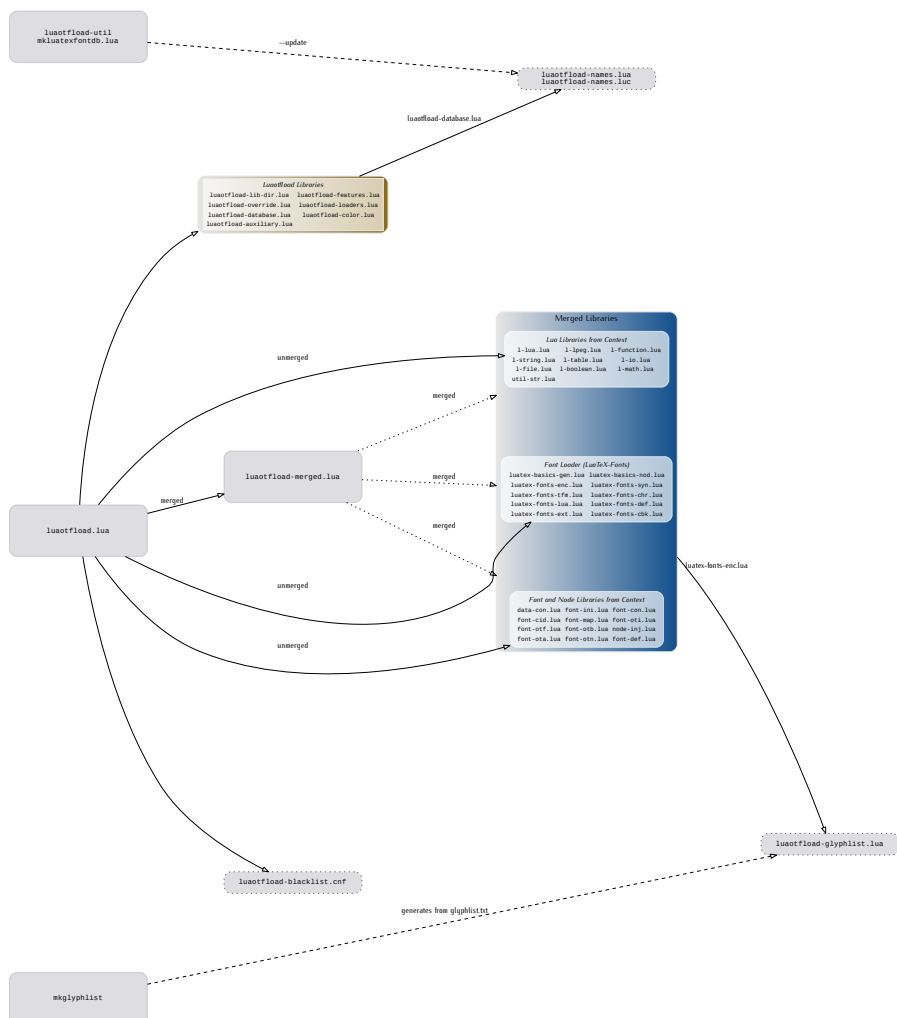
366 \bgroup\expandafter\expandafter\expandafter\egroup
367 \expandafter\ifx\csname ProvidesPackage\endcsname\relax
368   \input luatexbase.sty
369 \else
370   \NeedsTeXFormat{LaTeX2e}
371   \ProvidesPackage{luaotfload}%
372     [2013/05/23 v2.2d OpenType layout system]
373   \RequirePackage{luatexbase}
374 \fi
375 \ifnum\luatexversion<76
376   %% here some deprecation warning would be in order
377   \RequireLuaModule{lualibs}
378   \RequireLuaModule{luaotfload-legacy}
379 \else
380   \RequireLuaModule{luaotfload}
381 \fi
382 \endinput

```

$\langle \text{definition} \rangle$::= $\backslash \text{font}$, $CSNAME$, '=', $\langle \text{font request} \rangle$, [$\langle \text{size} \rangle$] ;
$\langle \text{size} \rangle$::= 'at', $DIMENSION$;
$\langle \text{font request} \rangle$::= 'n', $\langle \text{unquoted font request} \rangle$ 'n' 't', $\langle \text{unquoted font request} \rangle$ 't' $\langle \text{unquoted font request} \rangle$;
$\langle \text{unquoted font request} \rangle$::= $\langle \text{specification} \rangle$, [':' , $\langle \text{feature list} \rangle$] '[', $\langle \text{path lookup} \rangle$ ']', [[':'], $\langle \text{feature list} \rangle$] ;
$\langle \text{specification} \rangle$::= $\langle \text{prefixed spec} \rangle$, [$\langle \text{subfont no} \rangle$], { $\langle \text{modifier} \rangle$ } $\langle \text{anon lookup} \rangle$, { $\langle \text{modifier} \rangle$ } ;
$\langle \text{prefixed spec} \rangle$::= 'file:', $\langle \text{file lookup} \rangle$ 'name:', $\langle \text{name lookup} \rangle$;
$\langle \text{file lookup} \rangle$::= { $\langle \text{name character} \rangle$ } ;
$\langle \text{name lookup} \rangle$::= { $\langle \text{name character} \rangle$ } ;
$\langle \text{anon lookup} \rangle$::= $TFMNAME$ $\langle \text{name lookup} \rangle$;
$\langle \text{path lookup} \rangle$::= { $ALL_CHARACTERS$ - ']' } ;
$\langle \text{modifier} \rangle$::= '/', ('I' 'B' 'BI' 'IB' 'S=', { $DIGIT$ }) ;
$\langle \text{subfont no} \rangle$::= '(', { $DIGIT$ }, ')' ;
$\langle \text{feature list} \rangle$::= $\langle \text{feature expr} \rangle$, { ',', $\langle \text{feature expr} \rangle$ } ;
$\langle \text{feature expr} \rangle$::= $FEATURE_ID$, '=', $FEATURE_VALUE$ $\langle \text{feature switch} \rangle$, $FEATURE_ID$;
$\langle \text{feature switch} \rangle$::= '+' '-' ;
$\langle \text{name character} \rangle$::= $ALL_CHARACTERS$ - ('(' '/' ':') ;

Figure 1: Font request syntax. Braces or double quotes around the *specification* rule will preserve whitespace in file names. In addition to the font style modifiers (*slash-notation*) given above, there are others that are recognized but will be silently ignored: aat, icu, and gr. The special terminals are: $FEATURE_ID$ for a valid font feature name and $FEATURE_VALUE$ for the corresponding value. $TFMNAME$ is the name of a *TFM* file. $DIGIT$ again refers to bytes 48–57, and $ALL_CHARACTERS$ to all byte values. $CSNAME$ and $DIMENSION$ are the \TeX concepts.

Figure 2: Schematic of the files in Luaotfload



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Version 2, June 1991

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